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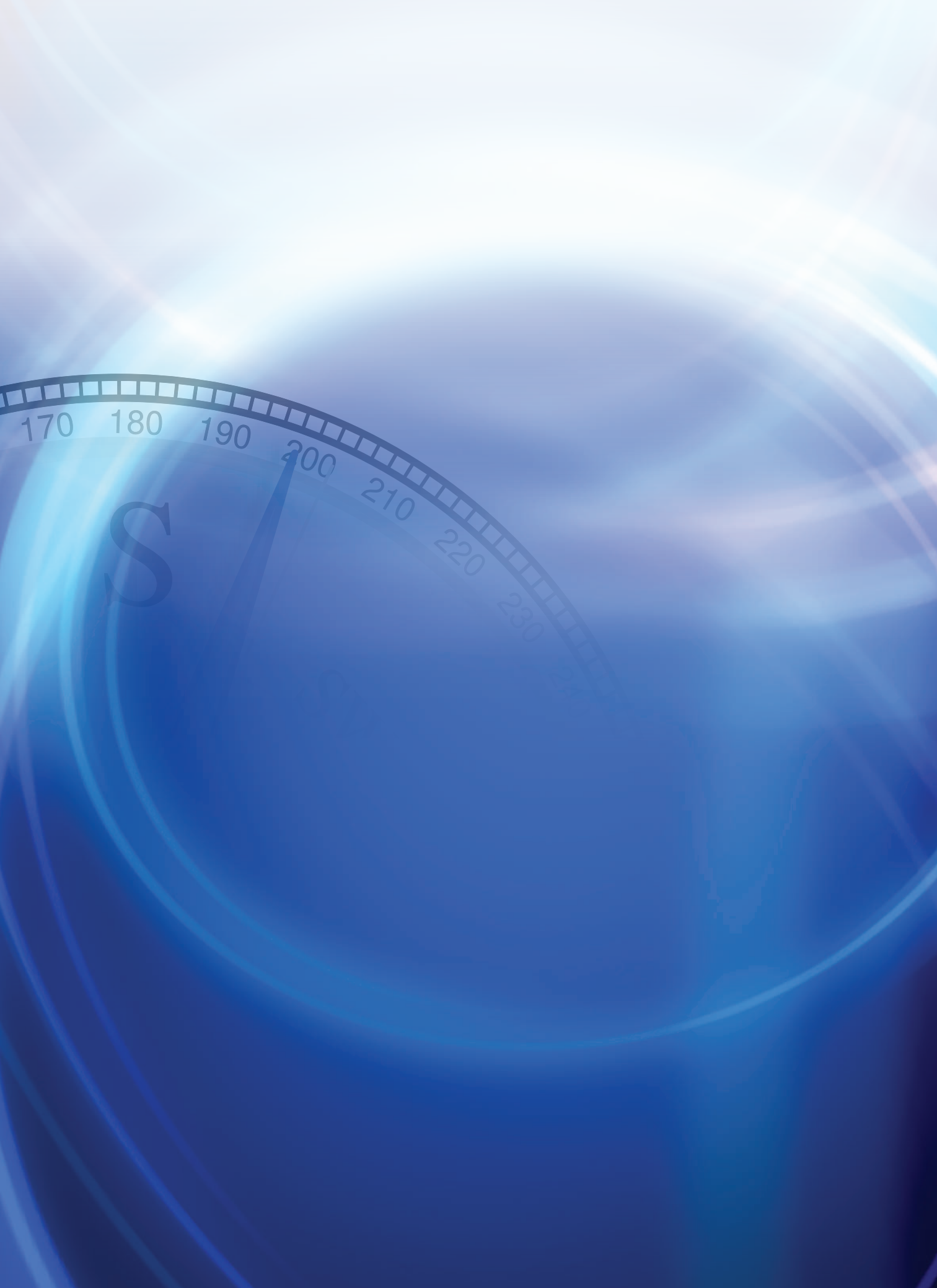
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Original Article

Flexible Multidose GnRH Antagonist Versus GnRH Agonist Protocols for Controlled Ovarian Stimulation in IVF: A Prospective Randomized Study Stratified by Ovarian Response

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Keywords: In vitro fertilization; GnRH antagonist protocol; GnRH agonist protocol; normal ovarian response; poor ovarian response; ovarian hyperstimulation syndrome.

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ABSTRACT

Objective: This prospective randomized controlled trial aimed to evaluate the effectiveness of a flexible multidose GnRH antagonist protocol compared with a long luteal GnRH agonist protocol in normal ovarian responders and a short GnRH agonist protocol in poor ovarian responders, focusing on stimulation characteristics, laboratory outcomes, pregnancy rates, and OHSS.

Methods: Patients scheduled for IVF with a BMI of 19–32 kg/m² were included. Participants were classified as normal or poor ovarian responders and randomized within each group to GnRH agonist or antagonist protocols using a sealed-envelope method. Follicular development was monitored by transvaginal ultrasonography and serum estradiol levels. Human chorionic gonadotropin was administered when at least two follicles reached 18–20 mm in diameter, followed by oocyte pick-up 35–36 hours later. The primary outcome was oocyte and embryo yield, while secondary outcomes included gonadotropin dose, stimulation duration, estradiol levels, cycle cancellation, clinical pregnancy, and OHSS.

Results: A total of 142 cycles were analyzed (normal responders: Long agonist n=34, antagonist n=28; poor responders: Short agonist n=42, antagonist n=38). In the normal responder group, the stimulation duration was shorter with the antagonist protocol, while the total gonadotropin dose was comparable between protocols. In both response groups, there were no significant differences in the numbers of total and mature oocytes, embryos obtained, embryos transferred, or cycle cancellation rates. Among normal responders, pregnancy rates per cycle, oocyte pick-up, and embryo transfer were similar between protocols. In poor responders, pregnancy rates tended to be lower in the antagonist group; however, the difference was not statistically significant. Mild ovarian hyperstimulation syndrome (OHSS) occurred only in two cases within the normal responder group, with no difference between protocols.

Conclusion: The flexible multidose GnRH antagonist protocol yielded comparable oocyte/embryo outcomes and pregnancy rates to agonist protocols in both normal and poor responders, while offering a shorter stimulation duration in normal responders.

INTRODUCTION

Infertility remains a prevalent health problem affecting a considerable proportion of couples of reproductive age, and advances in assisted reproductive technologies (ART), particularly in vitro fertilization (IVF), have substantially improved treatment outcomes over recent decades.[1] Among the key determinants of IVF success is the controlled ovarian stimulation (COS) process, which aims to obtain an adequate number of developmentally competent oocytes to optimize fertilization, embryo development, and pregnancy outcomes.[2]

Gonadotropin-releasing hormone (GnRH) analogues have been an integral component of COS protocols for more than two decades, primarily to prevent premature luteinizing hormone (LH) surge and to achieve synchronized fol-

licular development.[3] Long luteal GnRH agonist protocols were historically regarded as the standard approach owing to their strong and consistent pituitary suppression. Nevertheless, prolonged stimulation duration, increased gonadotropin consumption, hypoestrogenic adverse effects, and reduced patient convenience have been recognized as important limitations of agonist-based regimens.[3,4]

To overcome these drawbacks, GnRH antagonists were developed to achieve rapid and reversible suppression of gonadotropin secretion through competitive blockade of pituitary GnRH receptors.[5] The absence of an initial flare effect, shorter treatment duration, and a more patient-friendly stimulation course constitute the main theoretical advantages of antagonist protocols, which have led to their widespread use in contemporary IVF practice.[3] However, comparative studies evaluating GnRH agonist and antagonist protocols have yielded inconsistent results regarding oocyte yield, embryo quality, and pregnancy outcomes.[6,7]

Several methodological and biological factors may account for these discrepancies, including the lack of universally accepted criteria for defining ovarian response, heterogeneity of study populations, variability in stimulation agents and dosing strategies, and insufficient statistical power in some trials.[3,6,7] Importantly, normal and poor ovarian responders represent biologically distinct subgroups with fundamental differences in follicular reserve, gonadotropin sensitivity, and endocrine responsiveness, which may substantially influence their clinical outcomes under different COS protocols.[8,9]

In recent years, the flexible multidose GnRH antagonist protocol, in which antagonist initiation is individualized according to follicular development, has emerged as an alternative strategy aimed at optimizing treatment duration and medication exposure.[5] Nevertheless, evidence regarding the comparative effectiveness of this approach remains heterogeneous, particularly when evaluated across different ovarian response subgroups. Data directly comparing flexible antagonist protocols with long luteal GnRH agonist protocols in normal responders and with short GnRH agonist protocols in poor responders remain limited and inconclusive.[8-11]

Accordingly, the present study aimed to evaluate the effects of a flexible multidose GnRH antagonist protocol on COS outcomes and IVF outcomes by comparison with different GnRH agonist protocols in normal and poor ovarian responder groups. By stratifying patients according to ovarian response, this prospective randomized study seeks to provide clinically meaningful evidence to support individualized protocol selection in controlled ovarian stimulation.

MATERIALS AND METHODS

Study Design, Setting, and Ethical Approval

This prospective, stratified, randomized controlled trial was conducted at a tertiary, university-affiliated assisted reproductive technology center between January and July 2006. The study was approved by the local institutional ethics committee (Approval No: 1491-61-2005; December 30, 2005) and performed in accordance with the Declaration of Helsinki and Good Clinical Practice. Written informed consent was obtained from all participants. As the study was conducted during a period when prospective clinical trial registration was not yet routinely implemented at the institution, a clinical trial registration number is not available.

Participants: Eligibility, Baseline Assessment, and Cycle Definition

Women scheduled for IVF during the study period were consecutively screened for eligibility. Inclusion criteria comprised reproductive-age women undergoing IVF, body mass index (BMI) 19–32 kg/m², and complete baseline ovarian reserve assessment, including cycle day-3 serum follicle-stimulating hormone (FSH) and estradiol (E2) levels and transvaginal ultrasound–derived antral follicle count (AFC). Exclusion criteria included polycystic ovary syndrome, baseline ovarian cysts ≥2 cm, hypogonadotropic hypogonadism, known hypersensitivity to study medications, protocol nonadherence, failure to obtain sperm on the day of oocyte retrieval, or any medical condition contraindicating controlled ovarian stimulation according to routine clinical practice at the time. A standard infertility evaluation, including semen analysis, was performed in all couples. Each participant contributed a single initiated IVF cycle during the study period.

Ovarian Reserve Assessment and Responder Stratification

Baseline ovarian reserve evaluation consisted of cycle day-3 serum FSH and E2 measurements and transvaginal ultrasonographic AFC assessment. Prior to randomization, participants were stratified a priori into normal ovarian responder or poor ovarian responder groups based on ovarian reserve parameters and, when available, documented ovarian response in prior COS cycles.

Normal ovarian responders were defined as women aged <39 years with day-3 FSH≤10 IU/L, E2<80 pg/mL, and AFC≥5. Poor ovarian responders were defined by evidence of diminished ovarian reserve (AFC<5 and/or day-3 FSH>10 IU/L and/or E2≥80 pg/mL) and/or a clinical history suggestive of reduced ovarian response in previous COS cycles. These criteria reflect the routinely applied clinical definitions available in 2006; subsequently developed standardized classifications (e.g., Bologna or POSEIDON) were not applied.

Randomization, Allocation Concealment, and Blinding

Within each ovarian responder stratum, cycles were randomized in a 1:1 ratio to a GnRH agonist comparator protocol (long luteal for normal responders; short/flare-up for poor responders) or a flexible multidose GnRH antagonist

protocol. Randomization was generated before study initiation using a computer-based algorithm by an independent staff member, with block randomization and concealed block size to ensure balanced allocation. Allocation concealment was achieved using sequentially numbered, sealed, opaque envelopes opened after eligibility confirmation and informed consent. Blinding was not feasible due to the nature of the interventions; however, outcomes were predefined and assessed using standardized, objective criteria. Embryology assessments were conducted according to established laboratory protocols independent of the stimulation regimen.

Controlled Ovarian Stimulation and Pituitary Suppression Protocols

Controlled ovarian stimulation was performed using recombinant FSH (rFSH), initiated on cycle day 3. In normal responders, the starting dose was 150–225 IU/day; in poor responders, the starting dose was 300–450 IU/day (maximum daily dose 450 IU). Dose adjustments were individualized according to serial transvaginal ultrasonographic follicular measurements and serum E2 levels, consistent with the center's standardized practice at the time.

Pituitary suppression was achieved using one of the following regimens:

Flexible multidose GnRH antagonist protocol (both strata): Cetrorelix acetate 0.25 mg/day was initiated when the leading follicle reached approximately 12–14 mm in mean diameter and continued daily until the day of ovulatory triggering.

GnRH agonist comparator protocols:

• Normal ovarian responders (long luteal agonist): Triptorelin was started on day 21 of the preceding menstrual cycle. After confirmation of adequate suppression, rFSH stimulation commenced on cycle day 3.

• Poor ovarian responders (short/flare-up agonist): A short (flare-up) GnRH agonist regimen was administered, followed by high-dose rFSH stimulation as above.

Monitoring, Triggering, and Oocyte Retrieval

Follicular development was monitored every 2–3 days with transvaginal ultrasonography and serial serum E2 measurements. Final oocyte maturation was triggered using urinary human chorionic gonadotropin (hCG) 5,000–10,000 IU when at least two follicles reached a mean diameter of 18–20 mm. The hCG dose was selected according to ovarian response and the clinician's OHSS risk assessment. Transvaginal ultrasound-guided oocyte retrieval was performed 35–36 hours after hCG administration under intravenous sedation.

Fertilization Method, Embryology Procedures, and Embryo Transfer

Conventional IVF was performed in the absence of severe male factor infertility, whereas intracytoplasmic sperm injection (ICSI) was used for severe oligo-astheno-teratozoospermia, prior fertilization failure, surgically retrieved sperm, or use of cryopreserved sperm. Fertilization was assessed 16–18 hours after insemination or ICSI by confirmation of two pronuclei. Embryos were cultured under standardized laboratory conditions and evaluated using cleavage-stage morphological criteria. Embryo transfer was performed between days 2 and 5 after oocyte retrieval under transabdominal ultrasound guidance with a soft catheter, with the number of embryos transferred determined by maternal age, embryo quality, and institutional practice.

Luteal Phase Support

Luteal support consisted of vaginal micronized progesterone 200 mg administered twice daily, initiated on the day of or the day after oocyte retrieval and continued until a negative pregnancy test or, if pregnancy occurred, until 10 weeks of gestation.

Outcomes and Definitions

The primary outcome was the total number of oocytes retrieved per initiated cycle. Prespecified secondary outcomes included stimulation characteristics (stimulation duration, total gonadotropin dose, serum E2 levels), laboratory outcomes (number of mature oocytes and embryos obtained, number of embryos transferred), cycle cancellation, clinical pregnancy outcomes, and OHSS incidence. Biochemical pregnancy was defined as a positive serum β-hCG measurement approximately 12–14 days after oocyte retrieval. Clinical pregnancy was defined as ultrasonographic visualization of an intrauterine gestational sac with fetal cardiac activity at 6–7 weeks of gestation.

Pregnancy outcomes were calculated using the following denominators:

Per initiated cycle: All randomized cycles.

Per oocyte retrieval (OPU): Cycles that proceeded to oocyte retrieval.

Per embryo transfer (ET): Cycles that proceeded to embryo transfer.

Cycle Cancellation and Safety Assessment

Cycles were cancelled before oocyte retrieval for inadequate ovarian response (fewer than two developing follicles), insufficient estradiol increase, or premature ovulation. Post–oocyte retrieval cancellations occurred in cases of fertilization failure, absence of transferable embryos, or clinical contraindications to embryo transfer. Participants were monitored for ovarian hyperstimulation syndrome (OHSS), which was classified according to established criteria.

Statistical Analysis

Statistical analyses were performed using SPSS software

(version 12.0). Continuous variables were tested for normality using the Shapiro–Wilk test and are presented as mean ± SD or median (range), as appropriate. Within each ovarian response stratum, continuous variables were compared using Student's t test or the Mann–Whitney U test, while categorical variables were analyzed using the χ^2 test or Fisher's exact test. All analyses were two-sided, with $p<0.05$ considered statistically significant. All randomized cycles were analyzed according to the intention-to-treat principle. Primary outcome data were complete, and no formal a priori sample size calculation was performed; therefore, between-protocol comparisons were considered exploratory.

RESULTS

Study population and baseline characteristics

A total of 142 IVF cycles were included in the analysis. In the normal ovarian responder group, 34 cycles were treated using a long GnRH agonist protocol, and 28 cycles were treated using a GnRH antagonist protocol. In the poor ovarian responder group, 42 cycles received a short GnRH agonist protocol, while 38 cycles were treated using a GnRH antagonist protocol.

Baseline characteristics according to ovarian response and stimulation protocol are presented in Table 1. In the normal ovarian responder group, mean maternal age was 32.44±2.02 years and 32.32±3.19 years, respectively (P=0.858). In the poor ovarian responder group, mean maternal age was 36.88±2.44 years and 37.82±2.96 years, respectively (P=0.126).

The distribution of infertility indications in the normal ovarian responder group did not show a statistically significant difference (P=0.391). Likewise, no statistically significant difference was observed in the distribution of infertility indications in the poor ovarian responder group (P=0.926) (Table 1).

Ovarian stimulation and laboratory outcomes

Ovarian stimulation characteristics and laboratory outcomes are presented in Table 2. In the normal ovarian responder group, ovarian stimulation duration was recorded as 10.06±1.48 days and 9.14±0.93 days, and a statistically significant difference was observed (P=0.006). No statistically significant difference was observed in total gonadotropin dose (P=0.524). A statistically significant difference was detected in estradiol levels on stimulation day 1 (P<0.001), whereas no statistically significant difference was observed in estradiol levels on the day of hCG administration (P=0.198). A statistically significant difference was observed in the duration of GnRH analogue use (P<0.001). No statistically significant differences were observed in total number of oocytes retrieved, number of mature oocytes, number of embryos obtained, number of embryos transferred, or cycle cancellation rates (all P>0.05).

In the poor ovarian responder group, ovarian stimulation duration was 10.10±1.41 days and 9.53±1.20 days, with no statistically significant difference observed (P=0.057). A statistically significant difference was observed in total gonadotropin dose (P=0.026). No statistically significant difference was observed in estradiol levels on stimulation day 1 (P=0.367), while a statistically significant difference was detected in estradiol levels on the day of hCG administration (P=0.003). A statistically significant difference was observed in the duration of GnRH analogue use (P<0.001). No statistically significant differences were observed in total number of oocytes retrieved, number of mature oocytes, number of embryos obtained, number of embryos transferred, or cycle cancellation rates (all P>0.05) (Table 2).

Table 1. Baseline characteristics according to ovarian response and stimulation protocol

Characteristic	Normal responders–Long GnRH agonist (n=34)	Normal responders–GnRH antagonist (n=28)	P value	Poor responders–Short GnRH agonist (n=42)	Poor responders–GnRH antagonist (n=38)	P value
Age (years), mean ± SD	32.44±2.02	32.32±3.19	0.858	36.88±2.44	37.82±2.96	0.126
Infertility indication, n (%)			0.391†			0.926†
Male factor	8 (23.5)	3 (10.7)		8 (19.0)	6 (15.8)	
Tubal factor	8 (23.5)	6 (21.4)		4 (9.5)	4 (10.5)	
Unexplained infertility	18 (52.9)	18 (64.3)		20 (47.6)	17 (44.7)	
Endometriosis	0 (0.0)	1 (3.6)		—	—	
Advanced maternal age	—	—		8 (19.0)	10 (26.3)	
Pelvic factor	—	—		2 (4.8)	1 (2.6)	

Data are presented as mean ± standard deviation (SD) or number (percentage), as appropriate. Baseline demographic characteristics and infertility indications were comparable between stimulation protocols within each ovarian response group. P values refer to between-protocol comparisons within the same responder stratum. †P values for infertility indication distributions were calculated using the χ^2 test.

Table 2. Ovarian stimulation and laboratory outcomes according to ovarian response and stimulation protocol

Characteristic	Normal responders–Long GnRH agonist (n=34)	Normal responders–GnRH antagonist (n=28)	P value	Poor responders–Short GnRH agonist (n=42)	Poor responders–GnRH antagonist (n=38)	P value
Stimulation duration (days), mean±SD	10.06±1.48	9.14±0.93	0.006	10.10±1.41	9.53±1.20	0.057
Total gonadotropin dose (IU), median (range)	2262 (1300-7650)	2175 (1300-4800)	0.524	3125 (1600-4950)	3600 (2400-6000)	0.026
Estradiol on day 1 (pg/mL), median (range)	23 (5-46)	34.5 (11-78)	<0.001	36.5 (1-176)	31 (14-92)	0.367
Estradiol on hCG day (pg/mL), median (range)	2162 (514-6150)	1836.5 (808-4975)	0.198	1393.5 (503-6300)	988.5 (113-4818)	0.003
GnRH analogue duration (days), median (range)	19 (16-24)	4 (2–5)	<0.001	11 (8-14)	4 (2-6)	<0.001
Total number of oocytes, mean±SD	10.85±5.54	11.54±6.02	0.723	5.60±3.63	6.24±5.03	0.985
Number of mature oocytes, mean±SD	8.09±4.40	8.93±6.17	0.594	4.17±2.68	4.45±3.68	0.774
Number of embryos obtained, mean±SD	5.74±4.08	6.71±4.20	0.158	3.12±2.60	2.84±2.44	0.681
Number of embryos transferred, mean±SD	2.06±0.85	2.04±1.07	0.914	1.86±1.05	1.76±1.10	0.663
Cycle cancellation, n (%)	3 (8.8)	4 (14.3)	0.691	5 (11.9)	6 (15.8)	0.614

Continuous variables are presented as mean±SD or median (range), depending on data distribution. Categorical variables are presented as number (percentage). P values indicate comparisons between stimulation protocols within each ovarian response group. No comparisons were performed between normal and poor responder strata. GnRH analogue duration reflects the total number of days of agonist or antagonist administration.

Table 3. Pregnancy outcomes and ovarian hyperstimulation syndrome (OHSS) according to ovarian response and stimulation protocol

Characteristic	Normal responders–Long GnRH agonist (n=34)	Normal responders–GnRH antagonist (n=28)	P value	Poor responders–Short GnRH agonist (n=42)	Poor responders–GnRH antagonist (n=38)	P value
Clinical pregnancy per initiated cycle	20 (58.8)	15 (53.6)	0.678	13 (31.0)	6 (15.8)	0.153
Clinical pregnancy per oocyte retrieval (OPU)	58.8	53.6	0.678	31.7	16.7	0.127
Clinical pregnancy per embryo transfer (ET)	64.5	62.5	0.877	35.1	18.8	0.129
OHSS, n (%)	1 (2.9)	1 (3.6)	1.000	0	0	—

Clinical pregnancy was defined as ultrasonographic visualization of an intrauterine gestational sac with fetal cardiac activity at 6–7 weeks of gestation. Pregnancy outcomes are presented as n/N (%) using the following denominators: initiated cycle (all randomized cycles), OPU (cycles that proceeded to oocyte retrieval), and ET (cycles that proceeded to embryo transfer). P values indicate between-protocol comparisons within the same ovarian responder stratum. OHSS was classified according to standard criteria; no OHSS occurred in poor responders, therefore no statistical comparison was performed.

Pregnancy outcomes and ovarian hyperstimulation syndrome

Pregnancy outcomes and the incidence of ovarian hyperstimulation syndrome (OHSS) are summarized in Table 3. Among normal ovarian responders, clinical pregnancy per initiated cycle occurred in 20 of 34 cycles (58.8%) in the long GnRH agonist group and 15 of 28 cycles (53.6%) in the GnRH antagonist group, with no statistically significant difference between protocols (P=0.678). When pregnancy outcomes were analyzed per oocyte retrieval,

clinical pregnancy was achieved in 20 of 34 cycles (58.8%) in the agonist group and 15 of 28 cycles (53.6%) in the antagonist group (P=0.678). Similarly, clinical pregnancy per embryo transfer did not differ significantly between protocols, occurring in 20 of 31 embryo transfers (64.5%) in the agonist group and 15 of 24 embryo transfers (62.5%) in the antagonist group (P=0.877). Mild OHSS was observed in one cycle in each protocol group (1/34 [2.9%] vs 1/28 [3.6%]), with no statistically significant difference in incidence (P=1.000).

In poor ovarian responders, clinical pregnancy per initiated cycle was observed in 13 of 42 cycles (31.0%) in the short GnRH agonist group and 6 of 38 cycles (15.8%) in the GnRH antagonist group, without a statistically significant difference (P=0.153). Analysis per oocyte retrieval showed clinical pregnancy in 13 of 41 cycles (31.7%) in the agonist group and 6 of 36 cycles (16.7%) in the antagonist group (P=0.127). Clinical pregnancy per embryo transfer occurred in 13 of 37 transfers (35.1%) in the agonist group and 6 of 32 transfers (18.8%) in the antagonist group, again with no statistically significant difference (P=0.129). No cases of OHSS were observed among poor ovarian responders in either treatment arm.

DISCUSSION

Principal Findings

In this prospective randomized study, GnRH antagonist protocols produced reproductive outcomes comparable to GnRH agonist regimens in both normal and poor ovarian responders undergoing IVF. No significant differences were observed in oocyte yield, embryo numbers, cycle cancellation rates, or clinical pregnancy outcomes. Antagonist protocols were associated with shorter stimulation duration and reduced GnRH analogue exposure. However, a statistically significant reduction in stimulation duration was observed only in normal responders. In poor responders, antagonist use required higher gonadotropin doses and was associated with lower estradiol levels on the day of hCG administration. The low incidence of OHSS, together with balanced baseline characteristics, suggests that the findings are more likely attributable to protocol-related factors rather than patient-related confounding.

Normal Ovarian Responders

Among normal responders, the shorter stimulation duration observed with the antagonist protocol is consistent with the known advantages of antagonist-based regimens. Previous randomized trials and meta-analyses have also reported shorter stimulation periods and, in some cases, reduced gonadotropin use compared with long agonist protocols.[3,9,10] However, differences in starting doses and dose-adjustment strategies across studies may explain the lack of consistent findings regarding total gonadotropin consumption. In the present study, gonadotropin use was numerically lower in the antagonist group, but this difference was not statistically significant.

Oocyte yield did not differ significantly between protocols, although higher total and mature oocyte counts were observed in the antagonist group.[3,12] Reports suggesting lower oocyte yield with antagonist protocols are likely influenced by patient selection and stimulation strategies rather than intrinsic protocol differences.[7,13] In this study, relatively higher starting doses and early dose adjustments may have reduced such differences. However, this observation should be interpreted cautiously and considered hypothesis-generating.

Pregnancy rates calculated per initiated cycle, per oocyte retrieval, and per embryo transfer were similar between protocols. These findings are consistent with large randomized trials and guideline-based analyses.[14,15] Although some meta-analyses have reported slightly lower pregnancy rates with antagonist protocols,[16,17] the results observed here fall within the expected range and may reflect center-specific practices.

From a safety perspective, no moderate or severe OHSS cases were observed, and only one mild case occurred in each group. Due to the low event rate and limited sample size, these findings should not be interpreted as evidence of equivalent safety. Larger studies have consistently shown a reduced risk of OHSS with antagonist protocols. Therefore, the similar distribution observed in this study should be considered descriptive rather than conclusive.[4,6]

Poor Ovarian Responders

Management of poor ovarian responders remains complex due to variability in both definition and underlying mechanisms.[18] Although ovarian reserve tests provide useful prognostic information, the actual ovarian response to stimulation remains the most relevant clinical indicator.[19] High-dose gonadotropin protocols are frequently used in this population; however, evidence supporting their clinical benefit is inconsistent.[19,20]

In this study, the antagonist protocol did not demonstrate superiority over the flare-up agonist protocol in terms of oocyte yield, embryo development, or pregnancy outcomes. These findings suggest that treatment success in poor responders is primarily influenced by ovarian response and oocyte number rather than protocol type. This observation is consistent with analyses conducted within the POSEIDON framework.[21] Havrljenko et al.[22] reported no significant differences in live birth rates between protocols across POSEIDON groups, emphasizing the importance of oocyte number, quality, and age. Similarly, Polyzos et al.[21] showed that although increased oocyte yield under antagonist protocols improved cumulative live birth rates, pregnancy rates per fresh cycle reached a plateau beyond a certain threshold.

Although POSEIDON classification was not available at the time of the study, these comparisons are provided to contextualize the findings within current low-prognosis frameworks rather than to retrospectively classify patients.

Lower estradiol levels observed in the antagonist group

on the day of hCG administration did not result in differences in oocyte yield or pregnancy outcomes. This finding is consistent with randomized studies reporting no clear advantage of antagonist protocols over short or flare-up agonist protocols in poor responders. Overall, current evidence suggests that differences in endocrine profiles between protocols have limited impact on clinical outcomes in this group.[23]

Interpretation of results in poor responders is further complicated by variability in diagnostic criteria across studies.[23,24] Systematic reviews of randomized trials have not identified any stimulation protocol that consistently improves outcomes in this population.[25,26] In line with these findings, the present study did not demonstrate a clear advantage of antagonist, flare-up, or long agonist protocols. These results highlight that successful IVF outcomes in poor responders depend more on accurate patient characterization and individualized treatment strategies than on protocol selection alone.[27]

Limitations

This study has several limitations that should be considered. First, as the data were generated in 2006, subsequent developments in ovarian stimulation strategies, laboratory techniques, and embryo transfer approaches may restrict the generalizability of the results to contemporary IVF practice. Moreover, the classification of poor ovarian response relied on the clinical definitions available at that time, preceding current standardized criteria, which may limit direct comparison with more recent studies. Second, the sample size, although adequate for primary analyses, may have been insufficient to identify subtle differences between treatment protocols, particularly with respect to pregnancy rates and safety outcomes. Finally, blinding could not be implemented due to the nature of the interventions; nevertheless, outcome measures were prespecified and evaluated using objective parameters.

CONCLUSION

Within ovarian-response strata, a flexible multidose GnRH antagonist protocol yielded ovarian response, laboratory outcomes, cycle cancellation rates, and pregnancy outcomes comparable to long luteal GnRH agonist stimulation in normal responders and to flare-up agonist stimulation in poor responders, while significantly reducing the duration of GnRH analogue exposure and shortening stimulation duration in normal responders. These findings support protocol individualization based on patient burden, scheduling considerations, and center-specific practice rather than assumptions of protocol superiority, particularly in poor responders where intrinsic ovarian reserve and response capacity remain the predominant determinants of treatment success.

Ethics Committee Approval

The study was approved by the local institutional ethics committee of GATA (Date: 30.12.2005, Decision No: 1491-61-2005).

Informed Consent

Written informed consent was obtained from all participants prior to enrollment.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: A.Y., R.B.T.; Design: A.Y., R.B.T.; Supervision: R.B.T.; Data collection &/or processing: A.Y.; Analysis and/or interpretation: A.Y.; Literature search: A.Y., R.B.T.; Writing: A.Y.; Critical review: R.B.T.

Conflict of Interest

The authors declare no conflict of interest.

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IVF'de Kontrollü Ovaryan Stimülasyon İçin Uygulanan Esnek Multidoz GnRH Antagonist ve GnRH Agonist Protokollerinin Karşılaştırılması: Overyan Yanıta Göre Tabakalanmış Prospektif Randomize Bir Çalışma

Amaç: Bu prospektif randomize kontrollü çalışmada, IVF sikluslarında fleksibl multidoz GnRH antagonist protokolünün; normal over yanıtlı hastalarda uzun luteal GnRH agonist, düşük over yanıtlı hastalarda ise kısa GnRH agonist protokole kıyasla ovaryan stimülasyon parametreleri, laboratuvar sonuçları, gebelik oranları ve OHSS insidansı üzerindeki etkilerini değerlendirmek amaçlandı.

Gereç ve Yöntem: IVF tedavisi planlanan ve vücut kitle indeksi 19–32 kg/m² olan hastalar çalışmaya dahil edildi. Olgular ovaryan yanıta göre normal ve düşük yanıtlı olarak sınıflandırıldı ve her grupta kapalı zarf yöntemiyle GnRH agonist veya antagonist protokollerine randomize edildi. Foliküler gelişim transvajinal ultrasonografi ve serum estradiol düzeyleri ile izlendi. En az iki follikülün 18–20 mm'ye ulaşması üzerine hCG uygulanarak 35–36 saat sonra oosit pick-up gerçekleştirildi. Primer sonlanım oosit ve embriyo verimi; sekonder sonlanımlar gonadotropin dozu, stimülasyon süresi, E2 düzeyleri, siklus iptali, klinik gebelik ve OHSS olarak belirlendi.

Bulgular: Toplam 142 siklus analiz edildi (normal yanıt: Uzun agonist n=34, antagonist n=28; düşük yanıt: Kısa agonist n=42, antagonist n=38). Normal yanıt grubunda stimülasyon süresi antagonist protokolde daha kısa bulundu, ancak toplam gonadotropin dozu benzerdi. Her iki yanıt grubunda toplam ve matür oosit sayısı, embriyo sayısı, transfer edilen embriyo sayısı ve siklus iptal oranları açısından anlamlı fark saptanmadı. Normal yanıt grubunda siklus, oosit toplama ve embriyo transferi başına gebelik oranları benzerdi. Düşük yanıt grubunda antagonist protokolde gebelik oranları daha düşük eğilim göstermesine rağmen istatistiksel olarak anlamlı değildi. OHSS yalnızca normal yanıt grubunda iki hafif olguda gözlendi ve protokoller arasında fark bulunmadı.

Sonuç: Fleksibl multidoz GnRH antagonist protokolü, normal ve düşük over yanıtlı hastalarda agonist protokollere kıyasla oosit/embriyo verimi ve gebelik sonuçlarını anlamlı olarak değiştirmemiştir. Normal over yanıtlılarda antagonist protokol daha kısa stimülasyon süresi ile ilişkili bulunmuştur.

Anahtar Sözcükler: İn vitro fertilizasyon; GnRH antagonist protokolü; GnRH agonist protokolü; normal over yanıtı; düşük over yanıtı; ovaryan hiperstimülasyon sendromu.

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Original Article

Effects of Corrective Exercises and Postural Education on Forward Head Posture - A Randomized Controlled Trial

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ABSTRACT

Objective: The aim of this study is to compare the effects of a corrective exercise program and postural training on craniovertebral angle, shoulder angle, pain, and quality of life.

Methods: A total of forty-six (n=46) individuals (n=25 female; n=21 male) who met the inclusion criteria were evaluated by a single physical therapist before and after treatment. Participants were randomly assigned to three groups: Corrective exercise group (CEG=17), postural education group (PEG=17), and control group (CG=12). The CEG was included in the FHP corrective exercise program, which included stretching and strengthening exercises, while the PEG received postural education guidelines. No treatment was administered to the CG. Participants were assessed for craniovertebral angle, shoulder angle, pain levels, and quality of life before treatment and after 6 weeks.

Results: As a result, in the intra-group comparison after 6 weeks, statistically significant increases were observed in the CEG and PEG in terms of craniovertebral angle ($p=0.001$), shoulder angle ($p=0.005$), and pain ($p=0.001$), In the CG, increases were observed in craniovertebral angle ($p=0.001$) and pain ($p=0.002$). In the pre- and post-measurement of quality of life, no significant difference ($p>0.05$) was found for all groups except for the physical functioning component ($p<0.05$).

Conclusion: A personalized corrective exercise program and postural education improved craniovertebral angle, shoulder angle, and pain. These findings may highlight that simple, low-cost interventions can be effectively integrated into clinical and preventive settings to address forward head posture.

INTRODUCTION

Posture is a relative and comparative arrangement of the body parts at any one moment.[1] The forward head posture (FHP), which is considered a deviation from neutral posture, is a musculoskeletal abnormality characterized by the head's forward position in the sagittal plane relative to the neck.[2] It is connected to lower cervical spine flexion (C4-C7) and hyperextension of the upper cervical spine (C1-C3), and can result from the cervical spine being kept in a protracted position for an extended period of time, and runs the risk of permanent adoption, muscle remodeling alterations, and muscle imbalances.[3] The prevalence of FHP ranges from 11.4% to 67% among college-age students and from 52% to 68% among teenagers.[4] FHP has also been linked to protracted or rounded shoulders, kyphosis at the thoracic spine, and forward shoulder posture (FSP). FHP is a known culprit to cause headache, shoulder pain, neck pain, craniofacial pain, radiating pain to the scalp, TMJ dysfunction, impingement syndrome, limited cervical spine range of motion, cervical instability, and scapular or shoulder dyskinesia.[5] Causes of forward head and FSP may include excessive use of smartphones, and computers, mouth breathing, carrying heavyweight bags, a rounded upper back, and rounded shoulders.[6] The failure to address FHP during young or middle adulthood may result in its permanent manifestation due to spinal degeneration and remodeling.[5] A reliable and valid clinical approach to acquiring an objective measurement of FHP involves the evaluation of the craniovertebral angle (CVA.[7]

Two most common and advantageous methods used by health and fitness professionals to address FHP include postural education (PE) and the implementation of a corrective exercise program.[8] The protocol consisted a total of three stretching exercises and three strengthening exercises efficacious in rectifying particular neck and shoulder postures, as supported by several academic researches. A study demonstrated the effectiveness of a stretching program targeting shortened muscles and strengthening ex-

ercises to have a significant impact on correcting postural abnormalities associated with FHP.[9] In the present study, the 3-stretching and 3-strengthening corrective exercise protocol was not taken from a single source; rather, it was adapted from evidence-based corrective exercise models described in the literature. Specifically, the selection of exercises was guided by the corrective exercise framework proposed by Mehri et al.,[10] who demonstrated that stretching shortened cervical and pectoral muscles and strengthening cervical and scapular stabilizers improves posture and muscle activation in individuals with chronic neck pain. In addition, the exercise components were informed by the program described by Sikka et al.,[11] which showed that deep cervical flexor training effectively reduces forward head posture, neck pain, and functional limitations in adolescents who regularly use computers. These studies collectively support the rationale for combining stretching of overactive anterior musculature with strengthening of deep cervical flexors and scapular retractors, forming the basis of the protocol used in the present study.[10,11]

FHP is known to predispose the development of underactive and overly lengthened muscle groups in the head and neck region, resulting in muscle imbalance and loss of upright head and neck posture.[12] Therefore, the purpose of the study was to evaluate the effects of corrective exercises and postural education on craniovertebral angle and shoulder angle and their effect on pain and quality of life in people with forward head posture. However, although both corrective exercises and postural education are frequently recommended for forward head posture, the literature lacks randomized controlled studies directly comparing the relative effectiveness of these two approaches within the same design. This gap limits the ability to determine whether exercise-based correction or postural training alone produces greater improvements in cervical alignment and pain. Based on this gap, the present study hypothesized that corrective exercises would lead to larger improvements in craniovertebral angle, shoulder angle, and pain levels compared to postural education or no intervention. It was also expected that both intervention groups would outperform the control group, with only modest changes anticipated in overall quality of life outcomes.

MATERIALS AND METHODS

Study Design

A prospective, randomized controlled trial (RCT) design was utilized to assess the effects of correctives exercises (CE) and postural education (PE) on craniovertebral angle (CVA), shoulder angle (SA), pain and quality of life (QOL) in participants with FHP. The study was conducted for 6-weeks. Participants were randomly divided into three parallel groups, a correctives exercise group (CEG) (n=17), or postural education group (PEG) (n=17), and or a control group (CG) (n=12). Randomization was performed using a simple randomization method. An independent researcher who was not involved in participant assessment, intervention delivery, or data analysis generated the allocation sequence using a computer-based random number generator. Group assignments were placed in sealed, opaque envelopes to maintain allocation concealment. A total of 46 volunteer participants of young, and middle-aged adults between 20-40 years of age with FHP confirmed by CA less than or equal to 50° and SA less than or equal to 52° were included.[13] Any participants with a history of trauma, surgery, acute neck injuries i.e., whiplash, diagnosed balance disorders and aggressive structural abnormality e.g., scoliosis, kyphosis were excluded from the study.

The study protocol was approved by Marmara University Ethical committee (Protocol number: 56-2023, Date: 27/04/2023), and all procedures used in this study were completed under the declaration of Helsinki. The clinical trial is recorded in the ClinicalTrials.gov with the following registration number NCT05894941.

Sample Size

The sample size of this study was determined utilizing G*Power version 3.1.9.7, (Heinrich-Heine-Universität Düsseldorf, Düsseldorf Germany) software. Based on calculated results, a sample size of at least 42 participants is necessary for 80% power (1-β=0.80) with an effect size of d=0.5, and an alpha level (type I error) of 0.05. For matched pair t-test a sample size of at least 19 participants is necessary for 80% power (1-β=0.80) with an effect size of d=0.6, and an alpha level (type I error) of 0.05.[14]

Intervention

The participants who were assigned in the CEG commenced a 6-week program that encompassed both stretching and strengthening exercises. The participants were advised to exercise 3-5 times a week. A detailed description and instructions for each stretching and strengthening exercise are presented in Table 1.

Participants in the PEG did not receive any physical exercises. Instead, they were provided with a structured postural education program that included guidance on correct cervical and thoracic alignment, ergonomic recommendations for computer and smartphone use, proper sitting and standing posture, optimal screen height, and the recommended frequency of rest breaks. The education was delivered online through a standardized session supported by written and visual materials. Participants in the CG did not receive any intervention during the 6-week study period and were instructed not to initiate any new exercise program. As an ethical consideration, general postural advice was offered to the CG after the completion of data collection. All groups were followed remotely with weekly online check-ins to monitor adherence, answer questions, and ensure protocol compliance.

