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Efficacy of Corticosteroid Prophylaxis in Reducing the Incidence of Fat Embolism Syndrome in Patients with Lower Extremity Fractures

Alt Ekstremite Kırığı Olan Hastalarda Yağ Embolisi Sendromu İnsidansını Azaltmada Kortikosteroid Profilaksisinin Etkinliği

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ABSTRACT

Objective: Fat embolism syndrome (FES) is a relatively infrequent, yet potentially life-threatening complication associated with long bone fractures, exhibiting an incidence of approximately 2-5%. This study investigates the utilization of corticosteroids as a prophylactic measure to reduce the occurrence of FES in such cases.

Method: This retrospective, single-centre study was conducted at the Trauma University Hospital in Tirana, Albania, from January 2011 to January 2012. The study encompassed a cohort of 232 patients diagnosed with fractures of the lower extremities. The primary goal was to evaluate the prophylactic role of corticosteroids, specifically methylprednisolone at a dosage of 10 mg kg^{-1}, in the development of FES. Patients were dichotomized into two groups: Group 1, consisting of 116 patients administered corticosteroid prophylaxis, and Group 2, encompassing 116 patients without corticosteroid prophylaxis for FES.

Results: Within Group 1, the incidence of FES was recorded at 2.58%, with an absence of severe respiratory manifestations. In contrast, Group 2 exhibited a FES incidence of 11.20%, out of which 6.03% necessitated intensive care unit respiratory support. The prevalence of FES was significantly lower in Group 1, subjected to corticosteroid prophylaxis, in comparison to Group 2, where no such prophylaxis was administered ($p<0.05$). Group 2 patients also displayed heightened instances of pulmonary complications.

Conclusion: Administration of corticosteroid prophylaxis in cases of lower extremity fractures was correlated with a notable reduction in FES incidence. Furthermore, this intervention demonstrated its merit by effectively attenuating pulmonary complications associated with FES.

Keywords: Fat embolism syndrome, corticosteroids, lower extremity fractures

ÖZ

Amaç: Yağ embolisi sendromu (YES), uzun kemik kırıkları ile ilişkili nispeten nadir görülen ancak potansiyel olarak yaşamı tehdit eden bir komplikasyondur ve yaklaşık %2-5 oranında görülür. Bu çalışma, bu tür vakalarda YES oluşumunu azaltmak için profilaktik bir önlem olarak kortikosteroidlerin kullanımını araştırmaktadır.

Yöntem: Bu retrospektif, tek merkezli çalışma, Ocak 2011'den Ocak 2012'ye kadar Arnavutluk'un Tiran kentindeki Travuma Üniversite Hastanesinde gerçekleştirilmiştir. Çalışma, alt ekstremite kırıkları tanısı konulan 232 hastadan oluşan bir kohort çalışmasını kapsıyordu. Birincil amaç, YES gelişiminde kortikosteroidlerin, özellikle 10 mg kg^{-1} dozunda metilprednizolonun profilaktik rolünü değerlendirmekti. Hastalar iki gruba ayrıldı: Grup 1, YES için kortikosteroid profilaksisi uygulanan 116 hastadan oluşuyordu ve Grup 2, YES için kortikosteroid profilaksisi uygulanmayan 116 hastayı kapsıyordu.

Bulgular: Grup 1'de YES insidansı %2,58 olarak kaydedildi ve ciddi solunum belirtileri gözlenmedi. Buna karşılık, Grup 2'de %11,20 oranında YES insidansı saptandı ve bu hastaların %6,03'ü yoğun bakım ünitesinde solunum desteğine ihtiyaç duydu. Yağ embolisi sendromu prevalansı, kortikosteroid profilaksisi uygulanan Grup 1'de, profilaksi uygulanmayan Grup 2'ye kıyasla önemli ölçüde daha düşüktü ($p<0,05$). Grup 2 hastalarında ayrıca artmış pulmoner komplikasyon vakaları görüldü.

Sonuç: Alt ekstremite kırıklarında kortikosteroid profilaksisinin uygulanması, YES insidansında belirgin bir azalma ile ilişkilendirilmiştir. Dahası, bu müdahale, YES ile ilişkili pulmoner komplikasyonları etkili bir şekilde azaltarak faydasını göstermiştir.

