ORIGINAL ARTICLE

Cumulative soft-sign burden is associated with clinically significant injury in hemodynamically stable penetrating neck trauma

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ABSTRACT

BACKGROUND: Risk stratification remains challenging in hemodynamically stable patients with penetrating neck trauma and no hard signs. We evaluated the association between cumulative soft-sign burden and clinically significant injury (CSI) requiring therapeutic intervention.

METHODS: This retrospective cohort study included adults with penetrating neck trauma who were hemodynamically stable, had no hard signs, and underwent cervical computed tomography angiography (CTA). CSI was defined as a vascular or aerodigestive injury requiring therapeutic surgical or endovascular intervention. Soft-sign count was assessed using receiver operating characteristic analysis and logistic regression.

RESULTS: Of 109 patients, 33 (30.3%) had CSI. The median soft-sign count was higher among patients undergoing therapeutic surgery (2 vs. 1; p<0.001). Soft-sign count showed good discrimination for CSI (AUC, 0.81; 95% CI, 0.71–0.90). A threshold of ≥1 soft sign yielded 93.9% sensitivity and a 91.7% negative predictive value, whereas ≥2 soft signs yielded 89.5% specificity and a 73.3% positive predictive value. Each additional soft sign was independently associated with higher odds of CSI (adjusted OR, 4.83; 95% CI, 2.42–9.64; p<0.001). Gunshot mechanism was also strongly associated with CSI (OR, 10.58; 95% CI, 2.68–41.75).

CONCLUSION: Increasing soft-sign burden was strongly associated with CSI. The absence of soft signs reduced but did not eliminate the risk, whereas multiple soft signs identified a higher-risk group. Soft-sign count may support imaging prioritization and early surgical consultation but should not replace CTA.

Keywords: Clinically significant injury; computed tomography angiography; penetrating neck trauma; risk stratification; soft signs.

INTRODUCTION

Penetrating neck injury is an uncommon but potentially fatal form of trauma because major vascular and aerodigestive structures are concentrated within a small anatomical region.[1,2] Historically, wounds penetrating the platysma—particularly in Zone II—were managed with mandatory surgical exploration. However, the high frequency of non-therapeutic pro-

Cite this article as: Çalı HH, Akkoca M, Alicura Tokgöz S, Şirin İ, Akkoca Ö, Yılmaz F, Hicret Çalı A, Borazan İ. Cumulative soft-sign burden is associated with clinically significant injury in hemodynamically stable penetrating neck trauma. Ulus Travma Acil Cerrahi Derg 2025;32:1219-1228.

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Ulus Travma Acil Cerrahi Derg 2026;32(10):1219-1228 DOI: 10.14744/tjtes.2026.49290
Submitted: 07.08.2026 Revised: 08.09.2026 Accepted: 10.09.2026 Published: 06.10.2026
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cedures and advances in computed tomography angiography (CTA) have led to selective management and the contemporary "no-zone" approach.[3-5] Current management therefore relies primarily on physiological status, clinical findings, injury mechanism, and CTA rather than the external anatomical zone alone.[4-6]

Patients with hemodynamic instability or hard signs generally require urgent intervention, whereas stable patients without hard signs present a more difficult diagnostic problem. Hard signs, including active arterial bleeding, expanding hematoma, shock, airway compromise, pulse deficit, or bruit/thrill, are highly suggestive of major vascular and/or aerodigestive injury and generally mandate immediate operative management. In contrast, soft signs are less specific clinical findings that suggest, but do not confirm, the presence of significant underlying injury and therefore usually warrant further evaluation with CTA.[4,7,8] In this population, soft signs such as stable hematoma, venous bleeding, dysphonia, dysphagia, subcutaneous emphysema, minor hemoptysis, and pulse asymmetry may indicate underlying vascular or aerodigestive injury. Previous studies have demonstrated that physical examination can support selective management, particularly when no soft signs are present.[9-12] Nevertheless, most studies have assessed soft signs as binary findings or broad clinical categories, and the potential value of their cumulative burden remains insufficiently defined.

The number of concurrent soft signs may provide more clinically relevant risk information than the presence of an isolated finding. Such an assessment would not replace CTA but could assist in determining imaging priority, the urgency of surgical consultation, and the intensity of observation. This study therefore aimed to evaluate the association between cumulative soft-sign burden and clinically significant injury (CSI) requiring therapeutic surgical or endovascular intervention in hemodynamically stable patients with penetrating neck trauma and no hard signs. We also assessed the diagnostic performance of different soft-sign thresholds and examined the contributions of injury mechanism and initial hemodynamic variables.

MATERIALS AND METHODS

Study Design and Setting

This single-center retrospective cohort study was conducted in the Ankara Etlik City Hospital, Emergency Medicine Department of a tertiary care center with a high volume of trauma admissions. Consecutive adult patients evaluated for penetrating neck trauma between January 1, 2023, and May 1, 2026, were screened for eligibility. During the study period, 205 patients were assessed, of whom 96 were excluded and 109 were included in the final analysis (Fig. 1). The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations.