Following the initial assessment of baseline CVA, SA, QOL and pain, the participants assigned to the CG were notified that, they will not receive any intervention. They were instructed not to initiate any new exercise regimen or to make changes to their existing physical activity level for

Table 1. Description and instructions of stretching and strengthening exercises

Exercise	Principal Muscle	Description
Scalene & Upper Trapezius Stretch	Scalene & Upper Trapezius	Do it either in a sitting or standing position. Put one hand behind your back and the other on the opposite side of your head. Now lower the head so that it rests on your shoulder. To get a deeper stretch, gently press your head down with the hand on top. Aim for 2-3 repetitions while holding the position for 20–30 seconds on each side.
SCM Stretch	Sternocleidomastoid	Bring your ear down to your shoulder and place one hand on the side of your head that is opposite it. Leaning your head forward, scan the ceiling. To inc rease the stretch, pull your head back with your hand. Aim for 2-3 repeats while holding for 20–30 seconds then switch sides once again.
Unilateral/Bilateral Pectoral Stretch	Pectoralis minor	Approach a wall with one arm extended behind you, palm facing the wall at a 90° angle. Lean forward and away from the outstretched arm slightly at this point. Your chest should feel stretched. Aim for 2-3 repeats while holding for 20–30 seconds. Do this stretch bilaterally
Chin tucks	Longus Capitis Longus Colli	Put 2 fingers at the bottom of your chin. Retract your head back and gently tuck your chin in. Use your fingers to keep the chin tucked in the entire time while doing this. Hold this position for 3-5 seconds. Relax your neck for a moment (Let the neck come forward). -Aim for 2-3 sets of 10-15 repetitions. -Do it either standing, sitting or lying in the bed.
YTWL Exercise	Rhomboids Middle Trapezius Lower Trapezius Posterior Deltoid Rotator Cuff (Supraspinatus) Serratus Anterior	Can be done either standing or prone lying. Raise your arms straight to make a 'Y' Lower your arms to 90° to make 'T' with your body. Bent your elbows & tuck your arms close to your torso to make a 'W'. Now straighten your elbows to 90° to make 'L', kee ping your arms tucked. -Hold each position for 5-10 seconds -Aim for at least 10-15 repetitions.
Resisted Neck Extensions	Middle trapezius Serratus anterior Lower trapezius	Put the palm of your hand against the back of your head (Use either one or both hands). Press your head against your hand while resisting the movement with your hand/s. Hold this position for 5-10 seconds. -Aim for 2-3 sets of 10-15 repetitions.

the duration of the next six weeks.

Outcome Measures

All the primary and secondary outcome measures were taken at baseline, and after the 6-week intervention period.

Socio-demographics

The study objectives and methods were explained to the participants, and a structured questionnaire was developed to gather demographic information. This questionnaire was designed in line with the study protocol and covered details such as age, height, weight, education level, presence of systemic diseases and impairments, medication use, exercise habits, socio-demographic status, and history of traumas of the participants.

Craniovertebral Angle

The evaluation of the CVA is a reliable and valid clinical

Table 2. Comparison of descriptive statistics of demographics

Variables	CEG Mean±SD (Median)	PEG Mean±SD (Median)	CG Mean±SD (Median)	χ^2/H	p
Age	27.00±4.33 (27)	27.18±5.99 (27)	25.00±4.89 (24)	H: 1.931	0.381
Height (cm)	168.62±10.51 (169)	165±9.49 (160)	163.00±4.99 (163)	H: 2.217	0.330
Weight (kg)	65.53±14.69 (60)	59.82±9.22 (59)	59.67±22.53 (60)	H: 1.235	0.539
BMI (kg/m^2)	23.14±5.05 (22.22)	21.98±3.49 (21.36)	22.53±3.36 (23.10)	H: 0.495	0.781
Gender	1.53±.51 (2)	1.53±0.51 (2)	1.25±0.45 (1)	χ^2: 0.348	0.555
Education	1.53±0.62 (2)	0.88±0.78 (1)	0.35±0.49 (1)	χ^2: 2.913	0.233
Marital Status	0.24±0.43 (0)	0.35±0.73 (0)	0.25±0.45 (0)	χ^2: 8.696	0.320

Data expressed as Mean ± Standard deviation, SD: Standard Deviation; BMI: Body mass index; cm: centimeter; kg: kilogram; m^2: square-meters; CEG: Corrective exercise group; PEG: Postural exercise group; CG: Control group; χ^2: Chi-square; H: Kruskal wallis one-way ANOVA. p≤0.01.

Table 3. Baseline inter-group measurement for craniovertebral angle, shoulder angle, pain, and quality of life

Variables	Mean±SD	Median	H	p
CVA	41.61±4.48	42.00	0.426	0.808
SA	45.33±4.21	45.00	0.915	0.633
NPRS	3.09±.694	3.00	4.108	0.128
SF-36				
Physical Functioning	64.12±25.51	70.00	4.670	0.097
Limitation due to Physical Health	54.35±33.46	50.00	0.777	0.678
Limitation due to Emotional Problems	50.00±39.59	66.67	0.737	0.692
Energy/Fatigue	55.76±16.49	57.50	2.077	0.354
Emotional Well-being	62.78±17.54	64.00	1.217	0.544
Social Functioning	64.40±17.47	62.50	0.133	0.936
Pain	73.42±21.94	77.50	0.591	0.744
General Health	55.87±16.34	55.00	0.745	0.689

Data expressed as Mean±standard deviation. SD: Standard deviation; CVA: Craniovertebral angle; SA: Shoulder angle; NPRS: Numeric pain rating scale; SF-36: Short form 36; H: Kruskal wallis one-way ANOVA. p≤0.05.

method for determining an objective measurement of FHP.[7,13] The measurement of the angle was done with the help of a postural assessment software. This software has been proven to be highly reliable and valid.[15] The CVA was obtained by measuring an angle formed by the intersection of two lines drawn through particular anatomical landmarks and can be obtained using an image of the sagittal view of a person's head and neck. The first line starts from the tragus of the ear and ends at the spinous process of the C7 vertebrae, while the second line is drawn horizontally through the spinous process of the C7 vertebrae. Although there is no specific threshold for identifying FHP, individuals with smaller craniovertebral angles i.e., less than 50 degrees generally exhibit forward head posture.[16]

Shoulder Angle

Shoulder angle is defined as the angle formed by a horizontal line passing between the spinous process of seventh cervical vertebra and a line passing from the shoulder joint's midpoint to the C7 spinous process.[15]

Short Form-36

The 36-Item Short Form Survey (SF-36) is a well-established and extensively researched self-reported measure of health outcomes that is frequently employed. The SF-36 is scored across eight subdomains, each ranging from 0 to 100, with higher scores indicating better health status. Its primary function is to gauge the QOL of individuals. Re-

search indicates SF-36 to be one of the most responsive questionnaires to assess the changes in people with musculoskeletal disorders.[17] Both Turkish and English versions of this questionnaire were used in this study.[18]

Numeric Pain Rating Scale

The Numeric Pain Rating Scale (NPRS) that is a unidimensional measure of pain intensity in adults. This 11-point numeric scale ranges from '0' representing one pain extreme (e.g., "no pain") to '10' representing the worst pain imaginable.[19]

Statistical Analysis

Statistical analysis was performed by using SPSS (IBM SPSS Statistics 25) program. The characteristics of the study groups were defined using descriptive statistics. The Shapiro-Wilk test was performed to determine the normality of variables. The chi-square test was used to test whether there is a relationship between the two variables. Descriptive statistics for all continuous variables were calculated with mean, standard deviation and median. A nonparametric alternative of one-way ANOVA, the Kruskal Wallis One-Way ANOVA test was used to determine intergroup analysis to see any difference within groups. Wilcoxon signed rank test was used to test the equality of measurements and to compare the data of the intragroup before and after treatment. Effect sizes were calculated using r=Z/√N. Besides, a significance level of p≤0.05 was considered statistically significant.

RESULTS

Forty-six participants (31 female, 15 male), mean age 26.54, standard deviation 5.12, volunteered for this study. The participants were divided into three groups, CEG (n=17), PEG (n=17) and CG (n=12). The measurements were taken at baseline (T0) and after 6-week post-intervention (T1) for all three groups.

The demographic distribution of the participants was shown in (Table 2). There was no statistically significant difference was found after intergroup analysis (p>0.05).

T0 analysis of demographics measurements showed no significant differences across the groups (p>0.05). (Table 3). For T0 measurements of CVA, SA, pain, and QOL, it was found no significant difference across the groups (p>0.05).

Intergroup analysis showed significant difference in SA (p≤0.05), pain (p≥0.05), physical functioning and physical health limitations of the QOL in T1, while no difference was detected for CVA, and other component of the QOL at this time (p>0.05) (Table 4).

In addition, while there was a significant difference found in the CVA, SA and NPRS (p≤0.05) within the CE and PE group during the study, a significant difference was only detected in terms of CVA and NPRS in the CG (p≤0.05) (Table 4). However, a significant difference was found in

Table 4. Comparison of Baseline and post-intervention between- and intra-group measurements of craniovertebral angle, shoulder angle, and pain

Tests	CEG (n=17) Mean±SD (Median)		Z	p	Effect size	PEG (n=17) Mean±SD (Median)		Z	p	Effect size	CG (n=12) Mean±SD (Median)		Z	p	Effect size	Between-group comparison	
	T0	T1				T0	T1				T0	T1				H	p
CVA	41.47±4.71 (40)	47.65±7.91 (47)	77.403	0.001*	0.779	41.29±4.79 (42)	44.76±5.03 (45)	78.209	0.005*	0.667	42.25±4.00 (42)	48.08±5.36 (49)	48.195	0.005*	0.457	2.451	0.294
SA	44.82±4.14 (45)	56.59±7.62 (58)	77.403	0.001*	1.000	45.12±4.32 (45)	55.65±7.89 (55)	78.209	0.001*	1.000	46.33±4.33 (48)	47.00±3.88 (47)	48.195	1.000	0.001	12.615	0.002**
NPRS	2.88±0.69 (3)	0.71±0.68 (1)	16.000	0.001*	0.941	3.35±0.60 (3)	1.35±0.70 (1)	17.000	0.001*	1.000	3.00±0.73 (3)	1.33±0.88 (1)	10.000	0.002*	0.831	6.978	0.031*

Data expressed as Mean ± standard deviation. SD: Standard deviation; Z: Wilcoxon signed rank test; H: Kruskal Wallis one-way ANOVA, Effect size was calculated using the formula. r=Z/√N; CVA: Craniovertebral angle, SA: Shoulder angle; NPRS: Numeric pain rating scale; T0: baseline; T1: post-intervention ** p≤0.01 *p≤0.05.

Table 5. Comparison of baseline and post-intervention between- and intra-group measurement of quality of life

Tests	CEG (n=17) Mean±SD (Median)		Z	p	Effect size	PEG (n=17) Mean±SD (Median)		Z	p	Effect size	CG (n=12) Mean±SD (Median)		Z	p	Effect size	Between-group comparison	
	T0	T1				T0	T1				T0	T1				H	p
SF-36																	
Physical Function	72.88±21.78 (75)	90.88±15.23 (95)	7.118	0.009*	1.73	58.04±21.32 (55)	78.53±20.13 (85)	6.25	0.012*	1.52	60.32±33.45 (63)	85.00±8.79 (85)	6.400	0.011*	1.85	0.007**	0.007**
Limitation-Physical Health	58.82±36.38 (50)	80.88±24.25 (100)	1.333	0.248	0.32	50.00±31.86 (50)	60.78±30.15 (50)	2.000	0.157	0.49	54.17±33.42 (50)	56.25±26.38 (50)	0.001	1.000	0.00	0.034*	0.034*
Emotional Problems	52.94±37.37 (67)	78.43±35.24 (100)	10.000	0.002*	2.43	52.94±44.18 (67)	62.75±38.87 (100)	0.667	0.414	0.16	41.67±37.93 (33)	66.67±34.81 (67)	1.286	0.257	0.37	0.357	0.357
Energy/ Fatigue (50)	51.76±17.67 (65)	63.53±17.67	2.571	0.109	0.62	55.88±18.04 (60)	60.00±15.81 (60)	3.00	0.083	0.73	61.25±11.30 (60)	58.75±11.10 (58)	0.091	0.763	0.03	0.511	0.511
Emotional Well-being	66.12±18.55 (60)	67.76±16.76 (68)	0.25	0.617	0.06	59.06±18.57 (64)	57.65±15.62 (60)	0.077	0.782	0.002	63.33±14.75 (68)	57.83±8.06 (60)	3.000	0.083	0.87	0.117	0.117
Social Function	65.44±16.84 (63)	73.53±17.41 (78)	1.471	0.225	0.36	63.24±19.99 (63)	63.24±20.64 (68)	0.529	0.467	0.13	64.58±15.84 (63)	65.63±16.24 (68)	0.001	1.000	0.00	0.212	0.212
Pain	73.53±24.57 (78)	80.15±12.45 (78)	2.273	0.132	0.55	70.44±23.53 (68)	70.29±18.87 (68)	0.001	1.000	0.00	77.50±15.95 (74)	71.88±22.44 (78)	0.011	0.739	0.00	0.269	0.269
General Health	53.24±15.09 (55)	50.59±8.99 (45)	0.067	0.796	0.02	57.65±12.76 (60)	49.41±9.82 (50)	2.882	0.090	0.70	57.08±22.50 (53)	53.75±8.56 (55)	0.400	0.527	0.12	0.446	0.446

Data expressed as Mean±standard deviation, SD: Standard deviation; SF-36: Short-form 36; Z: Wilcoxon signed rank test, H: Kruskal wallis one-way ANOVA, Effect size was calculated using the formula r=Z/√N; T0: baseline; T1: post-intervention. *p≤0.05.

physical function component of the QOL within all the groups during the study process (p≤0.05). It was also showed a significant difference in emotional problem component in the CEG (p≤0.05) (Table 5).

DISCUSSION

The present study aimed to compare the effects of corrective exercises and postural education on craniovertebral angle, shoulder angle, pain, and quality of life in individuals with forward head posture. After the 6-week intervention, both corrective exercise and postural education groups demonstrated significant improvements in CVA, shoulder angle, and pain levels, while only limited changes were observed in most components of quality of life. Notably, physical functioning improved across all groups, including the control group, whereas no substantial change was detected in other quality of life domains. Overall, the findings indicate that both corrective exercises and postural education can provide short-term benefits in postural alignment and pain associated with forward head posture.

Poor posture results from muscle imbalance which occurs when muscles are weak, tight, too long or too short to perform effectively and hold the body in correct alignment.[6] The most common technique of CVA assessment in research and clinical practice incorporates the use of lateral-view photography and has been demonstrated as both a valid and reliable method for objective CVA measurement when compared to radiographic.[1,13] In a study comparing photographic and radiographic CVA assessment, high levels of intra-examiner reliability of photographic measures of CVA were found.[16] Although, there are studies which have used only CVA as their primary outcome measure to assess forward head and it still is the most widely accepted and commonly used measure for FHP and measuring angles of upper body. In the literature, there are studies that report no differences in the CVA between sitting and standing positions as well as several that do not provide subject position information during posture assessment.[15] Although a standardized protocol for assessing CVA is still required, a significant amount of literature supports the measurement of CVA in a standing position.[20] Consequently, participants were directed to assume an upright standing position while capturing their photographs as part of the study protocol. Subsequently, the CVA of the participants was measured in the standing position in the present study. Our study showed a significant difference in CVA score in the CEG, PEG and CG during the 6-week period.

The SA is formed when a horizontal line across the shoulder in a sagittal plane intersects a line drawn from the C7 vertebrae to the shoulder. To some extent, it shows how round the shoulders are. A forward or protracted shoulder would result in a smaller angle.[13] A systematic review found that the head position has a considerable impact on muscle activity, proprioception, breathing patterns, and neck pain.[21] Based on the evidence, it can be deduced that individuals suffering from FSP exhibit a considerably reduced shoulder angle in comparison to those without the condition. In a study done by Lewis (2005), the mean shoulder angle value 61.9°±10.4° is considered normal.[22] Thigpen and colleagues have reported that a total of 310 participants were assessed for their shoulder angle in a standing position, and they found the normal range to be 52.6°±15.3°.[23] This finding is consistent with the report by Raine and Twomey who evaluated 160 participants for shoulder angle in a standing position, and found that the normal range was 53.7°±11.5°.[24] In our study, the inter-group and intra-group analysis showed significant change in terms of SA for CE and PE groups during the study process. There was detected no change in the CG in terms of SA after T1.

Various studies have been conducted to explore the relationship between FHP and neck pain and its relation with other postural deformities such as FSP and kyphosis. The research has indicated that the reduced length of muscle fibers and decreased ability of muscles to produce tension in the FHP result in severe neck discomfort.[17] The failure to recognize the importance of body posture during work is a significant contributor to improper positioning of the head and neck. Individuals with neck pain are seen with alteration in the head posture, and muscular imbalance.[14] According to the results of our study, there was no difference found in baseline measurements of all 3 groups. In the present study, although T1 analysis for inter-group analysis showed significant change in pain during the study, the intra-group analysis showed a substantial difference for both CE, PE groups, and CG respectively.

The SF-36 Survey is widely utilized as a tool to assess QOL in research studies. Moreover, the questionnaire has been validated by demonstrating clear distinctions in self-reported health between the general population and individuals with common medical conditions.[17]

In the current study, no significant difference has been found in baseline measurements of QOL and shows a post-intervention difference in only the physical functioning component of this scale.

Corrective Exercise Program

FHP is associated with shortness of the cervical extensors and pectoralis muscles, as well as weakness in the deep cervical short flexors and mid-thoracic scapular retractors. The proper muscular balance between agonist and antagonist muscles can be restored to treat FHP.[25] The results of the current study also found an increase in CVA, SA and a decrease in pain levels, showing a significant difference during the study process in the CEG. In a study, it was explained the value of a focused exercise program that included strengthening and flexibility exercises over a 32 week period reduced FHP in adolescents.[5] In addition, two studies reported that a 10 week program of stretching and strengthening exercises was also successful in correcting the FHP.[26] Another study done by Heydari et al.,[27] found that an 8 week exercise program with strengthening and stretching exercises improved postural alignment associated with FHP. In the present study, an intervention protocol as a form of three strengthening (Chin

tucks, YTWL-shoulder retractor exercise, resisted neck extensions) and three stretching (Upper trapezius-middle Scale, sternocleidomastoid and pectorals) exercises were designed. The CEG performed all of the above-mentioned exercises these exercises per week for 6 weeks. In contrast to other investigations, the current study demonstrated that shorter treatment duration was still successful in correcting the FHP. By considering preferences of the participants, this research addresses a significant gap in the literature and offers valuable insights into the role of individual choice in optimizing exercise experiences.

Postural Education

PE commonly covers various topics, including educating individuals about health risks associated with FHP, provision of correct postural guidelines for when using electronic devices, and recommending frequency of rest breaks. The most prevalent posture-related health risks addressed in PE are musculoskeletal disorders affecting the spine and limbs.[14] The results of our study showed a significant improvement in the PEG after T1. There is limited study in the literature directly examining the effect of postural training on FHP. Similar to our study, a study done by Shon et. al. in (2012) studied the effects of postural education on CVA concluded that postural education can be an effective intervention for improving FHP.[28] Postural guidelines for using electronic devices include maintaining an upright sitting or standing position, avoiding slouching, elevating the device to eye level to prevent forward head bending, and providing support to the elbows using armrests, tables, or thighs while sitting. The present study incorporates evidence-based postural guidelines for computer and smartphone use, including maintaining an upright sitting or standing posture, elevating the device to eye level, and taking regular rest breaks, as recommended in previous studies on forward head posture and ergonomics.

A primary limitation of this current study is the intervention duration. As this study was conducted online, another limitation was the inability to control the physical activity level of participants. It is plausible that some participants may have engaged in a greater or lesser degree of physical activity than others during the 6-week period, which could have potentially impacted the study outcomes. Additional limitations of this study include the lack of researcher blinding and absence of a long-term follow-up to assess any sustained effects. Lastly, the study's findings are constrained by the fact that it exclusively examined static posture without any consideration for neuro-muscular or musculoskeletal pathology, thereby limiting its generalization to dynamic postures.

CONCLUSION

As a result of the intervention for forward head posture, this study showed a substantial improvement in the craniovertebral angle, shoulder angle, and pain following the application of corrective exercises and postural education. To the best of our knowledge, this is the first study to evaluate both approaches not only in terms of craniovertebral and shoulder angles, but also pain and quality of life. These findings support the effectiveness of corrective exercises in improving postural alignment and reducing discomfort associated with forward head posture.

The magnitude of the improvements observed within only six weeks indicates that even short-term, low-cost interventions can yield clinically meaningful benefits, highlighting their potential integration into routine physiotherapy practice, ergonomics education, and preventive programs for individuals with postural dysfunction. However, the limited change in quality of life suggests that structural improvements alone may not translate into broader functional gains, and longer or more comprehensive interventions may be needed.

Future research should examine the long-term sustainability of these postural improvements, consider the use of objective neuromuscular assessments, and compare different exercise intensities or supervised versus unsupervised approaches. Expanding sample diversity and including follow-up measurements would also enhance the generalizability and clinical applicability of these findings.

Ethics Committee Approval

The study was approved by the Marmara University Hospital Ethics Committee (Date: 27.04.2023, Decision No: 56-2023).

Informed Consent

The requirement for informed consent was waived due to the retrospective nature of the study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: E.A.K., W.K.; Design: E.A.K., W.K.; Supervision: E.A.K.; Materials: E.A.K., W.K.; Data collection &/or processing: W.K.; Analysis and/or interpretation: E.A.K., W.K.; Literature search: E.A.K., W.K.; Writing: E.A.K., W.K.; Critical review: E.A.K., W.K

Conflict of Interest

The authors did not present any potential conflicts of interest.

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Düzeltici Egzersizlerin ve Postüral Eğitiminin Öne Eğik Baş Postürü Üzerindeki Etkileri - Randomize Kontrollü Çalışma

Amaç: Bu çalışmanın amacı, düzeltici egzersiz programı ve postüral eğitimin kraniovertebral açı, omuz açısı, ağrı ve yaşam kalitesi üzerindeki etkilerini karşılaştırmaktır.

Gereç ve Yöntem: Dahil edilme kriterlerine uyan toplam kırk altı (n=46) (n=25 kadın; n=21 erkek) birey tedavi öncesinde ve sonrasında tek bir fizyoterapist tarafından değerlendirilmiştir. Katılımcılar düzeltici egzersiz grubu (CEG=17), postüral eğitim grubu (PEG=17) ve kontrol grubu (CG=12) olmak üzere rastgele olarak üç gruba ayrılmıştır. CE grubu, germe ve kuvvetlendirme egzersizlerini içerecek şekilde baş önde postürü düzeltici egzersiz programına dahil edilirken, PE grubuna postüral eğitim yönergesi verilmiştir. Ayrıca, CG'ye ise herhangi bir tedavi uygulanmamıştır. Tedavi öncesi ve 6 hafta sonra bireyler kraniovertebral açı omuz açısı, ağrı düzeyleri ve yaşam kalitesi açısından değerlendirilmiştir.

Bulgular: Sonuç olarak, 6 hafta sonrasında grup içi karşılaştırmada; CE ve PE gruplarında kranyovertebral açı ($p=0.001$), omuz açısı ($p=0.005$) ve ağrı ($p=0.001$) açısından istatistiksel olarak anlamlı artış gözlenirken, CG'da ise kranyovertebral açı ($p=0.001$) ve ağrıda ($p=0.002$) artış görülmüştür. Yaşam kalitesi öncesi ve sonrası ölçümünde, tüm gruplar için fiziksel işlevsellik bileşeni dışında ($p<0.05$) anlamlı bir fark ortaya çıkmamıştır ($p>0.05$).

Sonuç: Kişiselleştirilmiş düzeltici egzersiz programı ve postür eğitimi, kraniyovertebral açı, omuz açısı ve ağrıyı iyileştirdi. Bu bulgular, basit ve düşük maliyetli müdahalelerin, öne eğik baş postürünü düzeltmek için klinik ve önleyici ortamlara etkili bir şekilde entegre edilebileceğini vurgulamaktadır.

Anahtar Sözcükler: Ağrı; baş önde postür; düzeltici egzersiz; postür eğitimi.

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Original Article

Comparison of Peroneus Longus and Hamstring Autografts in Primary Anterior Cruciate Ligament Reconstruction: Clinical Outcomes and Graft Characteristics

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Keywords: ACL reconstruction; anterior cruciate ligament; autograft; hamstring tendon; knee function; peroneus longus tendon.

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ABSTRACT

Objective: The purpose of this study was to compare the donor-site morbidity, graft characteristics, and clinical outcomes of primary anterior cruciate ligament (ACL) reconstruction using autografts of hamstring tendon (HT) and peroneus longus tendon (PLT).

Methods: This was a retrospective cohort study in a single center; 100 patients who underwent primary ACL reconstruction from September 2023 to November 2024 were included for follow-up of at least one year. Patients were divided into 2 groups according to graft type: PLT (n=56) and HT (n=44). The functional evaluation included the International Knee Documentation Committee (IKDC) score, Lysholm score and Tegner activity scale preoperatively and at 12 months. Donor-site morbidity about the ankle was assessed in the PLT group by means of a comparison between both sides using the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score. Intraoperatively, graft length and diameter were recorded. Nonparametric tests were used for comparisons between groups, and multivariable linear regression models were used to control for potential confounders.

Results: At 12 months, both groups functional scores showed a notable improvement following surgery. IKDC and Lysholm scores were statistically higher in the PLT group, but the magnitude of these differences was still below the minimal clinically significant thresholds. The groups' Tegner activity scores were similar. Graft diameter and length were considerably increased by PLT harvest. At the final follow-up, there was no discernible difference between the ipsilateral and contralateral AOFAS scores, suggesting that there was no clinically significant ankle dysfunction.

Conclusion: Similar to hamstring autografts in primary ACL reconstruction, PLT autograft produces short-term functional results. PLT can produce a larger graft diameter, but this did not result in a clinically significant improvement in patient-reported outcomes. PLT is a dependable alternative graft option when proper patient selection is taken into account.

INTRODUCTION

Anterior cruciate ligament (ACL) rupture is a common cause of knee instability, particularly in young and active individuals.[1,2] Surgical reconstruction is frequently performed to restore joint stability and enable return to activity. Although advances in surgical technique and rehabilitation have improved outcomes, graft selection remains a critical factor influencing postoperative function and graft durability.[3]

Hamstring tendon (HT) autograft is widely used in primary ACL reconstruction and provides reliable clinical results. However, concerns persist regarding donor-site morbidity, postoperative hamstring weakness, and variability in graft diameter, especially in patients with smaller tendons.[4,5] Insufficient graft thickness has been associated

with increased risk of failure, encouraging exploration of alternative autograft options.

The peroneus longus tendon (PLT) has recently gained attention as a potential alternative. Biomechanical studies have demonstrated comparable tensile strength and the ability to obtain adequate graft length and diameter.[6-8] Since PLT harvest does not involve the knee flexor mechanism, it may theoretically preserve hamstring strength. However, concerns remain regarding possible ankle donor-site morbidity. Current clinical studies using validated outcome measures have generally reported no clinically significant ankle dysfunction after PLT harvest, particularly when distal tenodesis is performed.[9-15]

Comparative studies and recent meta-analyses suggest that PLT autografts provide functional outcomes comparable to HT grafts in the short and mid term.[16-19] Nevertheless, variations in study design and limited sample sizes indicate that further clinical data are needed.

The aim of this study was to compare functional knee outcomes and graft characteristics between PLT and HT autografts in primary ACL reconstruction, and to evaluate ankle donor-site morbidity following PLT harvest.

MATERIALS AND METHODS

Study Design

This investigation was conducted as a retrospective cohort analysis at a single tertiary referral center. Medical records of patients who underwent primary ACL reconstruction between September 2023 and November 2024 were reviewed. Ethical approval was obtained from the institutional review board (20.11.2025; ID: 425), and the study was carried out in accordance with the Declaration of Helsinki. All participants had provided informed consent prior to surgery.

Patients were eligible for inclusion if they had an isolated ACL injury and a minimum postoperative follow-up of 12 months. Exclusion criteria consisted of previous knee surgery, revision ACL reconstruction, multiligament injuries, lower extremity deformity, or incomplete clinical data.

Patients were allocated to HT or PLT groups according to graft type. Selection was surgeon-dependent, and no randomization was performed.

Surgical Technique and Rehabilitation

All procedures were performed arthroscopically by two senior orthopedic surgeons experienced in ACL reconstruction. After diagnostic arthroscopy and debridement of ACL remnants, the femoral tunnel was created through the anteromedial portal using a femoral guide to achieve an anatomic femoral footprint position. The tibial tunnel was subsequently drilled with the aid of a tibial guide targeting the native ACL tibial insertion.

In the HT group, the semitendinosus and gracilis tendons were harvested through a standard medial incision and prepared as a quadrupled graft. In the PLT group, the tendon was obtained through a small incision proximal to the lateral malleolus (Fig. 1). Following distal tenodesis to the peroneus brevis tendon, proximal harvesting was completed using a tendon stripper.

In both groups, femoral fixation was achieved using an adjustable-loop cortical suspension device. Tibial fixation was performed with a bioabsorbable interference screw supplemented by a staple. The same fixation strategy was applied for both graft types to ensure procedural consistency.

Intraoperative measurements of graft diameter and length were recorded for all patients (Fig. 2). Concomitant meniscal lesions were treated with either partial meniscectomy or repair when indicated.

A standardized rehabilitation protocol was applied postoperatively. Early range-of-motion exercises and quadriceps activation were initiated within the first week. Weight-bearing was allowed as tolerated, and proprioceptive training was progressively introduced. Clearance for return to sports was based on individualized clinical and functional assessment.

Clinical Assessment and Functional Outcome Scoring Protocol

Clinical assessments were performed preoperatively and at 12 months postoperatively. Knee function was evaluated using the Lysholm score and the International Knee Documentation Committee (IKDC) subjective score. Activity level was assessed using the Tegner scale.

In the PLT group, donor-site morbidity was examined by documenting early postoperative ankle pain and assessing ankle function at 12 months using the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score. Ipsilateral and contralateral ankle scores were compared to detect potential functional deficits.

Statistical Analysis

Data analysis was conducted using SPSS software (Version 26.0, IBM, NY, USA). Since the data did not follow a normal distribution, continuous variables were presented as median (interquartile range, IQR). The Mann-Whitney U test was utilized for comparing groups, while the Fisher exact test was applied to categorical variables. The Wilcoxon signed-rank test was used to compare pre- and post-operative values within the same group.

To account for potential confounding factors, multivariable linear regression models were constructed for postoperative functional scores. Age, sex, follow-up duration, preoperative Tegner score, and presence of meniscal injury were included as covariates. Statistical significance was defined as $p<0.05$.

RESULTS

Of the 134 patients initially identified, 34 were excluded

Table 1. Demographic characteristics, graft characteristics, and preoperative data

Variable	PLT (n=56)	HT (n=44)	p-value
Age (years)	29 (22–33)	30 (24–34)	0.18*
Male sex, n (%)	41 (73.2)	32 (72.7)	1.00†
Follow-up duration (months)	14 (12–15)	13 (12–15)	0.96*
Concomitant meniscal injury, n (%)	24 (42.9)	16 (36.4)	0.54†
Graft diameter (mm)	8.5 (8–9)	7.5 (7–8)	<0.001*
Graft length (mm)	120 (115–125)	110 (95–120)	<0.001*
Preoperative IKDC score	55 (47–59)	56 (48–61)	0.91*
Preoperative Lysholm score	57 (48–61)	59 (49–64)	0.70*
Preoperative Tegner activity score	3 (2–3)	3 (2–3)	0.68*

* Mann–Whitney U test. † Fisher exact test.

Table 2. Multivariable linear regression analysis for 12-month clinical scores

Outcome	β (PLT vs HT)	95% Confidence Interval	p-value
IKDC score	+5.8	3.1 to 8.4	<0.001‡
Lysholm score	+5.9	3.4 to 8.3	<0.001‡
Tegner activity score	+0.1	−0.2 to 0.4	0.62‡

‡ Multivariable linear regression analysis.



Figure 1. Representative intraoperative photograph demonstrating the identification and isolation of the peroneus longus tendon (PLT). Through a 2 cm longitudinal incision performed proximal to the lateral malleolus, the PLT is identified and carefully isolated using a hemostat prior to the harvesting procedure.



Figure 2. Intraoperative evaluation of the PLT graft on a specialized preparation table. The suspensory cortical fixation system is integrated into the graft, and the total length is verified to ensure it meets the requirements for the anatomically prepared femoral and tibial tunnels.

due to incomplete follow-up or missing clinical data. The final analysis included 100 patients, comprising 56 in the PLT group and 44 in the HT group. Baseline demographic and preoperative clinical characteristics were comparable between groups. No significant differences were observed in age distribution, sex ratio, follow-up duration, or preoperative functional scores. The frequency of associated meniscal injuries was also similar (Table 1).

Marked improvement in clinical scores at 12 months postoperatively compared to preoperative values was evident in both groups. In univariate analysis, the PLT group had significantly higher IKDC and Lysholm scores at 12 months compared to the HT group; however, there was no significant difference between groups regarding the Tegner activity score (Fig. 3).

The use of PLT was independently associated with higher 12-month IKDC and Lysholm scores. No significant difference between the PLT and HT groups regarding the Tegner activity score was detected (Table 2). Morbidity at the donor site in the PLT group was assessed in terms of ankle functional outcome.

There was no statistically significant difference between

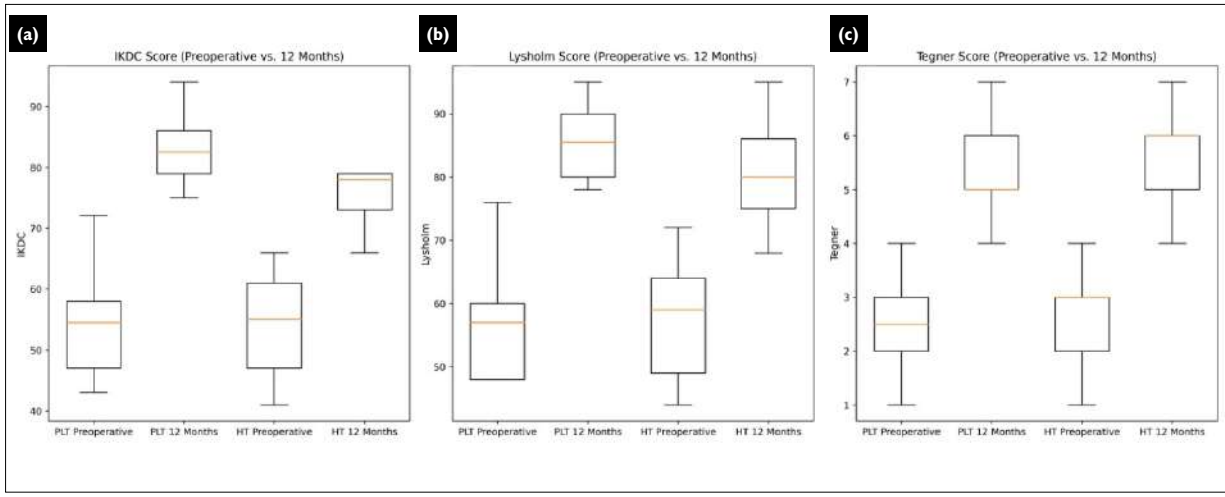


Figure 3. Comparison of preoperative and 12-month postoperative clinical scores in the peroneus longus tendon (PLT) and hamstring tendon (HT) groups. **(a)** IKDC scores, **(b)** Lysholm scores, and **(c)** Tegner activity scores (data are presented as median, interquartile range)

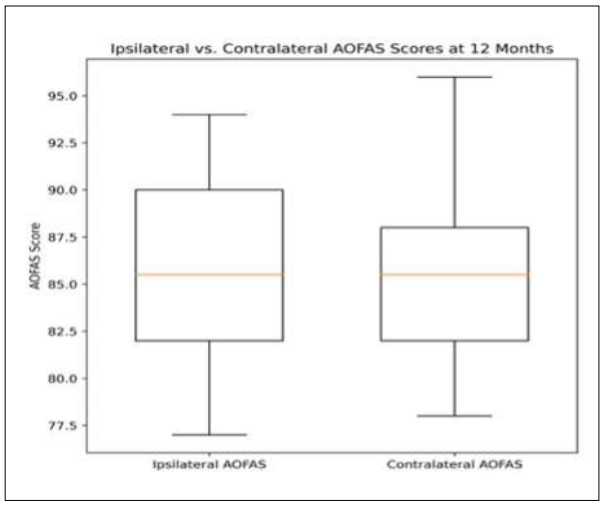


Figure 4. Comparison of operated and contralateral ankle AOFAS scores in the peroneus longus tendon (PLT) group (Data are presented as median, interquartile range).

ipsilateral and contralateral ankle AOFAS scores at the 12-month follow-up. Early postoperative ankle pain was reported in 3 patients, and all symptoms resolved during follow-up (Fig. 4).

DISCUSSION

This study evaluated clinical outcomes and graft characteristics of PLT and HT autografts in primary ACL reconstruction while also assessing ankle donor-site morbidity associated with PLT harvest. Both graft options resulted in significant postoperative functional improvement. Although IKDC and Lysholm scores were higher in the PLT group at final follow-up, the clinical relevance of this difference warrants careful interpretation.

Previous studies have defined the minimal clinically important difference (MCID) for IKDC as approximately 9–11 points and for Lysholm as 8–10 points.[20] In the present cohort, the magnitude of intergroup differences remained below these thresholds. Therefore, despite statistical significance, the observed superiority of PLT in functional scores is unlikely to represent a clinically meaningful advantage. From a practical standpoint, PLT appears to provide functional results comparable to HT rather than clear superiority. Activity levels measured by the Tegner scale did not differ significantly between groups. This suggests that the use of PLT does not negatively affect return to activity in the short term.

One of our study's noteworthy results in terms of graft characteristics is the PLT group's acquisition of a longer and larger graft diameter. Prior research has highlighted the significance of maintaining a sufficient graft diameter for biomechanical durability and long-term graft success.[21,22] The inability to obtain sufficient graft thickness, especially in patients with thin hamstring tendons, prompts surgeons to consider alternative graft options.[5]

Given this, the PLT's consistent ability to produce a thicker graft can be viewed as a major benefit in clinical settings.

Our study's functional knee results are in line with earlier clinical research comparing PLT and HT grafts in the literature. Functional knee scores have been found to be similar to those of hamstring tendons, even when the anterior half of the peroneus longus tendon is used.[9] Additionally, it has been shown that PLT-treated patients' IKDC and Lysholm scores are adequate and do not clinically fall short of those of the HT group.[10] In terms of short- and mid-term functional knee outcomes, current meta-analyses also show that the PLT autograft performs similarly to the HT autograft.[9,13,15,18]

One of the primary concerns regarding the use of the

peroneus longus tendon is ankle donor site morbidity. In this study, the AOFAS score was used to evaluate ankle functions in the PLT group, and no significant difference between ipsilateral and contralateral sides was noted. This finding means that harvesting a PLT graft does not lead to any clinically significant loss of ankle function.

Distal tenodesis between the peroneus longus and brevis tendons has been shown in numerous clinical and biomechanical studies to preserve plantar flexion and eversion functions.[6,10,12] Subsequent clinical series have confirmed similar findings.[13-15] Moreover, it has been pointed out that donor site morbidity for PLT is low with minimal functional loss reported.[12] The results of our study are consistent with these findings. The similarity of Tegner scores in both groups indicates that PLT utilization does not have any adverse effect on returning to sports. However, since this score is an assessment tool based on subjective opinion and does not represent the type and level of sport in detail, caution should be taken while interpreting it. Still, based on existing data, no findings were noted that would support PLT use as a limitation to functional activity levels.[3,13,16]

There are a number of limitations to this study that should be taken into account when looking at the results. First, the study's design is retrospective and not randomized, and the choice of grafts was based on the surgeon's preference and what was best for the patient during the surgery. This could lead to selection bias. Even though the groups had similar baseline characteristics and multivariate regression analyses were used to account for known confounders, the effect of unmeasured variables cannot be entirely ruled out. Second, we used validated patient-reported tools like the Lysholm, IKDC, and Tegner scores to look at clinical outcomes. Even though these measures are widely accepted and clinically useful, they mostly show how people feel about their own functional abilities. They weren't backed up by objective tests like instrumented laxity measurements or quantitative muscle strength testing, which might have made it harder to find small biomechanical differences between graft types. Finally, this was a single-center study where all procedures were done by experienced senior surgeons using the same method. While this methodology guaranteed technical uniformity, it may limit the applicability of the findings to institutions with divergent surgical practices or differing degrees of surgical expertise. Additional prospective, multicenter randomized controlled trials featuring objective functional assessments are necessary to more conclusively elucidate the comparative efficacy of the peroneus longus tendon in primary ACL reconstruction.

CONCLUSION

In primary ACL reconstruction, the PLT demonstrated clinical outcomes comparable to those achieved with hamstring autografts at short-term follow-up. Although greater graft diameter was obtained with PLT harvest, this did not translate into clinically meaningful superiority in functional scores. Importantly, no significant ankle functional impairment was detected following PLT use. These findings suggest that PLT represents a viable autograft option in selected patients, particularly when adequate hamstring graft diameter is a concern.

Ethics Committee Approval

Ethical approval was obtained from the institutional review board of Umraniye Training and Research Hospital (Date: 20.11.2025, Decision No: 425).

Informed Consent

All participants had provided informed consent prior to surgery.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: B.K., M.A., M.B.; Design: B.K., M.A., M.B., S.A.; Supervision: B.K., M.A., M.B., K.G.; Materials: B.K., M.A.; Data collection &/or processing: K.G., M.O., M.A.; Analysis and/or interpretation: B.K., S.A., M.B., M.O.; Literature search: B.K., M.B., K.G., M.O.; Writing: B.K., M.B., S.A.; Critical review: S.A., B.K., M.B.

Conflict of Interest

None declared.

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Primer Ön Çapraz Bağ Rekonstrüksiyonunda Peroneus Longus ve Hamstring Otogreftlerinin Karşılaştırmalı Klinik ve Greft Özellikleri

Amaç: Bu çalışmanın amacı, primer ön çapraz bağ (ÖÇB) rekonstrüksiyonunda hamstring tendon (HT) ve peroneus longus tendon (PLT) otogreftlerinin donör saha morbiditesi, greft özellikleri ve klinik sonuçlar açısından karşılaştırılmasıdır.