Anahtar sözcükler: Yağ embolisi sendromu, kortikosteroidler, alt ekstremite kırıkları

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INTRODUCTION

Fat embolism syndrome (FES) is a rare but potentially life-threatening complication associated with long bone fractures (1). Fat embolism syndrome is characterized by an initial asymptomatic period, which is subsequently followed by respiratory and neurological manifestations, along with haemorrhagic petechiae involving the skin and mucous membranes, reflecting its biphasic clinical course (2). The primary symptoms of FES are believed to result from the mechanical obstruction of multiple blood vessels by large fat globules, which are too big to pass freely through capillaries. These occlusions are often partial or tangential, as the smoothness and deformability of fat globules typically prevent complete blockage of capillary blood flow. The ensuing clinical manifestations are thought to arise from the hydrolysis of fat into free fatty acids, which then circulate systemically and exert toxic effects on various organs. Notably, a significant number of fat embolism cases may remain undiagnosed due to the subtlety or mild nature of their clinical presentation (3,4). However, a subset of patients encounter a scenario where these fat emboli obstruct small blood vessels within the lungs, brain, skin, and mucous membranes. This sequence of events initiates a complex cascade of inflammatory responses, microvascular dysfunction, and systemic physiological disturbances, ultimately leading to the development of FES. The resulting clinical picture reflects both mechanical vascular obstruction by fat globules and biochemical injury from free fatty acids, manifesting in multisystem involvement that includes respiratory distress, neurological impairment, and characteristic petechial rash.

Corticosteroids have been proposed as a prophylactic measure to mitigate the incidence and severity of FES, owing to their anti-inflammatory and membrane-stabilizing properties. However, the effectiveness and safety of corticosteroid prophylaxis in this context remain subjects of ongoing investigation.

MATERIAL and METHODS

This section details the methodology employed in a retrospective, unicentric study conducted at the Trauma University Hospital in Tirana, Albania, from January 2011 to January 2012. This specific timeframe was selected due to the absence of corticosteroid administration within the treatment protocol for long bone fractures during that period.

A total of 232 patients, aged 15 to 59 years, who were hospitalized with lower extremity fractures between [January 2011 to January 2012] were retrospectively included in this study. Patients were identified through hospital medical records and included if they had sustained isolated or multiple long bone fractures. Exclusion criteria were pre-existing coagulopathy, chronic corticosteroid therapy, or incomplete medical records. Patients were stratified into two groups according to corticosteroid administration. Group 1 comprised 116 patients who received intravenous methylprednisolone at a fix dose of 10 mg kg^{-1} (published papers report a dose range of 2–20 mg kg^{-1} for methylprednisolone) for the prevention of FES, based on individual clinician discretion due to the absence of an established institutional protocol. Group 2 included 116 patients who did not receive corticosteroids. The number of patients in Group 2 was matched to that of Group 1; however, a larger cohort of patients had not received corticosteroids, reflecting the absence of a standardized prophylactic protocol at our institution. Demographic and clinical data, including age, sex, fracture type, comorbidities, and outcomes related to FES, were retrospectively collected from medical records of prospective registry for subsequent analysis.

For this retrospective study, patients were included if they had fractures of the lower extremities, were admitted within the first 24 hours following trauma, had received no prior treatment before presentation to the emergency department, and maintained a preserved conscious state. Exclusion criteria comprised the presence of systemic or chronic diseases, concurrent dyslipidaemia, conditions affecting the bone marrow, pathological fractures, pregnancy, prior steroid therapy, fractures complicated by compartment syndrome, and fractures associated with chest, abdominal, or head trauma. The application of these criteria retrospectively allowed for the identification of a well-defined patient cohort, thereby enhancing the precision and validity of the analysis. The following sections present the outcomes derived from this carefully conducted investigation. The diagnostic criteria for FES were adopted in line with the major and minor parameters proposed by Gurd and Wilson (Table I) (5). In this retrospective study, vital signs of all patients were extracted from medical records and documented at hourly intervals, while gas (ABG) measurements were recorded daily. In patients in whom FES was subsequently confirmed, ABG assessments were performed more frequently, according to the severity of respiratory compromise. Laboratory parameters including hemoglobin, platelet count, erythrocyte sedimentation rate, renal function tests, and bilirubin levels along with heart rate, respiratory rate, and body temperature, were retrospectively collected. Comprehensive evaluation also included review of respiratory rate trends and chest radiographs. Fundoscopy findings were recorded when FES was clinically suspected. The presence of respiratory failure, neurological or consciousness alterations unrelated to head trauma, intoxication, or poisoning, together with petechial rash in typical locations (axilla, neck, shoulder, conjunctiva, and oral cavity), were considered indicative of FES (6).