Penetrating neck injury was defined as a wound that violated the platysma muscle, as confirmed by clinical examination and/or imaging. Superficial wounds that did not penetrate the platysma were classified as non-penetrating and were excluded.

Clinical and outcome data were obtained retrospectively from the hospital information management system, emergency department records, radiology reports, operative reports, inpatient records, discharge summaries, and available follow-up documentation. Data collection and clinical classification were performed under the supervision of specialists in emergency medicine, otorhinolaryngology–head and neck surgery, and general surgery. Records containing ambiguous clinical, imaging, or procedural information were jointly reviewed by the relevant specialists before final classification.

Ethics

This retrospective, observational, single-center study was approved by the Clinical Research Ethics Committee of the Ministry of Health Ankara Etlik City Hospital (Approval No: AEŞH-BADEK1-2026-626; Date: 29/07/2026). The study was conducted in accordance with the principles of the Declaration of Helsinki. Given the retrospective design and use of anonymized data, the requirement for informed consent was waived by the ethics committee.

Study Population

Patients aged 18 years or older who presented to the emergency department with penetrating neck trauma were screened for eligibility. Patients were included if they were hemodynamically stable at the initial assessment, had no hard signs of major vascular or aerodigestive injury, underwent cervical computed tomography angiography as part of their diagnostic evaluation, and had sufficient clinical, imaging, procedural, and outcome information to determine the study endpoints.

Hemodynamic stability was defined as an initial systolic blood pressure of at least 90 mmHg without vasopressor support, ongoing massive transfusion, or persistent signs of shock requiring immediate operative management.

Patients were excluded if they were younger than 18 years; had blunt neck trauma or a clinically documented superficial wound; presented with hemodynamic instability, cardiopulmonary arrest, or a hard sign requiring immediate intervention; were transferred after definitive diagnosis or surgical treatment at another institution; proceeded directly to emergency surgical exploration without CTA; did not undergo cervical CTA; were pregnant; or had insufficient clinical, imaging, procedural, or outcome data.

Laboratory and physiological parameters were recorded as part of routine clinical care. Patients whose core records or vital signs could not be retrieved were excluded at the screening stage (see Figure 1). Among the 109 patients included in the analysis, the extent of missing data was assessed