Gereç ve Yöntem: Bu çalışma tek merkezli retrospektif bir kohort çalışmasıdır. Eylül 2023 ile Kasım 2024 tarihleri arasında primer ÖÇB rekonstrüksiyonu uygulanan ve en az bir yıl takip edilen toplam 100 hasta dahil edilmiştir. Hastalar kullanılan greft tipine göre iki gruba ayrılmıştır: PLT (n=56) ve HT (n=44). Fonksiyonel değerlendirme ameliyat öncesinde ve postoperatif 12. ayda Uluslararası Diz Dokümantasyon Komitesi (IKDC) skoru, Lysholm skoru ve Tegner aktivite ölçeği kullanılarak yapılmıştır. PLT grubunda ayak bileğine ait donör saha morbiditesi, Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) arka ayak skoru kullanılarak iki tarafın karşılaştırılması yoluyla değerlendirilmiştir. İntraoperatif olarak greft uzunluğu ve çapı kaydedilmiştir. Gruplar arası karşılaştırmalarda nonparametrik testler kullanılmış, olası karıştırıcı değişkenleri kontrol etmek amacıyla çok değişkenli lineer regresyon modelleri uygulanmıştır.

Bulgular: On ikinci ayda her iki grubun fonksiyonel skorlarında ameliyat sonrası belirgin iyileşme gözlenmiştir. IKDC ve Lysholm skorları PLT grubunda istatistiksel olarak daha yüksek bulunmuş, ancak bu farkların büyüklüğü minimal klinik anlamlılık eşiklerinin altında kalmıştır. Tegner aktivite skorları açısından gruplar arasında benzerlik saptanmıştır. PLT kullanımı ile daha büyük çap ve daha uzun greft elde edilmiştir. Son takipte ipsilateral ve kontralateral AOFAS skorları arasında anlamlı bir fark izlenmemiş olup, klinik olarak anlamlı bir ayak bileği fonksiyon kaybı saptanmamıştır.

Sonuç: Primer ÖÇB rekonstrüksiyonunda PLT otogrefti, hamstring otogreftlere benzer kısa dönem fonksiyonel sonuçlar sağlamaktadır. PLT ile daha büyük greft çapı elde edilebilmesine rağmen bu durum hasta tarafından bildirilen sonuçlarda klinik olarak anlamlı bir üstünlük sağlamamıştır. Uygun hasta seçimi yapıldığında, PLT kullanımı güvenilir bir alternatif greft seçeneği olabilmektedir.

Anahtar Sözcükler: Ön çapraz bağ; peroneus longus tendonu; hamstring tendonu; otogreft; diz fonksiyonu; ön çapraz bağ rekonstrüksiyonu.

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Original Article

Prevalence of Device Utilization, Healthcare-Associated Infections and Antibiotic Use in the Intensive Care Unit

Akın Bilir, Türker Kan Taşcı, Yeliz Bilir, Elif Bombacı, Banu Cevik

ABSTRACT

Objective: Healthcare-associated infections (HAIs) represent a significant public health concern due to attributable mortality, prolonged hospital stays, and increased costs. The aim of this point-prevalence study was to evaluate device utilization rates, the prevalence of HAIs, associated risk factors, and clinical outcomes in the intensive care unit (ICU).

Methods: On the index day, for each patient, clinical data, infection status, antibiotic use (empirical, definitive, prophylactic), and device utilization were recorded. The definitions of HAIs were based on the Ministry of Health HAIs Surveillance Diagnostic Guidelines.

Results: Data from 104 patients were prospectively collected and analyzed. The median age was 70.5 years, and 57.7% were male. Overall, 69.2% had a central venous catheter (CVC), 95.2% a urinary catheter (UC), 68.3% mechanical ventilation (MV), 11.5% continuous renal replacement therapy and 14.4% parenteral nutritional support. Antibiotic use was identified in 70.2% of patients, with the most frequently isolated pathogens being *P. aeruginosa* (46.7%) and *A. baumannii* (20.0%). Patients were stratified into three groups: Community-acquired infection (n=37), nosocomial infection (n=35), and no infection (n=32). In the nosocomial infection group, rates of MV, tracheostomy, CVC, and dialysis catheter utilization were significantly higher ($p<0.05$). In addition, ICU length of stay was significantly longer in this group (24 days, $p=0.001$), and mortality was markedly higher ($p=0.007$). The overall prevalence of HAIs was 13.5%. The most common infection type was central line–associated bloodstream infection (42.9%), followed by catheter-associated urinary tract infections (28.6%), ventilator-associated events (14.3%), and surgical site infections (14.3%). Patients with HAIs had significantly longer ICU stays (54 days vs. 10 days, $p<0.001$). Mortality rates were 57.1% in the HAIs group and 42.9% in the non-HAIs group; however, this difference did not reach statistical significance ($p=0.360$). Additionally, APACHE-II scores, MV and tracheostomy rates were significantly higher in HAIs group ($p=0.005$, $p=0.035$, $p=0.005$).

Conclusion: The high frequency of antibiotic use and frequent isolation of resistant pathogens underscore the critical importance of antimicrobial stewardship programs, while the predominance of catheter-related infections highlights the necessity of reducing invasive procedures.

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Keywords: Healthcare-associated infections; intensive care unit; invasive devices; risk factors; mortality.

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INTRODUCTION

Healthcare-associated infections (HAIs) are one of the most critical complications in hospitalized patients and are responsible for major health and economic burdens. Despite advances in infection prevention and control strategies, HAIs remain a major global health concern contributing to prolonged hospitalizations, increased healthcare costs, and significant physical and psychological distress for affected patients. Notably, HAIs account for approximately 71% of infections caused by antibiotic-resistant bacteria, and up to 50% of these infections are considered preventable.[1]

According to the World Health Organization report "Surveillance of health care-associated infections at national and facility levels" approximately 7% of hospitalized patients in developed countries and 15% in developing countries acquire at least one HAIs representing a substantial economic burden at the societal level.[2] Intensive care units (ICUs) are particularly high-risk settings due to the frequent use of invasive procedures, which make all patients vulnerable to HAIs. The 2020 report by the Euro-

pean Center for Disease Prevention and Control highlighted that patients who remain in an ICU for more than two days are likely to develop at least one ICU-acquired HAIs.[3] A recent meta-analysis estimated the prevalence of HAIs in adult ICUs at 32%, with pneumonia—whether ventilator-associated (VAP) or non-VAP—being the most common type.[4] In 2022-2023, a multicenter point prevalence survey of HAIs and antimicrobial use in European acute care hospitals reported that 7.1% of patients had at least one HAIs.[5] In Turkiye, a meta-analysis synthesizing data from studies conducted over the past decade reported an invasive device-associated HAI rate of 4.19% in ICUs.[6] These findings demonstrate that HAIs remains a significant health care challenge worldwide and urgent need for targeted prevention strategies are needed particularly in high-risk settings such as ICUs.

The selection of effective antimicrobial agents in ICUs poses a significant clinical challenge, and empirical or prophylactic therapies are often preferred until pathogen isolation and susceptibility results are available. However, this approach may be time-consuming, and inappropriate antimicrobial use can further exacerbate resistance. The rising prevalence of HAIs, particularly bloodstream and respiratory infections, results in greater antimicrobial consumption, thereby accelerating the emergence of multidrug resistance organisms.[7] Consequently, antimicrobial resistance has gradually become a serious global concern.[8]

The aim of this point-prevalence study is to comprehensively evaluate device utilization rates, the prevalence of HAIs, associated risk factors, and antimicrobial use among adult ICU patients on the index day. The primary outcomes include length of ICU stay, total hospital stay, discharge status, and readmission, while the secondary outcome is to assess 28-day mortality.

MATERIALS AND METHODS

The study is approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (No: 2025/0l0.99/20/2l, Date: 29/09/2025) and conducted according to Declaration of Helsinki.

Study design and participants

This is a single center point prevalence study conducted in 127-ICU bed of a university-affiliated tertiary hospital. All adult patients who had been hospitalized for at least 48 hours on the index day were included in the study. All patients were ≥18 years.

Data collection

On the index day, all ICU beds were fully occupied. For each patient, medical records, nursing observation charts, and laboratory results were reviewed, and the following data were recorded:

Demographic and clinical characteristics: Age, sex, comorbidities, reason of admission, Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) score.

Advanced life support requirements: Mechanical ventilation, vasoactive agent infusion, and continuous renal replacement therapy (CRRT).

Device utilization: Presence of central venous catheter (CVC), dialysis catheter, endotracheal tube, tracheostomy, tube thoracostomy, urinary catheter, and surgical or drainage catheters. Device utilization rates were calculated as the proportion of patients with at least one device in place on the index day.

Antibiotic use: Frequency and spectrum of antimicrobial therapy. Antibiotic use was categorized as empirical (initiated before microbiological confirmation), definitive (based on culture and susceptibility results), or prophylactic (administered to prevent infection).

Infection status: Whether the infections were healthcare-associated, the presence of a community-acquired infection at admission, the site of infection, and culture positivity. In this study, the definitions of HAIs were adopted from the "Ministry of Health's HAI Surveillance Diagnostic Guidelines".

Statistical analysis

The data were analyzed using IBM SPSS Statistics version 26.0 (Armonk, NY, USA). In descriptive statistics, categorical variables were presented as frequency (n) and percentage (%), whereas continuous variables were summarized as median and interquartile range (IQR). The normality of the distribution was assessed by the Shapiro–Wilk test, and non-parametric methods were applied for non-normally distributed data. For comparisons between two groups, the Mann–Whitney U test was used, while the Kruskal–Wallis H test was applied for comparisons among three or more groups. Pearson's Chi-square test was used for the analysis of categorical variables; in cases where the expected cell count was less than five, the Fisher-Freeman-Halton or Fisher's Exact test was employed. A p-value of <0.05 was considered statistically significant for all analyses.

RESULTS

General Patient Characteristics

A total of 104 ICU patients who met the study criteria on the index day were included in the analysis. The median age was 70.5 years (IQR: 5), and 57.7% were male while 42.3% were female. Regarding device use and supportive therapies, 69.2% of patients had a central venous catheter and 95.2% had a urinary catheter in place. In addition, 68.3% required mechanical ventilation, 14.4% had a tracheostomy, 11.5% were receiving CRRT, and 14.4% were supported with parenteral nutrition (Table 1).

Table 1. Demograhic and clinical characteristics of patients (n=104)

Variable	
Age, median (IQR)	70.5 (21)
Male, Sex, n (%)	60 (57.7)
LOS median (IQR)	14 (19)
APACHE II, median (IQR)	18.5 (8)
SOFA median (IQR)	6 (4)
CCI Score, median (IQR)	5 (3)
Reason for ICU admission, n (%)	
Post operative monitoring	16 (15.4)
Trauma	4 (3.8)
Neurological disease	14 (13.5)
Pulmonary disease	42 (40.4)
Infection	16 (15.4)
Malignancy	11 (10.6)
Other (poisoning)	1 (1)
Mode of Nutrition, n (%)	
Enteral	66 (63.5)
Parenteral	15 (14.4)
Oral	10 (9.6)
Non	13 (12.5%)
Invasive procedures, n (%)	
Endotracheal tube	62 (59.6)
Tracheostomy	15 (14.4)
Central venous catheter	72 (69.2)
Urinary catheter	99 (95.2)
Hemodialysis	12 (11.5)
Tube thoracostomy	2 (1.9)
Presence of drainage	6 (5.8)
CVC site n (%)	
Juguler	51 (70.8)
Subklavian	7 (9.7)
Femoral	14 (19.4)

IQR: interquartile range; LOS: Lenght of stay in ICU; CCI: Charlson comorbidity index CVC: Central venous catheter; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment score.

Types of Infections in Adult ICUs

Patients were stratified into three categories: Community-acquired infection (CAI) (n=37), nosocomial infection (NCI) (n=35), and no infection (n=32). Within the nosocomial infection group, the incidence of invasive procedures—including endotracheal intubation, tracheostomy, central venous catheterization, and dialysis catheterization—was significantly higher compared to the other groups (p<0.05). Moreover, this group demonstrated a markedly prolonged length of stay in ICU (LOS) (median: 24 Days, p=0.001) and a significantly elevated mortality rate (p=0.007) (Table 2).

Among Nosocomial infections, 5.8% were bloodstream infections, 17.3% pulmonary infections, 5.8% urinary tract infections, and 1.9% soft tissue infections. The overall antibiotic utilization rate was 70.2%, of which 39.4% were definitive, 27.9% empirical, and 2.9% prophylactic regimens. The most frequently isolated pathogens were *Pseudomonas aeruginosa* (46.7%), *Acinetobacter baumannii* (20.0%), and *Proteus mirabilis* (13.3%), with the resistance profile summarized in Figure 1. The most commonly administered agents were meropenem, colistin, and teicoplanin, while 14.4% of patients received antifungal therapy.

Prevalence and mortality of HAIs

The overall prevalence of HAIs was 13.5%. The most common infection type was central line-associated bloodstream infections (CLABSIs) at 42.9%, followed by catheter-associated urinary tract infections (CAUTIs) at 28.6%, ventilator-associated events (VAEs) at 14.3%, and surgical site infections at 14.3%. Identified risk factors for HAIs development included chronic kidney disease (30%), malignancy (35%), immunosuppression (25%), and diabetes mellitus (45%). LOS in ICU was significantly longer in patients with HAIs compared to those without (54 days vs. 10 days, p<0.001). The mortality rate was 57.1% in the HAIs group versus 42.9% in the non-HAIs group, though this difference did not reach statistical significance (p=0.360). Moreover, patients with HAIs demonstrated significantly higher APACHE-II scores, a greater need for mechanical ventilation, and a higher rate of tracheostomy [p=0.005; p=0.035; p=0.005] (Table 3).

Logistic regression analysis was performed to identify independent predictors of HAIs development. The analysis demonstrated that the APACHE-II score was the only independent risk factor (p=0.016). Each one-point increase in the APACHE-II score was associated with an approximately 18% higher risk of developing an HAIs. In addition, the presence of tracheostomy showed borderline significance (p=0.077) and was associated with an approximately four-fold increased risk of HAIs occurrence (Table 4).

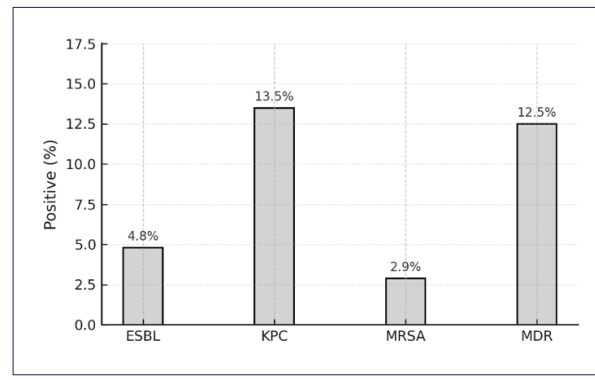


Figure 1. Resistance profile.

Table 2. Comparison of patient characteristics according to infection status

Variable	CAI (n=37)	NCI (n=35)	Non (n=32)	p-value
Age, median (IQR)	59 (7)	57 (20)	61 (21)	0.645
CCI score, median (IQR)	4 (3)	4 (2)	4 (3)	0.617
APACHE II, median (IQR)	17 (10)	20 (10)	15 (10)	0.070
SOFA, median (IQR)	5 (4)	7 (4)	5 (4)	0.054
LOS (days), median (IQR)	11 (8)	24 (15)	14 (10)	0.001
NIV n, (%)	2 (5.4)	0 (0%)	3 (9.4)	0.196
Invasive procedures, n (%)				
Endotracheal tube	20 (54.1)	32 (91.4)	19 (59.4)	0.001
Tracheostomy	1 (2.7)	9 (25.7)	5 (15.6)	0.021
Central venous catheter	25 (67.6)	30 (85.7)	17 (53.1)	0.015
Urinary catheter	36 (97.3)	35 (100)	28 (87.5)	0.044
Hemodialysis	10 (27)	5 (14.3)	0 (0)	0.006
Tube thoracostomy	0 (0)	2 (5.7)	0 (0)	0.134
Presence of drainage	3 (8.1)	0 (0)	3 (9.4)	0.194
Inotrope support n, (%)	5 (13.5)	10 (28.6)	4 (12.5)	0.152
Nutrition type n, (%)				
Parenteral	3 (8.1)	7 (20)	5 (15.6)	
Enteral	23 (62.2)	21 (60)	22 (68.8)	0.543
Oral	6 (16.2)	2 (5.7)	2 (6.3)	
CVC site n, (%)				
Jugular	14 (56)	23 (76.7)	14 (82.4)	0.117
Subclavian	2 (8)	4 (13.3)	1 (5.9)	
Femoral	9 (36)	3 (10)	2 (11.8)	
Mortality n, (%)	17 (30.4)	23 (41.1)	16 (28.6)	0.007

CAI: Community-acquired infection; NCI: Nosocomial infection; LOS: Lenght of stay in ICU; CVC: Central venous catheter; NIV: Noninvasive Ventilation; CCI:Charlson comorbidity index; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment score.

Table 3. Comparison of patients according to the presence of HAIs

Variable	No HAIs (n=90)	HAIs (n=14)	p-value
Age, median (IQR)	71 (21)	66.5 (26.7)	1.000
Male, Sex, n (%)	51 (85.0)	9 (15.0)	0.773
SOFA, median (IQR)	6 (4)	6 (3)	0.627
APACHE II, median (IQR)	18(7)	24 (9.2)	0.005
CCI score, median (IQR)	5(2)	4.5 (4)	0.571
Invasive procedures, n (%)			
Endotracheal tube	Var: 58 (81.7)	Var: 13 (18.3)	0.035
Tracheostomy	9 (60.0)	6 (40.0)	0.005
Central venous catheter	60 (83.3)	12 (16.7)	0.217
Urinary catheter	85 (85.9)	14 (14.1)	0.611
Hemodialysis	11 (91.7)	1 (8.3)	0.699
Tube thoracostomy	2 (100)	0 (0)	1.000
Presence of drainage	6 (100)	0 (0)	0.595
Inotropic support n (%)	15 (78.9)	4 (21.1)	0.457
LOS median (IQR)	10(16)	54 (47)	<0.001
Mortality n (%)	48 (53.3)	8 (57.1)	0.360

IQR: interquartile range; LOS: Lenght of stay in ICU; CCI: Charlson comorbidity index; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment score.

Table 4. Multivariable logistic regression analysis for HAIs

Variable	OR	95% CI	p-value
Age (per year increase)	1.011	0.963–1.062	0.660
CCI score	0.943	0.609–1.460	0.792
SOFA (per unit increase)	0.876	0.635–1.209	0.421
APACHE II (per unit increase)	1.184	1.032–1.359	0.016
Presence of tracheostomy	3.922	0.863–17.821	0.077
Inotrope support	2.435	0.404–14.678	0.331
Presence of MV	5.317	0.334–37.015	0.295

CCI: Charlson comorbidity index; APACHE II: Acute Physiology and Chronic Health Evaluation II; SOFA: Sequential Organ Failure Assessment score; MV: Mechanical ventilation.

DISCUSSION

In this single-center point prevalence study, the prevalence of HAIs in the ICU was found to be 13.5%. The most common type of HAIs was CLABSI (42.9%), followed by CAUTI (28.6%), VAEs (14.3%), and surgical site infections (14.3%). The presence of HAIs was significantly associated with prolonged length of stay while the APACHE-II score emerged as an independent risk factor, and tracheostomy showed borderline statistical significance. These results are consistent with the contemporary literature shaped around invasive device exposure, disease severity, and high antimicrobial consumption in ICUs.

A meta-analysis including 21 studies reported an overall HAIs prevalence of 32%, with pneumonia (including or excluding ventilator-associated pneumonia, VAP) identified as the most frequent infection type.[4] In contrast, the European Centre for Disease Prevention and Control reported in its point prevalence survey conducted across 26 countries that 7.1% of hospitalized patients had HAIs.[9,10] The higher prevalence observed in our study (13.5%) may be attributed to its single-center and single-day design, differences in patient population, higher rates of invasive procedures, and variations in local infection control practices.

A recent meta-analysis has reported a progressive increase in rates, a finding that aligns with the predominant distribution observed in our study.[11] This emphasizes once again the crucial importance of implementing bundle care practices. Evidence from multiple studies has consistently demonstrated that bundle-based interventions represent the most rational and effective strategy for preventing device- and catheter-associated infections, resulting in a significant reduction in CLABSI incidence.[12]

Similarly, a two-year prospective observational study evaluating nosocomial infections identified CLABSI as the most common HAIs type and reported that the average LOS in ICU (34.5 days) was significantly longer among patients with HAIs.[13] In parallel with these findings, the marked prolongation of LOS in our study among patients with HAIs reflects the clinical and economic burden documented in the literature, underscoring the necessity of cost-effective preventive strategies, such as meticulous line care and early catheter removal.

In another point-prevalence study, the rate of antibiotic use was reported to be remarkably high at 92.9%, with a predominant reliance on empirical therapy (67.5%) and broad-spectrum agents.[14] In comparison, the antibiotic utilization rate in our study was 70.2%, showing a similar trend toward empirical and broad-spectrum antibiotic use. These findings highlight that antimicrobial stewardship programs are not merely local initiatives but represent a global necessity in infection control and patient safety.

The literature consistently emphasizes the importance of reducing HAIs as a key strategy to limit the use of broad-spectrum antimicrobials.[15] Empirical broad-spectrum therapy, while often clinically justified initially, contributes to the selection and spread of resistant pathogens. In our study, the most frequently isolated microorganisms were *Pseudomonas aeruginosa* and *Acinetobacter baumannii*, both well-known for their high resistance potential. The isolation rates of these pathogens align closely with global data, and the elevated rate of antibiotic use—particularly of broad-spectrum agents—further underscores the escalating risk of antimicrobial resistance and the urgent need for judicious antibiotic utilization.

When HAIs and antimicrobial resistance are present, mortality increases substantially. Numerous studies have demonstrated a strong association between HAIs, prolonged hospitalization, and increased mortality.[16,17] Kafazi et al.[13] reported a mortality rate of 44.9% among patients who developed HAIs, compared to 24.8% in those without infection, emphasizing—consistent with our findings—that device-associated infections represent a major public health concern due to their attributable mortality, extended hospital stays, and additional healthcare costs.

Similarly, a multicenter study conducted during the COVID-19 pandemic reported a mortality rate of 35.5% in patients with HAIs.[18] The rise in mortality within the HAI group was predominantly linked to Gram-negative resistant pathogens, with bloodstream infections and ventilator-associated pneumonia being the most frequently identified infection types. These findings highlight that re-

ducing unnecessary catheterization and mechanical ventilation days, as well as implementing rapid de-escalation of empirical therapy based on early culture results, are key interventions associated with significant reductions in both length of hospital stay and mortality rates.

CONCLUSION

This study demonstrates that invasive device utilization and high antibiotic consumption are critical determinants in the development of HAIs in ICUs. The findings indicate that HAIs should not be regarded merely as complications but rather as fundamental indicators reflecting the quality of intensive care practices. Therefore, ensuring patient safety and improving clinical outcomes require moving beyond conventional infection control measures toward multidisciplinary collaboration and the adoption of innovative, evidence-based strategies. Such approaches to HAIs prevention can provide cost-effective and sustainable solutions, not only at the individual patient level but also within the broader framework of institutional and national healthcare policies.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (Date: 29.09.2025, Decision No: 2025/010.99/20/21).

Informed Consent

Point prevelans study. Written informed consent was obtained from all patients and/or their legal guardians prior to participation.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: B.C., Y.B., A.B.; Design: B.C., Y.B., A.B.; Supervision: B.C., Y.B.; Fundings: A.B.; Materials: A.B., E.B., T.K.T.; Data collection &/or processing: A.B., T.K.T.; Analysis and/or interpretation: Y.B., A.B.; Literature search: Y.B., A.B.; Writing: Y.B., A.B., B.C.; Critical review: B.C.

Conflict of Interest

None declared.

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Yoğun Bakımda Cihaz Kullanım Oranları, Sağlık Bakım Hizmetiyle Ilişkili Enfeksiyonlar ve Antibiyotik Kullanımı

Amaç: Sağlık bakımı ilişkili enfeksiyonlar (SBİE), atfedilebilir mortalite, uzamış yatış süresi ve artan maliyetler nedeniyle önemli bir halk sağlığı sorunudur. Bu nokta prevalans çalışmasının amacı, yoğun bakım ünitesinde (YBÜ) cihaz kullanım oranlarını, SBİE prevalansını, ilişkili risk faktörlerini ve klinik sonuçlarını değerlendirmektir.

Gereç ve Yöntem: İndeks gününde, çalışmaya 48 saattir YBÜ'de yatan, 18 yaş üstü tüm hastalar dahil edildi. Her hasta için klinik veriler, enfeksiyon durumu, antibiyotik kullanımı (ampirik, definitif, profilaktik) ve cihaz kullanımları kaydedildi. SBİE tanıları için, 'Sağlık Bakanlığı SBİE Sürveyans Tanı Rehberi' esas alındı.

Bulgular: Çalışmaya dahil edilen 104 hastanın medyan yaşı 70.5 yıl olup, %57.7'si erkekti. Tüm hastaların %69.2'sinde santral venöz kateter (SVK), %95.2'sinde üriner kateter (ÜK), %68.3'ünde mekanik ventilasyon (MV), %11.5'inde sürekli renal replasman tedavisi ve %14.4'ünde parenteral beslenme desteği mevcuttu. Antibiyotik kullanımı %70.2 oranında saptanmış olup, en sık izole edilen başlıca patojenler ise *P. aeruginosa* (%46.7), *A. baumannii* (%20.0) idi. Hastalar toplum kaynaklı enfeksiyon (n=37), nazokomiyal enfeksiyon (n=35) ve enfeksiyonsuz (n=32) olmak üzere 3 grupta değerlendirildi. Hastane kaynaklı enfeksiyon grubunda MV trakeostomi, SVK ve diyaliz kateteri kullanım oranları anlamlı daha yüksekti ($p<0.05$). Ayrıca bu grupta yoğun bakımda kalış süresi anlamlı daha uzun (24 gün, $p=0.001$), mortalite oranı belirgin daha yüksekti ($p=0.007$). Genel SBİE prevalansı %13.5 olarak saptandı. Ensık enfeksiyon tipi SVK ilişkili kan dolaşım enfeksiyonları (%42.9) olup, bunu ÜK ilişkili enfeksiyonlar (%28.6), ventilatör ilişkili olaylar (%14.3) ve cerrahi alan enfeksiyonları (%14.3) izledi. SBİE tanısı alan hastalarda yatış süresi anlamlı daha uzun bulunmuş (54 gün vs. 10 gün; $p<0.001$), mortalite oranı ise SBİE grubunda %57.1, SBİE'siz grupta %42.9 olarak saptanmış olup istatistiksel olarak anlamlı fark bulunmamıştır ($p=0.360$). Ayrıca SBİE grubunda APACHE-II skoru, MV ve trakeostomi oranları anlamlı düzeyde daha yüksekti ($p=0.005$, $p=0.035$, $p=0.005$).

Sonuç: Bu çalışma, yoğun bakımda invaziv cihaz kullanımının yüksek olduğunu ve SBİE gelişimiyle ilişkili bulunduğunu göstermiştir. Kateter ilişkili enfeksiyonların baskınlığı, invaziv girişimlerin azaltılmasını zorunlu kılmaktadır. Yüksek antibiyotik kullanımı ve dirençli patojenlerin sık izolasyonu akılcı antibiyotik programlarının önemini ortaya koymaktadır

Anahtar Sözcükler: Sağlık bakım ilişkili enfeksiyonlar; yoğun bakım ünitesi; invaziv cihazlar; risk faktörleri; mortalite.

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Original Article

Clinical Outcomes of Iatrogenic Colonic Perforations Managed with Endoscopic Clipping and Exploratory Findings Associated with Treatment Failure

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Keywords: Colonoscopy; iatrogenic colonoscopic perforation; endoscopic clip; perforation.

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ABSTRACT

Objective: Iatrogenic colonoscopic perforation (ICP) is an uncommon but potentially serious complication associated with significant morbidity. Endoscopic clip application has emerged as a minimally invasive alternative to surgery in appropriately selected patients. This study aimed to evaluate the clinical outcomes of ICP cases managed with endoscopic clipping and to explore potential factors associated with treatment failure.

Methods: A total of 17 patients who were diagnosed with ICP and treated with endoscopic clipping between January 2019 and August 2025 were retrospectively analyzed. Demographic characteristics, perforation-related features, treatment modalities, postoperative complications, time to initiation of oral intake, and length of hospital stay were examined. Treatment success was defined as clinical recovery without the need for surgery, whereas treatment failure was defined as the requirement for surgical intervention following clipping.

Results: Endoscopic treatment was successful in 10 patients (58.8%), while 7 patients (41.2%) required surgery. Age, sex, body mass index, comorbidity profile, previous abdominal surgery, bowel preparation quality, and perforation direction did not differ significantly between groups (all $p>0.05$). Time to oral intake and length of hospital stay were significantly longer in the failure group ($p=0.021$). The sigmoid colon was the most common perforation site, identified in 70.6% of cases.

Conclusion: Endoscopic clip application represents an effective therapeutic option for carefully selected ICP cases. This study provides exploratory data on the outcomes of endoscopic management and offers a foundation for future research in this field.

INTRODUCTION

Colonoscopy is widely carried out for both diagnostic and therapeutic indications and is commonly considered a safe procedure; however, iatrogenic perforation remains one of its most serious complications.[1] Published data reveal that the incidence of this complication ranges roughly from 0.016% to 0.8% in the existing literatüre during diagnostic colonoscopy and 0.02–8% when the procedure is performed for therapeutic purposes.[2-5] Approximately half of colonoscopic perforations are recognized by the endoscopist during the procedure, whereas the remainder are diagnosed post-procedurally based on emerging clinical signs and symptoms.[6] Delayed diagnosis or treatment may lead to peritonitis or sepsis, resulting in life-threatening conditions. Reported mortality rates following iatrogenic colonoscopic perforation range from 5% to 25% across published series.[4,7,8]

Once perforation is identified, either intraoperatively or through post-procedural clinical and radiological findings, a decision must be made between surgical and non-surgical management. The decision is influenced by multiple clinical and procedural factors, including the nature and extent of the injury type of injury, underlying colonic pathology, adequacy of bowel preparation, and hemodynamic steadiness of the patient.[9] Surgery is unavoidable in cases of large perforations or when patients present with signs of diffuse peritonitis; additionally, underlying colonic diseases requiring operative management necessitate surgical intervention.[9,10] Conservative management can be considered an appropriate option for patients who present with localized abdominal pain, absence of fever, radiologic evidence of free air without free fluid, hemodynamic stability, and adequate bowel cleansing.[11-14] Reported success rates for

conservative treatment of ICP range from 33% to 90%.[10] Nevertheless, conservative management does not negate the requirement for surgery; patients initially treated conservatively but later requiring surgery exhibit higher complication rates and longer hospital stays. Therefore, vigilant clinical monitoring is crucial during conservative management.[15]

The use of endoscopic clips for managing iatrogenic perforations emerged as a minimally invasive treatment option after it was initially introduced by Yoshikane et al.[16] in 1997. This technique can be implemented if the defect is identified at the time of colonoscopy or detected within the subsequent four-hour period, assuming that the bowel preparation is still satisfactory.[17] The decision to proceed with endoscopic clipping depends on factors such as perforation size and etiology, availability of appropriate endoscopic equipment, and the experience of the endoscopist.[17] The literature suggests that endoscopic clipping is recommended for perforations smaller than 1 cm, with reported success rates ranging from 59% to 100%.[14,18-22] However, the method has two notable limitations: difficulty in confirming complete closure of the perforation, and the potential development of intra-abdominal abscesses due to retained bowel contents or intermittent leakage.[18]

With advancements in intensive care, antimicrobial therapy, and endoscopic technology, there has been a growing shift toward conservative and non-operative management strategies.[23] Improvements in endoscopic accessories and operator experience have enabled successful endoscopic closure of perforations in many cases.[24] In light of these developments, evaluating the success rates of endoscopic clip application, identifying causes of treatment failure, and determining factors associated with the requiremen for surgery are clinically important. This study retrospectively examined the clinical trajectory of patients with iatrogenic colonoscopic perforation who underwent endoscopic clip closure and assessed the factors associated with successful versus unsuccessful therapeutic outcomes.

MATERIALS AND METHODS

This investigation was carried out through a retrospective review of colonoscopy procedures performed in our clinic between January 2019 and August 2025. Over the study period, a total of 98,125 colonoscopy procedures were performed. Colonoscopy reports were screened using the keyword "perforation," and 162 patients whose reports contained this term were identified. Detailed evaluation of these patients revealed that 51 cases represented iatrogenic colonoscopic perforation (ICP). Of these, 34 patients underwent immediate surgical management, while endoscopic clip closure was attempted in 17 patients.

The inclusion criteria were determined as follows: patients diagnosed with ICP who underwent endoscopic clip application and either recovered successfully without surgery or required surgical intervention due to treatment failure. Exclusion criteria included: patients younger than 18 years, those with a history of colorectal surgery or colorectal cancer, patients with colostomies, perforations not related to colonoscopy, cases managed by immediate surgical intervention without an attempt at endoscopic treatment, and patients who received prophylactic clipping after polypectomy.

Through-the-scope (TTS) clips were used for endoscopic management. Clip placement was performed during the same endoscopic session in which the perforation was recognized. Before and after the procedure, all patients were monitored with regard to vital signs, abdominal examination findings, laboratory parameters, and radiological assessments.

Demographic data (age, sex), colonoscopy indications, perforation characteristics (location and etiology), treatment modality (clipping or surgery), postoperative complications, length of hospital stay, and clinical outcomes were systematically analyzed. Successful endoscopic treatment was defined as complete clinical recovery without the need for surgery after clip placement. Cases requiring surgical intervention despite clipping were classified as "treatment failures." A flowchart summarizing included and excluded cases, as well as outcomes of endoscopic clipping, is presented in Figure 1.

All study-related procedures were conducted under the ethical oversight of the institutional and national regulatory bodies, fully adhering to the principles outlined in the Declaration of Helsinki (1964) and its subsequent revisions, as well as equivalent ethical frameworks. The research protocol underwent formal review and received authorization from the institutional ethics committee (Approval No: 2025/010.99/21/34; Date: 30.10.2025).

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or as median values with their corresponding ranges, while categorical data were reported as counts and percentages. Group differences in continuous variables were assessed with the Mann–Whitney U test. For categorical comparisons, either the chi-square test or Fisher's exact test was applied, depending on distributional characteristics. A p-value <0.05 was considered statistically significant.

RESULTS

Seventeen patients in total who developed iatrogenic colonoscopic perforation and underwent endoscopic clip application were included in the study. Endoscopic management was successful in 10 patients (58.8%), whereas 7 patients (41.2%) required surgical intervention due to treatment failure (Table 1).

The patient population had a mean age of 61.0±8.6 years,

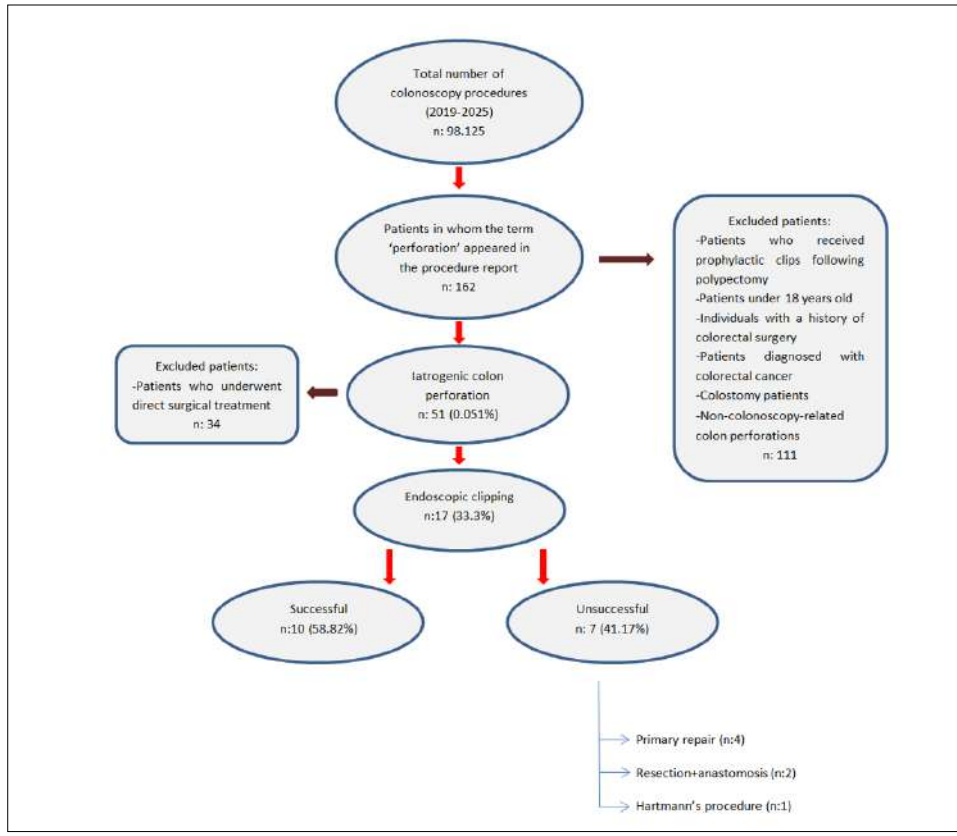


Figure 1. Flowchart of patient selection and treatment outcomes.

and the median patient age was 61 years (range: 42–74). Comparison of baseline characteristics revealed no statistically significant differences between the successful and unsuccessful treatment groups regarding age, sex (p=1.000), body mass index, comorbid conditions, previous abdominal operations, or adequacy of bowel preparation (all p>0.05). All patients in the study cohort exhibited serum albumin levels within the normal reference range.

The sigmoid colon constituted the predominant perforation site, accounting for 70.6% of all cases. Regarding perforation direction, 58.8% were intraperitoneal and 41.2% were extraperitoneal. Although perforations occurred more frequently during afternoon procedures (58.8%), this difference was not statistically meaningful (p=0.622). Only 3 patients (17.6%) had a defect larger than 2 cm. No significant association was found between defect size and success of endoscopic treatment (p=0.955).

Evaluation of continuous parameters demonstrated that the treatment-failure group exhibited significantly prolonged time to oral intake and extended hospitalization compared with the successful treatment group (p=0.021). The median time to oral intake was 3 (1–6) days in the successful group and 6 (3–16) days in the failure group. Similarly, the median length of hospitalization was 5 (2–8) days in the successful group and 8 (5–18) days in the failure group.

Table 2 summarizes the clinical and procedural characteristics of the patients who achieved successful endoscopic management (n=10). Complication rates in this group were low; two patients (20%) required rehospitalization. One patient was evaluated for abdominal pain without any pathological findings, while another developed a localized abscess adjacent to the clip site. Both patients improved with medical therapy alone, and no mortality occurred.

Clinical and operative details of patients who failed endoscopic management and required surgery (n=7) are shown in Table 3. All of these patients developed early abdominal pain and signs of peritonitis following clip application. Among them, four underwent primary repair, two underwent segmental resection with anastomosis, and one required a Hartmann procedure. The mean length of hospitalization in this subgroup was significantly longer (median 8 [5–18] days, p=0.021). One patient (14.3%) developed an anastomotic leak after primary repair and subsequently underwent a Hartmann procedure; the remaining patients required no additional surgery. All patients recovered uneventfully postoperatively, and no mortality was observed.

Representative colonoscopic images demonstrating the perforation site, clip application, and the two-month follow-up appearance are shown in Figure 2 (a: Perforation site – yellow arrow; b: Clip closure – red arrow; c: healing and granulation tissue at two-month follow-up – blue arrow).

Table 1. Comparison of clinical characteristics between successful and failed (surgery required) groups in iatrogenic colon perforations managed with endoscopic clipping

Parameter	Outcome of Endoscopic Clip Management			p value
	Successful Group (n: 10)	Failed (Surgery Required) Group (n: 7)	All patients	
Age (years)	60.5±8.3	61.7±9.1	61.0±8.6	0.493[c]
	60.0 (42.0-70.0)	63.0 (49.0-74.0)	61.0 (42.0-74.0)	
Gender, n (%)				1.000[a]
Female	7 (70.0)	5 (71.4)	12 (70.6)	
Male	3 (30.0)	2 (28.6)	5 (29.4)	
BMI, n (%)				0.638[b]
<18.5	1 (10.0)	-	1 (5.9)	
18.5-24.9	3 (30.0)	2 (28.6)	5 (29.4)	
>25	6 (60.0)	5 (71.4)	11 (64.7)	
Comorbidity, n (%)	8 (80.0)	6 (85.7)	14 (82.4)	1.000[a]
Abdominal surgery history, n (%)	3 (30.0)	4 (57.1)	7 (41.2)	0.350[a]
Albumin (gr/Dl), n (%)				-
Low	-		8 (19.0)	
Moderate	10 (100.0)	7 (100.0)	17 (100.0)	
High	-	-		
Colon cleanness, n (%)				1.000[a]
Clean	8 (80.0)	6 (85.7)	14 (82.4)	
Dirty	2 (20.0)	1 (14.3)	3 (17.6)	
Perforation location, n (%)				0.356[b]
Rectum	1 (10.0)	2 (28.6)	3 (17.6)	
Sigmoid colon	8 (80.0)	4 (57.1)	12 (70.6)	
Descending colon	-	1 (14.3)	1 (5.9)	
Transverse colon	1 (0.0)	-	1 (5.9)	
Ascending colon	-	-	-	
Cecum	-	-	-	
Perforation direction, n (%)				0.622[a]
Intraperitoneal	5 (50.0)	5 (71.4)	10 (58.8)	
Extraperitoneal	5 (50.0)	2 (28.6)	7 (41.2)	
Perforation time, n (%)				0.622[a]
At A.M.	5 (50.0)	2 (28.6)	7 (41.2)	
At P.M.	5 (50.0)	5 (71.4)	10 (58.8)	
Defect diameter, n (%)				0.955[b]
1 cm <	4 (40.0)	3 (42.9)	7 (41.2)	
1-2 cm	4 (40.0)	3 (42.9)	7 (41.2)	
>2 cm	2 (20.0)	1 (14.3)	3 (17.6)	
Initiation of oral intake (day)	3.3±1.8	7.4±4.4	5.0±3.5	
	3.0 (1.0-6.0)	6.0 (3.0-16.0)	4.0 (1.0-16.0)	0.021[c]
Hospitalization duration (day)	4.8±2.1	9.4±4.6	6.7±3.7	
	5.0 (2.0-8.0)	8.0 (5.0-18.0)	6.0 (2.0-18.0)	0.021[c]
Complication, n (%)				0.343[a]
Absent	9 (90.0)	6 (85.7)	15 (88.2)	
Present	1 (10.0)	1 (14.3)	2 (11.8)	
Rehospitalization, n (%)	2 (20.0)	-	2 (11.8)	0.485[a]
Mortality, n (%)	-	-	2 (4.8)	

a: Fisher's Exact Test; b: Chi-Square Test; c: Mann–Whitney U Test. Continuous variables are presented as mean±SD and median (min–max); categorical variables as n (%). $p<0.05$ was considered statistically significant.