Table I. The Major and Minor Criteria for Fat Embolism Proposed by Gurd and Wilson. The Presence of One Major Feature and Four Minor Features is Indicative of FES (5)

Major Features	• Petechial rash • Respiratory symptoms plus bilateral signs with positive radiographic changes • Cerebral signs unrelated to head injury
Minor Features	• Tachycardia > 120 min^{-1} • Pyrexia > 38.5°C. • Retinal fat or petechiae • Urinary fat globules or oligoanuria • Thrombocytopenia • Sudden drop in hemoglobin level • High erythrocyte sedimentation rate • Fat macroglobulinemia

FES: Fat embolism syndrome.

Statistical analysis

The dataset was subjected to comprehensive analysis utilizing MedCalc® Statistical Software version 20.104. Descriptive statistics were employed to portray numerical variables with their respective means and standard deviations, while categorical variables were represented via absolute and relative values. The Kolmogorov-Smirnov test was applied to evaluate the normality of distribution for quantitative data. Pearson's chi-square test and Fisher's exact test were both engaged to compare proportions between distinct categories. For the comparison of continuous variable means, the student's t-test for independent samples was employed. All statistical tests were executed as two-tailed tests, and the level of significance was set at $p<0.05$. This stringent statistical framework was employed to extract robust insights from the data, enhancing the validity and reliability of the study findings. Relevant demographic and clinical variables encompassing gender, age, fracture classification (open/closed), body mass index, and duration of fracture fixation were meticulously recorded for everyone. Additionally, for both cohorts enrolled in the study, an account of the types and quantity of fractures sustained were meticulously documented. Over a span of five consecutive days, comprehensive data in adherence with the diagnostic criteria for FES outlined by Gurd and Wilson were meticulously collected (5). A physician meticulously documented this information in a dedicated checklist. Subsequently, the recorded symptoms underwent re-examination and re-evaluation by a second physician to enhance reliability and accuracy. In this retrospective study, the primary objective was to determine the prevalence of FES in two distinct cohorts of patients with lower extremity fractures. In the first cohort, patients had received corticosteroid prophylaxis, specifically methylprednisolone at a dose of 10 mg kg^{-1}, whereas the second cohort did not receive any corticosteroid therapy. As a secondary outcome, the study aimed to evaluate the number of patients who developed FES and required respiratory support in the intensive care unit (ICU). All relevant clinical and laboratory data were retrospectively extracted from medical records across the patients' hospitalization period, providing comprehensive insights into the incidence, progression, and clinical course of FES within these cohorts. Informed consent was waived due to the retrospective design of the study, which involved analysis of pre-existing patient data without any direct intervention. The study protocol was duly registered and received formal approval from the Institutional Ethics Committee under approval number 34/1, ensuring compliance with ethical standards and the protection of patient confidentiality throughout the research process. By meticulously scrutinizing these clinical observations, we aim to unravel nuanced insights into the impact of corticosteroid prophylaxis on the occurrence and subsequent management of FES within the context of lower extremity fractures. The diagram shows patient stratification (Figure 1).

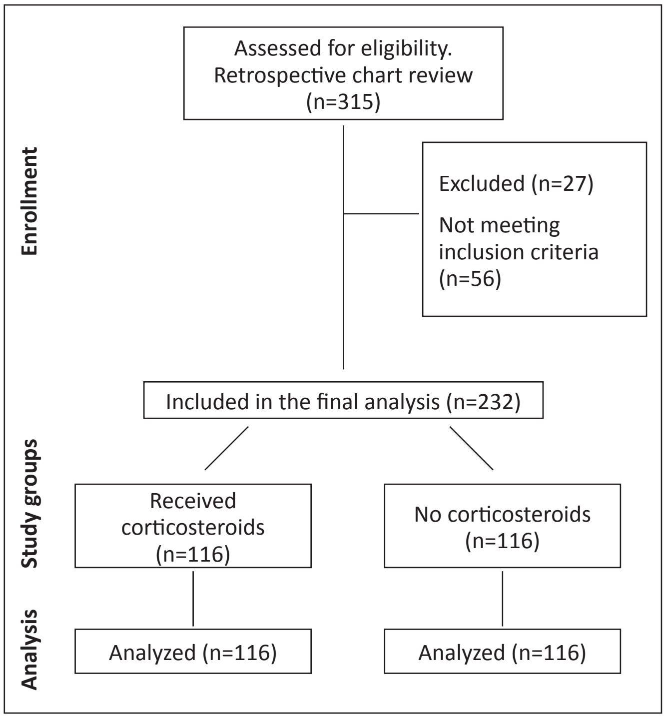

Figure 1. Study flow diagram.