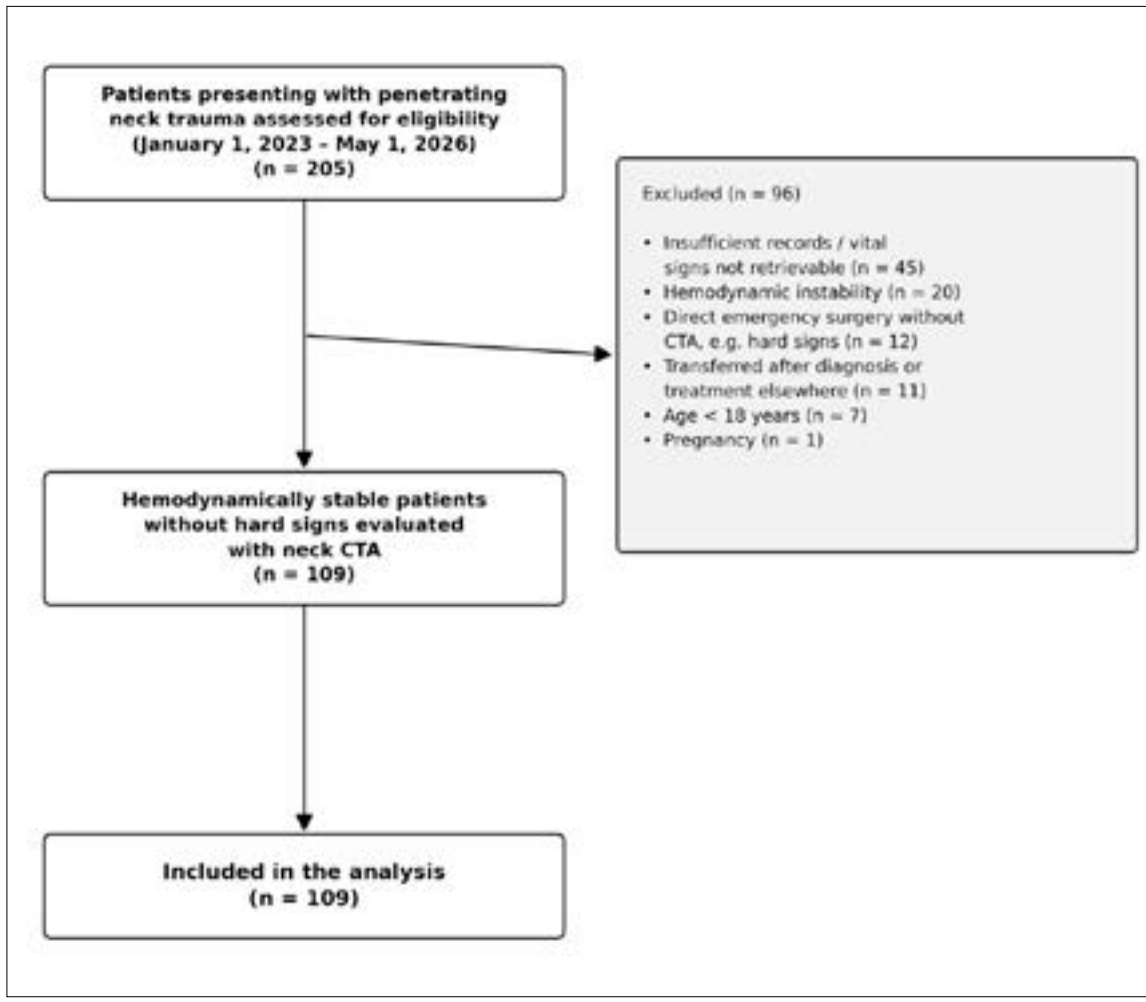

Figure 1. Study flow diagram. Of 205 patients assessed for eligibility, 96 were excluded and 109 were included in the analysis.

for every analyzed variable (demographics, mechanism, vital signs, laboratory values, each individual soft sign, and outcomes). Missing data were negligible: only hemoglobin had a missing value in a single patient (1/109, 0.9%); all remaining 25 variables were complete (0% missing). A complete-case analysis was therefore used, and no imputation was performed.

Data Collection

A structured data collection form was used to extract demographic characteristics, medical history, injury-related variables, initial physiological measurements, clinical examination findings, laboratory results, CTA findings, therapeutic procedures, and clinical outcomes.

Age, sex, hypertension, diabetes mellitus, coronary artery disease, malignancy, and current anticoagulant or antiplatelet treatment were recorded. Comorbidities and medication use were determined from admission records, previous diagnoses, medical history, and available medication lists.

The injury mechanism was categorized as a stab or other sharp-object injury, gunshot wound, glass-related injury or laceration, or another penetrating mechanism. The circumstance of injury was classified as assault, self-harm, or accident. The number of external neck wounds was recorded from the initial examination and consultation records.

The external wound location was classified according to the traditional anatomical neck zones. Zone I extended from the clavicles and sternal notch to the cricoid cartilage, Zone II from the cricoid cartilage to the angle of the mandible, and Zone III from the angle of the mandible to the skull base. Injuries involving more than one anatomical zone or wounds with trajectories crossing zonal boundaries were classified as multiple-zone injuries. Zonal classification was used for anatomical description and was not considered the primary basis for clinical risk stratification.

Physiological and Laboratory Variables

Initial vital signs recorded during the emergency department assessment were collected, including systolic and diastolic blood pressure, heart rate, respiratory rate, peripheral oxygen saturation, and Glasgow Coma Scale score. Shock index

was calculated as the initial heart rate divided by the systolic blood pressure. When available, pre-intervention values were used, and measurements obtained after major resuscitation, transfusion, intubation, surgery, or vasopressor therapy were excluded.

Laboratory parameters obtained before surgical or endovascular intervention were recorded, including hemoglobin, hematocrit, platelet count, serum lactate, and base excess. If multiple measurements were available, the earliest valid pre-intervention result was analyzed.

Assessment of Soft Clinical Signs

Soft signs were identified from the history and physical examination documented during the initial emergency department assessment before CTA or therapeutic intervention. Evaluated soft signs included stable hematoma, a history or observation of venous bleeding, dysphagia, odynophagia, hoarseness or dysphonia, clinically detected subcutaneous emphysema, minor hemoptysis or hematemesis, and peripheral pulse asymmetry.

Stable hematoma was defined as non-pulsatile and non-expanding. Minor hemoptysis or hematemesis referred to limited bleeding without respiratory compromise, hemodynamic instability, or massive ongoing hemorrhage. Only subcutaneous emphysema identified on physical examination was considered a soft sign; findings detected solely on CTA were classified as imaging findings. Neck tenderness was excluded because of its limited specificity in penetrating neck trauma.

For each patient, the soft-sign count was calculated as the unweighted sum of individual findings. In addition to the presence of any soft sign, thresholds of ≥1, ≥2, and ≥3 were analyzed.

CT Angiography and Injury Classification

According to the institutional trauma protocol at our center, neck CTA was obtained in all hemodynamically stable patients with penetrating neck injury, irrespective of the presence or absence of soft signs; imaging was therefore not selectively ordered on the basis of clinical suspicion. All included patients underwent contrast-enhanced neck CTA accordingly. CTA examinations were reviewed for vascular and aerodigestive injuries. Arterial injuries included contrast extravasation, occlusion, dissection, pseudoaneurysm, arteriovenous fistula, or other traumatic arterial abnormalities. Venous injuries included extravasation, thrombosis, occlusion, vessel disruption, or other traumatic venous abnormalities. Aerodigestive injuries were classified as laryngeal, tracheal, or esophageal.

Final injury classification was based on CTA findings together with operative or endovascular findings, additional diagnostic investigations when available, and the documented clinical course. Operative findings were considered definitive when present.

Study Outcomes

The primary outcome was clinically significant injury (CSI), defined as a confirmed vascular or aerodigestive injury requiring therapeutic surgical or endovascular intervention during the index hospitalization.