Table 2. Clinical and surgical characteristics of patients with iatrogenic colonic perforations successfully treated with endoscopic clipping

Parameter	1. Patient	2. Patient	3. Patient	4. Patient	5. Patient	6. Patient	7. Patient	8. Patient	9. Patient	10. Patient
Age (year)	62	62	42	66	62	53	70	54	59	55
Gender	Female	Male	Female	Male	Female	Female	Female	Female	Male	Female
BMI* (kg/m2)	High	High	High	High	High	Normal	Low	High	Normal	Normal
Comorbidity	Present	Present	Present	Present	Absent	Present	Present	Absent	Present	Present
Abdominal surgery history	Present	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent	Absent
Albumin (gr/Dl)	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Bowel preparation	Sufficient	Sufficient	Sufficient	Insufficient	Sufficient	Sufficient	Sufficient	Sufficient	Insufficient	Sufficient
Perforation location	Sigmoid colon	Sigmoid colon	Rectum	Sigmoid	Sigmoid colon	Sigmoid colon	Sigmoid colon	Transverse colon	Sigmoid colon	Sigmoid colon
Perforation direction	Intraperitoneal	Extraperitoneal	Extraperitoneal	Extraperitoneal	Extraperitoneal	Intraperitoneal	Intraperitoneal	Intraperitoneal	Extraperitoneal	Intraperitoneal
Perforation time	At A.M.	At A.M.	At P.M.	At P.M.	At P.M.	At P.M.	At A.M.	At P.M.	At A.M.	At A.M.
Defect diameter	1-2 cm	<1 cm	>2 cm	<1 cm	<1 cm	>2 cm	1-2 cm	1-2 cm	<1 cm	1-2 cm
Initiation of oral intake (day)	5	5	5	1	1	2	2	1	4-6	6
Hospitalization duration (day)	7	7	7	2	2	4	3	2	6-7	8
Complication	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Abscess near clip site	Absent
Rehospitalization	Absent	Absent	Absent	Present	Absent	Absent	Absent	Absent	Present	Absent
Mortality	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

* Low: <18.5, Normal: 18.5–24.9, High: >25.

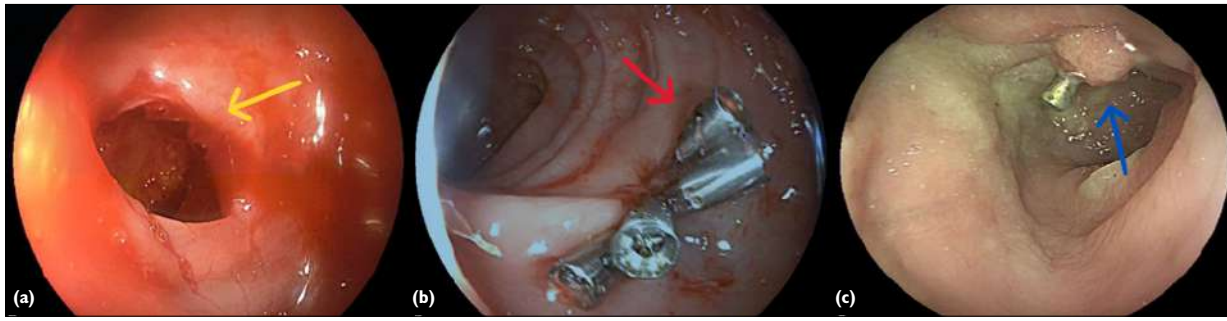


Figure 2. Stages of endoscopic clip application: **(a)** Perforation site (yellow arrow), **(b)** closure of the defect with clips (red arrow), **(c)** colonoscopic follow-up at two months demonstrating healing and granulation tissue (blue arrow).

Table 3. Clinical and surgical characteristics of patients with ıatrogenic colonic perforations requiring surgical management after failed endoscopic clipping

Parameter	1. Patient	2. Patient	3. Patient	4. Patient	5. Patient	6. Patient	7. Patient
Age (year)	63	74	49	53	69	68	56
Gender	Male	Female	Female	Female	Female	Female	Male
BMI* (kg/m²)	Normal	Normal	High	High	Normal	High	High
Comorbidity	Present	Present	Absent	Present	Present	Present	Present
Abdominal surgery history	Present	Present	Present	Present	Absent	Absent	Absent
Albumin (gr/Dl)	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Bowel preparation	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Insufficient
Perforation location	Sigmoid colon	Rectum	Sigmoid colon	Descending colon	Sigmoid	Rectum	Sigmoid colon
Perforation direction	Intraperitoneal	Intraperitoneal	Extraperitoneal	Intraperitoneal	Intraperitoneal	Intraperitoneal	Extraperitoneal
Perforation time	At A.M.	At P.M.	At P.M.	At P.M.	At P.M.	At P.M.	At A.M.
Defect diameter	>2 cm	<1 cm	<1 cm	1-2 cm	1-2 cm	1-2 cm	<1 cm
Initiation of oral intake (day)	16	6	3	9	9	6	3
Hospitalization duration (day)	18	8	5	11	11	8	5
Complication	Leakage after primary repair	Absent	Absent	Absent	Absent	Absent	Absent
Rehospitalization	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Mortality	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Surgery type	Hartmann's procedure	Primay repair	Resection+ Anastomosis	Primay repair	Laparoscopic primary repair	Resection+ Anastomosis	Primay repair

* Low: <18.5, Normal: 18.5–24.9, High: >25

DISCUSSION

Iatrogenic colonoscopic perforation (ICP) represents an uncommon but potentially fatal adverse event of colonoscopy, and both early recognition and appropriate therapeutic decision-making play a critical role in reducing mortality. For many years, surgery remained the mainstay of management for ICP; however, advances in endoscopic closure techniques have introduced a safe and effective alternative for selected patients.[25] In our cohort of 17 patients who underwent endoscopic clip closure between 2019 and 2025, non-operative management was successful in 10 cases (58.8%), whereas 7 patients (41.2%) required subsequent surgical intervention due to ineffective endoscopic closure. Reported success rates in the literature range between 59% and 100%.[14,18-22] The relatively lower success rate observed in our study is likely attributable to the limited availability of advanced closure devices, such as over-the-scope clips (OTSC), endoscopic suturing systems, and endoloop techniques, and the exclusive use of standard through-the-scope (TTS) clips in our center.

The mean age was 60.5±8.3 years in the successful group and 61.7±9.1 years in the failure group, with no significant difference between them. SSex distribution was also similar, with 70.6% of the overall cohort being female and 29.4% male (p=1.000). Hamdani et al. reported that low albumin levels increased the risk of colonoscopic perforation; however, albumin levels were within normal limits in all patients in our series, which contrasts with their find-

ings.[26] Neither the presence of comorbidities (82.4%) nor a history of previous abdominal surgery (41.2%) showed a significant association with treatment success.

The sigmoid colon constituted the most common site of perforation, accounting for 70.6% of cases, a distribution that aligns with previous literature.[2,3] In our study, 58.8% of perforations were intraperitoneal and 41.2% extraperitoneal. Intraperitoneal perforations were observed more frequently in the treatment-failure group; however, this distribution did not demonstrate statistical significance (p=0.622). Only three patients (17.6%) had a defect larger than 2 cm; clipping was successful in two of these cases, whereas one required surgery. ESGE and AGA guidelines recommend endoscopic closure for perforations <30 mm diagnosed within the first four hours, provided the patient is hemodynamically stable and bowel preparation is adequate.[27,28] However, due to their technical limitations, TTS clips are particularly suitable for defects <1 cm in size.[18,20]

Bowel preparation constitutes another important variable potentially affecting treatment outcomes. In our series, only three patients (17.6%) had inadequate bowel preparation, and most cases undergoing endoscopic clipping had a clean colon. Nevertheless, the literature suggests that inadequate preparation may negatively influence clinical progression and is associated with poorer outcomes.[29,30]

Comparison of clinical variables between the successful and unsuccessful treatment groups demonstrated statistically significant differences in both the timing of oral intake initiation and the duration of hospitalization. Median time to oral intake was 3 (1–6) days in the successful group versus 6 (3–16) days in the failure group; median length of stay was 5 (2–8) days and 8 (5–18) days, respectively (p=0.021). Consistent with our findings, An et al.[15] also reported significantly higher complication rates and longer hospital stays among patients who required surgery following failed endoscopic management. These findings indicate that outcomes may be worse in patients undergoing surgery after failed endoscopic closure than in those who undergo primary surgical treatment. This underscores the critical importance of appropriate patient selection and suggests that borderline or inappropriate candidates for endoscopic closure may experience poorer clinical results.

Overall complication rates in our cohort were low. In the successful group, two patients (20%) required rehospitalization—one for abdominal pain without detectable pathology, and one for a localized abscess near the clip site. Both recovered with medical therapy alone. Among the seven patients who required surgery, four underwent primary repair, two underwent segmental colonic resection with anastomosis, and one underwent a Hartmann procedure. One patient (14.3%) developed an anastomotic leak after primary repair and subsequently required conversion to a Hartmann procedure. No additional surgical interventions were required in the remaining patients, and all were discharged uneventfully. No mortality occurred in the present series.

The most notable limitation of this study is its relatively small sample size, which did not allow for multivariate modeling and restricted the analysis to descriptive evaluations and univariate comparisons. In addition, the retrospective methodology and single-center dataset further reduce the external validity and generalizability of the findings. Consequently, the associations identified should be viewed as exploratory trends rather than predictive determinants of treatment outcomes.

The present study, despite its inherent limitations, constitutes one of the limited regional investigations providing a comprehensive assessment of clinical features, therapeutic outcomes, and intergroup differences in iatrogenic colon perforations managed with endoscopic clipping. Our findings suggest that early recognition of perforation, small defect size, adequate bowel preparation, and minimal contamination may contribute positively to treatment success, whereas treatment failure is associated with prolonged time to oral intake and extended hospitalization.

CONCLUSION

Endoscopic clip application is a reliable and effective therapeutic option for selected cases of iatrogenic colonoscopic perforation. However, the likelihood of treatment failure increases in patients with large defects, intraperitoneal perforations, or contaminated colonic contents, making surgical intervention necessary in such scenarios. Therefore, early diagnosis, appropriate patient selection, and close clinical monitoring are critical determinants of treatment success. Our findings provide exploratory data that may guide future large-scale, prospective studies in this field.

Ethics Committee Approval

Ethical approval for the study was granted by the Institutional Review Board of the Kartal Dr. Lütfi Kırdar City Hospital Clinical Research Ethics Committee (Date: 30.10.2025, Decision No: 2025/010.99/21/34).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: G.C., A.B.; Design: A.B.; Supervision: G.C., A.B.; Fundings: G.C., A.B.; Materials: G.C.; Data: G.C., A.B.; Analysis: G.C.; Literature search: G.C., A.B.; Writer: G.C.; Critical Review: A.B.

Conflict of Interest

The authors declare no conflicts of interest. The funding sources had no involvement in the study design; data collection, analysis, or interpretation; manuscript preparation; or the decision to submit the article for publication.

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Endoskopik Klips ile Tedavi Edilen İyatrojenik Kolonik Perforasyonların Klinik Sonuçları ve Tedavi Başarısızlığıyla İlişkili Keşifsel Bulgular

Amaç: İyatrojenik kolonoskopik perforasyon (İKP), ciddi morbidite ile ilişkili, nadir ancak potansiyel olarak ağır bir komplikasyondur. Uygun seçilmiş hastalarda endoskopik klips uygulaması, cerrahiye minimal invaziv bir alternatif olarak öne çıkmaktadır. Bu çalışma, endoskopik klips ile yönetilen İKP olgularının klinik sonuçlarını değerlendirmeyi ve tedavi başarısızlığı ile ilişkili olabilecek faktörleri araştırmayı amaçlamıştır.

Gereç ve Yöntem: Ocak 2019 ile Ağustos 2025 tarihleri arasında İKP tanısı alan ve endoskopik klips ile tedavi edilen toplam 17 hasta retrospektif olarak incelendi. Hastaların demografik özellikleri, perforasyona ilişkin bulgular, uygulanan tedavi yöntemleri, postoperatif komplikasyonlar, oral alımın başlatılma zamanı ve hastanede kalış süresi değerlendirildi. Tedavi başarısı, cerrahi gereksinimi olmaksızın klinik iyileşme olarak tanımlanırken; tedavi başarısızlığı, klips uygulamasını takiben cerrahi müdahale gereksinimi olarak tanımlandı.

Bulgular: Endoskopik tedavi 10 hastada (%58.8) başarılı olurken, 7 hastada (%41.2) cerrahi müdahale gerekti. Yaş, cinsiyet, vücut kitle indeksi, komorbidite profili, geçirilmiş abdominal cerrahi, bağırsak hazırlığı kalitesi ve perforasyon yönü açısından gruplar arasında anlamlı fark yoktu (tüm $p>0.05$). Oral alımın başlama süresi ve hastanede yatış süresi tedavi başarısızlığı olan grupta anlamlı olarak daha uzundu ($p=0.021$). Perforasyon için en sık lokalizasyon sigmoid kolon olup, olguların %70.6'sında saptandı.

Sonuç: Endoskopik klips uygulaması, dikkatle seçilmiş İKP olgularında etkili bir tedavi seçeneği sunmaktadır. Bu çalışma, endoskopik yönetimin sonuçlarına ilişkin keşifsel veriler sağlayarak bu alandaki gelecekteki araştırmalara temel oluşturmaktadır.

Anahtar Sözcükler: Endoskopik klips; iyatrojenik kolonoskopik perforasyon; perforasyon; kolonoskopi.

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Original Article

Comparative Morphometric Analysis of Renal Vessels in Patients with Autosomal Dominant Polycystic Kidney Disease and Simple Renal Cysts

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Keywords: Autosomal dominant polycystic kidney disease; morphometric measurement; renal artery; simple renal cyst; renal vein.

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ABSTRACT

Objective: To investigate the morphometric changes of the renal vessels that Autosomal Dominant Polycystic Kidney Disease (ADPKD) and Simple Renal Cysts (SRC) may cause, and to compare the results with the control.

Methods: In this study, CT images of 95 cases between the years 2019-2024 were examined via the automation system in the Nephrology Clinic of the Hospital. The cases were grouped as ADPKD, SRC, and control, and morphometric measurements of the renal artery and renal vein were made.

Results: No significant difference was found between the level, angle, diameter, and length of the right and left renal artery leaving from the abdominal aorta and entering the renal hilum. There was also no significant difference in the levels where the right and left renal vein drain into the inferior vena cava, the angle, the length from the renal hilum to the inferior vena cava, and the diameter of the right renal vein between the three groups. However, the differences in the diameter of the left renal vein between ADPKD and control were found to be statistically significant.

Conclusion: It was determined that ADPKD and SRC developing due to renal cysts may cause morphometric changes in the renal veins when compared with control. It is thought that detailed knowledge of the vascular structures of these patients in preoperative planning will be effective in preventing complications that may occur during the operation.

INTRODUCTION

The kidneys are located retroperitoneally on both sides of the vertebral column, at the L2-L3 vertebral levels.[1] Blood supply to the kidneys is provided by the Renal Arteries (RA) at the L2 vertebral level. Approximately 70% of individuals have a single Main Renal Artery (MRA) supplying each kidney, while the remaining 30% have an Extra Renal Artery (ERA) accompanying this artery.[2] The vessels that carry oxygen-poor blood from the kidneys to the Inferior Vena Cava (IVC) are called the Renal Veins (RV).[3] Cystic enlargements of the kidney, which can be hereditary, acquired, or congenital, developing with syndromes or alone, are called "renal cysts". Simple Renal Cyst (SRC)

is a type that is not accompanied by any additional pathology, progresses with a single or small number of cysts, and has a prevalence of 10% in the adult population and 50% after the age of 50.[4] Advanced age, smoking, and hypertension are risk factors for the development of SRC. SRCs are generally asymptomatic and are detected incidentally. It can also present symptomatically with complaints such as pain, infection, and hematuria.[5] Autosomal Dominant Polycystic Kidney Disease (ADPKD) is a systemic disease characterized by numerous cysts in the kidneys and has a prevalence rate of 1/400-1/1000. It is the most common hereditary kidney disease and can cause renal and extrarenal involvement. In ADPKD, mutations in the Polycystic Kidney Disease-1 (PKD-1) and Polycystic Kidney Disease-2 (PKD-2) genes are the cause of this disease in 78% and 14%, respectively.[6] Although it is asymptomatic in childhood, it impairs kidney function in later ages, and ADPKD is responsible for almost 10% of End-Stage Renal Disease (ESRD) cases.[7] As a result of the kidneys sagging downward for various reasons, the arterial and venous structures also extend downward, and their diameters may narrow due to the extension. As a result, blood flow through the kidneys may become difficult.[8] ADPKD is transmitted in an autosomal dominant pattern, and the prevalence of ADPKD is approximately 1 in 400 to 1 in 1,000, making it the most common inherited kidney disorder.[9] Notably, about 95% of cases have a positive family history, while the remaining 5% arise from new mutations.[10] Although often asymptomatic early in life, ADPKD progresses over time and can lead to ESRD, with more than half of affected individuals requiring renal transplant after age 40. Cases with early-onset or diagnosis before 18 months tend to have a worse prognosis.[11] ADPKD accounts for approximately 5–10% of ESRD cases and is a progressive, multisystem disorder with varying clinical presentations, even among members of the same family.[9] For diagnosis, ultrasonography is the first-line imaging technique, as it effectively identifies simple cysts by their well-defined, smooth walls and clear fluid content. If cysts appear complex or are smaller than 1 cm, magnetic resonance imaging (MRI) or computed tomography (CT) may be required for further evaluation.[12]

This study aimed to compare morphometric parameters—such as diameter, angle, and length—of the RA and RV among three groups: ADPKD, SRC, and control. Additionally, vascular variations were assessed by documenting the number and courses of these vessels. Specifically, the following features were evaluated: The vertebral level at which the right and left RA, their diameters and angles at the origin, anatomical courses, and lengths from the abdominal aorta (AA) to the renal hilum. The number of RAs was also recorded. Similarly, for the RVs, the vertebral levels at which the RRV and LRV drained into the IVC, their diameters and angles at the drainage point, anatomical courses, and lengths from the renal hilum were measured.

MATERIALS AND METHODS

The study was approved by the University of Health Sciences Hamidiye Ethics Committee (Date: 13/10/2023, No: 2023/18).

Data collection

This retrospective study analyzed CT images from 95 adult patients diagnosed with ADPKD, SRC, or control at the Nefrology Clinic of the Hospital. Clinical, demographic, and laboratory data were recorded. Exclusion criteria included kidney cancer, dialysis, transplantation, non-standard CT scans, or indeterminate angles. After exclusions, 31 ADPKD, 31 SRC, and 33 control cases were evaluated. Morphometric measurements of renal vessels and kidney structure were performed by a radiology specialist. Data was obtained via the hospital's automation system and confirmed by nephrology specialists.

Data Measurement

CT scans were performed using a 128-slice multidetector CT device (Ingenuity 128 Slice, Philips Medical Systems, China). Following written informed consent, intravenous contrast-enhanced CT imaging was conducted with patients in the supine position. Scanning extended from the diaphragm to the symphysis pubis using 64 x 0.625 mm collimation, 1.016 pitch, 120 kV, and 300 mAs. Images were reconstructed with 0.625 mm slice thickness. Contrast images were captured 20–35 seconds after injecting 120 mL of nonionic iodinated contrast. A single breath-hold (10–12 seconds) was used to scan the entire abdomen. The total radiation dose was 1195.7 mGy·cm. After image acquisition, 3D multiplanar reconstructions were generated using the PACS system, and morphometric analyses were performed using the 3D Slicer software. Measurements focused on RRA and LRA, including their level of origin from the AA, diameter, angle, number, and length to the renal hilum. If more than one artery was present, measurements were taken from the main renal artery, excluding accessory arteries. Origin level, the coronal CT plane was used to determine the vertebral level at which RRA and LRA originated. The sacrum served as a reference point, and origins were categorized as from the top, middle, or bottom of the corresponding vertebra. Diameter measurements were made at the point where the renal arteries branched from the AA, using the coronal plane. If arteries were not visible in this plane, transverse images were evaluated instead. Diameters were recorded from the point of origin on the AA (Fig. 1).

Statistical Analysis

Descriptive statistics included mean, standard deviation, and frequency. Normality was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Variance homogeneity was also tested. One-way ANOVA or Kruskal-Wallis tests were applied for group comparisons. Post-hoc tests followed significant findings. Analyses were conducted with SPSS 28.0, and statistical significance was set at $p<0.05$.

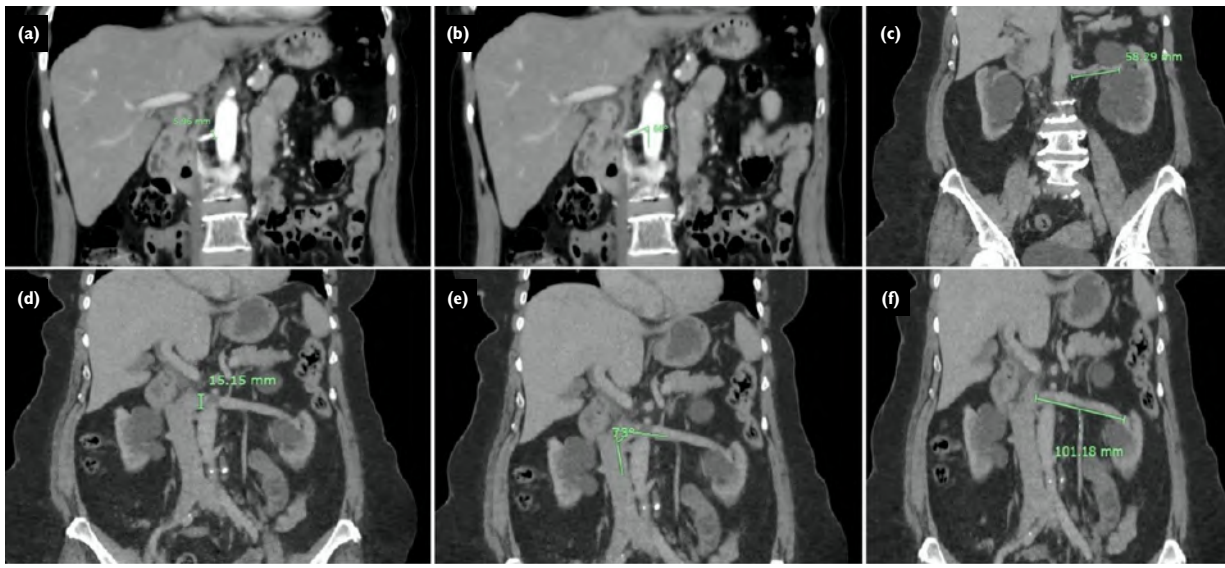


Figure 1. (a) Measurement of the diameter of the RA. **(b)** Measurement of the angle of the RA as it exits the AA. **(c)** Number, course, and length: The numbers of RA after separation from AA were determined and recorded. The course between the exit level and the renal hilum was observed, and its length was measured, and any variation was also noted. **(d)** Measurement of the diameter of the RV. **(e)** Measurement of the angle at the level where the RV drains into the IVC. **(f)** Number, course, and length: The numbers of RVs after they left the IVC were determined and recorded. The length was measured by observing the level where it drains into the IVC and the course between the renal hilum, and any variations were also noted.

RESULTS

Demographic Findings

The study included 95 cases: 31 with ADPKD, 31 with SRC, and 33 with control. Of these, 54 (58%) were female and 41 (43.2%) were male. Mean ages were 47.5 (ADPKD), 56.4 (SRC), and 48.5 (control), respectively.

Computed Tomography Measurement Findings

CT images of all participants were analyzed by group. Measurements included the diameters, lengths, numbers,

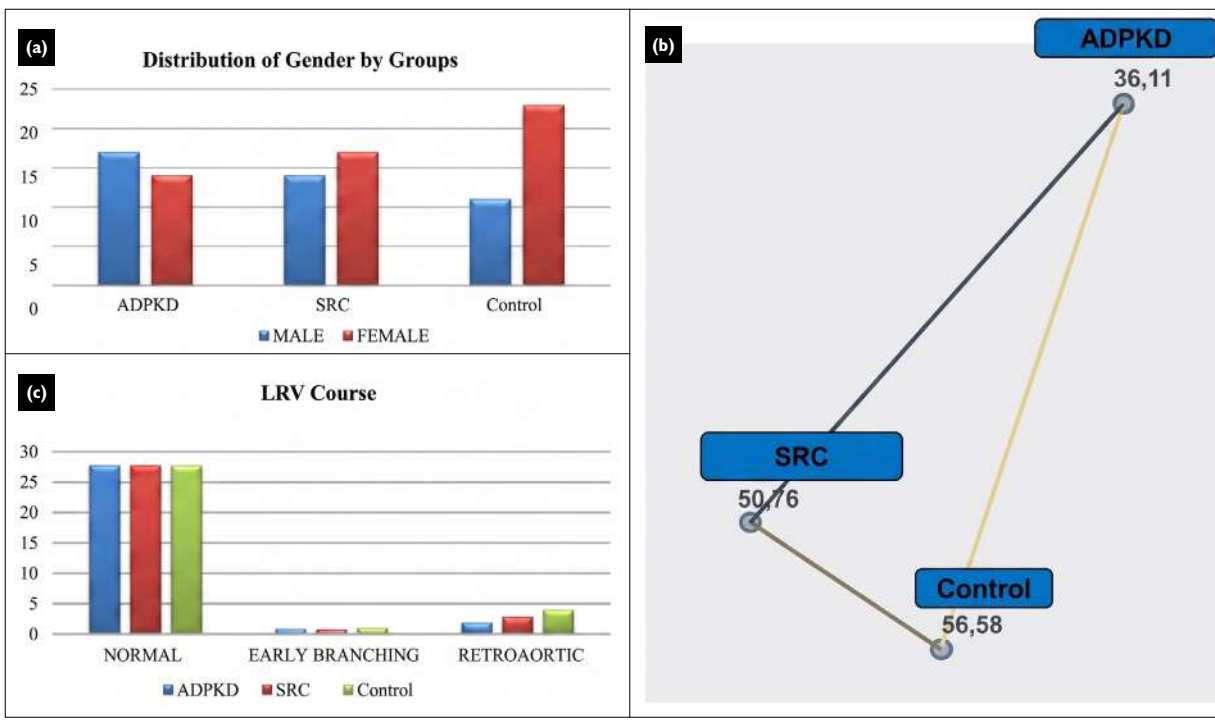


Figure 2. Shows the distribution of gender in terms of numbers according to groups **(a)**, the comparison of three groups between the measured values of the diameter of the LRV (**b**), and the course of the LRV until it empties into the IVC **(c)**.

courses, and aortic origin levels of the RRA and LRA, and the diameters, lengths, courses, and IVC entry levels of the RRV and LRV. These parameters were compared across ADPKD, SRC, and control. RA origin levels were categorized by vertebral position: T12 middle/lower; L1 upper/middle/lower; L2 upper/middle/lower; L3 upper/middle/lower. The RRA was observed to originate from all levels except L2 lower, L3 upper, and L3 lower, demonstrating anatomical variation among individuals. The distribution of gender by groups is shown in Figure 2.

Variations and Origin Levels of the RA

It was observed that the RRA originated from all levels except L2 lower, L3 upper, and L3 lower. It was observed that the LRA originated from all levels except the L2 middle, L2 lower, L3 upper, L3 middle, and L3 lower levels. (Fig. 3A, B) and (Fig. 4 A, B) display the number and percentage distribution of RRA and LRA based on their vertebral origin levels. For both RRA and LRA, the most common origin level was the lower L1. This was followed by the middle of L1 and the upper L2. The distribution of the outflow

Table 1. Comparison of the levels at which the RA branches from the AA and the levels at which the RV drains into the IVC between the groups

Parameters / Groups	ADPKD	SRC	CONT	p-value
Levels of the RRA originate				
T12 M	1 (3.2%)	0 (0.0%)	0 (0.0%)	0.532
T12 L	2 (6.5%)	1 (3.2%)	0 (0.0%)	
L1 U	1 (3.2%)	2 (6.5%)	5 (15.2%)	
L1 M	7 (22.6%)	10 (32.3%)	12 (36.4%)	
L1 L	15 (48.4%)	13 (41.9%)	12 (36.4%)	
L2 U	2 (6.5%)	4 (12.9%)	4 (12.1%)	
L2 M	3 (9.7%)	0 (0.0%)	0 (0.0%)	
L3 M	0 (0.0%)	1 (3.2%)	0 (0.0%)	
Levels of the LRA originate				
T12 M	1 (3.2%)	0 (0.0%)	0 (0.0%)	0.662
T12 L	2 (6.5%)	1 (3.2%)	0 (0.0%)	
L1 U	1 (3.2%)	1 (6.5%)	4 (15.2%)	
L1 M	9 (22.6%)	9 (32.3%)	11 (36.4%)	
L1 L	15 (48.4%)	14 (41.9%)	14 (36.4%)	
L2 U	2 (6.5%)	5 (12.9%)	4 (12.1%)	
L2 M	1 (9.7%)	0 (0.0%)	0 (0.0%)	
Levels of the RRV drains into the IVC				
T12 L	2 (6.5%)	1 (3.2%)	1 (3%)	0.395
L1 U	2 (6.5%)	3 (6.7%)	3 (9.1%)	
L1 M	4 (12.9%)	9 (29.0%)	5 (15.2%)	
L1 L	16 (51.6%)	14 (45.2%)	19 (57.6%)	
L2 U	6 (19.4%)	4 (12.9%)	2 (6.1%)	
L2 M	1 (3.2%)	0 (0.0%)	3 (9.1%)	
Levels of the LRV drains into the IVC				
T12 M	1 (3.2%)	0 (0.0%)	0 (0.0%)	0.951
T12 L	2 (6.5%)	1 (3.2%)	1 (3.1%)	
L1 U	5 (16.1%)	2 (6.5%)	7 (21.9%)	
L1 M	4 (12.9%)	10 (32.3%)	7 (21.9%)	
L1 L	14 (45.2%)	14 (45.2%)	11 (34.4%)	
L2 U	4 (12.9%)	3 (9.7%)	2 (6.3%)	
L2 M	1 (0.0%)	1 (0.0%)	0 (0.0%)	
L3 U	0 (0.0%)	0 (0.0%)	3 (9.4%)	
L3 L	0 (0.0%)	0 (0.0%)	1 (3.1%)	

Significance value of the levels at which the RRA originates, and significance value of the levels where the LRA originates are shown. Significance value of the levels where the RRV drains into the IVC, and significance value of the levels where the LRV drains into the IVC are shown as well. ADPKD: Autosomal dominant polycystic kidney disease; CONT: Control group; IVC: Inferior vena cava; L: Lower level; LRA: Left renal artery; LRV: Left renal vein; M: Middle level; RRA: Right renal artery; RRV: Right renal vein; SRC: Simple renal cyst; U: Upper level.

Table 2. Comparison of the lengths, diameters, and angles of the RA and RV between the groups

Parameters / Groups	ADPKD Mean±SD	SRC Mean±SD	CONT Mean±SD	p-value
Diameters of renal arteries (mm)				
RRA	7.03±1.03	7.35±1.02	7.07±1.02	0.470
LRA	6.74±1.01	7.44±1.17	6.60±1.17	0.139
Angles of the renal arteries				
RRA	53.5°± 15.2	61.0°±12.3	53.0°± 16.2	0.345
LRA	66.0°± 15.1	73.0°±12.9	67.0°± 13.6	0.105
Lengths of the renal arteries (mm)				
RRA	55.2±12.0	56.9±11.1	54.0±7.8	0.717
LRA	47.5±9.7	49.3±8.3	47.9±9.1	0.796
Angles of the renal veins				
RRV	46.0°± 17.4	43.0°± 19.6	43.0°± 14.1	0.306
LRV	73.0°± 10.6	75.0°± 10.8	78.0°± 10.3	0.343
Diameters of the renal veins				
RRV	10.5±3.1	11.8±2.6	12.6±2.7	0.229
LRV	11.4±4.1	13.5±4.1	15.5±4.5	0.010
Lengths of the renal veins				
RRV	30.2±11.8	33.0±9.9	33.5 ±7.0	0.579
LRV	74.9±10.8	78.5±11.7	73.9 ±8.2	0.225

Diameters of RA as they originate from the AA (mm), angles of the RA as they originate from the AA, and lengths of the RA after they originate from the AA to the renal hilum (mm) were shown. Angles of the RV as they drain into the IVC, diameters of the RV at the level where they drain into the IVC, and lengths of the RV from the hilum to the IVC were shown as well. ADPKD: Autosomal dominant polycystic kidney disease; CONT: Control group; IVC: Inferior vena cava; LRA: Left renal artery; LRV: Left renal vein; RRA: Right renal artery; RRV: Right renal vein; SRC: Simple renal cyst.

levels of the RA according to the groups displayed in Figure 5A, B. Across all three groups—ADPKD, SRC, and control—the most frequent origin for both RRA and LRA was lower L1. No RRA origins were observed at the L2 lower, L3 upper, or L3 lower levels in any group. Similarly, no LRA origins were recorded at the L2 lower, L3 middle, or L3 lower levels. In the three-group comparison, there was no statistically significant difference in the number or percentage of vertebral origin levels for the right renal artery (Table 1). No significant difference was found in the vertebral origin levels of the LRA among ADPKD, SRC, and control groups. Both RRA and LRA appeared normal. Multiple renal arteries were observed in 9 cases (9.47%) for RRA and 9 cases for LRA, never simultaneously in the same individual.

Morphometric Measurements of Renal Arteries

Morphometric analyses were conducted to measure the diameters, angles, and lengths of the RRA and LRA from their origin at the AA to the renal hilum. The mean RRA angle in the ADPKD was 54°, in SRC 61°, and in control 53°. The mean LRA angle, 66° in ADPKD, 73° in SRC, and 67° in control. For RRA, the mean diameter was 7.03 mm in ADPKD, 7.35 in SRC, and 7.07 in control. LRA diameters were 6.74 mm in ADPKD, 7.44 mm in SRC, and 6.60 mm in control (Fig. 4A, B). No significant diameter differences were found across groups for either artery. The mean length of the RRA was 55.16 mm in ADPKD, 56.86 mm in SRC, and 54.01 mm in control. As for LRA length, 47.5 mm in ADPKD, 49.33 in SRC, and 47.85 in control. Although lengths were longer in the SRC, no statistically significant difference was found between groups for either RRA or LRA lengths (Table 2).

Variations of RV and Drainage Levels to the IVC

The RRV was observed to drain into the IVC at six vertebral levels: T12 lower, L1 upper, L1 middle, L1 lower, L2 upper, and L2 middle. The most frequent drainage was the L1 lower, seen in 51.6% (Fig. 3C, D). No drainage was recorded from T12 middle, L2 lower, or any L3. For the LRV, drainage occurred at all vertebral levels except L2 lower and L3 middle. The most common drainage was the L1 middle, observed in 41.1% (Fig. 4C, D). Overall, while the RRV drained through six of 11 possible levels, the LRV showed a broader distribution, with drainage recorded at nine. Statistical comparison among the ADPKD, SRC, and control revealed no significant differences in the RRV or LRV drainage (Table 1). Regarding anatomical variations, the RRV was consistently normal in all groups. However, variations were noted in the LRV. In the ADPKD group, 1 early-branching (3.22%) and 2 retroaortic veins (6.45%) were found. In SRC, 3 retroaortic veins (9.67%) were observed with no early branching. In the control, 1 early-branching vein (3.03%) and 4 retroaortic veins (12.12%) were identified. The rest of the LRV courses were normal in each group (Fig. 5C, D).

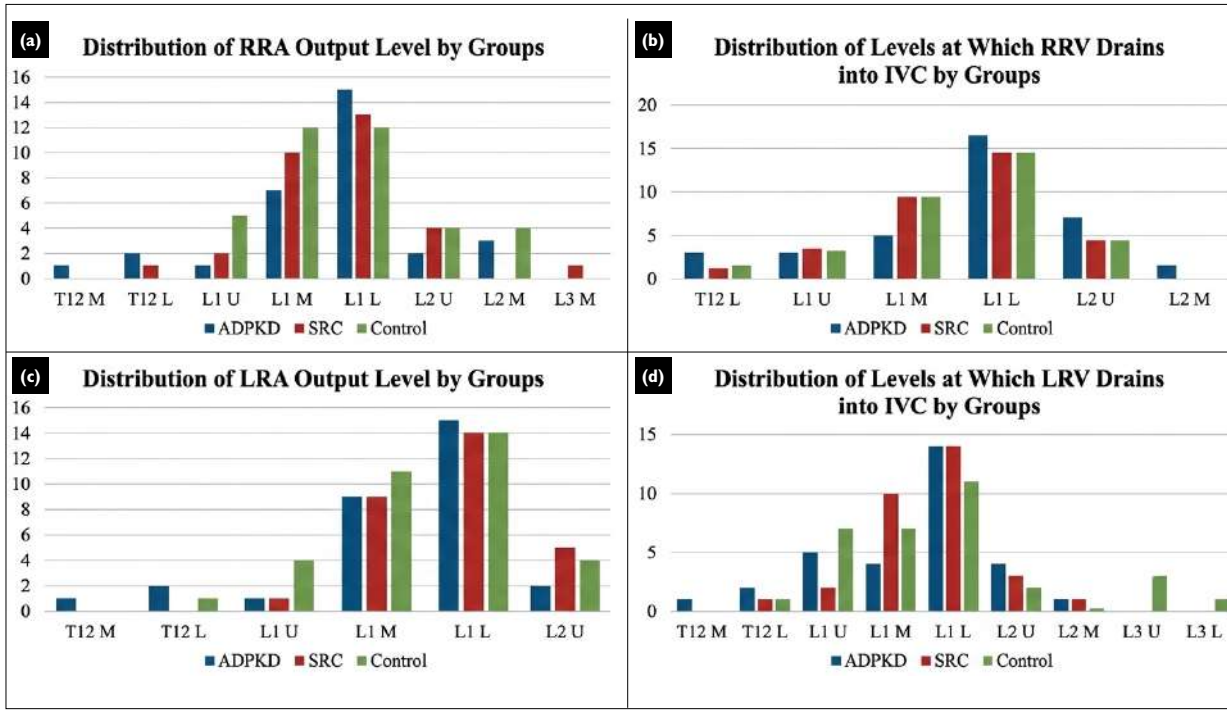


Figure 3. Showed the percentage distribution of levels where the RRA originated **(a)**, the percentage distribution of levels where the LRA originated **(b)**, the percentage distribution of levels where the right renal vein drained into the IVC **(c)**, and the percentage distribution of levels where the left renal vein drained into the IVC **(d)**.

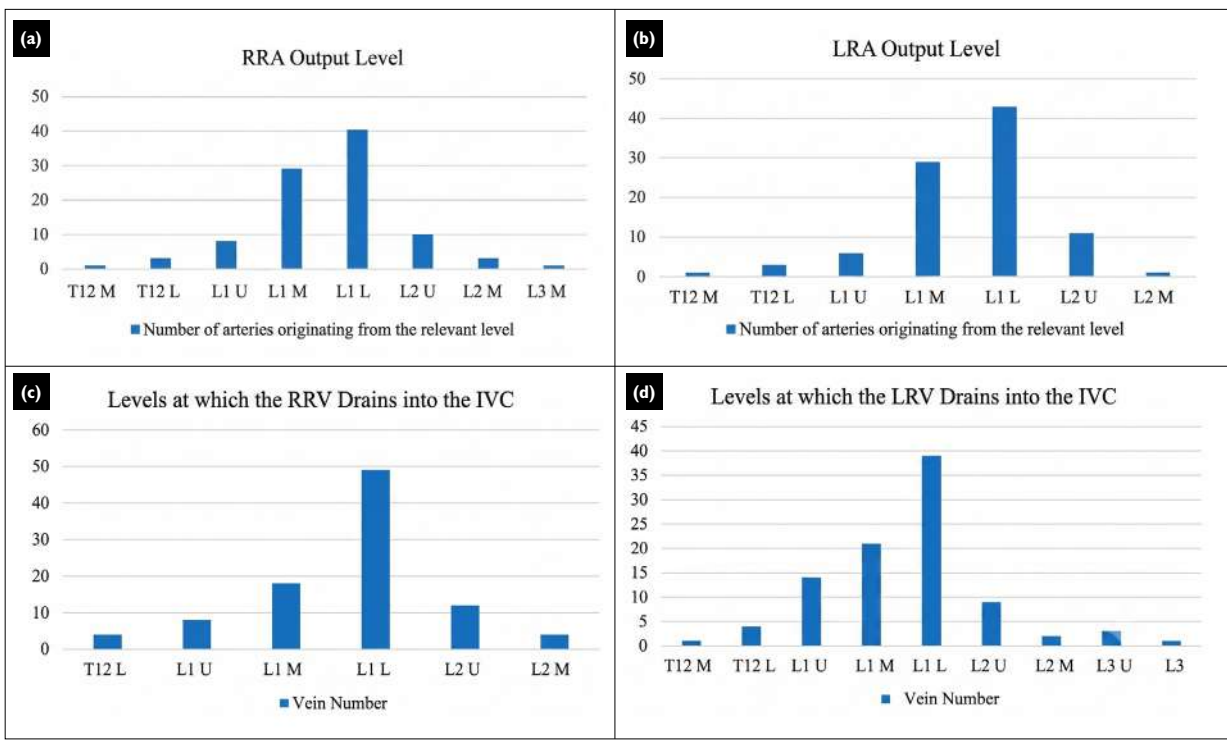


Figure 4. Showed the numbers of the RRA according to the levels it originated **(a)**, the numbers of the LRA according to the levels it originated **(b)**, the numbers of the RRV according to the levels it drained into the IVC **(c)**, and the numbers of the LRV according to the levels it drained into the IVC **(d)**.