RESULTS

Between January 2011 and January 2012, a total of 232 patients diagnosed with lower extremity fractures admitted to Trauma University Hospital. Among these, 116 patients received corticosteroid prophylaxis, specifically methylprednisolone at a dosage of 10 mg kg^{-1}, while the remaining 116 patients did not receive such prophylaxis. The baseline characteristics of the patients demonstrated comparability across both groups, as detailed in Table II. Gender distribution, age, fracture type, and weight exhibited no significant discrepancies. Age spanned from 15 to 59 years, with a mean age of 36.1 ± 15.8 years. Of the total patients, 145 were male (62.5%), and 87 were female (37.5%). Although both groups displayed a male predominance, the male-to-female (M/F) ratio closely approximated unity, indicating no noteworthy gender-related variations. The average ages within both groups were notably similar, demonstrating absence of significant age-related disparities. Additionally, no considerable distinctions emerged in terms of fracture types between the two cohorts (Table III). Fat embolism syndrome diagnose was established within the initial 5 days of hospitalization through comprehensive assessments involving clinical, laboratory, and imaging data, alongside adherence to Gurd and Wilson criteria (5). The incidence of FES among patients who received corticosteroid prophylaxis stood at 2.58%, as outlined in Table IV. In contrast, among patients devoid of corticosteroid prophylaxis, the FES incidence escalated to 11.20%. Across the entire patient population under study, the cumulative FES incidence settled at 6.89%. Within the cohort refraining from corticosteroid prophylaxis, 7 patients (3.01%) necessitated ICU intervention. Strikingly, the second cohort exhibited a significantly higher prevalence of FES patients requiring ICU respiratory support in comparison to the first cohort. Among the 232 patients included in this study, the incidence of FES was 2.58% in the group that received corticosteroid prophylaxis, compared to 11.20% in the group that did not. This represents an absolute risk reduction of 8.62%, with a 95% confidence interval ranging from 2.39% to 14.85% (p = 0.017). The calculated relative risk was 0.23 (95% CI: 0.07 to 0.76), indicating a 77% relative reduction in the risk of developing FES among patients who received methylprednisolone. These findings suggest a substantial protective effect of corticosteroids in this clinical context. To assess the statistical robustness of this result, a post-hoc power analysis using a two-proportion z-test was

Table II. Clinical and Demographic Information for the Study Groups

Characteristics	MP (n=116)	Without MP (n=116)	Total	p-value*
Patient gender M/F, n (%)	71/45 (61.0/39.0)	74/42 (63.7/36.3)	145/87 (62.5/37.5)	0.684
Patient age, years	35.8 ± 15.6	36.4 ± 16.7	36.1 ± 15.8	0.777
Open fracture, n (%)	24 (20.68)	26 (22.41)	50 (21.55)	0.750
Closed fracture, n (%)	92 (79.31)	90 (77.58)	182 (78.44)	
Body mass index, kg m^{-2}	25.8 ± 3.8	26.4 ± 3.4	26.2 ± 3.8	0.206
Fracture fixation time <24 hours, n (%)	46 (39.65)	49 (42.24)	95 (40.94)	0.689
Fracture fixation time >24 hours, n(%)	70 (60.34)	67 (57.75)	137 (59.05)	

MP: Methylprednisolone, **M/F:** Male/Female, **n (%):** Number and percentage. *P values were calculated using Student's t-test (independent samples) for continuous variables and Pearson's chi-square test for categorical variables; p-value<0.05 is significant.