Therapeutic surgical exploration was defined as an operation in which an injured vascular or aerodigestive structure was repaired, ligated, reconstructed, drained, controlled, or otherwise treated. An operation limited to exploration without a therapeutic procedure was not classified as CSI solely because surgery had been performed. Endovascular intervention included embolization, stent placement, vascular occlusion, or another catheter-based therapeutic procedure performed for a traumatic cervical vascular injury.

Therapeutic surgical exploration and endovascular intervention were additionally recorded as separate components of the primary outcome. Thirty-day all-cause mortality was evaluated as a secondary outcome. Deaths occurring during the index hospitalization or within 30 days of the initial emergency department presentation were included.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). All tests were two-sided, and $p<0.05$ was considered statistically significant.

Continuous variables were assessed for normality using the Shapiro–Wilk test and are presented as mean±standard deviation or median (interquartile range), as appropriate. Categorical variables are reported as frequencies and percentages.

Patients with and without therapeutic surgical exploration were compared using the independent-samples t test or Mann–Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables.

The diagnostic performance of the soft-sign count for CSI was evaluated using receiver operating characteristic (ROC) analysis. The area under the curve (AUC), optimal cutoff (Youden index), sensitivity, specificity, predictive values, and likelihood ratios were calculated for the predefined thresholds (≥1, ≥2, and ≥3).

Univariable logistic regression was used to identify candidate predictors of CSI, and clinically relevant variables were entered into the multivariable model. Soft-sign count was analyzed as a continuous variable. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Model discrimination was assessed using the AUC and calibration using the Hosmer–Lemeshow goodness-of-fit test.

Gunshot mechanism was excluded from the multivariable model because the high proportion of CSI among patients with gunshot wounds resulted in sparse data and potentially unstable estimates; therefore, its association with CSI was evaluated only in the univariable analysis.

Table 1. Baseline demographic, clinical, and outcome characteristics (N=109).

Variable	Value
Demographics	
Age (years)	31.00 [21.00–45.00]
Female sex	15 (13.76%)
Anticoagulant/antiplatelet use	1 (0.92%)
Hypertension	4 (3.67%)
Diabetes mellitus	4 (3.67%)
Coronary artery disease	2 (1.83%)
Malignancy	0 (0.00%)
Injury characteristics	
Mechanism	
Stab/sharp	59 (54.13%)
Gunshot	13 (11.93%)
Glass/laceration	10 (9.17%)
Other	27 (24.77%)
Cause	
Assault	43 (39.45%)
Self-harm	33 (30.28%)
Accident	33 (30.28%)
Zone	
Zone I	32 (29.36%)
Zone II	30 (27.52%)
Zone III	11 (10.09%)
Multiple	36 (33.03%)
Number of wounds	1.00 [1.00–2.00]
Vital signs	
Systolic BP (mmHg)	115.00 [110.00–125.00]
Diastolic BP (mmHg)	70.64±15.26
Heart rate (/min)	84.97±16.33
Respiratory rate (/min)	17.00 [15.00–18.00]
SpO2 (%)	97.00 [95.00–98.00]
GCS	15.00 [15.00–15.00]
Shock index	0.71 [0.61–0.78]
Soft clinical signs	
Any soft sign	85 (77.98%)
Soft sign count	1.00 [1.00–2.00]
Stable hematoma	27 (24.77%)
Venous bleeding history	21 (19.27%)
Dysphagia	1 (0.92%)
Odynophagia	0 (0.00%)
Hoarseness/dysphonia	3 (2.75%)
Subcutaneous emphysema	73 (66.97%)
Minor hemoptysis/hematemesis	1 (0.92%)
Peripheral pulse asymmetry	0 (0.00%)
Laboratory	
Hemoglobin (g/dL)	14.01±1.81
Hematocrit (%)	42.47±4.98
Platelet (10^3/μL)	268.00 [224.00–314.00]
Lactate (mmol/L)	2.20 [1.56–3.03]
Base excess	-2.10 [-4.10–0.30]
Imaging/Injury (CTA)	
Arterial injury	4 (3.67%)
Venous injury	13 (11.93%)
Laryngeal injury	3 (2.75%)
Tracheal injury	9 (8.26%)
Esophageal injury	1 (0.92%)
Outcomes	
Therapeutic surgical exploration	32 (29.36%)
Endovascular intervention	1 (0.92%)
CSI (therapeutic surgical/endovascular)	33 (30.28%)
30-day mortality	3 (2.75%)

Continuous: mean ± SD (normal) or median [IQR] (non-normal), per Shapiro–Wilk. Categorical: n (%). CSI, clinically significant injury.

Sample Size

Because of the retrospective design, no a priori sample size calculation was performed. All consecutive eligible patients were included. The multivariable model contained two predictors for 33 CSI events (16.5 events per variable), exceeding the conventional minimum of 10 events per variable.

RESULTS

A total of 109 hemodynamically stable patients with penetrating neck injury without hard signs who underwent CTA were included. The median age was 31 years [interquartile range (IQR), 21–45]; 15 (13.76%) were female. The most common mechanism was stab/sharp injury (59, 54.13%), followed by gunshot injury (13, 11.93%). At least one soft sign was present in 85 patients (77.98%). Baseline demographic, clinical, and injury characteristics are summarized in Table 1.