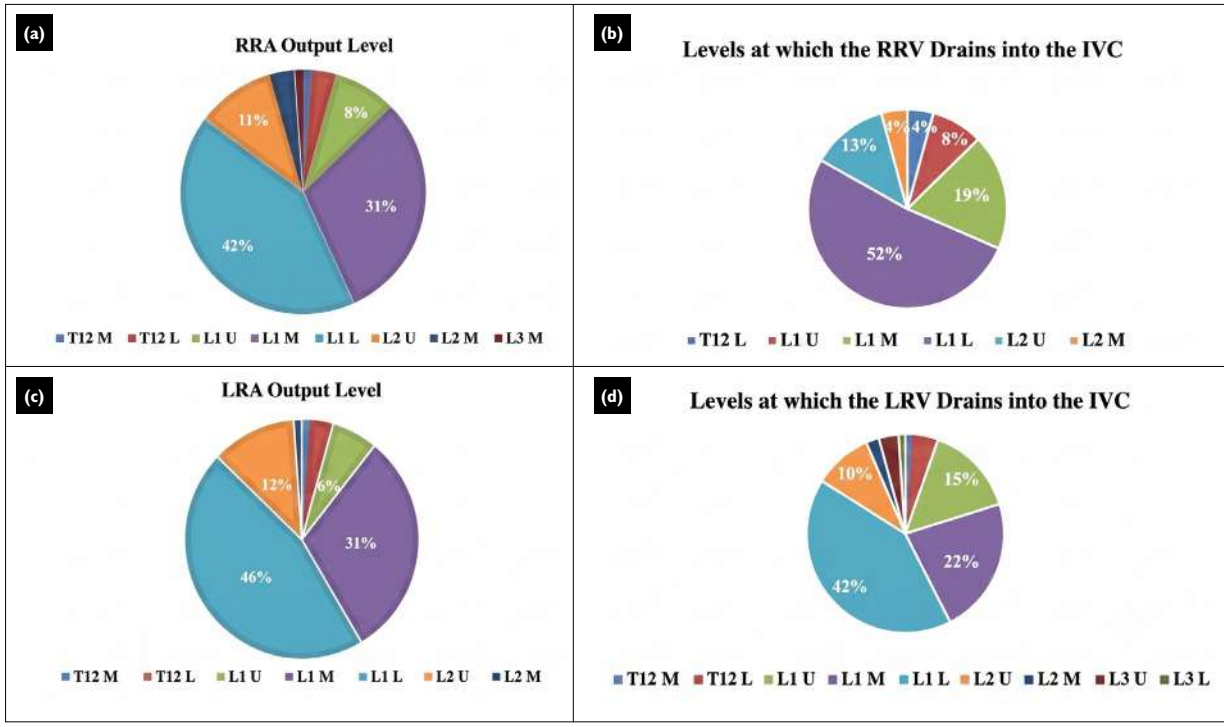


Figure 5. Showed the distribution of the exit levels of the RRA by groups **(a)**, the distribution of the levels at which the RRV drained into the IVC by groups **(b)**, the distribution of the output levels of the LRA by groups **(c)**, and the distribution of the levels at which the LRV drained into the IVC by groups **(d)**.

Morphometric Measurements of the Renal Vein

The diameters, angles, and lengths of the RRV and LRV at their drainage into the IVC were assessed. For the RRV angle, the mean is 46°in ADPKD, 43° in SRC, and 43° in control. For the LRV, angles mean 73° in ADPKD, 75° in SRC, and 78° in CONT. Although RRV angles were higher in ADPKD, and LRV angles were highest in control, no significant differences were observed. In terms of diameter at the IVC entry point, RRV mean diameters were 10.52 mm in ADPKD, 11.79 mm in SRC, and 12.59 mm in control. LRV mean diameters were 11.37 mm in ADPKD, 13.46 mm in SRC, and 15.45 mm in control. Comparisons showed higher RRV diameters in the control, but the difference was not statistically significant. However, LRV diameters were significantly lower in ADPKD compared to control, indicating a notable difference in venous caliber between these groups (Table 2). The mean length of the RRV was 30.16 mm in ADPKD, 32.95 mm in SRC, and 33.49 mm in control. For the LRV, mean lengths were 74.91 mm in ADPKD, 78.49 mm in SRC, and 73.92 mm in control. No statistically significant difference was found in RRV lengths among the groups. Although LRV lengths varied among the groups, the difference was not significant (Table 2).

DISCUSSION

We found in the present study that the ADPKD and control groups exhibited highly similar angular patterns, whereas the SRC group showed a distinctly larger angle for both renal arteries. This divergence in SRC patients may reflect disease-related vascular remodeling or altered hemodynamic forces, indicating a potential area for further targeted investigation. Notably, these angle measurements are consistent with the observations of Stojadinovic et al.,[13] supporting the reproducibility of renal artery orientation across different populations. Across all groups, the RRA diameter was consistently greater than that of the LRA, a pattern previously described by Stojadinovic et al.[13] and Taşdemir et al.[14] This asymmetry likely reflects normal anatomical predominance of the RRA but may also be influenced by right-sided hemodynamic variations and organ displacement by the liver. Arterial lengths followed a similar pattern. The consistent predominance of RRA length over LRA length agrees with previously published anatomical data, although Khanal et al. reported generally shorter RA lengths in both sexes.[15] Differences across studies may arise from demographic variability, imaging modality sensitivity, or disease-specific vascular changes. As for venous morphology, the significantly greater length of the LRV is a well-recognized anatomical characteristic, resulting from its course anterior to the aorta and posterior to the superior mesenteric artery. Our findings align with classical and contemporary anatomical studies, including those by Ballesteros et al.,[16] Floch-Prigent, and Satyapal et al.[17,18]

In our study, the clustering of both RRA and LRA origins around the L1 level reinforces the classical anatomical description of renal artery emergence, suggesting

that, despite pathological conditions in patient groups, the craniocaudal position of artery origin remains relatively conserved. The slightly wider range observed for the RRA (up to L3) may reflect natural variability or right-sided anatomical influences such as liver position or aortic rotational asymmetry. In contrast, the narrower distribution of the LRA origin may indicate greater left-sided stability in vascular branching patterns.[14] In addition, we examined the vertebral levels at which the RVs drained into the IVC. The RRV was drained at six distinct levels, spanning from the lower third of T12 to the mid-level of L2. Its most frequent drainage point was the lower level of L1, followed by the mid-level of L1. In contrast, the LRV exhibited greater variability, draining at nine different vertebral levels between the mid-level of T12 and the lower level of L3. Similar to the RRV, the LRV most commonly drained at the lower level of L1, with the mid-level of L1 being the second most frequent site. These findings are in agreement with those reported by Satyapal et al.[18] Although both renal veins often enter the IVC at comparable vertebral levels, the LRV tends to drain slightly superior to the RRV in a considerable proportion of cases. This subtle asymmetry may be related to the longer and more complex anatomical course of the LRV, which traverses anterior to the aorta and beneath the superior mesenteric artery—an arrangement that may impose positional adjustments at its point of entry into the IVC. Beckmann and Abrams also demonstrated drainage variability, reporting RRV termination between T12 and L2–L3 and LRV drainage extending from T12 to the upper L3.[19] The broad range of vertebral levels observed in both our study and prior literature underscores the considerable anatomical diversity of RV anatomy. This variability is clinically relevant, particularly in renal transplantation, retroperitoneal surgery, and endovascular interventions, where precise preoperative mapping of venous entry points can reduce the risk of iatrogenic injury.

Moreover, in this study, a total of 11 RV variations were identified, corresponding to a variation rate of 11.57%. Although these percentages appear to differ from those reported in the literature, the discrepancies are likely attributable to the modest sample size and heterogeneous distribution among groups, which can disproportionately influence prevalence estimates for relatively uncommon anatomical variants. Previous studies provide a broader context for the variability of RV anatomy.[20-22] These findings illustrate that RV variations are not rare and show substantial inter-study variability, likely influenced by demographic factors, imaging modalities, and classification criteria. With regard to venous entry angles, the slightly wider RRV angle in ADPKD may reflect anatomical distortion due to enlarged polycystic kidneys, although the difference remained modest. Meanwhile, LRV angles in ADPKD and SRC were comparable but marginally lower than in the control group. Such differences may be due to sample size limitations or subtle ethnic and anatomical variations rather than strong disease-specific effects. Satyapal similarly documented an average RRV angle,[18] highlighting the dynamic nature of venous geometry. Beckmann and Abrams emphasized that RRV angles may vary with respiration and reported mean angles of the RRV and the LRV.[19] Regarding venous diameters, RRV measurements showed no statistically significant differences. However, the LRV showed marked variation: The ADPKD group had a substantially smaller diameter compared with controls. This reduction in LRV diameter in ADPKD may be attributed to compromised renal function and reduced venous return, despite underlying kidney enlargement—a paradoxical but physiologically plausible finding.

Lastly, previous studies demonstrate a wide range of reference values, underscoring anatomical diversity.[16-18] The variability across studies reinforces that RV dimensions are highly population-dependent and sensitive to methodological differences, emphasizing the importance of context when interpreting comparative vascular measurements.

CONCLUSION

This study used CT imaging to evaluate renal arterial and venous morphology—including levels, angles, diameters, lengths, and variations—in ADPKD, SRC, and control groups. Except for a smaller LRV diameter in ADPKD, no significant differences were detected. As the first study focusing on vascular features in cystic kidney diseases, it suggests that subtle anatomical alterations may occur despite overall structural preservation. Although limited by a small sample size, the findings emphasize the need for thorough preoperative vascular assessment and support future large-scale, multicenter investigations.

Ethics Committee Approval

The study was approved by the University of Health Sciences Hamidiye Ethics Committee (Date: 13.10.2023, Decision No: 2023/18).

Informed Consent

Written consent retrieved from those who were involved in the study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Design: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Supervision: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Fundings: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Materials: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Data collection &/or processing: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Analysis and/or interpretation: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Literature search: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.; Writing: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y Critical review: N.Y., R.D., S.Y., R.Di, T.B., B.S.Y.

Conflict of Interest

None declared.

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Otozomal Dominant Polikistik Böbrek Hastaları ve Basit Böbrek Kisti Hastalarında Böbrek Damarlarının Karşılaştırmalı Morfometrik Analizi

Amaç: Otozomal Dominant Polikistik Böbrek Hastalığı (ADPKD) ve Basit Böbrek Kistleri'nin (SRC) neden olabileceği böbrek damarlarının morfometrik değişikliklerini araştırmak ve sonuçları kontrol ile karşılaştırmak.

Gereç ve Yöntem: Bu çalışmada, 2019-2024 yılları arasında 95 olgunun BT görüntüleri, Sağlık Bilimleri Üniversitesi, İstanbul, Türkiye Kartal Dr. Lütfü Kırdar Şehir Hastanesi Nefroloji Kliniği'ndeki otomasyon sistemi aracılığıyla incelendi. Olgular ADPKD, SRC ve Kontrol olarak gruplandırıldı ve renal arter ve renal venin morfometrik ölçümleri yapıldı.

Bulgular: Abdominal aorttan ayrılıp renal hilusa giren sağ ve sol renal arterin seviyesi, açısı, çapı ve uzunluğu arasında anlamlı bir fark bulunmadı. Sağ ve sol renal venin inferior vena kavaya döküldüğü seviye, açı, renal hilumdan inferior vena kavaya kadar olan uzunluk ve sağ renal ven çapı açısından üç grup arasında anlamlı bir fark bulunmamıştır. Ancak, ADPKD ve kontrol arasında sol renal ven çapı açısından istatistiksel olarak anlamlı fark bulunmuştur.

Sonuç: Böbrek kistlerine bağlı gelişen ADPKD ve SRC'nin, kontrol ile karşılaştırıldığında renal venlerde morfometrik değişikliklere neden olabileceği belirlenmiştir. Ameliyat öncesi planlamada bu hastaların vasküler yapılarının detaylı olarak bilinmesinin, ameliyat sırasında ortaya çıkabilecek komplikasyonların önlenmesinde etkili olacağı düşünülmektedir.

Anahtar Sözcükler: Arteria renalis; basit böbrek kisti hastalığı; morfometrik ölçüm; otozomal dominant polikistik böbrek hastalığı; vena renalis.

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Original Article

The Association of ARISCAT Score with Operative Characteristics and Length of Hospital Stay in Patients Referred for Preoperative Pulmonology Consultation

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ABSTRACT

Objective: The ARISCAT score is a validated tool for predicting postoperative pulmonary complications. However, its relationship with operative characteristics and length of hospital stay in patients referred for preoperative pulmonology consultation remains insufficiently explored.

Methods: This retrospective observational study included 198 patients who underwent preoperative pulmonology consultation prior to elective surgery. Patients were classified into low-risk and intermediate–high-risk groups according to ARISCAT scores. Demographic data, comorbidities, operative variables, and postoperative outcomes were compared between groups. Associations between ARISCAT scores and clinical parameters were assessed using Spearman correlation analysis.

Results: Among the 198 patients, 166 (83.8%) were classified as low risk and 32 (16.2%) as intermediate–high risk. The intermediate–high-risk group had significantly higher rates of major surgery (93.8% vs. 66.9%, p=0.002), longer operative duration (>2 hours: 65.6% vs. 13.3%, p<0.001), and more frequent use of general anesthesia (93.8% vs. 73.5%, p=0.035). Median length of hospital stay was significantly longer in the intermediate–high-risk group (4.0 vs. 2.0 days, p<0.001). ARISCAT score demonstrated a moderate positive correlation with length of hospital stay (r=0.382, p<0.001). No significant differences were observed in postoperative pulmonary complications or mortality between groups.

Conclusion: In patients undergoing preoperative pulmonology consultation, higher ARISCAT scores are primarily associated with increased operative complexity and prolonged hospital stay. Although some score components overlap with perioperative risk factors, the persistent association with length of stay suggests broader perioperative implications. The lack of significant differences in postoperative pulmonary complications may reflect the impact of preoperative respiratory optimization in this selected population.

INTRODUCTION

Postoperative pulmonary complications (PPCs) are an important source of perioperative morbidity and contribute to prolonged hospital stay and increased healthcare burden. Identifying patients at increased pulmonary risk before surgery is essential for perioperative planning and risk reduction strategies.[1]

The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) score is a validated clinical tool designed to estimate the risk of PPCs using readily available preoperative and operative variables. These include age, preoperative oxygen saturation, recent respiratory infection, anemia, surgical site, duration of surgery, and emergency status.[2] Previous studies have confirmed its predictive value across different surgical populations.[3-5]

Although ARISCAT is primarily used to predict pulmonary complications, its potential association with other perioperative outcomes remains less clearly defined. In particular, its relationship with operative characteristics such as surgical complexity, duration of surgery, and anesthesia type has not been fully evaluated. In addition, the association between ARISCAT score and length of hospital stay independent of PPC occurrence is not well established.

Some studies suggest that higher pulmonary risk scores may be associated with prolonged hospitalization, but available evidence is limited and mainly derived from general surgical cohorts.[6]

Patients referred for preoperative pulmonology consultation represent a distinct clinical subgroup. These patients often undergo detailed respiratory evaluation and optimization before surgery. As a result, the relationship between baseline pulmonary risk and postoperative outcomes may differ from that observed in unselected surgical populations.

Therefore, this study aimed to evaluate the association between ARISCAT score, operative characteristics, and length of hospital stay in patients undergoing preoperative pulmonology consultation. By focusing on this specific population, we sought to clarify the broader perioperative relevance of the ARISCAT score beyond its established role in predicting pulmonary complications.

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee of Kartal Dr. Lütfi Kırdar City Hospital (No: 2026/010.99 /25/12, Date:24/02/2026) and conducted in accordance with the Declaration of Helsinki.

Study Design and Population

This retrospective observational study was conducted at a high-volume tertiary care hospital where preoperative pulmonology consultation is routinely requested for surgical candidates. Medical records of patients who underwent preoperative pulmonology consultation prior to elective surgery between January 1 and January 30, 2025 were reviewed. All consecutive adult patients (≥18 years) evaluated during this period were screened for eligibility. No sampling or selection strategy was applied. A total of 198 consecutive patients with complete data were included in the final analysis. Patients with incomplete medical records, missing ARISCAT score components, or unavailable perioperative data were excluded.

Data Collection

Demographic characteristics (age, sex), smoking status, comorbidities (chronic obstructive pulmonary disease, asthma, hypertension, diabetes mellitus, coronary artery disease, heart failure, malignancy, and other chronic diseases), and recent respiratory infections were recorded. Clinical parameters including peripheral oxygen saturation (SpO_2), hemoglobin levels, chest radiography findings, and pulmonary function test requests were obtained from hospital records. Operative variables included surgical specialty, type of surgery (major/minor), duration of surgery, anesthesia type, American Society of Anesthesiologists (ASA) physical status classification, and postoperative intensive care unit (ICU) requirement.

Surgical procedures were categorized based on operative complexity and expected physiological stress. Major surgery was defined as procedures involving thoracic, intraperitoneal, or major vascular operations and/or an operative duration ≥2 hours, reflecting higher surgical complexity and physiological impact. Minor surgery included superficial, endoscopic, or short-duration procedures not involving major body cavities.

Postoperative pulmonary complications (pneumonia, pleural effusion, hypoxemia, and atelectasis), length of hospital stay, and in-hospital mortality were also recorded.

ARISCAT Score Assessment

ARISCAT score was determined retrospectively for all patients using the validated scoring framework based on preoperative and intraoperative clinical parameters. The score incorporates several variables reflecting patient condition and surgical characteristics, including age, peripheral oxygen saturation before surgery, recent respiratory infection, hemoglobin level, surgical site, duration of the procedure, and emergency surgery status.

Each parameter contributes a predefined number of points, and the total ARISCAT score represents the sum of all component values. Based on the total score, patients are classified into three categories: Low risk (<26 points), intermediate risk (26–44 points), and high risk (≥45 points).

For analytical purposes, patients were further grouped into two categories: Low risk and intermediate–high risk, consistent with previously established risk stratification approaches. All required variables were extracted from electronic medical records, and ARISCAT scores were calculated retrospectively (Table 1).

Due to the small number of patients in the high-risk category (n=2), intermediate- and high-risk groups were combined for statistical analysis to ensure analytical stability.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were evaluated for distributional normality using the Kolmogorov–Smirnov test. Normally distributed variables were reported as mean and standard deviation, whereas non-normally distributed variables were presented as median and interquartile range. Categorical variables were summarized as frequencies and percentages.

Between-group comparisons were performed using the independent samples t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate.

Given the limited number of postoperative pulmonary complication events (n=6), multivariable regression analysis was not performed to avoid model overfitting.

The relationship between ARISCAT score and continuous clinical variables was examined using Spearman's rank cor-

Table 1. ARISCAT score for preoperative evaluation

Parameter	Criteria	Points
Age≤50 years	0	
Age51–80 years	3	
Age>80 years	16	
Preoperative SpO_2 (room air)	≥96%	0
Preoperative SpO_2 (room air)	91–95%	8
Preoperative SpO_2 (room air)	≤90%	24
Respiratory infection in the last month	No	0
Respiratory infection in the last month	Yes	17
Preoperative hemoglobin	≥10 g/dL	0
Preoperative hemoglobin	<10 g/dL	11
Surgical incision site	Peripheral	0
Surgical incision site	Upper abdominal	15
Surgical incision site	Intrathoracic	24
Surgery duration	<2 hours	0
Surgery duration	2–3 hours	16
Surgery duration	>3 hours	23
Emergency surgery	No	0
Emergency surgery	Yes	8
Risk Classification		
Total Score	Risk of Postoperative Pulmonary Complications	
<26	Low risk (~1.6%)	
26–44	Intermediate risk (~13.3%)	
≥45	High risk (~42.1%)	

relation analysis. A two-tailed p-value of less than 0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

A total of 198 patients evaluated by the pulmonology department before surgery were analyzed. According to ARISCAT score classification, 166 patients (83.8%) were assigned to the low-risk group and 32 patients (16.2%) to the intermediate–high-risk group. Demographic features and most baseline clinical variables were similar between the two groups. There were no significant differences in age, sex, smoking status, or major comorbid conditions such as chronic obstructive pulmonary disease, hypertension, diabetes mellitus, coronary artery disease, and asthma (all p>0.05). However, other chronic diseases were more prevalent among patients in the intermediate–high-risk group compared with the low-risk group (37.5% vs. 16.9%, p=0.008). In addition, a history of respiratory infection within the preceding month was more frequently observed in the intermediate–high-risk group (25.0% vs. 8.4%, p=0.012). Symptoms suggestive of upper respiratory tract infection were also more common in this group (25.0% vs. 4.3%, p=0.001).

No significant differences were observed between groups regarding preoperative oxygen saturation or hemoglobin levels (p>0.05). Detailed baseline characteristics are summarized in Table 2.

Table 2. Distribution of demographic, comorbidity, and clinical characteristics according to ARISCAT score risk groups

Variables	All Patients (n=198)	Low ARISCAT (n=166)	Intermediate–High ARISCAT (n=32)	p value
Age (years)	63.25±11.55	63.18±11.41	63.63±12.41	0.843[a]
Female sex	113 (57.1)	94 (56.6)	19 (59.4)	0.774[b]
COPD	26 (13.1)	24 (14.5)	2 (6.3)	0.264[c]
Hypertension	100 (50.5)	81 (48.8)	19 (59.4)	0.273[b]
Heart failure	4 (2.0)	4 (2.4)	0	1.000[c]
Coronary artery disease	31 (15.7)	26 (15.7)	5 (15.6)	0.996[b]
Diabetes mellitus	61 (30.8)	52 (31.3)	9 (28.1)	0.720[b]
Asthma	40 (20.2)	32 (19.3)	8 (25.0)	0.460[b]
Thyroid disease	19 (9.6)	17 (10.2)	2 (6.3)	0.744[c]
Malignancy	26 (13.1)	19 (11.4)	7 (21.9)	0.148[c]
Other diseases	40 (20.2)	28 (16.9)	12 (37.5)	0.008[b*]
Current smoker	48 (26.7)	41 (26.6)	7 (26.9)	0.975[b]
Smoking (pack-years)	2.0 (0.0-25.0)	1.0 (0.0-25.0)	4.0 (0.0-20.0)	0.883[d]
Pulmonary infection (last month)	22 (11.1)	14 (8.4)	8 (25.0)	0.012[c*]
Upper respiratory symptoms	15 (7.7)	7 (4.3)	8 (25.0)	0.001[c*]
Abnormal chest X-ray	17 (8.6)	14 (8.4)	3 (9.4)	0.742[c]
Pulmonary function test requested	54 (27.3)	47 (28.3)	7 (21.9)	0.454[b]
Peripheral oxygen saturation (SpO_2, %)	97.53±1.23	97.61±1.14	97.09±1.59	0.086[a]
Hemoglobin (g/dL)	12.91±1.58	12.99±1.61	12.49±1.39	0.079[a]

Values are presented as mean±SD, n (%), or median (IQR). [a]Independent samples t-test; [b]Pearson χ^2 test; [c]Fisher's exact test; [d]Mann–Whitney U test. *Statistically significant (p<0.05).

Table 3. Distribution of surgical and perioperative characteristics according to ARISCAT risk groups

Variables	All Patients (n=198)	Low ARISCAT (n=166)	Intermediate–High ARISCAT (n=32)	p value
Surgical department				
General surgery	65 (32.8)	52 (31.3)	13 (40.6)	
Ophthalmology	12 (6.1)	12 (7.2)	0	
Obstetrics &	42 (21.2)	35 (21.1)	7 (21.9)	
Gynecology ENT	16 (8.1)	12 (7.2)	4 (12.5)	0.711[a]
Cardiovascular surgery	4 (2.0)	4 (2.4)	0	
Neurosurgery	17 (8.6)	14 (8.4)	3 (9.4)	
Orthopedics	8 (4.0)	8 (4.8)	0	
Plastic & reconstructive	8 (4.0)	7 (4.2)	1 (3.1)	
Urology	26 (13.1)	22 (13.3)	4 (12.5)	
Major surgery	141 (71.2)	111 (66.9)	30 (93.8)	0.002[b*]
Anesthesia type				
General	152 (76.8)	122 (73.5)	30 (93.8)	
Spinal	34 (17.2)	33 (19.9)	1 (3.1)	
Local	8 (4.0)	8 (4.8)	0	0.035[a*]
Sedation	4 (2.0)	3 (1.8)	1 (3.1)	
Surgery duration >2 h	43 (21.7)	22 (13.3)	21 (65.6)	<0.001[b*]
ASA score				
0	1 (0.5)	0	1 (3.2)	
1	3 (1.5)	3 (1.8)	0	0.058[a]
2	76 (38.6)	69 (41.6)	7 (22.6)	
3	113 (57.4)	91 (54.8)	22 (71.0)	
4	4 (2.0)	3 (1.8)	1 (3.2)	
Postoperative ICU admission	15 (7.6)	11 (6.6)	4 (12.5)	0.272[c]
Pulmonary complications	6 (3.0)	4 (2.4)	2 (6.3)	0.250[c]
Length of hospital stay (days)	2.0 (2.0-4.0)	2.0 (2.0-4.0)	4.0 (3.0-6.7)	<0.001[d*]
Mortality	2 (1.0)	2 (1.2)	0	1.000[c]

n (%), Median (IQR), [a]: Fisher–Freeman–Halton test; [b]: Pearson chi-square test; [c]: Fisher exact test; [d]: Mann–Whitney U test; *: p<0.05.

Operative Characteristics

Operative variables for both groups are presented in Table 3. Major surgical procedures were performed more often in patients classified as intermediate–high risk than in those in the low-risk category (93.8% vs. 66.9%, p=0.002). Likewise, general anesthesia was used more frequently among intermediate–high-risk patients (93.8% vs. 73.5%, p=0.035). Procedures lasting longer than two hours were also markedly more common in this group (65.6% vs. 13.3%, p<0.001). In contrast, ASA physical status, need for postoperative intensive care, and incidence of postoperative pulmonary complications did not differ significantly between the two risk groups (p>0.05).

Postoperative Outcomes

Patients in the intermediate–high-risk group experienced a significantly longer hospital stay compared with those in the low-risk group (median 4.0 [3.0–6.7] days vs. 2.0 [2.0–4.0] days, p<0.001). Postoperative pulmonary complications were identified in 6 patients (3.0%), and the frequency of these complications did not differ significantly between the risk groups (p=0.250). Two patients (1.0%) in the low-risk group died during hospitalization, whereas no deaths were recorded in the intermediate–high-risk group (p=1.000) (Table 3).

Correlation Analysis

ARISCAT score showed a moderate positive association with length of hospital stay (r=0.382, p<0.001). A weak inverse relationship was also identified between ARISCAT score and hemoglobin level (r=−0.141, p=0.048). In contrast, ARISCAT score was not significantly associated with age, smoking exposure, or peripheral oxygen saturation (p>0.05) (Table 4).

DISCUSSION

In this retrospective study of patients undergoing preoperative pulmonology consultation, higher ARISCAT scores were associated with more complex surgical procedures, longer operative duration, and prolonged hospital stay. Patients in the intermediate–high-risk group were more likely to undergo major surgery and receive general anesthesia.

Table 4. Correlation between ARISCAT score and clinical variables

	ARISCAT	
	r	p-value
Age	0.114	0.109
Smoking amount	0.032	0.670
SpO_2	-0.117	0.101
Hemoglobin	-0.141	0.048*
Length of hospital stay	0.382	<0.001*

[a]: Spearman korelasyon testi; *:p<0.05

In addition, ARISCAT score showed a moderate positive correlation with length of hospital stay. However, no significant differences were observed in postoperative pulmonary complications or mortality between risk groups. The overall PPC rate in our cohort was 3.0%, which is relatively low compared to rates reported in general surgical populations. Although this study was not designed to evaluate the direct impact of preoperative interventions, the structured pulmonology consultation process may have contributed to this finding. In routine practice, consultations typically include smoking cessation counseling (when applicable), education on incentive spirometry and breathing exercises, optimization of bronchodilator therapy for underlying respiratory conditions, and management of comorbidities such as anemia or nutritional deficiencies when identified.

The observed association between higher ARISCAT scores and prolonged hospital stay may reflect the broader clinical vulnerability of patients with increased perioperative respiratory risk. Several components of the ARISCAT score, such as advanced age, anemia, reduced oxygen saturation, and longer surgical duration, are known to influence postoperative recovery. These factors may contribute not only to pulmonary complications but also to delayed mobilization, slower functional recovery, and increased need for perioperative monitoring. In addition, patients with higher ARISCAT scores in our cohort were more likely to undergo major surgery and general anesthesia, both of which may further prolong postoperative recovery and hospitalization. Therefore, the association between ARISCAT score and length of stay likely reflects the cumulative effect of multiple perioperative risk factors rather than pulmonary risk alone. In addition, preoperative respiratory optimization strategies have been shown to reduce postoperative pulmonary complications and improve postoperative recovery in surgical patients.[7] Preoperative anemia, one of the components of the ARISCAT score, has been associated with adverse postoperative outcomes and delayed recovery.[8]

Previous studies have shown that pulmonary risk indices are associated with adverse postoperative outcomes and increased perioperative risk[9] Arozullah et al.[10] demonstrated that higher pulmonary risk scores were linked to greater postoperative morbidity and increased healthcare utilization. In addition, structured preoperative pulmonary assessment has been emphasized as an important component of perioperative risk stratification and clinical decision-making.[11] The ARISCAT score has also been validated as a reliable predictor of postoperative pulmonary complications in different surgical populations, including thoracic and major abdominal surgery.[6,12,13] Our findings are consistent with these observations and further demonstrate that higher ARISCAT scores are associated with prolonged hospital stay in patients undergoing preoperative pulmonology consultation. This suggests that ARISCAT may reflect overall perioperative risk and recovery potential beyond its established role in predicting pulmonary complications.

The findings of this study have several important clinical implications. The association between higher ARISCAT scores and prolonged hospital stay suggests that this score may be useful not only for predicting pulmonary complications but also for identifying patients at risk of delayed postoperative recovery. Early recognition of high-risk patients may help clinicians optimize perioperative management, improve resource planning, and anticipate postoperative care needs. In addition, the use of ARISCAT score during preoperative pulmonology consultation may support risk stratification and guide individualized perioperative monitoring and intervention strategies. These findings highlight the potential value of ARISCAT as a practical tool for broader perioperative risk assessment in this specific patient population.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the retrospective and single-center design may limit generalizability and introduce potential selection bias. Second, the relatively small number of patients in the intermediate–high-risk group and the low incidence of postoperative pulmonary complications may have limited the ability to detect differences in less frequent outcomes. Third, the short study period may not fully reflect variations in surgical practice or patient characteristics over time. Finally, detailed data on perioperative respiratory optimization strategies were not consistently available, which may have influenced postoperative outcomes.

CONCLUSION

Higher ARISCAT scores are associated with increased operative complexity and prolonged hospital stay in patients undergoing preoperative pulmonology consultation. In this selected population, ARISCAT may provide clinically relevant information beyond pulmonary complication risk and may support perioperative risk stratification and anticipatory clinical planning.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (Date: 24.02.2026, Decision No: 2026/010.99 /25/12).

Informed Consent

The requirement for informed consent was waived due to the retrospective nature of the study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: B.Z.E.; Design: B.Z.E.; Supervision: B.Z.E., S.S.C.; Fundings: B.Z.E., S.S.C., A.H., E.Y.; Materials: S.S.C., A.H., E.Y., R.O.; Data collection &/or processing: A.H., E.Y., R.O., B.Z.E., S.S.C.; Analysis and/or interpretation: B.Z.E., S.S.C.; Literature search: B.Z.E., R.O.; Writing: B.Z.E.; Critical review: B.Z.E.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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Preoperatif Göğüs Hastalıkları Konsültasyonu İstenen Hastalarda ARISCAT Skoru, Operatif Özellikler ve Hastanede Yatış Süresi

Amaç: ARISCAT skoru, ameliyat sonrası pulmoner komplikasyonları öngörmede doğrulanmış bir araçtır. Ancak, preoperatif pulmonoloji konsültasyonuna yönlendirilen hastalarda ameliyat özellikleriyle ve hastanede kalış süresiyle ilişkisi yeterince araştırılmamıştır.

Gereç ve Yöntem: Bu retrospektif gözlemsel çalışma, elektif cerrahi öncesi preoperatif pulmonoloji konsültasyonu yapılan 198 hastayı kapsamaktadır. Hastalar ARISCAT skorlarına göre düşük riskli ve orta–yüksek riskli gruplara ayrılmıştır. Demografik veriler, eşlik eden hastalıklar, ameliyat değişkenleri ve postoperatif sonuçlar gruplar arasında karşılaştırılmıştır. ARISCAT skoru ile klinik parametreler arasındaki ilişkiler Spearman korelasyon analizi kullanılarak değerlendirilmiştir.

Bulgular: 198 hastanın 166'sı (%83.8) düşük riskli, 32'si (%16.2) orta–yüksek riskli olarak sınıflandırılmıştır. Orta–yüksek riskli grupta majör cerrahi oranı anlamlı derecede daha yüksekti (%93.8'e karşı %66.9; p=0.002), ameliyat süresi daha uzundu (>2 saat: %65.6'ya karşı %13.3; p<0.001) ve genel anestezi kullanımı daha sıktı (%93.8'e karşı %73.5; p=0.035). Medyan hastanede kalış süresi orta–yüksek riskli grupta anlamlı derecede uzundu (4,0 güne karşı 2,0 gün; p<0.001). ARISCAT skoru ile hastanede kalış süresi arasında orta düzeyde pozitif korelasyon saptandı (r=0.382; p<0.001). Gruplar arasında postoperatif pulmoner komplikasyonlar veya mortalite açısından anlamlı fark gözlenmemiştir.

Sonuç: Preoperatif pulmonoloji konsültasyonu yapılan hastalarda yüksek ARISCAT skorları öncelikle artmış ameliyat karmaşıklığı ve uzamış hastanede kalış süresi ile ilişkilidir. Skorun bazı bileşenleri perioperatif risk faktörleriyle örtüşse de, hastanede kalış süresiyle kalıcı ilişki daha geniş perioperatif çıkarımlara işaret etmektedir. Postoperatif pulmoner komplikasyonlarda anlamlı fark olmaması, bu seçilmiş popülasyonda preoperatif solunum optimizasyonunun etkisini yansıtabilir.

Anahtar Sözcükler: ARISCAT skoru; hastanede yatış süresi; preoperatif değerlendirme.

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Original Article

Comparative Outcomes of Grade 3–4 Hiatal Hernia Repair Between Non-elderly and Elderly Patients: A Single-center Retrospective Analysis of 105 Patients

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ABSTRACT

Objective: Type 3 and 4 hiatal hernias are less common and represent the most severe forms, often requiring surgical correction due to significant anatomical displacement and associated gastroesophageal reflux. This study aimed to compare perioperative and postoperative outcomes of Type 3 and 4 hiatal hernia repairs across two age groups (<65 years and ≥65 years) and to analyze the impact of comorbidities, previous abdominal surgeries, and intraoperative findings.

Methods: A retrospective review was conducted of 105 patients who underwent surgical repair for Type 3 and 4 hiatal hernia between January 2015 and December 2023 at a single tertiary center. Fifty-five patients were younger than 65 years, and 50 were 65 years or older. Among the elderly group, 3 patients underwent open repair and 47 underwent laparoscopic repair. The collected data included demographic parameters, comorbidities, perioperative variables, intraoperative findings, and postoperative outcomes. Statistical analysis was performed using Student's t-test and chi-square tests, with $p<0.05$ considered significant.

Results: Elderly patients demonstrated significantly prolonged operative durations, increased intraoperative blood loss, extended length of hospital stay, and a higher incidence of postoperative respiratory complications compared with non-elderly patients. Furthermore, advanced age and elevated American Society of Anesthesiologists scores were found to be significantly associated with delayed postoperative recovery.

Conclusion: Laparoscopic repair of Type 3 and 4 hiatal hernia is safe and effective across age groups, including elderly patients with comorbidities, provided that appropriate perioperative management is applied. There is a substantial need for multicenter prospective studies to generate higher-quality evidence and allow for broader clinical generalization.

INTRODUCTION

Hiatal hernia (HH) is classified into four major types. Hill's Type 1, also called sliding HH, is the most common type (95%); Hill's Type 2, called paraesophageal HH, is also called rolling HH; Hill's Type 3 is a mix of sliding and paraesophageal HH; and Hill's Type 4 HH is wide enough for herniation of additional organs, representing the most complex and clinically significant form.[1] Giant hiatal hernia (GHH), which is also called Hill's Type 3 or 4, represents the protrusion of some or all of the stomach and other abdominal contents through the esophageal hiatus into the mediastinum.[2] The prevalence of HH increases with age, with studies estimating an incidence of up to 60% in individuals older than 65 years. The global demographic shift toward an aging population has led to a steady increase in the number of individuals aged 65 years and older.[3] Consequently, surgical treatment of age-related conditions, including giant hiatal hernia, is being performed with greater frequency in elderly patients. Accumulating evidence suggests that advanced age is associated with an elevated risk of postoperative morbidity following hiatal hernia repair, with elderly patients demonstrating higher complication rates compared with younger populations.[4,5] These findings underscore the importance of careful patient selection and risk stratification when considering surgical intervention in this growing demographic.

Giant hiatal hernia (GHH) represents a clinically important condition that can lead to a wide range of symptoms, such as early satiety, dysphagia, dyspnea, retrosternal pain, ab-

dominal distension, and gastroesophageal reflux, often resulting in a marked decline in health-related quality of life.[2] As the prevalence of hiatal hernia increases with advancing age, these symptoms are encountered more frequently in elderly individuals. Although a proportion of patients may remain asymptomatic, longitudinal data indicate that a subset will progress to acute complications requiring emergency surgical intervention, with an estimated annual incidence of approximately 1.1% among asymptomatic patients.[6] Given the anatomical extent and physiological consequences of GHH, this risk is likely to be amplified in older patients, underscoring the need for careful evaluation and timely management strategies in this vulnerable population.

In recent years, laparoscopic repair has emerged as the predominant surgical strategy for the treatment of hiatal hernia, reflecting a substantial shift in clinical practice. Compared with open surgical techniques, minimally invasive repair has been shown to confer significant advantages, including reduced perioperative morbidity and improved short-term survival, as evidenced by lower 30-day mortality rates.[7]

A growing body of literature has explored the outcomes of laparoscopic fundoplication in older patient cohorts.[8,9] Collectively, these studies indicate that clinical results in elderly patients are broadly comparable to those observed in younger populations. Nevertheless, the majority of reported series include hiatal hernias across a wide range of sizes, with only a small subset of investigations specifically examining outcomes in patients with GHH.

Although there are limited studies in the literature regarding the laparoscopic treatment of hiatal hernia in elderly patients, there are no comparative studies evaluating the outcomes of laparoscopic repair of GHH between elderly and non-elderly patient groups. The present study aimed to contribute to the literature by evaluating the perioperative and short-term clinical outcomes of laparoscopic repair in elderly patients with GHH, with particular emphasis on postoperative morbidity and mortality. By comparing outcomes across age groups and assessing the impact of comorbidity burden, this study sought to clarify whether laparoscopic intervention can be performed safely in this high-risk population and to address the existing gap in the literature regarding the surgical management of GHH in elderly patients.

MATERIALS AND METHODS

Study Design and Patient Selection

This retrospective, single-center study was conducted at the Department of General Surgery between January 2015 and December 2023. Ethical approval was obtained from the hospital institutional review board (IRB No. 2025/010.99/22/7). A total of 105 patients who underwent surgery for Type 3 and 4 hiatal hernia were included in the analysis.

Inclusion criteria were as follows:

1. Diagnosed GHH based on preoperative imaging, upper gastrointestinal endoscopy, and intraoperative confirmation.

2. Elective surgical repair via a laparoscopic or open approach.

3. Complete clinical and follow-up data available for at least 12 months postoperatively.

Exclusion criteria included emergent surgery for gastric strangulation, previous antireflux procedures, or incomplete records.

Patients were categorized into two age-based cohorts:

• Group A (<65 years): 55 patients (mean age, 54.2±8.1 years).

• Group B (≥65 years): 50 patients (mean age, 71.3±4.9 years).

Surgical Technique

All laparoscopic procedures were performed by one senior surgeon using a standard 5-port technique under general anesthesia. The hernia sac was carefully dissected, and the esophagus was mobilized to achieve at least 3 cm of intra-abdominal length. The crura were approximated posteriorly with 2.0 nonabsorbable interrupted sutures, and a 360° Nissen fundoplication was performed in all cases. Dual mesh (Parietex™ Composite Mesh) reinforcement was applied only in three elderly patients whose hiatal hernia defects were large (>5 cm) and in whom the diaphragmatic crura could not be approximated without tension. For open repairs (n=3), a transabdominal upper midline incision was used. Adhesiolysis was performed as required, followed by similar crural repair and fundoplication steps.

Perioperative and Postoperative Management

All patients underwent preoperative assessment, including complete blood count, metabolic panel, electrocardiogram, and chest X-ray.

Comorbidities were classified according to the Charlson Comorbidity Index (CCI), and ASA scores were recorded preoperatively. Prophylactic antibiotics and low-molecular-weight heparin were administered to all patients. Early ambulation and a liquid diet were initiated within 24 hours postoperatively in laparoscopic cases.

Patients were followed for at least 12 months for postoperative complications such as dysphagia, recurrence, respiratory complications, and incisional or trocar site hernia.

Data Collection and Statistical Analysis

The variables analyzed included the following:

• Demographic variables: age, sex, BMI, comorbidities, and previous abdominal surgeries.

• Perioperative variables: operative time, estimated blood

loss, and intraoperative complications.