Table III. The Type of Fractures for Both Groups in the Study

The type of fractures	MP (n=116)	Without MP (n=116)	Total (232)	p-value*
Unilateral femur fracture, n (%)	24 (20.68)	26 (22.41)	50 (21.55)	0.750
Bilateral femur fractures, n (%)	12 (10.34)	10 (8.62)	22 (9.48)	0.654
Unilateral cruris fracture, n (%)	43 (37.06)	45 (38.79)	88 (37.93)	0.787
Bilateral cruris fractures, n (%)	18 (15.51)	16 (13.79)	34 (14.65)	0.711
Femur fracture + cruris fracture, n (%)	8 (6.89)	7 (6.03)	15 (6.46)	0.789
Femur fracture + bilateral cruris fractures, n (%)	6 (5.17)	6 (5.17)	12 (5.17)	1.0
Bilateral femur fractures + unilateral cruris fracture, n (%)	5 (4.31)	6 (5.17)	11 (4.74)	0.757

MP: Methylprednisolone, **n (%):** Number and percentage, ***P** values were calculated using Fisher's exact test. P-value<0.05 is significant.

Table IV. FES and Pulmonary Complications Incidence

Group	MP	Without MP	Total	p-value*
Patients, n	116	116	232	
FES, n (%)	3 (2.58)	13 (11.20)	16 (6.89)	**0.017**
ICU admission, n (%)	0	7 (6.03)	7 (3.01)	**0.014**

MP: Methylprednisolone, **FES:** Fat Embolism Syndrome, **ICU:** Intensive Care Unit, **n (%):** Number and percentage. *P values were calculated using Fisher's exact test. P-value <0.05 is significant.

performed. Using the observed event rates in both groups and a two-tailed significance level of 0.05, the analysis yielded a power of 78.5%. Although this power falls slightly below the conventional 80% threshold, it still supports the validity of the observed difference given the clinically meaningful effect size and narrow confidence intervals.

These results highlight the salient impact of corticosteroid prophylaxis on FES occurrence within the context of lower extremity fractures. The observed discrepancies in FES incidence and subsequent ICU requirements underscore the potential significance of corticosteroid administration in mitigating the severity of FES.

DISCUSSION

Our study presents our retrospectively data, in case of totally lack of standardized protocol. To better understand the severity of the condition, and to compare our data with the literature, we conducted this retrospective review of our database. The goal was to gather comprehensive data that would inform the development of a standardized protocol aimed at guiding anesthesiologists, orthopedic surgeons, and emergency physicians in the timely recognition and management of FES and related complications.

Fat embolism syndrome presents significant challenges in both diagnosis and treatment. Clinical manifestations can range from mild, abortive symptoms to the full spectrum of classic features, contributing to increased morbidity and mortality. The classic presentation typically includes respiratory failure, neurological impairment, and a petechial rash (7).

Addressing the rapid onset of respiratory complications after orthopedic and trauma surgeries of the extremities, procedural protocols should encompass not only pulmonary thromboembolism but also the often-overlooked FES. Fat embolism syndrome frequently occurs during various orthopedic procedures and skeletal trauma cases (2,8). Kainoh et al. conducted a nested case-control study using data from the Japan Trauma Data Bank spanning 2004 to 2017. The study included 204 patients diagnosed with FES and reported a mortality rate of 5.4%. Their comprehensive analysis identified delayed surgical intervention and the presence of multiple fractures as significant risk factors associated with the development and severity of FES. These findings highlight the importance of timely surgical management, particularly in patients with complex fracture patterns, to potentially reduce the risk and improve outcomes related to FES (8). The progression of FES can be highly unpredictable and may become rapidly fatal, leading to death within a few hours—even in otherwise healthy young patients. This unpredictability underscores the critical need for early recognition and prompt intervention to improve patient outcomes (9). Nevertheless, Lempert et al. concluded the syndrome has been predominantly documented in the context of long bone fractures and multiple fractures, with isolated, though rare, cases reported as a complication following hip and knee arthroplasty (10). Caricato et al. reported the diagnosis of FES was made after excluding pulmonary thromboembolism, a condition commonly observed after the fifth postoperative day (11). The clinical description of FES was first provided by Von Bergmann in 1873, who detailed the syndrome's symptoms in a patient with a femur fracture (12). Various clinical forms of FES have been reported, ranging from silent presentations—detectable only during autopsy—to fulminant, life-threatening cases. Ihnat and colleagues contributed important findings in their study of 134 deaths following major blunt trauma, where 19 cases showed no apparent traumatic cause of death. In four of these instances, fulminant pulmonary fat embolism was confirmed as the cause of death, underscoring the often subtle and sometimes fatal nature of this condition (13,14). The heterogeneity of clinical presentations and the unpredictable nature of this complication make it a significant concern for forensic medicine and histopathology. Morena et al. concluded in their review that a better understanding of the etiopathogenesis, along with improved diagnostic tools, is essential (15). Bulger et al. reported FES incidence rates ranging from 0.25% to 1.25% in patients with fractures, with higher rates of 5% to 10% observed in those with multiple bone fractures (16). Tsai et al. conducted a retrospective cohort study analyzing data from the National Trauma Data Bank collected between 2007 and 2014. Out of approximately 6 million trauma patients, only 451 were diagnosed with FES, highlighting the relative rarity of this complication. The study reported an overall mortality rate of 11.8% among FES patients. Notably, mortality increased significantly to 17.6% in patients aged over 65 years. Through multivariate analysis, the researchers identified age above 65 as an independent predictor of increased mortality in patients suffering from FES. These findings underscore the heightened vulnerability of elderly trauma patients to poorer outcomes when affected by FES and highlight the need for targeted clinical vigilance in this demographic (17). In our study, the overall incidence of FES among the patient cohort was 6.89%. This finding highlights the clinical relevance of FES in the population studied and underscores the importance of vigilant monitoring and early prophylactic interventions to reduce associated morbidity and improve patient outcomes. This figure may be elevated due to the exclusion of certain patient groups in whom diagnosis is more challenging, rendering the classic diagnostic criteria used in our protocol inapplicable (18,19). Notwithstanding this limitation, our study highlighted the increased incidence of FES in patients with multiple fractures, particularly those with bilateral femur fractures as literature supports (20).