A clinically significant injury (CSI), defined as an injury requiring therapeutic surgical or endovascular intervention, occurred in 33 patients (30.28%). Therapeutic surgical exploration was performed in 32 (29.36%), and endovascular intervention was performed in 1 (0.92%). Thirty-day mortality was 2.75% (3).

Because only one patient underwent endovascular intervention, the group requiring therapeutic surgical exploration was virtually identical to the CSI group; the between-group comparison is therefore presented according to therapeutic surgical exploration. When compared according to therapeutic surgical exploration (Table 2), patients requiring surgery had significantly higher soft-sign counts (median, 2.00 vs 1.00;

Table 2. Comparison by therapeutic surgical exploration

Variable	Therapeutic (n=32)	No therapeutic (n=77)	Effect size (95% CI)[a]	p
Soft signs				
Any soft sign	30 (93.75%)	55 (71.43%)	22.32 (9.20 to 35.44)	0.021
Soft sign count	2.00 [1.00–3.00]	1.00 [0.00–1.00]	Δmed 1.00	<0.001
Stable hematoma	14 (43.75%)	13 (16.88%)	26.87 (7.75 to 45.98)	0.007
Venous bleeding history	12 (37.50%)	9 (11.69%)	25.81 (7.57 to 44.06)	0.004
Dysphagia	0 (0.00%)	1 (1.30%)	-1.30 (-3.83 to 1.23)	1.000
Hoarseness/dysphonia	3 (9.38%)	0 (0.00%)	9.38 (-0.72 to 19.47)	0.024
Subcutaneous emphysema	30 (93.75%)	43 (55.84%)	37.91 (24.00 to 51.81)	<0.001
Vitals & demographics				
Shock index	0.72 [0.66–0.90]	0.71 [0.61–0.77]	Δmed 0.01	0.146
Systolic BP	112.00 [105.00–119.75]	118.00 [112.00–125.00]	Δmed -6.00	0.008
Heart rate	86.75 ± 18.42	84.23 ± 15.45	2.52 (-4.74 to 9.77)	0.500
Age	37.00 [19.00–52.00]	31.00 [22.00–44.00]	Δmed 6.00	0.790
Gunshot mechanism	10 (31.25%)	3 (3.90%)	27.35 (10.72 to 43.99)	<0.001

Categorical: χ^2 or Fisher's exact; continuous: t-test or Mann–Whitney U. Note: non-therapeutic explorations and conservatively managed patients are grouped as 'no therapeutic surgery'. [a]Effect size denotes the risk difference (%) with 95% CI for categorical variables and the difference in means or medians for continuous variables.

Table 3. Diagnostic performance for CSI (therapeutic surgical/endovascular intervention).

Predictor / cut-off	AUC (95% CI)	Cut-off	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV %	NPV %	LR+	LR−
Soft sign count	0.81 (0.71–0.90)	≥2	66.67 (49.61–80.25)	89.47 (80.58–94.57)	73.33	86.08	6.33	0.37
Gunshot mechanism	0.63 (0.51–0.75)	≥1	30.30 (17.38–47.34)	96.05 (89.03–98.65)	76.92	76.04	7.68	0.73
Systolic BP	0.68 (0.56–0.79)	≤115	72.73 (55.78–84.93)	59.21 (47.98–69.56)	43.64	83.33	1.78	0.46
Soft count ≥1		≥1	93.94 (80.39–98.32)	28.95 (19.96–39.96)	36.47	91.67	1.32	0.21
Soft count ≥2		≥2	66.67 (49.61–80.25)	89.47 (80.58–94.57)	73.33	86.08	6.33	0.37
Soft count ≥3		≥3	27.27 (15.07–44.22)	97.37 (90.90–99.28)	81.82	75.51	10.36	0.75

Variables significant in Table 2 included. AUC by ROC; cut-off by Youden index; soft-count thresholds shown for reference. Wilson 95% CIs.

p<0.001) and higher rates of stable hematoma (p=0.007), a history of venous bleeding (p=0.004), hoarseness/dysphonia (p=0.024), and subcutaneous emphysema (p<0.001). Gunshot mechanism (p<0.001) and lower SBP (p=0.008) were also associated with therapeutic surgery.

On ROC analysis (Table 3, Fig. 2), soft-sign count discriminated CSI with an AUC of 0.81, which was higher than that of gunshot mechanism (AUC, 0.63) and SBP (AUC, 0.68). On DeLong comparison (Table 3b), soft-sign count showed significantly better discrimination than gunshot mechanism (p=0.004). At a threshold of ≥1 soft sign, sensitivity was 93.94%, and the negative predictive value was 91.67%, indicating that patients with no soft signs had a low probability of CSI.

On logistic regression analysis (Table 4), soft-sign count was independently associated with CSI (adjusted odds ratio [aOR], 4.83; 95% CI, 2.42–9.64; p<0.001) in a model that included SBP (model AUC, 0.84; Hosmer–Lemeshow p=0.16). Gunshot mechanism, a strong univariable predictor (OR, 10.58; 95% CI, 2.68–41.75; p=0.001), was therefore reported separately; because most patients with gunshot wounds sustained CSI (10 of 13), the resulting sparse data precluded stable adjusted estimation.