• Postoperative variables: length of hospital stay, respiratory events, recurrence, reoperation, and trocar or incisional hernia.

Statistical analysis was performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation and compared using Student's t-test; categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.[10]

RESULTS

A total of 105 patients were analyzed. Group A (<65 years) included 55 patients (mean age, 54.2±8.1 years), and Group B (≥65 years) included 50 patients (mean age, 71.3±4.9 years). Sex distribution was similar between the groups (female, 58.1% vs. 60%; p=0.82).

Six patients in Group A (10.9%) and four in Group B (8%) had a history of previous abdominal surgery, including cholecystectomy, appendectomy, hysterectomy, or an unspecified procedure, as the patient was unable to recall the procedure. Among the elderly patients, five (10%) presented under emergency conditions with acute symptoms, such as vomiting and retching, suggestive of gastric outlet obstruction; however, none had gastric strangulation. All underwent successful surgical management without mortality.

Comorbidities were significantly more frequent in the ≥65-year group (p=0.01). The mean ASA score was 2.1±0.6 in Group A versus 2.9±0.8 in Group B. Cardiopulmonary disease (44%), diabetes mellitus (38%), and hypertension (54%) were the most prevalent comorbidities in the older cohort.

Operative and Perioperative Outcomes

Laparoscopic repair was performed in 102 patients (97.1%), while open repair was performed in 3 elderly patients who underwent emergency surgery. Two of these patients were converted from laparoscopy to open surgery due to extensive adhesions or previous complex surgery, and one underwent an open technique from the outset due to severe chronic obstructive pulmonary disease. Dual-mesh reinforcement was required in three patients in the elderly group; two of these patients underwent open repair, while the remaining patient was managed laparoscopically. Mesh reinforcement was necessitated by the large size of the hiatal hernia defect and the inadequacy of crural approximation. The mean operative time was shorter in Group A (102±24 min) than in Group B (136±33 min; p=0.02).

Four intraoperative complications occurred, all in laparoscopic cases, with two in each group (3.6% in Group A vs. 4% in Group B). These included 2 small pleural tears and 2 minor gastric serosal injuries, all of which were managed intraoperatively. Estimated blood loss was significantly lower in Group A than in Group B (78±35 mL vs. 155±60 mL, respectively; p=0.001).

Postoperatively, early oral intake (<24 h) was achieved in all laparoscopic patients, whereas in the other patients, it was initiated after the first passage of flatus. The mean hospital stay was 2.1±1.1 days for Group A and 5.6±2.4 days for Group B (p<0.001). Postoperative pulmonary complications were more common in elderly patients than in non-elderly patients (12% vs. 5.4%, respectively), and the difference was statistically significant (p=0.02). There were no significant differences between the two groups with regard to temporary dysphagia, hernia recurrence, or reoperation within the first postoperative year. In addition, no perioperative mortality or incisional or trocar-site hernia was observed in either group during the follow-up period.

DISCUSSION

Giant hiatal hernia (GHH), encompassing Hill Type III and IV hiatal hernias, is frequently accompanied by a spectrum of clinically relevant symptoms, including early satiety, dysphagia, dyspnea, retrosternal discomfort, abdominal distension, and heartburn, which can lead to a substantial deterioration in patients' health-related quality of life.[5] In elderly patients, the decision to pursue surgical intervention for giant hiatal hernia requires careful consideration of the balance between operative risk and potential functional benefit. Age-related declines in cardiopulmonary reserve, together with an increased burden of comorbid disease, may predispose this population to higher perioperative morbidity. Improvement in cardiopulmonary status is observed after hernia reduction and relief of cardiac inflow obstruction in patients with GHH.[11] Our findings suggest that, in appropriately selected elderly patients, laparoscopic repair of giant hiatal hernia can yield meaningful physiological and functional improvements, including enhanced pulmonary mechanics and relief of hernia-related cardiac compression, which may translate into improved exercise tolerance and overall quality of life. These potential benefits should therefore be weighed against surgical risk within the context of individualized patient assessment rather than chronological age alone.

While some studies have reported comparable outcomes of foregut surgery in elderly patients compared with younger individuals, others have demonstrated less favorable results.[11-13] This single-center retrospective study compared the perioperative and postoperative surgical outcomes of GHH repair across non-elderly (<65 years) and elderly (≥65 years) patient groups.

Oor et al.[14] demonstrated that operative duration did not differ significantly between elderly and non-elderly patient cohorts, suggesting that advanced age alone does not adversely affect surgical efficiency during hiatal hernia repair. Molena et al.[15] reported higher mean procedure times among elderly patients compared with those in this study (>150 vs. 136±33 min). Furthermore, in our com-

parison of operative times between Groups A and B, we observed a significantly shorter duration in Group A. This discrepancy may be explained by the fact that three patients in Group B were not suitable candidates for primary laparoscopic hiatal hernia repair. Conversion to an open approach was required in two of these patients, while the remaining patient underwent primary open surgery due to patient-related or technical considerations. In addition, dual-mesh reinforcement was necessary in all three cases because of the large hiatal defect size and inadequate crural approximation.

Guan et al.[16] reported no statistically significant differences between elderly and younger patient cohorts with respect to intraoperative blood loss or operative time. In contrast, Tor et al.[14] observed significantly greater blood loss in younger patients (p=0.039). In the present study, however, both intraoperative blood loss and operative time were significantly increased in the elderly group. This discrepancy may be explained by the higher prevalence of extensive intra-abdominal adhesions and the larger size of hiatal hernia defects observed in our elderly patients, which necessitated more extensive surgical dissection.

Comorbidities, particularly those affecting the cardiopulmonary system, are known to be more prevalent among elderly patients and have been associated with delayed postoperative recovery and an increased risk of respiratory complications.[17] These observations highlight the necessity of comprehensive preoperative evaluation and careful perioperative optimization in older individuals. Despite a higher burden of comorbid conditions, including hypertension, diabetes mellitus, chronic obstructive pulmonary disease, and coronary artery disease, the present study did not demonstrate an increased rate of intraoperative complications in the elderly patient group.

Guan et al.[16] demonstrated statistically significant differences in both length of hospital stay and the incidence of pulmonary complications when comparing elderly patients with younger cohorts. Consistent with these findings, the present study also identified a significantly prolonged hospital stay and a higher rate of pulmonary complications in the elderly patient group.

There is growing recognition that laparoscopic repair of large Type III hiatal hernias represents a technically demanding procedure and may carry an increased risk of hernia recurrence, in addition to other procedure-related complications, such as vagal nerve injury.[18,19] Consequently, greater surgical expertise, extended follow-up periods, and continued refinement of operative techniques are required before laparoscopic repair of large hiatal hernias can be universally endorsed as the standard therapeutic approach. In the present study, hernia recurrence was observed in three patients within the first postoperative year, occurring in one patient in Group A and two patients in Group B.

Guan et al.[16] demonstrated that the incidence of postoperative pulmonary complications did not differ significantly in patients aged >75 years, despite a higher prevalence of elevated ASA scores within the elderly cohort. In the present study, however, although Group B patients exhibited higher ASA classifications, pulmonary complications were the only postoperative outcome that showed a statistically significant increase among elderly patients (p=0.02).

In the present study, surgical intervention in the elderly patient cohort was shown to be safe. No 30-day mortality was observed in either the elderly or non-elderly group. These findings are consistent with those reported by Oleksandr et al.[4] and Stylopoulos et al.,[6] who demonstrated that elective surgery for giant hiatal hernia in elderly patients is associated with short-term mortality rates comparable to those observed in non-geriatric populations.

In contrast, large contemporary studies have consistently demonstrated that elderly patients undergoing surgical procedures are at increased risk of postoperative complications and mortality.[19] Story et al.[20] reported that emergency surgery was associated with odds ratios for mortality and major complications comparable to those observed in patients aged 80–89 years. Similarly, Fullum et al.[21] identified age >80 years as the strongest independent predictor of mortality among patients undergoing repair of giant hiatal hernia.

Hernia recurrence following surgical repair remains an important postoperative complication that warrants careful consideration. Migaczewski et al.[22] reported hernia recurrence in one female patient, corresponding to a rate of 4%. More broadly, recurrence rates documented in the literature vary considerably, ranging from approximately 5% to >20%.[23] In the present study, hernia recurrence within the first postoperative year was identified in one patient (1.8%) in the non-elderly group and in two patients (4%) in the elderly group; notably, all recurrent cases occurred following primary repair without the use of dual-mesh reinforcement. These findings indicate recurrence rates that are acceptable and comparatively lower than those reported in previous studies.

The mean operative time was longer in older patients (136 min vs. 102 min), likely reflecting increased adhesions, technical difficulty, and conversion to open surgery. Notably, five elderly patients (10%) presented emergently with vomiting and retching, findings often associated with gastric volvulus or strangulation in advanced hernias. Timely laparoscopic management avoided progression to ischemia, reflecting the value of early surgical referral even in high-risk individuals.

Our results underscore that previous abdominal surgery, although traditionally considered a relative contraindication to laparoscopy, did not significantly impact outcomes. With careful adhesiolysis and experienced surgeons, laparoscopy remains feasible even in reoperative scenarios. From a technical perspective, meticulous dissection of the hernia sac and adequate esophageal mobilization are essential for durable repair. The use of nonabsorbable su-

tures for crural closure remains standard, although some authors advocate biologic mesh augmentation in large hiatal defects.

Various precautions should be taken for elderly patients, including thorough preoperative evaluation, shorter operative time, lower pneumoperitoneum pressure, and ICU care when necessary.

Study Limitations

This study has several limitations. It is a retrospective and single-center analysis, which inherently restricts the generalizability of its findings. In addition, the relatively small sample size may limit the statistical power of the results. Furthermore, heterogeneity in patient characteristics and treatment approaches inherent to real-world clinical practice could not be fully controlled. Due to incomplete accessibility to long-term follow-up data, outcomes beyond the observed period could not be comprehensively evaluated. Additionally, certain confounding factors may not have been fully accounted for, despite rigorous data review and analysis. Therefore, the results should be interpreted with caution, and prospective multicenter studies with larger cohorts are warranted to validate these findings. Long-term follow-up beyond 12 months was not available for all cases.

Despite these limitations, the study provides valuable insight into age-specific outcomes for Grade 3–4 hernias in real-world surgical practice, and the findings may serve as a foundation for future prospective, multicenter research with larger cohorts and standardized follow-up protocols.

CONCLUSION

Laparoscopic repair of GHH is safe, effective, and associated with superior short-term outcomes compared with open surgery, even among elderly patients with comorbidities. Emergency presentations with obstructive symptoms, although more common in older individuals, can be managed successfully with minimally invasive approaches when performed by experienced teams. Age alone should not be a contraindication for laparoscopic repair, provided that preoperative optimization and multidisciplinary care are ensured. To ensure that the findings are more broadly and clinically generalizable, rigorously designed, multicenter prospective studies are needed.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lutfi Kirdar City Hospital Ethics Committee (Date: 26.11.2025, Decision No: 2025/010.99/22/7).

Informed Consent

Written informed consents were obtained from patients who participated in this study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: O.A.; Design: O.A.; Supervision: O.A.; Materials: O.A.; Data Collection and/or Processing: O.A., Y.A.; Analysis and/or Interpretation: Y.A.; Literature Search: O.A.; Writing: O.A.; Critical Reviews: Y.A.

Conflict of Interest

The author declare that there is no conflict of interest.

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Evre III–IV Hiatal Herni Onarımının Genç ve Yaşlı Hastalarda Karşılaştırmalı Sonuçları: 105 Hastayı İçeren Tek Merkezli Retrospektif Analiz

Amaç: Tip III ve IV hiatal herniler daha az görülen ancak en ağır formlar olup, belirgin anatomik yer değiştirme ve buna eşlik eden gastroözofageal reflü nedeniyle sıklıkla cerrahi düzeltme gerektirir. Bu çalışmanın amacı, Tip III–IV hiatal herni onarımının <65 yaş ve ≥65 yaş olmak üzere iki yaş grubu arasında perioperatif ve postoperatif sonuçlarını karşılaştırmak; komorbiditelerin, geçirilmiş abdominal cerrahilerin ve intraoperatif bulguların etkisini analiz etmektir.

Gereç ve Yöntem: Ocak 2015 ile Aralık 2023 tarihleri arasında tek bir üçüncü basamak merkezde Tip III–IV hiatal herni nedeniyle cerrahi onarım uygulanan 105 hasta retrospektif olarak incelendi. Hastaların 55'i 65 yaşın altında, 50'si ise 65 yaş ve üzerindeydi. Yaşlı hasta grubunda 3 hastaya açık cerrahi, 47 hastaya laparoskopik cerrahi uygulandı. Toplanan veriler; demografik parametreler, komorbiditeler, perioperatif değişkenler, intraoperatif bulgular ve postoperatif sonuçları içeriyordu. İstatistiksel analiz Student'ın t-testi ve ki-kare testleri kullanılarak yapıldı ve $p<0.05$ değeri istatistiksel olarak anlamlı kabul edildi.

Bulgular: Yaşlı hastalar, genç hastalarla karşılaştırıldığında anlamlı derecede daha uzun ameliyat süreleri, artmış intraoperatif kan kaybı, uzamış hastanede yatış süresi ve daha yüksek postoperatif solunum komplikasyonu insidansı göstermiştir. Ayrıca ileri yaş ve yüksek Amerikan Anesteziyologlar Derneği (ASA) skorlarının, gecikmiş postoperatif iyileşme ile anlamlı şekilde ilişkili olduğu bulunmuştur.

Sonuç: Tip III–IV hiatal herninin laparoskopik onarımı, uygun perioperatif yönetim sağlandığında, komorbiditeleri bulunan yaşlı hastalar da dâhil olmak üzere tüm yaş gruplarında güvenli ve etkilidir. Bununla birlikte, daha geniş ve klinik olarak daha genellenebilir kanıtlar elde edilebilmesi için çok merkezli prospektif çalışmalara önemli ölçüde ihtiyaç vardır.

Anahtar Sözcükler: Hiatal herni; laparoskopi; yaşlı hastalar.

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Original Article

Clinical and Surgical Predictors of Visual and Anatomical Outcomes Following Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment

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ABSTRACT

Objective: To investigate the clinical and surgical factors affecting visual outcomes and recurrence rates following pars plana vitrectomy (PPV) for rhegmatogenous retinal detachment (RRD).

Methods: This retrospective study included 226 patients who underwent PPV for RRD between 2022 and 2024 at a tertiary care center in Türkiye. Demographic data, duration of symptoms, macular status, presence of proliferative vitreoretinopathy (PVR), type of intravitreal tamponade, pre- and postoperative best-corrected visual acuity (BCVA), intraocular pressure (IOP), and recurrence rates were analyzed.

Results: Patients had a mean age of 57.9±14.4 years and were predominantly male (67.7%); 76.5% were macula-off, and 25.7% had PVR. Mean BCVA improved significantly from 1.8±0.7 to 1.0±0.6 logMAR ($p<0.001$), with preoperative BCVA independently predicting postoperative BCVA ($\beta=0.185$, $p=0.003$). Visual improvement was poorer in eyes with macula-off status ($p=0.044$) and preoperative PVR ($p=0.046$), better with earlier surgical intervention (<7 days; $p=0.030$), and greater with C3F8 tamponade than with other agents ($p=0.043$), while combined cataract surgery did not influence outcomes ($p=0.917$). IOP increased modestly from 13.9±3.9 to 15.3±3.9 mmHg ($p<0.001$); 17.3% of patients required antiglaucomatous therapy, more often with silicone oil (SO) tamponade ($p=0.023$), without affecting final BCVA ($p=0.917$). Recurrent RRD occurred in 18.6% of patients and was higher in those with PVR (39.7% vs. 11.3%; $p<0.01$). Multivariable analysis identified PVR as the only independent predictor of recurrence (OR=3.44, $p=0.023$), and recurrence was lower with C3F8 than with SO (11.1% vs. 24.1%; $p=0.026$).

Conclusion: These findings underscore the importance of preserving macular attachment, minimizing surgical delay, and recognizing PVR as a key determinant of both functional recovery and recurrence in optimizing outcomes after PPV for RRD.

INTRODUCTION

Rhegmatogenous retinal detachment (RRD) represents the most common form of retinal detachment (RD), typically arising from a full-thickness retinal tear that allows liquefied vitreous to enter the subretinal space.[1] The reported incidence of RRD is approximately 13 per 100,000, with a notable male predominance.[2] Posterior vitreous detachment is frequently implicated as a precipitating event, facilitating retinal tears and subsequent detachment.[3] Clinically, patients often present with photopsia, floaters, and progressive peripheral visual field loss.[3]

Surgical management remains the definitive treatment for RRD, with pars plana vitrectomy (PPV) increasingly preferred due to its efficacy in complicated cases.[4] Despite advancements in surgical techniques, outcomes are influenced by various clinical and surgical factors. The status of

the macula at presentation serves as a critical prognostic indicator; macula-on detachments generally result in superior postoperative visual acuity compared with macula-off detachments, highlighting the importance of timely intervention.[5] Proliferative vitreoretinopathy (PVR), characterized by cellular proliferation and membrane contraction, remains the principal cause of surgical failure and recurrent RD.[6] Additional factors, including preoperative best-corrected visual acuity (BCVA), selection of tamponade agent, and duration of symptoms, also influence anatomical and functional outcomes, although their specific roles require further investigation.[7]

In the present study, we aimed to evaluate the clinical and surgical characteristics of patients with RRD and assess their associations with visual prognosis, with a particular focus on macular status, duration of symptoms, PVR, intraoperative tamponade, and complications related to RRD.

MATERIALS AND METHODS

This retrospective cohort study was conducted at the Department of Ophthalmology, Kartal Dr. Lütfi Kırdar City Hospital, and included patients who underwent PPV for RRD between January 2022 and December 2024. This study adhered to the principles of the Declaration of Helsinki and was approved by the institutional ethics committee (No: 2025/010.99/1918, Date: 27/08/2025).

Patients aged ≥18 years who underwent surgical repair for RRD and had a minimum postoperative follow-up of three months were included. The exclusion criteria comprised tractional or serous RD, a history of previous vitreoretinal surgery, retinal dystrophies, trauma-related RD, advanced proliferative diabetic retinopathy, pregnancy or lactation, neurodegenerative disorders, and use of psychotropic medications.

Baseline demographic data and clinical parameters were recorded. The preoperative ophthalmic evaluation included BCVA measured using a Snellen chart and converted to the logarithm of the minimum angle of resolution (logMAR), intraocular pressure (IOP) assessed using a non-contact computerized tonometer (Topcon CT-80), lens status evaluation, and detailed dilated fundus examination. Macular status was determined clinically and confirmed by optical coherence tomography (DRI OCT Triton; Topcon Inc., Tokyo, Japan) when available. Macula-on was defined as the absence of subretinal fluid involving the fovea, and macula-off was defined as foveal involvement.

All surgeries were performed by two experienced vitreoretinal surgeons using a standard 23-gauge PPV system. In selected phakic patients, cataract extraction and PPV were performed during the same surgical session. The intraoperative data collected included the presence of grade C or higher PVR and the type of intravitreal tamponade used (silicone oil [SO], sulfur hexafluoride [SF6], or perfluoropropane [C3F8] gas).

Patients were evaluated on postoperative day 1, week 1, month 1, and at subsequent follow-up visits. Follow-up assessments included BCVA, IOP measurement, anterior segment examination using slit-lamp biomicroscopy, and dilated fundus examination. Postoperative complications, such as ocular hypertension, recurrent RD, and cataract formation, were documented.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). The normality of the data distribution was assessed visually using histograms and statistically using the Kolmogorov-Smirnov test. Parametric tests were used for normally distributed variables, and non-parametric tests were applied for variables that did not show a normal distribution. For comparisons within dependent groups, the paired t-test or Wilcoxon signed-rank test was used, depending on the distribution. For comparisons between independent groups, the independent samples t-test or Mann-Whitney U test was applied. Categorical variables were compared using the chi-square test or Fisher's exact test, where appropriate. The multivariate model included macular status, presence of preoperative PVR, type of tamponade agent, duration of surgical delay, and preoperative lens status. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 226 patients who underwent PPV for RRD were included in the study. The mean age was 57.9±14.4 years (range: 18–92 years), with a male predominance of 67.7% (n=153). The mean duration of symptoms was 13.8±5.8 days. The preoperative ocular characteristics are presented in Table 1.

Intraoperative findings revealed that among the phakic patients, 88.3% underwent combined vitrectomy with cataract extraction, whereas 11.7% underwent lens-preserving PPV. The tamponade agents used included SO in 58.8% (n=133), C3F8 gas in 31.9% (n=72), and SF6 gas in 9.2% (n=21) of patients.

The mean postoperative BCVA was 1.0±0.6 logMAR, representing a statistically significant improvement compared with the preoperative BCVA of 1.8±0.7 logMAR (p<0.001). When the influence of preoperative and intraoperative characteristics on changes in postoperative BCVA was analyzed, preoperative BCVA was an independent predictor of postoperative BCVA according to linear regression analysis (β=0.185, p=0.003; R^2=0.039). Patients with macula-off RRD demonstrated substantially less improvement in BCVA from the preoperative baseline compared with those with macula-on RRD (p=0.044). Patients who underwent surgery within 7 days of symptom onset demonstrated significantly better mean visual improvement than those operated on after day 7 (p=0.030) (Table 2). Furthermore, the mean visual improvement was markedly lower in the PVR group compared with the non-

Table 1. The preoperative ocular characteristics of patients.

Characteristic	Category	Number of Patients (n)	Percentage (%)
BCVA (logMAR, Mean±SD)	1.8±0.7	226	—
IOP (mmHg, Mean±SD)	13.9± 3.9	226	—
Macular Status	Macula-off	173	76.5
	Macula-on	53	23.5
The presence of PVR	Present	58	25.7
	Absent	168	74.3

BCVA: Best-corrected visual acuity; logMAR: Logarithm of the minimum angle of resolution; IOP: Intraocular pressure; PVR: Proliferative vitreoretinopathy.

Table 2. Visual acuity outcomes stratified by preoperative and ıntraoperative variables

Factor	Category	n	Preoperative BCVA (logMAR, Mean±SD)	Postoperative BCVA (logMAR, Mean±SD)	Mean Improvement (ΔlogMAR)	p-value
Macular status	Macula-off	173	1.90±0.70	1.10±0.70	0.80	p=0.044
	Macula-on	53	1.50±0.60	0.80±0.49	0.70	
Preoperative PVR	Absent	168	1.83±0.74	0.87±0.04	0.92±0.06	p<0.001
	Present	58	2.15±0.54	1.50±0.10	0.62±0.12	
Combined cataract surgery	Performed	128	1.92±0.70	1.04±0.60	0.88	p=0.917
	Not Performed	17	1.86±0.65	1.10±0.65	0.76	
Tamponade	Silicone Oil	133	1.94±0.06	1.20±0.06	0.74±0.07	p=0.043
	C3F8 Gas	72	1.83±0.08	0.81±0.06	1.00±0.10	
	SF6 Gas	21	1.74±0.17	0.72±0.09	1.02±0.13	
Duration of symptoms	<7 days	93	1.91±0.7	0.90±0.58	1.01±0.85	p=0.030
	>7 days	63	1.83±0.7	1.14±0.7	0.68±0.88	

BCVA: Best-corrected visual acuity; logMAR: Logarithm of the minimum angle of resolution; IOP: İntraocular pressure; PVR: Proliferative vitreoretinopathy; C3F8: Perfluoropropane; SF6: Sulfur hexafluoride.

PVR group (p=0.046). Postoperative visual improvement varied according to the type of intravitreal tamponade; patients receiving C3F8 gas tamponade demonstrated significantly greater visual improvement than those receiving other tamponades (p=0.043). No significant difference in visual outcomes was observed between patients undergoing combined cataract surgery and those with lens preservation (p=0.917) (Table 2).

Additionally, the mean postoperative IOP was 15.3±3.9 mmHg, with a statistically significant change compared with preoperative measurements (13.9±3.9 mmHg) (p<0.001). No significant difference in final visual acuity was observed between patients with and without elevated IOP postoperatively (logMAR 1.01±0.6 vs. 1.04±0.6; p=0.917). All patients with elevated IOP (>21 mmHg) received antiglaucomatous treatment and were monitored throughout follow-up, remaining stable under medical therapy. Antiglaucomatous medication was required in 17.3% of patients (n=39), predominantly in the SO group (n=30; p=0.023).

Recurrent RD was observed in 18.6% (n=42) of the patients. The recurrence rate of RD was significantly higher in patients with preoperative PVR (39.7%, 23/58) than in

Table 3. Multivariable logistic regression analysis of preoperative factors associated with recurrence

Variable	Univariate Analysis p value	Multivariable OR (Exp(B))	95% CI	p value
Macular status	0.815	1.46	Not significant	0.471
Preoperative PVR	0.002	3.44	(approx. 1.2–9.8)*	0.023
Duration of syptoms	0.108	1.03	Not significant	0.953
Tamponade type	0.077	0.81	Not significant	0.338

PVR: Proliferative vitreoretinopathy.

those without PVR (11.3%, 19/168) (p<0.01). Multivariate logistic regression analysis identified preoperative PVR as an independent risk factor for recurrence (OR=3.44, p=0.023), whereas macular status, type of intravitreal tamponade, and duration of symptoms were not significantly associated with recurrence (Table 3).

DISCUSSION

Rhegmatogenous retinal detachment is an ophthalmic emergency that can cause irreversible, severe vision loss without prompt and appropriate intervention. Although advances in surgical techniques and intraoperative technology have produced high anatomical reattachment rates, these successes do not always translate into satisfactory functional recovery.[7] RRD represents a significant public health concern, particularly within the studied populations, due to its association with reduced life expectancy, loss of workforce productivity, and increased healthcare burden. Consequently, it is essential not only to achieve anatomical retinal reattachment after RRD surgery but also to assess and optimize long-term visual prognosis. This study, which examines the influence of preoperative, intraoperative, and postoperative factors on visual outcomes, is important for improving patient management and attaining more predictable functional results.

Comprehensive evidence from the literature consistently indicates that preoperative visual acuity plays a decisive role in postoperative visual outcomes following RRD surgery. Williamson et al.[8] emphasized a strong positive correlation between initial visual acuity and final outcome, reporting that better preoperative vision was associated with a more favorable postoperative prognosis. Benda et al.[9] emphasized that this parameter has the highest predictive value statistically compared with many other clinical variables. The primary explanation for this strong association is that poor preoperative vision often reflects macular involvement (macula-off), prolonged symptom duration, or advanced-stage PVR and is therefore linked with multiple concomitant risk factors.[10] Consistent with the literature, our results confirm that preoperative BCVA is an independent predictor of final functional success.

One of the most important determinants of functional success in RRD surgery is preoperative macular status. Separation of the neurosensory retina from the RPE is known to induce irreversible photoreceptor damage and apoptosis, particularly affecting the outer segments in macula-off RRD, leading to a detrimental effect on visual function.[11] In addition, large-scale studies by Altındal et al.[12] and Murtagh et al.[13] demonstrated that visual outcomes in macula-on cases are significantly superior to those observed in the macula-off group. In our study, consistent with previous reports, patients with macula-on status had a more favorable visual prognosis, likely attributable to preservation of the foveal photoreceptor layer.

Several studies have investigated the relationship between symptom duration and final visual outcomes following surgical repair, with many demonstrating the beneficial effects of early surgical intervention on postoperative visual acuity.[14,15] Chatziralli et al.[16] reported that RD persisting for more than one week was associated with poor visual outcomes after surgery. Similarly, Guner et al.[17] showed that patients who underwent surgery within seven days achieved significantly better visual acuity at all follow-up visits than those who underwent surgery later. Lee et al.[18] further emphasized the importance of early intervention by demonstrating a strong positive correlation between the duration of detachment and final visual acuity. Consistent with these findings, our study also demonstrated that early surgical intervention within 7 days was associated with significantly better postoperative visual outcomes. Performing surgery at an early stage allows intervention before the acceleration of photoreceptor atrophy and apoptotic processes, thereby increasing the likelihood of favorable visual recovery.

When examining the effect of preoperative PVR on postoperative BCVA, Chatziralli et al.[16] and Guner et al.[17] reported that the presence of preoperative PVR was an important prognostic factor for poor postoperative BCVA, whereas Lee et al.[18] demonstrated that final visual outcomes were significantly lower in cases with grade C or higher PVR. In contrast, Benda et al.[9] and Gopal et al.[19] reported that preoperative PVR did not have a decisive impact on visual outcomes., These discrepancies may be attributed to heterogeneity among study populations or to the masking effect of strong prognostic factors, such as preoperative BCVA and duration of detachment, on the impact of PVR. Accordingly, the findings of this study support the widely held view that retinal traction and cellular damage caused by PVR limit functional recovery.[20]

Poulsen et al.,[21] Baba et al.,[22] and Park et al.[23] examined the effect of intraoperative tamponade on postoperative visual acuity and found that SO was associated with poorer visual outcomes. Conversely, other studies, including those by Chatziralli et al.,[16] Gopal et al.,[19] and Geiger et al.,[24] reported that the type of tamponade did not significantly affect visual recovery. In our study, patients treated with C3F8 tamponade achieved better final BCVA than those treated with SO tamponade. This finding may be attributed to selection bias, as SO is often used in more complex cases with a higher risk of PVR, the potential long-term toxic effects of prolonged SO tamponade on the retina, and additional damage caused by secondary surgeries required for SO removal.[25]

An additional factor that may influence visual prognosis following RRD surgery is elevated IOP.[26] In a systematic review and meta-analysis by Aflitto et al.,[27] PPV was identified as a risk factor for intraocular hypertension (IOH) and glaucoma. In our study, IOP elevation was observed in 17% of patients; however, this increase did not adversely affect visual prognosis. We attribute this outcome to the early detection of IOP elevation in patients and the efficacy of their treatment and follow-up. Barth et al.,[28] on the other hand, specifically noted that IOP was higher in

eyes with SO tamponade compared with those with gas tamponade. This can be attributed to the physicochemical and biomechanical properties of SO tamponade.[25] Similarly, in this study, the number of patients who developed elevated IOP and were started on antiglaucomatous treatment was higher in the silicone group.

In addition to elevated IOP following RD surgery, another potential complication is the recurrence of RD. The literature consistently identifies PVR as a significant risk factor for recurrence. PVR is characterized by the proliferation and contraction of fibrous membranes on the retinal surface, leading to recurrent RD through tractional or combined tractional-rhegmatogenous mechanisms.[29] Multivariate analysis by Tawfik et al.[30] demonstrated the significant impact of PVR on recurrence, with an odds ratio (OR) of 8.42. Similarly, Ambiya et al.[31] emphasized that the risk of recurrence is notably higher in the presence of grade C or more severe PVR. In contrast, Irigoyen et al.[32] did not find a significant association between PVR and recurrence in their study. This discrepancy may be attributed to the low prevalence of PVR in their cohort and the inclusion of patients at all PVR stages. In our study, we identified PVR as the only independent risk factor for recurrent RD. This finding is likely associated with the specific inclusion of only patients with grade C or higher PVR and the resulting PVR prevalence rate (25%) in our study population.

This study had several limitations that should be considered when interpreting the results. First, it was a retrospective study with a short follow-up period. Detailed anatomical descriptors, such as retinal break characteristics and the extent of detachment, were not consistently recorded in the clinical charts. Tamponade selection and intraoperative variations were based on the surgeon's preference rather than a standardized protocol, which may have influenced postoperative outcomes.

CONCLUSION

This study highlights that visual and anatomical outcomes after pars plana vitrectomy for rhegmatogenous retinal detachment are primarily determined by preoperative macular status, timing of surgery, and the presence of proliferative vitreoretinopathy. In particular, proliferative vitreoretinopathy emerged as the strongest predictor of both poor functional recovery and retinal detachment recurrence. These findings underscore the clinical importance of early diagnosis, timely surgical intervention, and careful risk stratification to optimize postoperative outcomes and reduce the likelihood of recurrence. Prospective studies with longer follow-up periods and standardized surgical protocols are warranted to further refine prognostic models and guide evidence-based clinical decision-making.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (Date: 27.08.2025, Decision No: 2025/010.99/19/8).

Informed Consent

Written informed consents were obtained from patients who participated in this study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: G.A., I.K.K., E.T.K.; Design: G.A., I.K.K., E.T.K., U.K.; Supervision: G.A., U.K., I.K.K.; Materials: G.A., U.K., I.K.K., D.C.Y., K.B., H.S.K.; Data Collection and/or Processing: E.T.K., D.C.Y., K.B.; Analysis and/or Interpretation: I.K.K., U.K., H.S.K.; Literature Search: G.A., U.K., E.T.K.; Writing: G.A., U.K., E.T.K., I.K.K.; Critical Reviews: G.A., U.K.

Conflict of Interest

The author declare that there is no conflict of interest.

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Regmatojenöz Retina Dekolmanında Pars Plana Vitrektomi Sonrası Görsel ve Anatomik Sonuçları Etkileyen Klinik ve Cerrahi Öngördürücüler

Amaç: Bu çalışmanın amacı, regmatojenöz retina dekolmanı (RRD) nedeniyle pars plana vitrektomi (PPV) uygulanan hastalarda görsel sonuçları ve nüks oranlarını etkileyen klinik ve cerrahi faktörleri araştırmaktır.

Gereç ve Yöntem: Bu retrospektif çalışmaya, Türkiye'de üçüncü basamak bir merkezde 2022-2024 yılları arasında RRD nedeniyle PPV uygulanan 226 hasta dâhil edildi. Hastaların demografik özellikleri, semptom süresi, maküla durumu, proliferatif vitreoretinopati (PVR) varlığı, kullanılan tamponad tipi, ameliyat öncesi ve sonrası en iyi düzeltilmiş görme keskinliği (EDGK), göz içi basıncı (GİB) ve retina dekolmanı nüks oranları analiz edildi.

Bulgular: Hastaların ortalama yaşı 57.9±14.4 yıl olup, %67.7'si erkekti. Olguların %76.5'i maküla-off, %25.7'sinde PVR mevcuttu. Ortalama EDGK, 1.8±0.7 logMAR'dan 1.0±0.6 logMAR'a anlamlı düzeyde iyileşti ($p<0.001$) ve ameliyat öncesi EDGK, ameliyat sonrası EDGK'nın bağımsız bir öngördürücüsü olarak saptandı ($\beta=0.185$; $p=0.003$). Görsel iyileşme, maküla-off durumunda ($p=0.044$) ve preoperatif PVR varlığında ($p=0.046$) daha kötü; erken cerrahi (<7 gün; $p=0.030$) ve C3F8 tamponadı kullanılan olgularda ise daha iyi bulundu ($p=0.043$). Kombine katarakt cerrahisinin görsel sonuçlar üzerine anlamlı etkisi izlenmedi ($p=0.917$). Ortalama GİB'de hafif bir artış gözlendi (13.9±3.9'dan 15.3±3.9 mmHg'ya; $p<0.001$); hastaların %17.3'ünde antiglokomatöz tedavi gereksinimi ortaya çıktı ve bu durum silikon yağı tamponadı ile daha sık ilişkiliydi ($p=0.023$). Ancak GİB artışı nihai EDGK'yı etkilemedi ($p=0.917$). RRD nüksü %18.6 oranında görüldü ve PVR varlığında anlamlı olarak daha yüksekti (%39.7'ye karşı %11.3; $p<0.01$). Çok değişkenli analizde PVR, nüks için tek bağımsız öngördürücü olarak belirlendi (OR=3.44; $p=0.023$). Nüks oranı C3F8 tamponadı kullanılan hastalarda silikon yağına kıyasla daha düşüktü (%11.1'e karşı %24.1; $p=0.026$).

Sonuç: Bu bulgular, maküla bütünlüğünün korunmasının, cerrahi gecikmenin en aza indirilmesinin ve PVR'nin hem fonksiyonel iyileşme hem de nüks açısından temel bir belirleyici olarak tanınmasının, RRD için PPV sonrası sonuçların optimize edilmesinde kritik öneme sahip olduğunu göstermektedir.

Anahtar Sözcükler: Regmatojenöz retina dekolmanı; pars plana vitrektomi; görme keskinliği; nüks.

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Original Article

Demographic and Clinical Characteristics in Patients with Atrophic Gastritis: An Experience of Single Tertiary Center

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Keywords: Atrophic gastritis; demography; risk factors; symptoms.

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ABSTRACT

Objective: Atrophic gastritis (AG) is a progressive disease characterized by chronic inflammation of the gastric mucosa, glandular atrophy, and parietal cell loss. Clinically, AG may be asymptomatic or present with nonspecific symptoms. This study aimed to evaluate the demographic and clinical characteristics of patients with AG to improve diagnosis and management.

Methods: This retrospective study included 192 patients aged 18–65 years diagnosed with AG. Symptoms at initial presentation were analyzed. Gastrointestinal symptoms, including weakness, fatigue, abdominal pain, chest pain, bloating, diarrhea, constipation, reflux, nausea, vomiting, early satiety, dysphagia, and odynophagia, as well as non-gastrointestinal symptoms, such as forgetfulness, attention deficit, tongue fissures, angular cheilitis, skin lesions, bleeding, and generalized bone pain, were recorded.

Results: In this study, 111 patients (58.8%) were female, and the mean age was 50±19.0 years. Sixty patients (31.3%) were illiterate, and 147 (76.6%) were married. Thirty-nine patients (20.3%) smoked, and 3 (1.6%) consumed alcohol. Low income was observed in 162 patients (84.4%). Sixty-nine patients (35.9%) lived in rural areas, and 87 (45.3%) lived in both urban and rural areas. The most frequent complaints were weakness and fatigue in 147 patients (76.6%), epigastric pain in 147 (76.6%), and chest pain in 99 (51.6%).

Conclusion: This study shows that AG is more common in middle-aged and older individuals, women, and patients with low socioeconomic status. Early diagnosis and management are essential to prevent complications. The broad spectrum of symptoms highlights the need for a multidisciplinary approach.

INTRODUCTION

Atrophic gastritis (AG) is a progressive disorder characterized by chronic inflammation of the gastric mucosa, glandular atrophy, and loss of parietal cells. This condition can lead to impaired vitamin B12 absorption due to reduced gastric acid secretion (hypochlorhydria) and intrinsic factor deficiency, potentially resulting in severe complications such as pernicious anemia.[1] AG is commonly associated with two primary mechanisms: Helicobacter pylori (H. pylori) infection and autoimmune processes. H. pylori infection, which is particularly prevalent in developing countries, represents one of the most frequent causes of chronic gastritis. Prolonged infection may promote mucosal inflammation and glandular atrophy.[2] Autoimmune atrophic gastritis, in contrast, is generally linked to autoantibodies targeting parietal cells and intrinsic factor and occurs more often in women and in association with other autoimmune disorders.[3]

AG not only induces structural changes in the gastric mucosa but also serves as a significant risk factor for malignancies, including gastric cancer and gastric lymphoma, which remain leading causes of cancer-related mortality worldwide.[4,5] In addition, the disease has been associated with systemic effects, such as iron deficiency anemia, osteoporosis, and neurological disorders.[6] Clinically, AG is often asymptomatic or presents with nonspecific symptoms, such as epigastric pain, bloating, early satiety, and fatigue, which may delay diagnosis and lead to detection at advanced stages.[7]

The diagnosis and management of AG vary depending on the underlying etiology. Eradication of H. pylori infection can halt the progression of infection-related atrophic gastritis, whereas no specific treatment exists for

autoimmune gastritis, necessitating regular monitoring to prevent complications.[8] The present study aimed to provide a detailed evaluation of the demographic and clinical characteristics of patients with atrophic gastritis, thereby contributing to the understanding of diagnostic and therapeutic approaches for this condition.

MATERIALS AND METHODS

Patient Selection

The patients included in this study were those diagnosed and followed up at the Gastroenterology and Hepatology outpatient clinic of our hospital. The study was designed as a retrospective review. Among a total of 18,064 patients who visited our clinic between 2017 and 2025, 320 (1.77%) were diagnosed with atrophic gastritis (AG). For all patients diagnosed with AG, the diagnosis was confirmed histopathologically through upper gastrointestinal (GI) endoscopic biopsies performed when clinical or laboratory findings raised suspicion.[9] Patients who discontinued follow-up, had incomplete data, or were pregnant were excluded from the study. Ultimately, 192 patients aged 18–65 years with complete data, regular follow-up, and written informed consent were included.

Assessment of Demographic and Clinical Characteristics

Demographic and anthropometric characteristics, including age, sex, smoking and alcohol use, educational level, marital status, height, weight, and body mass index (BMI), were recorded for all patients. BMI was calculated using the following formula: weight (kg)/height² (m²). Patients were classified as underweight (BMI<18.5), normal weight (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), or obese (≥30 kg/m²).[10] Symptoms at the time of initial presentation were documented. All participants were evaluated for GI symptoms, including fatigue, abdominal pain, chest pain, bloating, diarrhea, constipation, reflux, nausea, vomiting, early satiety, dysphagia, and odynophagia.[11] In addition, the presence of non-GI symptoms, such as memory impairment, attention deficit, tongue fissures, angular cheilitis, skin lesions, bleeding complaints, and widespread bone pain, was recorded.

Ethical Statement

All participants provided written informed consent to participate in the study. The study protocol was approved by our hospital's Ethics Committee. All procedures were conducted in accordance with the ethical standards of our institutional human research committee and the Declaration of Helsinki.

Statistical Analysis

Statistical analyses were performed using NCSS (Number Cruncher Statistical System, NCSS, LLC, Kaysville, Utah, USA). Descriptive statistical methods, including mean, standard deviation, median, frequency, and percentage, were used to evaluate the study data.