Treatment encompasses pharmacological therapy (such as corticosteroids), hemodynamic support (including catecholamines and vasopressors for right ventricular failure), respiratory support (with endotracheal intubation and mechanical ventilation), and, in severe cases, extracorporeal membrane oxygenation (ECMO). Interestingly, there is a scarcity of data regarding the efficacy of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) in the management of pharmacologically refractory FES. While supportive care remains the mainstay of treatment, its limitations become evident in severe cases unresponsive to conventional therapies such as vasopressors, corticosteroids, and mechanical ventilation. Yamafuji et al. reported a compelling case involving a patient with severe, treatment-resistant FES who exhibited profound hemodynamic instability and hypoxemia despite maximal medical therapy. The initiation of VA-ECMO provided effective cardiopulmonary support, leading to clinical stabilization and eventual recovery. This case highlights the potential role of VA-ECMO as a life-saving intervention in select, critically ill FES patients when standard therapies fail (21).

The role of corticosteroids in FES treatment has long been debated in the medical literature. The theoretical rationale for their use includes potential stabilization of granulocyte membranes, reduction of catecholamine levels, delayed platelet aggregation, suppression of complement system activation, and protection of the capillary endothelium. While corticosteroids have shown efficacy in reducing the incidence of FES when used prophylactically, their therapeutic benefit in alleviating established clinical symptoms remains unclear and warrants further investigation (22).

Bederman et al. published noteworthy findings from their meta-analysis, in which only 7 studies were included out of 104 initially identified. The majority were excluded due to small sample sizes, poor data quality, and non-standardized protocols and data collection methods. Their analysis demonstrated that corticosteroid use can reduce the risk of developing FES by up to 78%, as well as lessen the severity of associated hypoxia. However, no statistically significant effects were observed in terms of reducing mortality or infection rates (23). In our series, the incidence of FES was 2.58% among patients who received methylprednisolone prophylaxis, compared to 11.20% in those who underwent conventional treatment without corticosteroid use. This represents a 77% relative reduction in FES incidence, highlighting the potential effectiveness of methylprednisolone in preventing this serious complication. Notably, these findings are comparable and compatible with previously published data, which report FES incidence ranging from 0.25% to 10% depending on fracture type and patient population. Our results not only reinforce the recognized variability of FES incidence across different settings but also provide additional evidence supporting the role of corticosteroid prophylaxis in reducing its occurrence. Silva et al. did not endorse the use of corticosteroids in the management of FES, as their study found no statistically significant evidence supporting their efficacy. Despite previous reports suggesting potential benefits in reducing the incidence or severity of FES, their findings indicated that corticosteroid administration did not lead to meaningful improvements in clinical outcomes. These results contribute to the ongoing debate and highlight the need for further high-quality, standardized research to clarify the role of corticosteroids in this context (24). Baba et al. published a case report of a 73-year-old woman who developed severe hypoxia and right ventricular failure due to pulmonary fat embolism following an orthopedic surgical procedure. They reported that administration of 250 mg of methylprednisolone led to clinical improvement, despite the patient's ongoing treatment with dobutamine and noradrenaline (25). Other authors have supported that early accurate diagnosis and treatment with methylprednisolone can improve prognosis (26). Velloze et al, reported a case of a young lady suffering massive alveolar bleeding due to FES after motorcycle collision. They used steroids, albumin, and respiratory supportive treatment (27).