Table 3b. Pairwise comparison of AUCs (DeLong test)

Comparison	AUC vs AUC	ΔAUC	z	p
Soft sign count vs Gunshot mechanism	0.81 vs 0.63	+0.18	2.86	0.004
Soft sign count vs Systolic BP	0.81 vs 0.68	+0.13	1.71	0.088
Gunshot mechanism vs Systolic BP	0.63 vs 0.68	-0.05	-0.64	0.522

DeLong test for correlated ROC curves.

Table 4. Univariable and multivariable logistic regression for CSI

Predictor	Univariable OR (95% CI)	p	Multivariable aOR (95% CI)	p
Soft sign count	5.19 (2.63–10.23)	<0.001	4.83 (2.42–9.64)	<0.001
Gunshot mechanism	10.58 (2.68–41.75)	0.001		
Systolic BP	0.96 (0.93–0.99)	0.020	0.98 (0.95–1.01)	0.241
Age	1.02 (0.99–1.05)	0.199		

Multivariable model: soft sign count + systolic BP (33 events, EPV≈16). Model AUC = 0.84; Hosmer–Lemeshow p = 0.16. Gunshot mechanism (univariable OR 10.58 (2.68–41.75), p=0.001) was reported separately as its strong association approached separation.

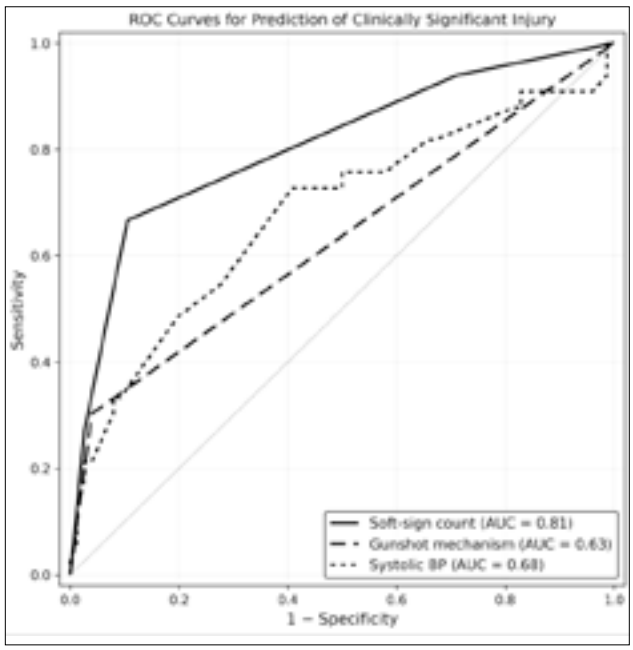

Figure 2. Receiver operating characteristic (ROC) curves for the prediction of clinically significant injury by soft-sign count, gunshot mechanism, and systolic blood pressure.

DISCUSSION

The principal finding of this study was that cumulative soft-sign burden was strongly associated with clinically significant injury in hemodynamically stable patients with penetrating neck trauma and no hard signs. Approximately one-third of the cohort required therapeutic surgical or endovascular intervention, demonstrating that the absence of hard signs does not define a uniformly low-risk population. Patients requiring intervention had more soft signs, and each additional soft sign was associated with a substantial increase in the odds of CSI. Soft-sign count also provided better overall discrimination than either systolic blood pressure or gunshot mechanism alone. Nevertheless, none of the evaluated thresholds achieved sufficient performance to safely replace CTA.

The transition from mandatory neck exploration to selective management has considerably reduced non-therapeutic procedures without an apparent increase in missed clinically important injuries.[3,10,13] Contemporary algorithms distinguish patients with hard signs or physiological instability, who generally require immediate intervention, from stable patients who can undergo clinical assessment and CTA.[4,6,7] However, this second group remains heterogeneous. In our cohort, 30.3% of patients required therapeutic intervention despite being hemodynamically stable and having no hard signs. This finding emphasizes that physiological stability should be interpreted as a prerequisite for structured investigation rather than as evidence that a significant injury is absent.

Previous studies have primarily examined whether any soft sign is present. Isaza-Restrepo et al.[9] reported that the presence of any soft sign had a sensitivity of 97.4% and a negative predictive value of 98.7% for injuries requiring surgical repair. Other studies have similarly suggested that a normal physi-

cal examination may identify patients at relatively low risk of clinically important vascular injury.[11,14] In our study, the presence of at least one soft sign showed a sensitivity of 93.9% and a negative predictive value (NPV) of 91.7%. Although these findings support the value of physical examination, two patients without documented soft signs still had CSI. Accordingly, the absence of soft signs reduced the probability of therapeutic intervention but did not exclude it with sufficient certainty to justify omitting CTA.