RESULTS

A total of 192 patients aged 18–85 years diagnosed with AG were included in the study. Of these patients, 81 (42.2%) were male and 111 (58.8%) were female. The age range was 18–85 years, with a mean age of 50±19.0 years. Height and weight measurements were taken to calculate BMI. The mean height was 166.2±6.7 cm (range, 150–180 cm), and the mean weight was 67.3±14.7 kg (range, 40–

Table 1. Demographic characteristics of patients with atrophic gastritis

Variables	Mean±SS	Min-Max/Percentage
Age 50 ±19.0	18-85	
Gender		
Female	111	(57.8%)
Male	81	(42.2%)
Height (cm)	166.2±6.7	150 – 180
Weight (kg)	67.3±14.7	40 – 95
BMI	24.3±5.1	14 – 38.7
BMI		
Underweight	30	(15.6%)
Normal	78	(40.6%)
Overweight	60	(31.3%)
Obesity	24	(%12.5)
Educational status		
Illiterate	60	(31.3%)
Primary school	78	(40.6%)
High school	33	(17.2%)
University	21	(10.9%)
Marital Status		
Married	147	(76.6%)
Single	27	(14.1%)
Widowed	18	(9.4%)
Smoking		
Drinking	39	(20.3%)
Not drinking	99	(51.6%)
Quitting	45	(23.4%)
Passive smoker	9	(4.7%)
Alcohol consumption		
Drinks	3	(1.6%)
Does not drink	189	(98.4%)
Socioeconomic status		
Low	162	(84.4%)
Medium	24	(12.5%)
High	6	(3.1%)
Place of residence		
Rural	69	(35.9%)
City center	36	(18.8%)
Rural+city center	87	(45.3%)

Table 2. Initial presenting symptoms in patients with atrophic gastritis

Symptoms	Number-Percentage	Symptoms	Number-Percentage
Weakness-Fatigue	147 (76.6%)	Diarrhea	51 (26.6%)
Epigastric pain	147 (76.6%)	Gastrointestinal bleeding	42 (21.9%)
Chest pain	99 (51.6%)	Jaundice	0 (0.0%)
Bloating	120 (62.5%)	Ascites	0 (0.0%)
Nausea	63 (32.8%)	Reflux	93 (48.4%)
Vomiting	39 (20.3%)	Forgetfulness	111 (57.8%)
Early satiety	81 (42.2%)	Attention deficit	99 (51.6%)
Post-meal satiety	105 (54.7%)	Skin rash	39 (20.3%)
Dysphagia	51 (26.6%)	Cracked tongue	45 (23.4%)
Odinophagia	39 (20.3%)	Cracked corners of the mouth	60 (31.3%)
Constipation	81 (42.2%)	Widespread bone pain	111 (57.8%)

95 kg). The mean BMI was 24.3±5.1 (range, 14.0–38.7). Among the patients, 78 (40.6%) had a normal BMI, 30 (15.6%) were underweight, 60 (31.3%) were overweight, and 24 (12.5%) were obese.

Regarding educational status, 60 patients (31.3%) were illiterate, 78 (40.6%) had completed primary school, 33 (17.2%) were high school graduates, and 21 (10.9%) were university graduates. Marital status showed that 147 patients (76.6%) were married, 27 (14.1%) were single, and 18 (9.4%) were widowed. Regarding smoking status, 39 patients (20.3%) were current smokers, 99 (51.6%) had never smoked, 45 (23.4%) were former smokers, and 9 (4.7%) were passive smokers. Alcohol consumption was reported in 3 patients (1.6%), while 189 patients (98.4%) did not consume alcohol.

When evaluating economic status, 162 patients (84.4%) were classified as low-income, 24 (12.5%) as middle-income, and only 6 (3.1%) as high-income. Residential status indicated that 69 patients (35.9%) lived in rural areas, 36 (18.8%) in city centers, and 87 (45.3%) had residences in both urban and rural areas (Table 1).

Assessment of initial presenting symptoms revealed the presence of both GI and non-GI symptoms among the patients. Among patients with AG, 147 (76.6%) reported fatigue, 147 (76.6%) reported epigastric pain, 99 (51.6%) reported chest pain, 120 (62.5%) reported bloating, 63 (32.8%) reported nausea, 39 (20.3%) reported vomiting, 81 (42.2%) reported early satiety, 105 (54.7%) reported postprandial fullness, 51 (26.6%) reported dysphagia, 39 (20.3%) reported odynophagia, 81 (42.2%) reported constipation, 51 (26.6%) reported diarrhea, 42 (21.9%) reported GI bleeding, and 93 (48.4%) reported gastroesophageal reflux (Table 2).

Regarding non-gastrointestinal symptoms, 111 patients (57.8%) had memory impairment, 99 (51.6%) had attention deficits, 39 (20.3%) had skin rashes, 45 (23.4%) had tongue fissures, 60 (31.3%) had angular cheilitis, and 111 (57.8%) had widespread bone pain.

DISCUSSION

AG is a disorder characterized by chronic inflammation of the gastric mucosa, loss of glandular structure, and metaplasia. This condition is commonly associated with autoimmune mechanisms, environmental factors, and H. pylori infection.[12,13] In our study, the demographic and clinical characteristics of patients diagnosed with AG were retrospectively analyzed, yielding important insights into the clinical spectrum of the disease.

The majority of patients diagnosed with AG were women (58.8%). The higher prevalence of autoimmune diseases in women supports this finding.[14] The literature indicates that autoimmune gastritis is more common in women and that hormonal factors may contribute to this predisposition.[15] The mean age of 50±19 years suggests that AG occurs more frequently in middle-aged and older individuals, consistent with findings from other studies.[16] Among the patients, 40.6% had a normal BMI, indicating that AG is not directly associated with a specific BMI category, such as obesity or underweight. Furthermore, the relatively low obesity rate (12.5%) suggests no direct association between AG and metabolic syndrome.

Regarding socioeconomic factors, 31.3% of patients were illiterate, and 84.4% were classified as low-income, suggesting that AG may be more prevalent among individuals with lower socioeconomic status. This could be explained by the impact of low socioeconomic status on dietary habits, access to healthcare, and overall health.[17] The relatively high proportion of patients living in rural areas (35.9%) indicates that environmental factors and lifestyle may play a role in the development of AG. The literature reports that H. pylori infection is more common among individuals living in rural regions, representing an important risk factor for AG development.[18]

In our study, 76.6% of patients diagnosed with AG were married, 14.1% were single, and 9.4% were widowed. This may be related to married individuals having more regular access to healthcare, leading to more frequent diagnosis

of AG. The literature suggests that married individuals utilize healthcare services more frequently and may have an advantage in the early detection and management of chronic diseases.[19] Conversely, the lower prevalence of AG among widowed individuals may be linked to barriers in accessing healthcare. Widowed individuals may experience higher rates of depression and chronic stress, which have been proposed to contribute to the development of autoimmune diseases.[20] In addition, unhealthy lifestyle habits, which are more prevalent among widowed individuals, may play an indirect role in the development of AG.

The proportion of smokers among the patients was 20.3%, suggesting that smoking may be a risk factor for the development of AG. Smoking is known to increase inflammation in the gastric mucosa and impair mucosal healing.[21] Due to the very limited alcohol consumption in our region, evaluation was restricted; however, the literature indicates that alcohol intake may damage the gastric mucosa and contribute to the development of AG.[22]

Gastrointestinal symptoms, such as fatigue (76.6%), epigastric pain (76.6%), and bloating (62.5%), were observed in a large proportion of patients. These findings align with the literature, indicating that AG often presents with nonspecific symptoms, making diagnosis challenging.[23] Furthermore, neurological symptoms were noted in 57.8% of patients with memory impairment and 51.6% with attention deficits, which should be considered consequences of vitamin B12 deficiency associated with AG. This finding is consistent with pernicious anemia, which is commonly observed in the autoimmune form of AG.[1]

Strengths and Study Limitations

One of the strengths of this study is the inclusion of a large patient population. The data obtained from the patients included in the study provide an important dataset for understanding the demographic and clinical characteristics of AG. This extensive patient population allowed for the evaluation of the distribution of AG across different age groups, sexes, and socioeconomic levels. However, the study has several limitations. First, the retrospective design may increase the likelihood of incomplete or inaccurate data. Second, conducting the study at a single center limits the generalizability of the findings. Additionally, the lack of detailed data on the etiology of AG and the absence of information regarding long-term outcomes and complications are further limitations of the study.

CONCLUSION

The findings of our study indicate that AG is more frequently observed in middle-aged and older individuals, women, and those with lower socioeconomic status. In addition, AG can present with both gastrointestinal and non-gastrointestinal symptoms. Early diagnosis and management of AG are critical for preventing complications. Education and awareness programs may facilitate the early detection of AG, particularly among individuals with lower socioeconomic status. The broad spectrum of symptoms associated with AG underscores the importance of a multidisciplinary approach in the diagnosis and management of the disease.

Ethics Committee Approval

The study was approved by the Van Education and Research Hospital Hospital Ethics Committee (Date: 06.02.2023, Decision No: GOKAEK/2026/02/23).

Informed Consent

Written informed consents were obtained from patients who participated in this study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: A.O., I.K.; Design: A.O., I.K.; Supervision: A.O., I.K.; Resource: A.O., I.K.; Materials: A.O., I.K.; Data Collection and/or Processing: A.O., I.K.; Analysis and/or Interpretation: A.O., I.K.; Literature Search: A.O., I.K.; Writing: A.O., I.K.; Critical Reviews: A.O., I.K.

Conflict of Interest

The author declare that there is no conflict of interest.

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Atrofik Gastrit Hastalarında Demografik ve Klinik Özellikler: Tersiyer Sağlık Merkezinin Deneyimi

Amaç: Atrofik gastrit (AG), mide mukozasında kronik inflamasyon, glandüler atrofi ve paryetal hücre kaybı ile karakterize, ilerleyici bir hastalıktır. Klinik olarak, AG genellikle asemptomatik seyredebilir veya nonspesifik semptomlarla kendini gösterebilir. Bu çalışmada, AG hastalarının demografik ve klinik özellikleri detaylı bir şekilde incelenerek, hastalığın tanı ve tedavi süreçlerine katkı sağlanması amaçlanmıştır.

Gereç ve Yöntem: Çalışmamız retrospektik olarak tasarlanmış olup 18-85 yaş aralığında, AG tanısı konulan 192 hasta dahil edildi. Katılımcıların ilk başvuru anındaki semptomları analiz edildi. Hastalarda halsizlik, yorgunluk, karın ağrısı, göğüs ağrısı, şişkinlik, diare, konstipasyon, reflü, bulantı, kusma, erken doyma, disfaji, odinofaji gibi GİS semptomlarının dışında unutkanlık, dikkat eksikliği, dilde çatlama, ağız kenarında çatlama, cilt lezyonları varlığı, kanama şikayeti, yaygın kemik ağrısı varlığı kaydedildi.

Bulgular: Hastalardan 111'i (%58.8) kadın ve ortalama yaş 50±19.0 idi. Okur yazar olmayan hasta sayısı 60 (%31.3) iken, evli olanların sayısı 147 (%76.6) idi. Sigara kullanan hastaların sayısı 39 (%20.3) iken, alkol kullananların sayısı 3 (%1.6) idi. Hastaların 162 (%84.4)'si düşük gelirli iken, 69 (%35.9)'u kırsalda, 87 (%45.3)'si de hem şehir merkezi hem de kırsalda yaşamaktadır. AG tanılı hastalarda, sıklıkla halsizlik yorgunluk [147 (%76.6), epigastrik ağrı 147 (%76.6) ve göğüs ağrısı 99 (%51.6)] şikayetleri saptandı.

Sonuç: Çalışmamız, AG'nin genellikle orta yaş ve üzerindeki bireylerde, kadınlarda ve düşük sosyoekonomik düzeydeki bireylerde daha sık rastlandığını göstermektedir. AG'nin erken tanısı ve yönetimi, komplikasyonların önlenmesi açısından kritik öneme sahiptir. Bu açıdan AG'nin bu geniş semptom yelpazesi, hastalığın tanı ve yönetiminde multidisipliner bir yaklaşımın önemini vurgulamaktadır.

Anahtar Sözcükler: Atrofik gastrit; demografi; semptomlar; risk faktörleri.

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Original Article

Clinical Impact of Sinus Tract Diameter and Excision Volume on Postoperative Outcomes in Pilonidal Sinus Surgery

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Keywords: Drain placement; Excised specimen volume; Pilonidal sinus disease; Recurrence; Sinus tract diameter; Wound dehiscence.

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ABSTRACT

Objective: To evaluate the relationship between sinus tract diameter and excised specimen volume with postoperative complications and clinical outcomes in patients undergoing surgery for pilonidal sinus disease (PSD).

Methods: Data from 75 patients who underwent PSD surgery between October 2023 and January 2024 were retrospectively reviewed. Associations between tract diameter and excised volume with postoperative wound infection, wound dehiscence, drain placement, length of hospital stay, and recurrence were analyzed using non-parametric statistical methods.

Results: The median age was 24.5 years (IQR, 10), and 81.3% of the patients were male. Wound infection occurred in 14.7% and wound dehiscence in 41.3%. A significant moderate positive correlation was found between tract diameter and excised volume (Spearman ρ=0.441; p<0.001). Both parameters were higher in drained patients (diameter: p=0.002; volume: p=0.016). Wound dehiscence was more frequent in patients with larger tract diameters (p=0.003). BMI was positively associated with complex tract morphology (p=0.002). The recurrence rate was 1.3% at a median follow-up of 15 months (IQR, 9).

Conclusion: Tract diameter and excised volume provide quantifiable indicators of disease severity in PSD and correlate with postoperative outcomes. Larger tract diameter was associated with both wound dehiscence and intraoperative drain use. The low recurrence rate observed is consistent with published outcomes for off-midline surgical techniques. Current evidence does not support routine placement of drains in PSD surgery.

INTRODUCTION

Pilonidal sinus disease (PSD) is an acquired condition of the natal cleft caused by the penetration of hair shafts into the skin and subcutaneous tissue, resulting in a cycle of chronic foreign-body inflammation. It may present acutely as a fluctuant abscess or follow a prolonged relapsing course lasting months to years.[1] Reported incidence varies substantially between countries, from approximately 26 per 100,000 in the United States to 48 per 100,000 in Germany.[1,2] The disease predominantly affects young adults aged 15-30 years, with males approximately 2.2 times more likely than females to be affected.[1] This results in considerable productivity loss and healthcare utilization in the working-age population.

Treatment decisions in PSD remain highly individualized, as no single approach has achieved universal acceptance. Surgical options range from open excision with secondary-intention healing to primary midline closure and off-midline flap techniques, including the Karydakis procedure, the Bascom cleft lift, and the Limberg rhomboid transposition flap. Established risk factors for disease development include obesity, hypertrichosis, prolonged sitting, local skin irritation, family history, and poor perineal hygiene.[3] While the recurrence advantage of off-midline closure techniques is well supported in the literature,[2] predictors of postoperative morbidity at the individual patient level remain poorly defined.

Despite being routinely available in operative pathology reports, morphological factors, such as maximum sinus

tract diameter and excised tissue volume, are rarely incorporated into clinical decision-making or outcome analyses. These measurements directly reflect the anatomical extent of disease, a dimension recognized as central to disease staging and surgical decision-making,[4] yet their utility as quantitative outcome predictors has not been systematically evaluated. We hypothesized that both parameters would correlate with clinically meaningful postoperative endpoints, including wound dehiscence, wound infection, and drain placement. The present study aimed to test this hypothesis in a retrospective cohort of 75 consecutive patients treated at a single institution.

MATERIALS AND METHODS

Study Design and Patient Selection

This was a single-center, retrospective, observational cohort study. All consecutive patients who underwent elective surgical treatment for PSD at our institution between October 2023 and January 2024 were screened for inclusion. Patients were eligible if they were aged 18 years or older, had no systemic comorbidities, were non-smokers, had undergone surgical excision for primary PSD, had an available and interpretable pathology report, and had complete clinical and postoperative follow-up data. Patients younger than 18 years, those with systemic comorbidities, active smokers, and those with incomplete clinical or pathological records were excluded. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the local ethics committee (approval number: 160/2025). Given the retrospective observational design, individual patient consent was waived.

Data Collection

Demographic and clinical variables were retrieved from the institutional electronic medical records. Recorded variables included age, sex, body mass index (BMI, kg/m²), disease type (primary or recurrent), operative technique (Karydakis flap, primary midline closure, Bascom cleft lift, Limberg rhomboid flap, or lay-open), drain placement (yes/no), presence of complex sinus tract morphology (yes/no), postoperative wound infection, wound dehiscence, length of hospital stay, recurrence, and total follow-up duration. Two quantitative parameters were prespecified as surrogates of disease severity: sinus tract diameter (mm), defined as the maximum diameter of the excised sinus tract as documented in the formal pathology report, and excised specimen volume (cm³), defined as the total volume of the resected tissue.

Surgical Technique

All procedures were performed under general or spinal anesthesia. The choice of closure technique and the intraoperative decision to place a drain were made at the attending surgeon's discretion based on wound geometry, disease extent, and the complexity of the sinus tract as assessed intraoperatively. All patients received 2 g of intravenous cefazolin as perioperative antibiotic prophylaxis.

Outcome Definitions

Postoperative wound infection was defined as purulent discharge from the operative site requiring antibiotic therapy or wound re-exploration within 30 days of the index procedure, as documented in the clinical record. Wound dehiscence was defined as partial or complete disruption of the surgical closure in the absence of overt infection, identified on clinical examination at a follow-up visit. Recurrence was defined as the reappearance of PSD symptoms and clinical or radiological signs at or adjacent to the operative site after a documented disease-free interval, confirmed at outpatient review or by telephone interview. Follow-up duration was calculated in months from the date of surgery to the date of last patient contact.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Normality was assessed using the Shapiro–Wilk test; all continuous variables deviated significantly from normality; therefore, non-parametric methods were applied throughout. Continuous variables are presented as median and interquartile range (IQR), and categorical variables as absolute frequencies and percentages. Between-group comparisons of continuous variables were performed using the Mann–Whitney U test. Associations between categorical variables were evaluated using the Pearson chi-square test, Fisher's exact test, or the Monte Carlo simulation-based Fisher–Freeman–Halton exact test, as appropriate. Correlations between continuous variables were quantified using Spearman's rank correlation coefficient (ρ). Ordinal trends were assessed with the linear-by-linear association chi-square test. One extreme outlier in the excised specimen volume distribution was excluded from volume-related analyses; all remaining analyses were conducted on the complete cohort. Statistical significance was defined as $p<0.05$ (two-tailed).

RESULTS

A total of 75 patients were included in the analysis. The median age was 24.5 years (IQR, 10; mean±SD, 26.5±7.6), and 61 patients (81.3%) were male. The median BMI was 26.1 kg/m² (IQR, 3.8; mean, 26.3±3.6 kg/m²). BMI data were unavailable for 11 patients (14.7%), and all BMI-related analyses were restricted to the 64 patients with complete data. Seventy-four patients (98.7%) had primary PSD, and one patient (1.3%) had recurrent disease. The most frequently performed procedure was the Karydakis flap (38.7%), followed by primary closure (37.3%) and the Bascom cleft lift (18.7%). Limberg flap and lay-open techniques were each performed in two patients (2.7%). Patient characteristics are summarized in Table 1.

Postoperative wound infection developed in 11 patients

Table 1. Baseline demographic and clinical characteristics of the study population (n=75).

Variable	Value n (%)
Age (years), median (IQR)*	24.5 (10)
Body mass index (kg/m²), median (IQR)*†	26.1 (3.8)
Sex, n (%)	
Male	61 (81.3)
Female	14 (18.7)
Disease presentation, n (%)	
Primary	74 (98.7)
Recurrent	1 (1.3)
Surgical technique, n (%)	
Karydakis flap	29 (38.7)
Primary closure	28 (37.3)
Bascom cleft lift	14 (18.7)
Limberg flap	2 (2.7)
Lay open	2 (2.7)
Sinus tract diameter (mm), median (IQR)*	20.0 (20.0)
Excised specimen volume (cm³), median (IQR)*	39.8 (67.5)
Drain placement, n (%)	
Yes	55 (73.3)
No	20 (26.7)
Complex sinus tract, n (%)	
Yes	3 (4.0)
No	72 (96.0)
Postoperative wound infection, n (%)	
Yes	11 (14.7)
No	64 (85.3)
Wound dehiscence, n (%)	
Yes	31 (41.3)
No	44 (58.7)
Hospital length of stay (days), median (IQR)*	1 (0)
Follow-up duration (months), median (IQR)*	15 (9)

Continuous variables are presented as median (interquartile range, IQR), reflecting the non-normal distribution confirmed by the Shapiro–Wilk test. Categorical variables are presented as number (%). †BMI data were missing in 11 patients (14.7%); BMI-related analyses were restricted to the 64 patients with available data.

(14.7%) and wound dehiscence in 31 (41.3%). The mean hospital stay was 1.25±0.87 days (median, 1 day; IQR, 0). Over a median follow-up of 15 months (IQR, 9 months), recurrence was documented in 1 patient (1.3%).

One extreme outlier in the excised volume distribution was identified and excluded from volume-specific analyses. Spearman correlation analysis demonstrated a statistically significant moderate positive relationship between sinus tract diameter and excised specimen volume (ρ=0.441; p<0.001).

Regarding excised specimen volume, patients with drainage had significantly higher values than those without drainage (mean rank, 41.76 vs. 27.65; p=0.016). Volume showed no significant association with wound infection (p=0.879), wound dehiscence (p=0.102), complex sinus tract morphology (p=0.565), sex (p>0.05), or recurrence (p=0.357).

Sinus tract diameter was also significantly greater in drained patients than in undrained patients (mean rank, 42.60 vs. 25.35; p=0.002). Patients who developed wound dehiscence had significantly larger tract diameters than those who did not (mean rank, 47.00 vs. 31.66; p=0.003). No significant associations were found between tract diameter and wound infection (p=0.093), complex tract morphology (p=0.497), sex (p=0.338), or recurrence (p=0.448).

Cross-tabulation analyses showed that drain placement was significantly associated with wound dehiscence (χ^2=5.119; p=0.024) but not with wound infection (Fisher's exact p=1.000). A significant positive linear trend was observed between BMI and complex sinus tract morphology (p=0.002). BMI showed no significant associations with wound infection, wound dehiscence, drain placement, or hospital stay (Spearman ρ_s=0.180; p=0.156). Sex was not significantly associated with any postoperative outcome. Given that only 1 recurrence was observed, statistical analyses involving recurrence were of limited inferential value. Detailed results are presented in Table 2.

DISCUSSION

This retrospective single-center study examined sinus tract diameter and excised specimen volume as quantitative indicators of disease severity in PSD. Both parameters were significantly higher in patients who required intraoperative drain placement, and tract diameter was independently associated with postoperative wound dehiscence. These findings suggest that morphological measurements routinely documented in pathology reports may carry clinically relevant prognostic information that is currently underutilized.

The demographic profile of our cohort was consistent with the established epidemiology of PSD. The median age of 24.5 years aligns closely with the values reported by Søndenaa et al.,[1] who recorded a median presentation age of 21 years in males and 19 years in females in their 322-patient series, and with the mean age of 27.1 years in Maclean et al.[5] multicenter Australian cohort. In a systematic review and meta-analysis of more than 88,000 patients, Oetzmann von Sochaczewski et al.[6] found that 5-year recurrence rates in young adults (18–21 years) were similar to those in older adults, supporting the use of standard surgical protocols in this age group. The male predominance of 81.3% in our series is consistent with ratios of 2–3:1 reported by Mahmood et al.[7] and with the 79.7% male proportion in Maclean et al.[5] 774-patient multicenter cohort. Aysan et al.[3] identified male sex as an independent epidemiological risk factor for PSD in autopsy-based prevalence data.

The significant positive linear association between BMI and complex sinus tract morphology (p=0.002) observed

Table 2. Associations between sinus tract diameter and excised specimen volume with clinical and postoperative variables

Clinical variable	Tract diameter (mm) Mean rank	p	Excised volume (cm³) Mean rank	p
Drain placement				
No (n=20)	25.35	0.002	27.65	0.016
Yes (n=55)	42.60		41.76	
Wound dehiscence				
Absent (n=44)	31.66	0.003	34.13	0.102
Present (n=31)	47.00		43.50	
Wound infection				
Absent (n=64)	36.26	0.093	38.22	0.879
Present (n=11)	48.14		36.73	
Complex sinus tract				
Absent (n=72)	38.35	0.497	38.31	0.565
Present (n=3)	29.67		30.50	

Between-group comparisons were performed using the Mann–Whitney U test. Statistically significant p values ($p<0.05$) are shown in bold. Analyses for excised volume excluded one outlier. Recurrence analyses were of limited statistical power due to the single event.

in our study is consistent with prior reports.[3,5] Increased natal cleft depth, impaired local tissue perfusion, and greater mechanical shear forces in overweight individuals may collectively promote more extensive tract formation. In clinical practice, patients with elevated BMI may benefit from individualized preoperative planning, with particular attention to tension-free wound closure and perioperative tissue oxygenation.

Our wound infection rate of 14.7% falls within the range reported in the literature for excision-based procedures. In a 160-patient retrospective study, Alptekin et al.[8] reported an SSI rate of 11.9% and identified excised specimen volume as an independent predictor of wound infection on multivariate logistic regression (OR, 18.78; 95% CI, 2.38–148.10). Although a directionally consistent trend was observed in our data, statistical significance was not reached, likely due to limited power. Iesalnieks and Ommer noted that wound complication rates following midline closure range from 14% to 74% across published series, illustrating the substantial influence of technique selection.[2] The higher infection rate of 28.8% reported by Maclean et al.[5] may reflect the heterogeneous surgical practices inherent to a multicenter study design.

The wound dehiscence rate of 41.3% in our series requires contextual interpretation. In a cohort of grade IV (complicated) PSD patients, Güneş and Teke reported dehiscence rates of 45.5% and 13.6% following Karydakis and Limberg procedures, respectively ($p=0.021$).[9] Imam et al.[10] documented a rate of 38.1% after the Bascom cleft lift, and Maclean et al.[5] reported 28.4% across their multicenter cohort. Given that 73.3% of our patients received a drain, reflecting greater disease complexity, a dehiscence rate in this range is proportionate. The significant association between tract diameter and wound dehiscence ($p=0.003$) raises the possibility that preoperative or intraoperative measurement of tract diameter could serve as a practical risk stratification tool for wound healing outcomes.

The moderate positive correlation between sinus tract diameter and excised specimen volume ($\rho=0.441$; $p<0.001$) has not, to our knowledge, been directly quantified in prior PSD series. The moderate, rather than strong, magnitude of this correlation implies that additional morphological factors, such as tract branching, cavity depth, and involvement of surrounding tissue, contribute to total excision volume. Nevertheless, the strength of the correlation is sufficient to support the use of tract diameter as a single-measurement surrogate for overall disease extent in settings where volumetric specimen assessment is not routinely performed. The median excised volume in our series (39.8 cm³) was considerably higher than the 18.3 cm³ reported by Gümüşoğlu and Ertürk for Limberg flap patients,[11] denoting a greater average disease burden in our cohort.

Drain placement in 73.3% of patients, with both tract diameter and excised volume significantly higher in drained cases, reflects a practice driven by intraoperative assessment of disease extent rather than a fixed protocol. The association between drain use and wound dehiscence ($p=0.024$) is most likely attributable to confounding by disease severity, as both drain placement and dehiscence were more frequent in patients with larger, more complex lesions. This interpretation is supported by the wider evidence base. In a prospective randomized trial, Erdem et al.[12] found no significant differences in early wound complications or recurrence between drained and undrained Limberg flap patients but reported a significantly longer hospital stay in the drain group ($p<0.001$). A meta-analysis by Milone et al.[13] of 1,252 patients similarly concluded that drainage did not significantly reduce wound infection (OR, 0.71) or recurrence (OR, 0.80). Imam et al.[10] advocated selective rather than routine drainage to minimize cost and infectious risk, and Maclean et al.[5] reported significantly higher dehiscence rates among patients who were drained ($p=0.005$). Taken together, these data do not

support the routine use of closed-suction drainage in PSD surgery.

The recurrence rate of 1.3% at a median follow-up of 15 months is consistent with short-term outcomes reported for off-midline closure techniques. Iesalnieks and Ommer cited recurrence rates of 1.4%, 4.5%, and 11% for off-midline closure, open healing, and midline closure, respectively.[2] Mahmood et al.[7] reported 5-year recurrence rates of 10%, 16.8%, and 17.9% for these respective approaches. In a met a-analysis of 18 randomized controlled trials, McCallum et al.[14] estimated that off-midline closure reduces the risk of recurrence approximately fivefold compared with midline closure (Peto OR, 4.95; 95% CI, 2.18–11.24). However, a follow-up of 15 months is insufficient to characterize long-term recurrence patterns. Karita et al.[15] reported a recurrence rate of 14.5% at a median follow-up of 5.2 years following laser ablation, and Stauffer et al.[16] meta-analysis of more than 89,000 patients documented a consistent positive relationship between follow-up duration and reported recurrence rates. This recurrence figure should therefore be interpreted as a preliminary estimate.

Several limitations of this study should be acknowledged. The retrospective, single-center design introduces potential selection and ascertainment bias that cannot be fully accounted for. The cohort size of 75 patients, although adequate for exploratory analyses, limited statistical power for certain endpoint-specific comparisons, as reflected by the non-significant trend between excised volume and wound infection. Incomplete BMI data in 14.7% of patients restrict the generalizability of obesity-related findings. A median follow-up of 15 months is insufficient for reliable long-term recurrence estimation, for which a minimum of 5 years is generally recommended.[15] Finally, the observational design precludes causal inference, and residual confounding by unmeasured variables cannot be excluded.

CONCLUSION

In this retrospective cohort of 75 patients, sinus tract diameter and excised specimen volume emerged as clinically informative quantitative indicators of disease severity in PSD. Tract diameter was significantly associated with postoperative wound dehiscence and correlated with intraoperative decisions regarding drain placement, suggesting its potential utility as a preoperative risk stratification parameter. The significant positive correlation between tract diameter and excised volume supports the use of diameter as a practical surrogate for overall disease burden. The observed recurrence rate of 1.3% at 15 months is concordant with published short-term data for off-midline surgical techniques. The available evidence, including the present findings, does not support the routine use of drains in PSD surgery. Prospective multicenter studies with standardized morphological measurement protocols and extended follow-up are needed to establish evidence-based thresholds and validate these findings across different surgical settings.

Ethics Committee Approval

The study was approved by the University of Health Sciences, Gaziantep City Hospital Ethics Committee (Date: 19.02.2025, Decision No: 160/2025).

Informed Consent

Written informed consents were obtained from patients who participated in this study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: B.G.; Design: B.G.; Supervision: E.T.; Materials: B.G.; Data Collection and/or Processing: M.E.U.; Analysis and/or Interpretation: B.G.; Literature Search: S.Y.; Writing: B.G.; Critical Reviews: E.T.

Conflict of Interest

The author declare that there is no conflict of interest.

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Pilonidal Sinüs Cerrahisinde Sinüs Trakt Çapı ve Eksizyon Hacminin Postoperatif Sonuçlara Klinik Etkisi

Amaç: Pilonidal sinüs hastalığı (PSH) cerrahisi geçiren hastalarda sinüs trakt çapı ve eksize edilen doku hacminin postoperatif komplikasyonlar ve klinik sonuçlarla ilişkisini değerlendirmek.

Gereç ve Yöntem: Ekim 2023-Ocak 2024 tarihleri arasında PSH cerrahisi uygulanan 75 hastanın verileri retrospektif olarak incelendi. Trakt çapı ve eksize edilen hacmin postoperatif yara enfeksiyonu, yara ayrışması, dren yerleştirilmesi, hastanede yatış süresi ve nüks ile ilişkileri parametrik olmayan istatistiksel yöntemlerle analiz edildi.

Bulgular: Medyan yaş 24.5 yıl (IQR 10) olup hastaların %81.3'ü erkekti. Yara enfeksiyonu %14.7, yara ayrışması %41.3 oranında görüldü. Trakt çapı ile eksize edilen hacim arasında istatistiksel olarak anlamlı orta düzeyde pozitif korelasyon saptandı (Spearman ρ=0.441; p<0.001). Her iki parametre dren uygulanan hastalarda daha yüksekti (çap: p=0.002; hacim: p=0.016). Daha büyük trakt çapına sahip hastalarda yara ayrışması daha sık gözlemlendi (p=0.003). VKİ ile kompleks trakt morfolojisi arasında pozitif bir doğrusal ilişki saptandı (p=0.002). Medyan 15 aylık takip süresinde nüks oranı %1.3 olarak belirlendi.

Sonuç: Trakt çapı ve eksize edilen hacim, PSH'de hastalık şiddetinin ölçülebilir göstergeleri olup postoperatif sonuçlarla ilişkilidir. Daha büyük trakt çapı hem yara ayrışması hem de intraoperatif dren kullanımı ile ilişkili bulunmuştur. Gözlemlenen düşük nüks oranı, orta hat dışı cerrahi teknikler için yayımlanan kısa dönem sonuçlarıyla uyumludur. Mevcut kanıtlar, PSH cerrahisinde rutin dren kullanımını desteklememektedir.

Anahtar Sözcükler: Dren yerleştirme; eksize edilen doku hacmi; nüks; pilonidal sinüs hastalığı; sinüs trakt çapı; yara ayrışması.

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Research Article

The Effect of Weather on Lung Tomography Findings of COVID-19

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ABSTRACT

Objective: We aimed to evaluate the influence of meteorological parameters (air temperature, wind speed, and relative humidity) on lung involvement in patients with COVID-19.

Methods: This retrospective, single-center study was conducted between July 14, 2020, and August 31, 2020. We included patients aged between 18 and 65 years who had no chronic diseases and resided within the borders of Ankara province. Air temperature, relative humidity, and wind speed data were included for the last 5 days before the PCR test sample was obtained. We used the Computed Tomography Severity Score and the percentage of diseased lung involvement to examine lung involvement in COVID-19. Computed Tomography Severity Scores were calculated by an emergency medicine physician who examined the CT scans of the patients included in the study. Diseased lung rates on thoracic CT were calculated using the program Aquilion 4.7-Thoracic VCAR, General Electric, USA.

Results: A total of 283 patients were included in the study. Of these patients, 177 (62.5%) were male, and 106 (37.5%) were female. In total, 272 patients (92.1%) lived in central districts, and 11 (3.9%) lived in non-central districts. There was no statistically significant difference in air temperature, relative humidity, or wind speed according to the percentage of diseased lung involvement or Computed Tomography Severity Scores.

Conclusion: In our study, neither the Computed Tomography Severity Score nor the lung involvement rate showed a statistically significant association with meteorological parameters. We selected the summer months, when the population spends more time outdoors, because we aimed to better evaluate the effect of meteorological parameters on lung involvement; however, we found that limited changes in air temperature, humidity, and wind speed did not affect lung involvement. In the future, multicenter studies can be conducted in geographical regions with different meteorological data during the same season.

INTRODUCTION

In Wuhan, the capital of China's Hubei province, in December 2019, multiple patients presented to hospitals with complaints of severe cough, fever, shortness of breath, and weakness. By the end of December 2019, China had reported this infection as an epidemic to the World Health Organization (WHO). Later, on January 7, a new coronavirus was isolated and named 2019 novel coronavirus (2019-nCoV).[1] It was later renamed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by the WHO, and the clinical picture it caused was named coronavirus disease 2019 (COVID-19). After the epidemic was observed in 113 more countries, it was declared a pandemic by the WHO on March 11, 2020, the same date on which the first confirmed case was detected in Türkiye.[2]

COVID-19 can progress across a wide range of clinical presentations, from simple upper respiratory tract disease to severe respiratory failure. Pneumonia, multiple organ dysfunction syndrome (MODS), and even death may develop in severe cases.[2]

Reverse transcriptase polymerase chain reaction (RT-PCR) is routinely used in the diagnosis of COVID-19.[3] However, its negative predictive value is 40%-60%, and it may miss some patients.[4] On the other hand, COVID-19, which usually involves the lungs, can be diagnosed with computed tomography (CT) with high sensitivity.[5] This further increases the importance of CT.

Outbreaks of coronavirus have shown that the virus can be transmitted through the air or by direct contact with contaminated surfaces.[6] COVID-19, which is most commonly transmitted by droplets and affects the lungs, is also directly affected by the parameters that influence weather conditions. Studies have shown that the trans-

mission of severe acute respiratory syndrome virus (SARS-CoV-2003) and Middle East respiratory syndrome virus (MERS-CoV-2012), which belong to the same phylogenetic family and caused epidemics years ago, is also affected by weather parameters.[7,8] In these studies, the increase in MERS-CoV-2012 cases was associated with a decrease in temperature and humidity.[7] Similarly, it has been shown that there is an increase in the number of SARS-CoV-2003 cases at optimal temperature values (16°C-28°C) and an inverse correlation between relative humidity and the number of cases.[9] There are differences between studies regarding the incubation period of COVID-19. The Centers for Disease Control and Prevention (CDC) reports the incubation period as 4-5 days on average.[10] On the other hand, the WHO states that it takes 5-6 days on average.[11]

The aim of this study was to determine whether current meteorological parameters have an effect on lung involvement in patients diagnosed with COVID-19 pneumonia. We aimed to investigate the effects of relative humidity, air temperature, and wind speed on lung involvement in this disease.

MATERIALS AND METHODS

Our study was planned as a retrospective, single-center study and was conducted in a tertiary hospital that served as the central pandemic hospital during the pandemic period between July 14, 2020, and August 31, 2020. An average of 630,000 patients present to the Department of Emergency Medicine annually, and the patients in our study were selected from among those who presented to the emergency department with suspected COVID-19. Our study was conducted in accordance with the World Medical Association Declaration of Helsinki, and ethics committee approval was obtained from the Ankara City Hospital No. 1 Clinical Research Ethics Committee on January 13, 2021 (Ethics Committee Decision No: E2-21-33). The exclusion and inclusion criteria in our study are stated below.

Inclusion Criteria

18 years or older, 65 years or younger

COVID-19 PCR test positive

Patients residing in Ankara and not coming from outside the city

Patients whose first application to our hospital

Patients whose thorax CT was taken in our hospital.

CT findings typical for COVID-19

Exclusion Criteria

Pregnant women

Breastfeeding

Dispatched arrivals

Patients with chronic disease

Table 1. Computed tomography severity score

Lung lobe involvement (%)	Points
1-25%	1
26-50%	2
51-75%	3
76-100%	4

Mild (0-7 points). Moderate and severe (8-20 points).

The meteorological parameters included in our study (air temperature, relative humidity, and wind speed) for the last 5 days before the positive PCR sample was obtained were obtained from the Turkish Republic General Directorate of Meteorology. Meteorological data for Ankara and its districts were collected. We used two different scales to examine lung involvement. The first scale was the Computed Tomography Severity Score (CTSS) (Table 1). The second scale was the percentage of diseased lung involvement. CTSS scores were calculated by an emergency medicine physician who examined the CT scans of the patients included in the study. Diseased lung rates on thoracic CT were calculated using the program Aquilion 4.7-Thoracic VCAR, General Electric, USA. Less than 25% was accepted as mild disease, and 25% and above as moderate-to-severe disease. This calculation was made by an experienced radiology technician using the program.

Statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics 24). Findings were interpreted using frequency tables and descriptive statistics. Non-parametric methods were used for measured values that did not comply with normal distribution. To compare the measured values of two independent groups, the Mann-Whitney U test (Z-table value) method was used in accordance with non-parametric methods. Pearson χ^2 crosstabs were used to examine relationships between two qualitative variables. The p value was used for statistical significance, and $p<0.05$ was considered significant.

RESULTS

In our study, 7409 patients who presented to the emergency medicine clinic between July 14, 2020, and August 31, 2020, and whose PCR tests were positive were included. After the inclusion and exclusion criteria were examined, a total of 283 patients were included in the study. In the demographic feature analysis, the CT severity scores of the patients were examined according to age, sex, and place of residence.

Of our patients, 177 (62.5%) were male, and 106 (37.5%) were female. The mean age of the male patients was 44.84±11.89 years, and the mean age of the female patients was 45.57±10.73 years. The places where the patients lived were classified as central and non-central districts. The central districts were Altındağ (n=20), Çankaya

(n=56), Etimesgut (n=46), Gölbaşı (n=13), Keçiören (n=28), Mamak (n=32), Pursaklar (n=7), Sincan (n=43), and Yenimahalle (n=27). The non-central districts were defined as Bala (n=5), Çubuk (n=1), Güdül (n=1), Haymana (n=1), Kahramankazan (n=2), and Nallıhan (n=1). In total, 272 patients (92.1%) lived in central districts, and 11 (3.9%) lived in non-central districts. The relationship between CTSS and meteorological data is shown in Table 2.

There was no statistically significant difference in air temperature, relative humidity, or wind speed according to diseased lung ratio classes (p>0.05) (Table 3).

DISCUSSION

Within the scope of our study, we included patients aged 18–65 years who presented to the emergency department, whose lung computed tomography findings were interpreted as compatible with COVID-19 by the radiology clinic, and who did not have any additional diseases. Our purpose in choosing this method was to prevent chronic diseases from affecting the study results. In addition, the summer months were preferred as the study period. We thought that an aerosol-transmitted disease could be transmitted more frequently in closed environments during the colder months, independent of external meteorological data. We also thought that meteorological data would have a greater effect on contagion and lung involvement when patients spent more time outdoors. SARS-CoV-2 has also been found to be highly contagious outdoors. In China, a COVID-positive patient infected 39 people while jogging in a park in the summer.[12] The temperature was around 40°C during the event.[13]

CTSS is a semi-quantitative scoring system designed to assess the severity and extent of lung involvement in viral pneumonia. The scoring system can be used to estimate the extent of COVID-19 pneumonia in the lungs of patients and to evaluate their clinical status.[14]

Studies suggest that increased wind speed reduces the viral load in the air and that increased temperature is unfavorable for enveloped viruses; therefore, increased temperature and wind speed reduce transmission.[15,16] High temperatures damage the lipid layer of the virus, reducing its stability and causing inactivation of the virus, thereby reducing the transmission rate. In addition, exposure to

Table 2. Comparison of CT severity classes and meteorological findings

Meteorological finding	1-7: Mild (n=263)		≥8: Moderate/Severe (n=20)		Statistical analysis[a] Possibility
	X̄±S.S.	Median [Min-Max]	X̄±S.S.	Median [Min-Max]	
Air temperature (°C)	24.85(1.41)	25.2 [17.4-27.5]	24.46(1.45)	24.6 [21.6-26.4]	Z=-1.179 P=0.238
Relative Humidity (%)	40.12(5.00)	40.0 [27.5-60.2]	39.02(3.51)	39.9 [30.6-43.7]	Z=-0.857 P=0.391
Wind speed (m/sn)	2.68(0.92)	3.0 [0.9-4.3]	2.81(1.04)	3.0 [1.2-4.2]	Z=-0.336 P=0.737

[a]Mann-Whitney U test (Z-table value) statistics were used to compare the measurement values of two independent groups that did not have normal distribution.