Our results extend the binary present-versus-absent approach by demonstrating that the accumulation of soft signs carries additional risk information. Soft-sign count achieved an AUC of 0.81, indicating good but incomplete discrimination. A threshold of at least two soft signs provided 89.5% specificity, a positive predictive value of 73.3%, and a positive likelihood ratio of 6.33. Thus, patients with two or more soft signs represented a distinctly higher-risk group that may warrant expedited CTA, early surgical consultation, and closer monitoring. By contrast, the sensitivity of this threshold was only 66.7%, meaning that approximately one-third of patients with CSI would not be identified. The threshold should therefore be considered a risk-enrichment criterion rather than a rule for determining whether imaging is required.

The presence of at least three soft signs was highly specific for CSI, with a specificity of 97.4%, a positive predictive value (PPV) of 81.8%, and a positive likelihood ratio of 10.36. This degree of risk concentration may be clinically useful when prioritizing patients and mobilizing surgical or endovascular resources. However, its low sensitivity precludes its use as a screening threshold. Taken together, the threshold analyses suggest two different clinical functions: the absence of soft signs identifies a relatively lower-risk group but does not safely rule out CSI, whereas multiple concurrent signs identify patients with an increasingly high probability of requiring therapeutic intervention. This graded interpretation is more informative than treating all soft signs as equivalent binary findings.

Several individual findings were also associated with therapeutic surgery. Stable hematoma and a history of venous bleeding may reflect underlying vascular injury, whereas dysphonia and subcutaneous emphysema raise concern for laryngeal or tracheal involvement. The accumulation of these findings may therefore represent either increasing injury severity or involvement of more than one anatomical compartment. However, rare findings such as dysphonia should be interpreted cautiously because estimates based on small numbers are inherently unstable. Moreover, a simple count assigns equal importance to clinically different findings. The present results support cumulative assessment but should not be interpreted as validation of a definitive clinical score.

Gunshot mechanism was another important indicator of CSI. Ten of the 13 patients with gunshot wounds required therapeutic intervention, and gunshot injury was associated with more than a tenfold increase in the unadjusted odds of CSI. This is consistent with previous reports showing a higher frequency of significant injury after gunshot wounds than after stab wounds, which likely reflects greater energy transfer, tissue cavitation, and less predictable wound trajectories.[2,3,15] The AUC of gunshot mechanism was lower than that of soft-sign count because it identified only a relatively small subgroup and therefore had limited sensitivity. Nevertheless, its high specificity and positive likelihood ratio indicate that it remains clinically important. Soft-sign burden and injury mechanism should therefore be viewed as complementary rather than competing sources of risk information. Our findings further support the need for careful evaluation of civilian cervical gunshot injuries, complementing a recent Turkish case series emphasizing individualized management of vertebral artery injuries in this setting.[16]

Systolic blood pressure was lower among patients requiring therapeutic surgery, but its association was no longer significant after adjustment for soft-sign count. Heart rate and shock index were also not significantly different between the groups. These findings suggest that clinically important localized vascular or aerodigestive injuries may be present before overt systemic hemodynamic deterioration develops. Normal vital signs should therefore not override concerning examination findings. Conversely, modest differences in systolic blood pressure within the conventionally stable range should not be used as an independent indication for intervention.

The role of clinical examination in this setting should be considered complementary to CTA. Multidetector CTA offers high diagnostic accuracy for vascular injury and provides valuable information regarding the wound trajectory and structures at risk.[6,17] It has also contributed to the decline in mandatory exploration and conventional angiography.[5,6] Nevertheless, CTA can be affected by metallic artifacts and may be less reliable for subtle pharyngeal or esophageal injuries, for which additional endoscopic or contrast evaluation may be necessary when clinical suspicion persists.[7,8] Our findings do not support replacing CTA with a soft-sign threshold. Instead, soft-sign burden may help determine how urgently imaging should be obtained and which patients require early multidisciplinary evaluation despite apparently stable physiology.

The anatomical zone of entry was not central to the present analysis. Although traditional zone classifications remain useful for describing injury location and planning operative exposure, external wounds may not accurately reflect the trajectory or internal structures involved.[5,18] This limitation has supported the adoption of the no-zone approach, in which the entire neck is assessed according to clinical findings and CTA results. Accordingly, our results suggest that cumulative clinical findings and injury mechanisms may be more relevant for initial risk stratification than the external zone alone.

Limitations

This study has several limitations. First, its retrospective,

single-center design carries an inherent risk of incomplete or inconsistent documentation. In particular, soft signs were recorded during routine clinical care rather than through a standardized, prospectively applied examination protocol, and their assessment may therefore have varied among clinicians; subtle findings such as minor subcutaneous emphysema or minor bleeding are especially susceptible to this variability. Second, subcutaneous emphysema was more frequent than the other individual soft signs and may have contributed disproportionately to the performance of the cumulative soft-sign count. Third, missing data were minimal (hemoglobin was missing in one patient [0.9%], with all other analyzed variables complete). Although a patient-flow diagram is provided (Fig. 1), the retrospective design means that residual selection effects cannot be entirely excluded. Fourth, the cohort comprised only patients who underwent CTA. At our institution, neck CTA is obtained in all hemodynamically stable patients with penetrating neck injury according to the trauma protocol, which mitigates selection based on clinical severity; nevertheless, stable patients discharged without imaging or managed at other facilities would not have been captured, and this may have contributed to the observed rate of clinically significant injury. Fifth, the CSI outcome was defined by therapeutic surgical or endovascular intervention and may therefore have been influenced by local practice and surgeon decision-making. Sixth, several individual soft signs were uncommon, and the diagnostic thresholds were derived and evaluated in the same cohort, which may have produced optimistic performance estimates. Finally, the relatively small number of events limited the multivariable analysis; notably, gunshot mechanism could not be incorporated into the adjusted model because most patients with gunshot wounds sustained CSI, and the resulting sparse data would have yielded unstable estimates. These findings should therefore be regarded as hypothesis-generating and require prospective, multicenter validation before clinical application.

CONCLUSION

In conclusion, clinically significant injuries were common among hemodynamically stable patients with penetrating neck trauma despite the absence of hard signs. Increasing soft-sign burden was independently associated with therapeutic intervention and provided good discrimination for CSI. The absence of soft signs identified a lower-risk group but did not safely exclude significant injury, whereas two or more concurrent findings substantially increased the probability of intervention. Soft-sign burden should therefore be regarded as a tool for risk stratification, imaging prioritization, and early surgical consultation rather than as a substitute for CTA.

Ethics Committee Approval: This study was approved by the Clinical Research Ethics Committee of the Ministry of Health Ankara Etlik City Hospital (Date: 29.07.2026, Decision No: AEŞH-BADEK1-2026-626).

Informed Consent: Given the retrospective design of the study and the use of anonymized data, the requirement for written informed consent was waived by the institutional ethics committee.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: H.H.C., M.A., Ö.A.; Design: S.A.T., İ.Ş., F.Y.; Supervision: H.H.C., M.A., Ö.A.; Resource: S.A.T.; Materials: S.A.T., F.Y.; Data collection and/or processing: İ.Ş., F.Y., İ.B.; Analysis and/or interpretation: H.H.C., M.A., S.A.T.; Literature review: İ.B.; Writing: İ.Ş., İ.B.; Critical review: H.H.C., M.A., Ö.A.

Conflict of Interest: None declared.

Financial Disclosure: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Use of AI for Writing Assistance: Artificial intelligence tools were not used in the design, conduct, data analysis, or writing of this manuscript, except for routine grammar and spell-checking assistance.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Kümülatif yumuşak bulgu yükü, hemodinamik olarak stabil penetran boyun travmasında klinik olarak önemli yaralanma ile ilişkilidir

AMAÇ: Hemodinamik olarak stabil, ciddi bulgusu olmayan penetran boyun travmalı hastalarda risk sınıflaması güçlüğünü korumaktadır. Bu çalışmada, kümülatif yumuşak bulgu yükü ile terapötik girişim gerektiren klinik olarak önemli yaralanma (KÖY) arasındaki ilişki değerlendirildi.
GEREÇ VE YÖNTEM: Bu retrospektif kohort çalışmasına, hemodinamik olarak stabil olan, ciddi bulgusu bulunmayan ve servikal bilgisayarlı tomografi anjiyografi (BTA) uygulanan penetran boyun travmalı erişkin hastalar dahil edildi. KÖY, terapötik cerrahi veya endovasküler girişim gerektiren vasküler ya da aerodigestif yaralanma olarak tanımlandı. Yumuşak bulgu sayısı, alıcı işlem karakteristik (ROC) analizi ve lojistik regresyon ile değerlendirildi.
BULGULAR: Toplam 109 hastanın 33'ünde (%30,3) KÖY saptandı. Terapötik cerrahi uygulanan hastalarda ortanca yumuşak bulgu sayısı daha yüksekti (2'ye karşı 1; p<0,001). Yumuşak bulgu sayısı KÖY için iyi ayırt edicilik gösterdi (EAA, 0,81; %95 GA, 0,71–0,90). ≥1 yumuşak bulgu eşiği %93,9 duyarlılık ve %91,7 negatif prediktif değer sağlarken; ≥2 yumuşak bulgu %89,5 özgüllük ve %73,3 pozitif prediktif değer sağladı. Her bir ilave yumuşak bulgu, KÖY olasılığında bağımsız artışla ilişkiliydi (düzeltilmiş OO, 4,83; %95 GA, 2,42–9,64; p<0,001). Ateşli silah mekanizması da KÖY ile güçlü şekilde ilişkiliydi (OO, 10,58; %95 GA, 2,68–41,75).
SONUÇ: Artan yumuşak bulgu yükü KÖY ile güçlü şekilde ilişkiliydi. Yumuşak bulgu yokluğu riski azaltmakla birlikte tamamen ortadan kaldırmadı; buna karşın çok sayıda yumuşak bulgu daha yüksek riskli bir grubu tanımladı. Yumuşak bulgu sayısı, görüntüleme önceliklendirmesini ve erken cerrahi konsültasyonu destekleyebilir; ancak BTA'nın yerini almamalıdır.

Anahtar sözcükler: Bilgisayarlı tomografi anjiyografi; hafif bulgular; klinik olarak önemli yaralanma; penetran boyun travması; risk sınıflaması.

Ulus Travma Acil Cerrahi Derg 2026;32(10):1219-1228 DOI: 10.14744/tjtes.2026.49290