Table 3. Comparison of meteorological findings according to diseased lung ratio classes

Meteorological finding	<%25 (n=270)		≥%25 (n=13)		Statistical analysis[a] Possibility
	X̄±S.S.	Median [Min-Max]	X̄±S.S.	Median [Min-Max]	
Air temperature (°C)	24.85(1.43)	25.2 [17.4-27.5]	24.46(1.17)	24.4 [22.6-26.4]	Z=-1.331 P=0.183
Relative Humidity (%)	40.14(4.97)	40.1 [27.5-60.2]	38.28(3.26)	39.5 30.6-41.8]	Z=-1.416 P=0.157
Wind speed (m/sn)	2.69(0.93)	3.0 [0.9-4.3]	2.66(0.94)	3.0 [1.1-4.0]	Z=-0.436 P=0.663

[a]Mann-Whitney U test (Z-table value) statistics were used to compare the measurement values of two independent groups that did not have normal distribution.

simulated sunlight has been observed to rapidly inactivate the SARS-CoV-2 virus on various surfaces and in the air.[17]

Ahmadi et al. showed an inverse relationship between increasing humidity and wind speed and the number of COVID-19 cases.[18] They stated that low relative humidity supports the survival of viruses in contaminated areas. In Bangladesh, Haque et al. showed that the spread of the disease decreased at high humidity and temperature values. [19] In the same study, they stated that the spread reached its highest rate at 26°C and 55% humidity. Considering that the viral load in the air increases when optimal conditions occur, it can be thought that the rate of uptake in the lungs will increase.

The meteorological data we obtained were close to the values reported by Haque et al. (average, 25°C; minimum, 17°C; maximum, 28°C). Therefore, there may not be a relationship between meteorological values and the rate of lung involvement. Various studies have evaluated meteorological data in relation to COVID-19. These studies compared meteorological parameters with the number of cases. Another common aspect of these studies is that there were not many exclusion criteria on a case-by-case basis. Patients with additional diseases were not excluded from the study groups. We could not find any studies similar to ours in the literature. Considering that meteorological parameters may directly affect the viral load taken into the body and that the viral load first settles in the lungs, we accepted that they could show parallelism with our study. In our study, neither CTSS nor the lung involvement rate showed a statistically significant association with the meteorological parameters we studied, such as daily average temperature, relative humidity, and wind speed.

It should be noted that this was a single-center study, and the observations made during the July-August period may not account for broader meteorological changes, given that this period is within the same season.

CONCLUSION

As a result, we found that meteorological parameters, such as wind speed, air temperature, and relative humidity, had no effect on lung involvement in COVID-19. We did not find a similar study in the literature. We think that large-scale, multicenter studies with different patient groups should be conducted to reveal the importance of meteorological parameters in COVID-19 lung involvement.

Ethics Committee Approval

The study was approved by the The Ankara City Hospital No. 1 Clinical Research Ethics Committee (Date: 13.01.2021, Decision No: E2-21-33).

Informed Consent

Written informed consents were obtained from patients who participated in this study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: A.E.Y., C.Y., S.G.; Design: A.E.Y., C.Y., S.G., F.A.K.; Supervision: G.K.C., M.C.; Resource: S.G., M.C. ; Materials: A.E.Y., C.Y., S.G.; Data Collection and/or Processing: A.E.Y., C.Y., M.C., F.A.K., G.K.C., S.G.; Analysis and/or Interpretation: A.E.Y., C.Y., M.C., F.A.K., G.K.C., S.G.; Literature Search: A.E.Y., C.Y., M.C., F.A.K., G.K.C., S.G.; Writing: A.E.Y., C.Y., M.C., F.A.K., G.K.C., S.G.; Critical Reviews: G.K.C., S.G.

Conflict of Interest

The author declare that there is no conflict of interest.

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Hava Durumunun COVID-19'da Akciğer Tomografi Bulguları Üzerindeki Etkisi

Amaç: Hava sıcaklığı, bağıl nem ve rüzgar hızı gibi meteorolojik parametrelerin COVID-19 hastalarının akciğer tutulumuna etkisini değerlendirmeyi amaçladık.

Gereç ve Yöntem: Çalışmamız retrospektif, tek merkezli olarak planlandı ve 14.07.2020-31.08.2020 tarihleri arasında gerçekleştirildi. Yaşları 18 ile 65 arasında değişen, kronik hastalığı olmayan ve Ankara ili sınırları içerisinde ikamet eden hastaları dahil ettik. PCR test örneğinden önceki son 5 güne ait hava sıcaklığı, bağıl nem ve rüzgar hızı dahildir. COVID 19'un akciğer tutulumunu incelemek için Bilgisayarlı Tomografi Şiddet Skorunu ve hastalıklı akciğer tutulumu yüzdesini kullandık. Bilgisayarlı Tomografi Şiddet Skorları, çalışmaya dahil edilen hastaların tomografi taramalarını inceleyen acil tıp doktoru tarafından hesaplandı. Toraks tomografisinde hastaların hastalıklı akciğer oranları Aqullani 4.7-Torasik VCAR, General Electric, ABD programı ile hesaplandı.

Bulgular: Çalışmaya toplam 283 hasta dahil edildi. Hastalarımızın 177'si (%62.5) erkek, 106'sı (%37.5) kadındı. Hastaların 272'si (%92.1) merkez ilçelerde, 11'i (%3.9) merkez dışı ilçelerde yaşamaktadır. Bilgisayarlı Tomografi Şiddet Skoru ve hastalıklı akciğer tutulumu yüzdesi açısı ile hava sıcaklığı, bağıl nem ve rüzgar hızı arasında istatistiksel olarak anlamlı farklılık saptanmadı.

Sonuç: Çalışmamızda hem Bilgisayarlı Tomografi Şiddet Skoru hem de akciğer tutulum oranı meteorolojik parametrelerle istatistiksel olarak anlamlı bulunmadı. Çalışmamızda meteorolojik parametrelerin akciğer tutulumuna etkisini daha çok görmek istediğimiz için popülasyonun açık havada vakit geçirdiği yaz aylarını seçtik ancak hava sıcaklığı, nem ve rüzgar hızındaki kısıtlı değişimlerin akciğer tutulumuna etki etmediğini gördük. Gelecekte aynı mevsim içinde farklı meteorolojik verilere sahip coğrafi bölgelerde çok merkezli olarak çalışmalar yapılabilir.

Anahtar Sözcükler: COVID-19; tomografi; sıcaklık; rüzgar; nem.

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Case Report

Ankle Fracture Dislocation with Interposition of the Tibialis Anterior and Tibialis Posterior Tendons: A Case Report

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Keywords: Ankle; Foot; Fracture-dislocation; Tibialis anterior tendon; Tibialis posterior tendon.

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ABSTRACT

Ankle fracture-dislocations are very common injuries, although it is highly unusual for them to be irreducible. A 55-year-old male patient presented to our department with a bimalleolar supination-external rotation-type ankle fracture-dislocation and multiple metatarsal fractures after dropping a weight on his left foot. After sedation, partial reduction of the ankle fracture was obtained in the emergency room. Following wound care, skeletal traction was applied. To avoid soft tissue complications, it was decided to wait before performing open reduction. The patient was followed up with traction for 2 weeks until the skin was ready for surgery. In the operating room, the tibialis posterior and tibialis anterior tendons were found to be trapped within the medial malleolar fracture site, thereby inhibiting reduction. After removal of the tissue, the ankle was restored to anatomical alignment. At 12 months postoperatively, the patient experienced mild pain and had resumed activities of daily living. At the latest follow-up examination, 38 months after surgery, the patient had moderate pain and stage 4 ankle arthritis. To the best of our knowledge, this is the first reported case of ankle fracture-dislocation accompanied by tibialis anterior tendon and tibialis posterior tendon interposition.

INTRODUCTION

An irreducible ankle fracture is rare.[1,2] Ankle dislocations are seen at lower rates than ankle fractures, but approximately 94% of ankle dislocations or subluxations are accompanied by a fracture.[3,4] With initial treatment in the emergency department, almost all ankle fracture-dislocations can be reduced using closed reduction techniques.[5] Failure to achieve proper closed reduction of an ankle fracture during the initial treatment intervention may complicate the management of the injury, and repeated reduction attempts can cause additional damage and unnecessary discomfort.[6-8] Soft tissue, the deltoid ligament, the extensor digitorum longus tendon, the tibialis posterior tendon, the neurovascular bundle, and malleolar fracture fragments are factors that may be responsible for the impossibility of closed reduction of an ankle fracture.[1,2,9-13] Inadequate closed reduction of fracture-dislocation may lead to complications, including skin necrosis and additional structural and vascular problems.[1] This case report presents a patient who was admitted to the emergency department after a crush injury with fractures of the left second, third, fourth, and fifth metatarsals and an irreducible ankle fracture-dislocation. The intraoperative findings of this complex injury pattern and the 38-month follow-up results are discussed.

CASE REPORT

A 55-year-old male patient was admitted to the emergency department after dropping a weight on his left foot. The patient stated that an object first hit his left cruris and then fell onto his foot. He was unable to walk and described moderate pain at the time of the initial examination. Ankle joint deformity was present, with the tibia prominent posteromedially. The patient had minimal active ankle plantarflexion and dorsiflexion and hallux extension. There was an 8 cm open wound on the medial plantar side of the foot. The open wound was classified as type 2 according to the Gustilo classification.[14] After irrigation and

debridement, the wound was sutured. Light-touch sensation assessment was performed for the deep and superficial peroneal, saphenous, and sural nerve distributions. Palpation of the dorsalis pedis artery was positive. Due to swelling, it was not possible to palpate the posterior tibial artery, but normal capillary refill was observed in the foot and toes. Anteroposterior, mortise, and lateral X-rays were obtained. On the initial radiographs, the ankle fracture-dislocation was characterized by a transverse medial malleolus fracture, and the comminuted fracture of the lateral malleolus was classified as type B2 according to the Danis-Weber classification. Tibiotalar joint subluxation and an anterolateral shift of the talus were also observed (Fig. 1). The injury was categorized as supination-external rotation stage 4 according to Lauge-Hansen. Fractures of the second, third, fourth, and fifth metatarsals were also observed (Fig. 2). CT images were obtained for further and more detailed evaluation. The patient had a medical history of smoking 40 pack-years. Intravenous ketamine at 2 mg/kg was then administered for closed reduction of the dislocation. The left knee was flexed, and an anterior force was applied to the heel with a posteriorly directed force to the mid-tibia with traction. A short-leg plaster splint was applied after a palpable reduction was achieved. However, post-reduction films showed that this maneuver had failed and that a non-reducible and unstable ankle dislocation remained. The patient was admitted to the orthopedic ward for clinical observation while the leg was elevated.

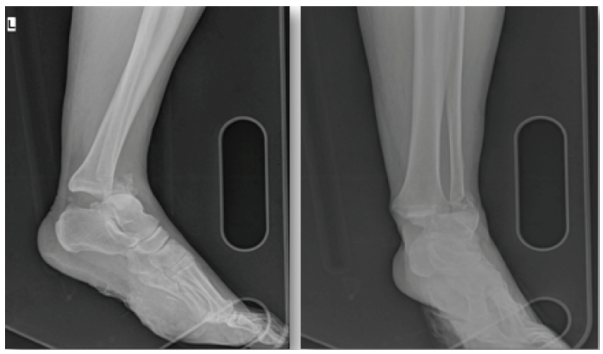


Figure 1. Lateral and AP views showing the ankle–fracture dislocation.



Figure 2. Fracture of the 2nd, 3rd, 4th, and 5th metatarsals.

Swelling was observed in the medial soft tissue, and as a consequence of the dislocation, there was a large blister on the anteromedial side over the medial malleolus. To avoid further wound complications, no incision was made. On the following day, because of the high risk of skin necrosis, it was decided to postpone open reduction and internal fixation. A pin was placed in the calcaneus for skeletal traction to restore normal length and protect the soft tissues (Fig. 3). Prophylactic antibiotic treatment (1000 mg intravenous cefazolin sodium for 3 days), nonsteroidal anti-inflammatory drugs (75 mg intravenous diclofenac sodium for 7 days), and venous thromboembolism prophylaxis (anti-Xa IU, 40 mg enoxaparin sodium subcutaneously) were administered until surgery 14 days after the injury.

The surgical procedure was performed under spinal anesthesia with the patient positioned supine after inflation of a thigh tourniquet to 250 mmHg under sterile conditions. The medial side was addressed first. A curvilinear incision was made over the medial malleolus, which was then bluntly dissected. On inspection, interposition of the tibialis anterior and tibialis posterior tendons was identified in the medial malleolar fracture site (Fig. 4). The tibialis posterior tendon was subluxated out of the groove because of the ruptured posterior tibialis tendon retinaculum. After reducing the tendon interposition, the medial malleolar fracture fragment could be returned to its anatomical position, and proper ankle reduction was achieved. Although the tendons were damaged and stretched, no complete tear was observed, and thus adequate reduction could be achieved with open reduction and internal fixation (ORIF).



Figure 3. Mortise and lateral post skeletal traction applied films.

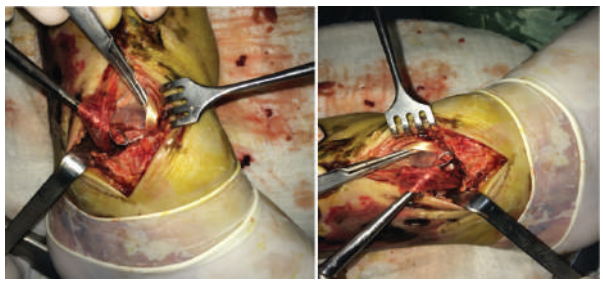


Figure 4. Interposed tendons in the ankle joint.



Figure 5. Post–op AP view of left ankle with plating of the distal fibula, syndesmotic screw fixation.



Figure 6. Clinical appearance of the patient' foot at 38 months postoperatively.

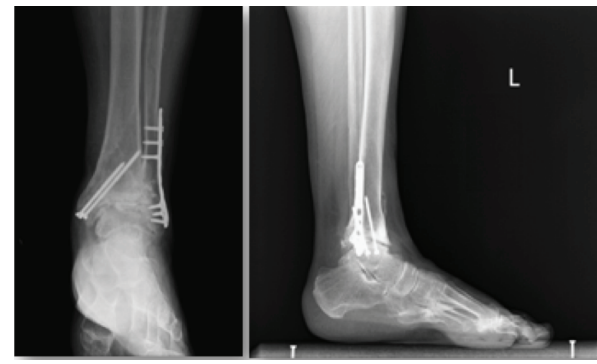


Figure 7. Weightbearing AP and lateral radiographs of the patient at 38 months after surgery, the patient had stage 4 ankle arthritis.

The flexor retinaculum was also repaired. Two parallel cancellous screws were used for stabilization of the medial malleolus. Then, a linear skin incision was made for management of the comminuted fibular fracture, and the fragments were fixated with a combination of screws and an anatomical locking plate. Pressure was then applied to the syndesmosis in the sagittal and coronal planes, and it was found to be unstable. Reduction of the ankle and syndesmosis was confirmed using fluoroscopy, and the distal tibiofibular joint was fixated with a single 3.5 mm cortical screw. The immediate postoperative radiographs showed good triplanar correction (Fig. 5). The metatarsal fractures were treated conservatively. The patient received routine antibiotic treatment and venous thromboembolism prophylaxis. A well-padded splint was applied. The patient was discharged from the hospital 3 days after surgery and was seen at 2 weeks postoperatively, at which time the staples were removed. Radiographic assessment showed excellent anatomical alignment. The patient was referred to physiotherapy. Using a short-leg splint and crutches, the patient was kept non-weight-bearing for 8 weeks; then, progressive partial weight-bearing as tolerated was allowed. Radiographs showed union of the medial and lateral malleoli and metatarsals at 3 months after surgery, and the patient returned to normal footwear. The syndesmotic screws were removed at the end of 5 months.

At the 12-month postoperative follow-up examination, the patient had mild pain according to the VAS and had resumed activities of daily living. Plantarflexion was 18°, and dorsiflexion was 22° in the left ankle. The American Orthopaedic Foot and Ankle Society ankle-hindfoot scale (AOFAS) score was 75. There was scar tissue in the wound area and hypoesthesia in the sensory area of the tibial nerve. No problems related to the tibialis posterior and tibialis anterior tendons, such as rupture or insufficiency, were observed.

In the most recent patient follow-up assessment, 38 months after surgery, there was limitation of ankle joint range of motion; the dorsiflexion angle was 5°, and plantarflexion was 5° (Fig. 6). The AOFAS score was 45. The patient could walk 1 km, and resting pain was 5 and activity pain was 7 according to the VAS. Radiographic assessment showed stage 4 arthritis of the ankle according to the Takakura classification.[15] (Fig. 7).

DISCUSSION

Ankle fracture-dislocations are frequently seen injuries, and there are usually no problems in applying closed reduction in the emergency department.[5] Irreducible ankle fractures are rare. Connors et al.[1] stated that in the event of the appearance of a disproportionately wide medial clear space before and after reduction attempts, the surgeon should consider the possibility of soft tissue interposition. Dislocation of the tibialis posterior tendon can be the reason for difficulty experienced in reducing the medial malleolus.[1,2,6] Natoli and Summers reported a 33-year-old male with an irreducible ankle fracture-dislocation due to subluxation of the tibialis anterior caused by jumping from a height and twisting injury.[16] That was the first reported case in which tibialis anterior tendon subluxation prevented closed reduction of an ankle fracture-dislocation.[16] It is very rare to encounter an irreducible ankle fracture-dislocation due to entrapment of the extensor digitorum longus tendon, flexor digitorum longus, flexor hallucis longus, deltoid ligament, neurovascular bundle, tibial nerve, and posterior tibial artery and vein.[1,9,12,17]

Ankle fractures with posterior tibialis tendon subluxation generally occur with higher-energy pronation-type injuries.[1,10,11] Most reported cases have been characterized by a pronation-external rotation injury mechanism.[10-12,18] This is generally an injury resulting from high-energy trauma, such as a motor vehicle accident or a fall from a height.[10-12,18] The injury mechanism in the current patient was a posteriorly directed force on the tibia. This mechanism of injury can be considered to have led to subluxation of the tibialis posterior tendon, and the initial reduction maneuver applied might have resulted in subluxation of the tibialis anterior tendon.

Patients with ankle fractures without dislocation have better outcome measurements than those with irreducible ankle fracture-dislocation.[19] Comparisons of the results of early and delayed treatment of ankle fractures have shown that delayed treatment was associated with wound complications and a short hospital stay.[20] Soft tissue trauma is minimized with early open reduction and internal fixation, thereby avoiding the necessity for closed reduction.[21] In this case report, a 55-year-old male presented with an ankle fracture-dislocation with concomitant severe soft tissue swelling and an increased risk of skin necrosis following unsuccessful closed reduction. Due to the risk of skin necrosis and soft tissue swelling, surgery was not performed. When soft tissue is not in immediate danger, surgery can be delayed to allow further healing of the soft tissue.[21] In this case, open reduction became impossible because of the partial reduction and missed soft tissue interposition that remained undetected in the following hours. It was decided to wait for healing of the soft tissues with skeletal traction. In a case with tibialis posterior tendon impingement, Lacasse et al.[11] suggested that magnetic resonance imaging is important to avoid a delayed diagnosis. MRI was not used to evaluate the current case. CT evaluation focused on bone tissue and was insufficient to detect the soft tissue interposition. In addition, the application of skeletal traction might have increased the damage to the interposed tendons.

Delayed open reduction and internal fixation does not necessarily lead to a poor outcome. In a report of three patients for whom surgery was delayed, the outcome obtained was excellent, with minimal or no limitation in ankle range of motion, most probably due to careful management of soft tissue swelling.[22,23] Post-traumatic arthritis from malunion of the unreduced proximal fibula posterior to the tibia has been shown to lead to arthrodesis as the ultimate pain relief procedure within 2 years of injury.[15,24] Failure to restore ankle congruity will result in poor outcomes, such as the development of severe osteoarthritis and subsequent arthrodesis.[22] Anderson and Hansen[18] also reported a 30-year-old male who needed ankle arthrodesis because of severe ankle arthritis due to late diagnosis. However, Lacasse et al.[11] stated that the 9-month follow-up period is insufficient to show the development of ankle arthritis in a case with tibialis posterior tendon entrapment in the syndesmosis, and ankle dorsiflexion remained diminished (5°), although the patient had returned to regular activities. In the current case, the patient resumed activities of daily living with moderately restricted range of motion in plantarflexion at 12 months after surgery. However, at 3 years postoperatively, post-traumatic arthritis had developed and restricted the range of motion in plantarflexion and dorsiflexion. There are few reports in the literature with long-term follow-up results for these types of patients.

CONCLUSION

In conclusion, the ankle crush injury reported in this paper was a complex, rare, irreducible fracture-dislocation. Anatomical restoration could not be achieved with the initial closed reduction. Open reduction had to be postponed, as interposed soft tissue was initially overlooked. Following intraoperative identification of the interposed tendons, satisfactory anatomical reduction was obtained. Although uncommon, the possibility of tendon interposition should be considered by the foot and ankle surgeon if the initial closed or open reduction attempts are not successful.[1] A successful outcome will depend on awareness that the fracture requires open reduction and, following careful intraoperative examination, application of the appropriate surgical technique to correct interposed tissues.[11] In these injuries, treatment should be performed within 24-48 hours.[25] Urgent operation and reduction of the distal fibula fracture-dislocation may help decrease the risk of post-traumatic arthritis.[2,15,22]

Informed Consent

Written informed consents were obtained from patient and his family.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: I.C.; Design: I.C.; Supervision: I.C., G.B.; Mate-

rials: I.C.; Data Collection and/or Processing: I.C.; Analysis and/or Interpretation: I.C., G.B.; Literature Search: I.C., G.B.; Writing: I.C.; Critical Reviews: I.C.

Conflict of Interest

None declared.

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Tibialis Anterior ve Tibialis Posterior Tendonlarının İnterpozisyonun Eşlik Ettiği Ayak Bileği Kırıklı-Çıkığı: Bir Olgu Sunumu

Ayak bileği kırıklı çıkıkları çok sık karşılaşılan ortopedik yaralanmalar olmasına rağmen redükte edilememeleri oldukça nadirdir ve bu olgular özel ilgi gerektirir. 55 yaşında erkek hasta, sol ayağına ağırlık düşmesi (ezilme yaralanması) nedeniyle bimalleolar supinasyon - eksternal rotasyon tipi ayak bileği kırıklı çıkığı ve çoklu metatars kırıkları şikayeti ile başvurdu. Sedasyon sonrası acil serviste ayak bileği kırığının kısmi redüksiyonu sağlandı. Yara irrigasyonu ve debridmanından sonra, yumuşak doku yaralanmasını ve şişliği en aza indirmek için kalkaneusa iskelet traksiyonu uygulandı. Yumuşak doku komplikasyonlarını önlemek için açık redüksiyon için beklenilmesine karar verildi. Cilt cerrahi için hazır olana kadar hasta 2 hafta boyunca iskelet traksiyon ile takip edildi. Ameliyat sırasında, tibialis posterior ve tibialis anterior tendonlarının medial malleol kırık hattında sıkıştığı ve bu nedenle redüksiyonu engellediği saptandı. Sıkışan doku uzaklaştırıldıktan sonra ayak bileğinin anatomik dizilimi elde edildi. Ameliyattan 12 ay sonra, hastanın hafif ağrısı mevcuttu ve günlük yaşam aktivitelerine geri dönebilmişti. Tedaviden 38 ay sonra yapılan son kontrol muayenesinde ise hastanın orta derecede ağrısı ve evre 4 ayak bileği artriti mevcuttu. Bilgimiz dahilinde, vakamız tibialis anterior ve tibialis posterior tendonunu interpozisyonunun ayak bileği kırıklı çıkığının redüksiyonunu engellediği ilk vakadır.

Anahtar Sözcükler: Ayak bileği; ayak; kırıklı – çıkık; tibialis anterior tendonu; tibialis posterior tendonu.

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Case Report

Life-Threatening Hemoptysis Requiring Left Pneumonectomy: Diagnostic and Therapeutic Challenges in a Young Female Patient

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Keywords: Bronchial artery embolization; hemoptysis; intensive care units; necrotizing pneumonia; pneumonectomy.

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ABSTRACT

Life-threatening hemoptysis is an uncommon but severe emergency requiring rapid diagnosis and management. Bronchial artery embolization (BAE) is generally the first-line treatment; however, surgical intervention may become necessary when bleeding is refractory, or lung parenchyma is irreversibly damaged. We report the case of a 27-year-old woman with type 1 diabetes mellitus and hypothyroidism who presented with recurrent massive hemoptysis. Despite bronchoscopic evaluation and emergent BAE, only temporary hemostasis was achieved, and the patient developed two cardiopulmonary arrest episodes requiring prolonged resuscitation. Progressive unilateral consolidation with necrotizing changes and persistent bleeding led to an intrapericardial left pneumonectomy. Her postoperative course required prolonged intensive care support, including mechanical ventilation and vasopressors, but no major surgical complications occurred. She gradually recovered and was discharged in stable condition. At 16-month follow-up, she remained asymptomatic. This case emphasizes the challenges in managing massive hemoptysis and highlights pneumonectomy as a life-saving option when conservative measures fail.

INTRODUCTION

Massive hemoptysis, commonly defined as more than 200–600 ml of blood expectorated in 24 hours, carries a mortality exceeding 50% without rapid treatment.[1] Although the clinical presentation is dominated by the immediate risk of airway obstruction and asphyxiation, the underlying etiologies vary substantially across populations, encompassing post-tuberculosis bronchiectasis, active pulmonary infection, malignancy, and a spectrum of vascular anomalies. This heterogeneity often complicates timely diagnosis and necessitates a tailored, multidisciplinary approach.[2]

Advances in imaging and interventional radiology have made bronchial artery embolization the gold standard for initial management for most patients.[3] Despite its high rate of initial hemostasis, recurrent bleeding remains a significant limitation, especially in individuals with chronic inflammatory lung disease or complex vascular pathology. In such cases, surgical intervention becomes essential. Depending on the extent and localization of the disease, operative strategies range from anatomical resections—typically lobectomy—to more extensive procedures such as pneumonectomy.[4,5] Pneumonectomy is generally avoided because of high morbidity and mortality, particularly when performed emergently, it continues to repre-

sent the only curative option for highly selected patients with uncontrolled hemorrhage or irreversibly destroyed lung parenchyma.[6]

Herein, we describe a young female patient with life-threatening massive hemoptysis refractory to both bronchoscopic intervention and bronchial artery embolization, for whom left pneumonectomy emerged as the only definitive therapeutic option.

CASE REPORT

A 27-year-old female with known type 1 diabetes mellitus and Hashimoto thyroiditis, who had been admitted to the ICU one month earlier for diabetic ketoacidosis, presented with recurrent massive hemoptysis (>750 ml). She reported progressive cough and blood-streaked sputum for several days before admission. Written informed consent was obtained from the patient for publication of this case report and accompanying images.

On arrival, chest computed tomography (CT) revealed left upper lobe consolidation with features suggestive of alveolar hemorrhage (Fig. 1). Flexible bronchoscopy demonstrated mucus plug–like material obstructing the left main bronchus. Multiple biopsies were taken, and frozen section analysis was negative for malignancy.

On the first day of ward follow-up, the patient suffered massive hemoptysis leading to cardiac arrest. Cardiopulmonary resuscitation (CPR) was performed for 30 minutes, after which spontaneous circulation was restored. She received 1 unit erythrocyte suspension (ES) and 3 units fresh frozen plasma (FFP) during resuscitation. She was intubated, sedated, and transferred to the ICU. The cardiac arrest was attributed to airway obstruction and severe hypoxemia caused by massive endobronchial bleeding.

Emergent bronchial artery embolization (BAE) was performed. Nonselective thoracic aortography demonstrated diffuse pathological vascularity in the left lung supplied by multiple systemic collaterals, including bronchial, intercostal, internal mammary–related, and lateral thoracic arteries. Selective embolization was performed for accessible feeding vessels using particulate embolic material. However, some vessels, including the left bronchial artery, could not be selectively catheterized due to small caliber and unfavorable origin angles, and only temporary hemostasis was achieved. However, recurrent massive hemoptysis occurred, leading to airway flooding and a second hypoxic cardiac arrest in the ICU, requiring 10 minutes of CPR. Extensive rheumatological investigations were performed to rule out vasculitis or autoimmune causes; results were negative.

On day 5 after BAE, bronchoscopy showed non-massive but persistent bleeding. On day 7, the patient was clinically diagnosed with necrotizing pneumonia, and corticosteroid therapy (methylprednisolone) was initiated. On day 7 she was re-evaluated for repeat embolization, but interventional radiology deemed the procedure unsuitable.

On day 8, after another hemoptysis episode, the decision was made for surgery. A posterolateral thoracotomy through the 5th intercostal space was performed. Intraoperatively, the left lung was extensively consolidated with hemorrhagic and necrotic areas, consistent with necrotizing pneumonia. A secondary distal pulmonary artery bleeding site was identified and clamped. This finding explained the persistent bleeding but was not the primary cause of the preoperative cardiac arrest. Due to severe inflammatory changes, dense hilar adhesions, and the need for rapid proximal vascular control in the setting of ongoing bleeding, an intrapericardial approach was preferred. A left intrapericardial pneumonectomy was performed with massive transfusion (4 units ES, 4 units FFP, 2 g fibrinogen). Due to intraoperative cardiac instability, internal cardiac massage was required. The bronchial stump was closed in standard fashion (Fig. 2). A chest tube was placed and removed on postoperative day 2.

Histopathological examination revealed extensive parenchymal necrosis with neutrophilic infiltration, intra-alveolar hemorrhage, and fibrin deposition, consistent with necrotizing pneumonia.

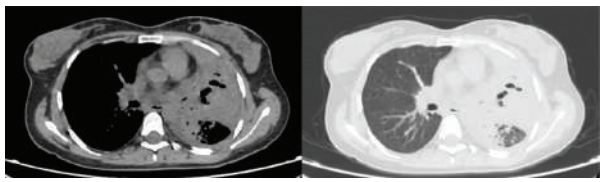


Figure 1. Contrast-enhanced axial chest CT images (mediastinal and lung windows) demonstrating dense consolidation and alveolar hemorrhage pattern localized to the left upper lobe.

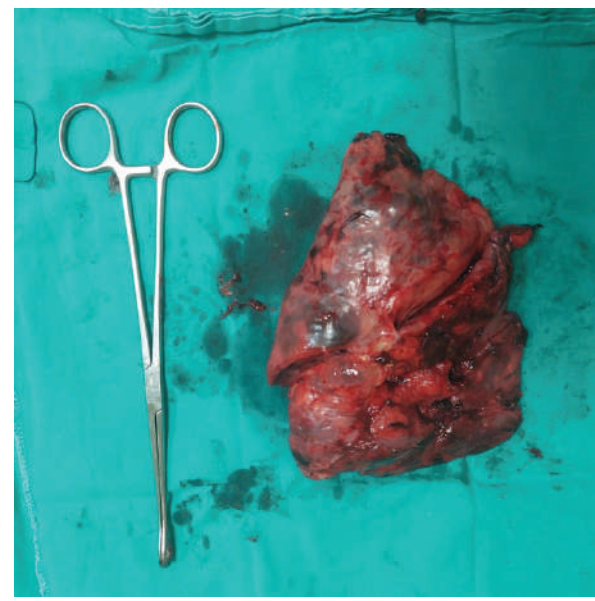


Figure 2. Intraoperative view and gross specimen demonstrating extensive hemorrhagic and necrotic consolidation of the left lung consistent with necrotizing pneumonia.

Table 1. Chronological summary of clinical events, interventions, and outcomes in the patient with life-threatening hemoptysis

Day	Event / Intervention	Outcome
0	Admission with massive hemoptysis (>750 ml); CT[a] showing left upper lobe hemorrhage	Initial stabilization, bronchoscopy performed
1	First cardiac arrest → CPR[b] 30 min; ICUc admission	ROSC[d] achieved, BAE[e] performed
2–4	Temporary bleeding control after embolization	Intermittent minor bleeding
5	Bronchoscopy: persistent bleeding	Necrotizing pneumonia suspected
7	Corticosteroids started; repeat BAE not feasible	Worsening respiratory function
8	Recurrent massive hemoptysis → Decision for surgery	Left intrapericardial pneumonectomy performed
Postoperative 1-28	ICU stay, prolonged ventilation, infection, neurological recovery	Discharged stable
16 months	Outpatient follow-up	No recurrence, good quality of life

Table note: [a]CT: Computed tomography; [b]CPR:Cardiopulmonary resuscitation; [c]ICU: Intensive care unit; [d]ROSC: Return of spontaneous circulation; [e]BAE: Bronchial artery embolization.

Postoperatively, the patient required prolonged ICU care with mechanical ventilation, vasopressor support, and broad-spectrum antibiotics. Septic complications and neurological impairment due to prolonged resuscitation occurred, but gradual recovery was achieved with multidisciplinary care. She was discharged on postoperative day 28 in stable condition. At 16 months follow-up, she remains asymptomatic, with no recurrence of hemoptysis or pulmonary complications, and reports good quality of life.

DISCUSSION

Massive hemoptysis is an uncommon but life-threatening emergency. The primary goals of management include airway protection, bleeding localization, and hemodynamic stabilization.[1] Chest CT and bronchoscopy are complementary in identifying the bleeding source, though localization may remain difficult in unstable patients.[2]

Bronchial artery embolization (BAE) is now considered the treatment of choice for initial control, with success rates up to 90% but recurrence rates of 10–55%.[3] In our patient, BAE provided only temporary control, and recurrent hemoptysis necessitated surgical resection.

Surgical resection is generally reserved for patients with unilateral lung destruction, recurrent bleeding after embolization, or underlying diseases such as tuberculosis, bronchiectasis, or vascular malformations.[4,5] Importantly, several large series have reported that benign but destructive conditions, including chronic infection, post-tuberculosis sequelae, and necrotizing pneumonia, may also necessitate pneumonectomy when bleeding is uncontrollable.[7,8]

Emergency pneumonectomy carries the highest risk compared with elective procedures. In a clinical analysis of 86 patients who underwent emergent pneumonectomy for massive hemoptysis, significantly higher mortality rates were observed, emphasizing that less extensive resections should be preferred whenever possible. Nevertheless, pneumonectomy remains a life-saving option when other measures fail.[9,10]

Similarly, our patient has remained symptom-free for 16 months, demonstrating that despite the inherent risks, young patients with preserved contralateral lung function may achieve excellent recovery and good quality of life following pneumonectomy.

Our case underscores these challenges (Table 1). Despite aggressive bronchoscopy and embolization, bleeding persisted, leaving pneumonectomy as the only viable intervention.

Life-threatening hemoptysis in young patients requires rapid multidisciplinary intervention. Although pneumonectomy is a last-resort procedure with high perioperative risk, this case demonstrates that excellent long-term outcomes are achievable. Sixteen months after surgery, our patient remains alive and well, highlighting pneumonectomy as a viable life-saving option in carefully selected cases.

Informed Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: C.I., B.C.; Design: C.I., B.C.; Supervision: B.C.; Materials: C.I., M.I., F.B.D.; Data: C.I., M.I., F.B.D.; Analysis: C.I., M.I., F.B.D.; Literature search: C.I., F.B.D.; Writing: C.I.; Critical revision: B.C., M.I.

Conflict of Interest

None declared.

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Sol Pnömonektomi Gerektiren Yaşamı Tehdit Eden Hemoptizi: Genç Bir Kadın Hastada Tanısal ve Terapötik Güçlükler

Yaşamı tehdit eden hemoptizi, hızlı tanı ve yönetim gerektiren nadir ancak ciddi bir acil durumdur. Bronşiyal arter embolizasyonu (BAE) genellikle birinci basamak tedavi olarak kabul edilse de, kanamanın dirençli olduğu veya akciğer parankiminin geri dönüşümsüz olarak hasar gördüğü durumlarda cerrahi müdahale gerekebilir. Bu yazıda, tekrarlayan masif hemoptizi ile başvuran tip 1 diyabetes mellitus ve hipotiroidisi bulunan 27 yaşındaki bir kadın olguyu sunuyoruz. Bronkoskopik değerlendirme ve acil BAE'ye rağmen yalnızca geçici hemostaz sağlanabilmiş, hasta uzun süreli resüsitasyon gerektiren iki kardiyopulmoner arrest epizodu geçirmiştir. Nekrotizan değişiklikler ve devam eden kanama ile seyreden ilerleyici tek taraflı konsolidasyon, intraperikardiyal sol pnömonektomi uygulanmasına yol açmıştır. Postoperatif dönemde mekanik ventilasyon ve vazopressör gereksinimi dahil yoğun bakım desteği gerekmiş, ancak majör cerrahi komplikasyon gelişmemiştir. Hasta kademeli olarak iyileşmiş ve stabil durumda taburcu edilmiştir. On altı aylık takipte asemptomatik olan hastada hemoptizi tekrarlamamıştır. Bu olgu, masif hemoptizinin yönetimindeki zorlukları vurgulamakta ve konservatif yöntemlerin başarısız olduğu durumlarda pnömonektominin hayat kurtarıcı bir seçenek olabileceğini göstermektedir.

Anahtar Sözcükler: Bronşiyal arter embolizasyonu; hemoptizi; nekrotizan pnömoni; pnömonektomi; yoğun bakım üniteleri.

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Updates on the Management of Diabetic Retinopathy

Lokman Balyen

To the Editor,

Diabetes mellitus (DM), a substantial cause of morbidity and mortality, is a serious public health concern worldwide. Therefore, DM has physical, psychological, social, and economic impacts on individuals with DM, their families, and society. It is one of the most frequent chronic diseases affecting children and adolescents, and the incidence and prevalence of DM are progressively increasing. Diabetic retinopathy (DR) is the most common complication of DM and remains the major cause of preventable blindness among working-age people in most developed countries.[1-5] DR can be classified as non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). Diabetic macular edema (DME) is one of the main causes of central vision loss in patients with DR and may manifest at any stage of DR.[1-5] DME is a condition characterized by blood-retinal barrier breakdown, increased vascular permeability, swelling of the macula, cystic macular thickening, and deposition of hard exudates.[1] DR has long been recognized as a microvascular disease. However, in addition to microvascular disorder, laboratory and clinical evidence has shown that inflammation and retinal neurodegeneration may also contribute to diabetic retinal damage in the early stages of DR. Further elucidation of the underlying molecular and pathological mechanisms may pave the way for new medical approaches and the development of new therapeutic methods.[1]

There are four main DR treatment methods, including conventional laser photocoagulation, intravitreal anti-VEGF or corticosteroid injections, and vitreoretinal surgery. However, many of these treatments are invasive, have serious complications, are costly, and are used in the advanced stages of DR. Although intravitreal anti-VEGF drugs have been the first treatment option for DME and PDR in the last decade, the use of anti-VEGF drugs in clinical practice is limited due to the need for frequent injections, endophthalmitis, poor patient compliance, and financial burden. Retinal laser photocoagulation has not lost its importance in the treatment of DR as adjuvant therapy. However, retinal laser photocoagulation with conventional laser systems is limited due to side effects, including exacerbation of ME, macular and peripheral scotoma with decreased central and peripheral vision, disruption of retinal anatomy through scarring, and reduced night vision. Intravitreal corticosteroids have shown clinical benefits in the treatment of recalcitrant DME or in cases that do not respond to anti-VEGF medication. However, the use of intravitreal corticosteroids is limited due to the high risk of serious adverse ocular events, such as endophthalmitis, high intraocular pressure, and cataract formation. Vitreoretinal surgery has an important role in advanced cases of PDR. Because of serious postoperative complications, such as rhegmatogenous retinal detachment, vitreous hemorrhage, cataract formation, and neovascular glaucoma, the vitrectomy procedure is sometimes controversial. Therefore, early detection through regular eye examination is the only way to prevent or reduce visual impairment and medical costs. In addition to conventional methods, new and effective prevention strategies and multidisciplinary approaches are required.[1,3]

Microvascular complications of DM, such as retinopathy, nephropathy, and neuropathy, have a devastating effect on quality of life. DM has physical, psychological, social, and economic impacts on individuals with DM, their families, and society. Additionally, the economic, social, and life satisfaction impacts of visual loss are also important.

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Vision loss imposes a significant burden on society, both economically and socially, in terms of medical and non-medical costs. Vision loss results in reduced quality of life, decreased productivity, increased medical expenses, and increased other direct and indirect costs.[5] However, in this context, visual impairment, blindness, life dissatisfaction, medical expenses, and other direct and indirect costs caused by DR may be reduced with early detection and treatment of DR.

As previously mentioned, vision loss due to DR can be prevented and treated with early diagnosis and treatment. New diagnostic and treatment modalities in DR management are promising. Nowadays, novel diagnostic devices, such as ultra-widefield retinal imaging, optical coherence tomography angiography, and adaptive optics retinal imaging, have improved the earlier, faster, and more accurate detection of DR. Subthreshold micropulse laser and other laser photocoagulation applications may be alternatives to conventional retinal photocoagulation with fewer complications for DR treatment. In addition, in recent years, unmanned automated-based diagnostic and treatment methods and newly developed intravitreal drugs and implants may offer more diagnostic and treatment options with promising results.[1-4]

In conclusion, in recent years, with advances in new diagnostic methods, pharmacotherapy, and vitreoretinal surgery techniques, there have been significant improvements in both the diagnosis and treatment of DR. With novel and more efficient preventive and interventional strategies based on a better understanding of the pathogenesis of the early stages of the disease, visual loss from late-stage DR may be prevented and treated in the early periods. In short, both the incidence and progression of DR can only be reduced by more effective and consistent preventive medical and interventional methods. Deep integration of artificial intelligence, machine learning, and deep learning into clinical ophthalmology has the potential to revolutionize the existing disease diagnosis system and create a significant clinical effect in ophthalmic healthcare services.

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