Calleja et al. conducted a systemic review of PubMed, EMBASE aiming to assess whether prophylactic corticosteroids prevent FES in patients with long bone fractures. Secondary aims included evaluating effects on hypoxaemia, mortality, infection risk, and avascular necrosis. Eight studies (545 patients) met inclusion criteria. Among 246 patients receiving methylprednisolone, 10 developed FES, compared with 59 of 299 patients in the control group ($p<0.05$). Corticosteroid use was also associated with reduced risk of hypoxia. The authors concluded that prophylactic corticosteroids may reduce the incidence of FES and hypoxia in patients with long bone fractures. However, existing studies have limitations, and large-scale randomized trials are needed to confirm these findings (28).

He et al. reviewed 1,090 manuscripts on FES from June 2010 to June 2020, ultimately including 135 patients (>14 years) with confirmed FES and complete clinical data. Fat embolism syndrome was most associated with bone fractures (57.4%), particularly femur fractures (43.4%). Respiratory abnormalities were the most frequent presenting symptom (34.6%). Corticosteroid therapy was significantly associated with reduced mortality (OR 0.143), whereas age ≥65 years and non-orthopedic conditions were linked to increased mortality (29).

Prashanth et al. published data from their double-blind randomized controlled trial was conducted over 2 years and including 44 patients with subclinical fat embolism. Patients were randomly assigned to a control group (n=21, placebo saline) or a study group (n=23, single-dose methylprednisolone 30 mg kg^{-1}). Clinical FES developed in 33.3% of the control group versus 8.7% of the steroid group. Mean ventilator duration was longer in controls (9.25 vs. 7.33 days). They concluded that a single prophylactic dose of Methyl Prednisolone 30 mg kg^{-1} significantly reduces the incidence of FES (30).

In our retrospective analysis of 232 patients with lower extremity fractures, we compared the incidence of FES between two groups with similar fracture types and demographic characteristics. Notably, patients in Group I, who received corticosteroid prophylaxis, experienced a significantly lower incidence of FES compared to those without prophylaxis. This reduction is consistent with previously reported ranges of FES incidence in the literature, which vary depending on fracture type and patient population, thereby demonstrating that our findings are compatible with established data. Furthermore, the corticosteroid group had markedly fewer ICU admissions, suggesting a potential protective effect of prophylactic corticosteroid administration. These results underscore the value of corticosteroid prophylaxis not only in reducing the risk of FES following lower extremity fractures but also in potentially mitigating the severity of complications and improving overall patient outcomes. In settings with limited resources, where advanced monitoring or specialized interventions may not be readily available, this protocol offers a practical and standardized approach to reducing the risk of FES. By providing clear dosing guidance and a short, defined treatment course, it can be safely implemented even in hospitals with constrained personnel or monitoring capabilities. Implementation of this protocol may therefore help reduce variability in corticosteroid use, enhance patient safety, and improve outcomes in both high- and low-resource clinical environments.

Based on the results of our retrospective analysis, we recommend the administration of methylprednisolone at a total daily dose of 10 mg kg^{-1} on the day of hospital admission. The total dose should be divided into 4 separate administrations to optimize pharmacologic efficacy and minimize potential side effects. This regimen should be continued for a total of three consecutive days.

CONCLUSION

Our investigation's findings indicate that incorporating corticosteroids as a prophylactic measure in lower extremity fracture cases produces compelling results. This intervention proved to be a key factor in significantly reducing the incidence of FES, while also effectively decreasing pulmonary complications. Of particular importance is the recommendation for the careful use of corticosteroid prophylaxis in patients considered "high risk" for FES, especially those with long bone fractures. This targeted strategy has the potential to improve clinical outcomes by protecting patients from the debilitating effects of FES and its related complications. The insights from this study contribute valuable knowledge toward optimizing clinical management and patient care in the treatment of lower extremity fractures.

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Ai tools (ChatGPT) were untilized to help enhance the readability of this manuscript. The authors take full responsability.

AUTHOR CONTRIBUTIONS

Conception or design of the work: MB, RD
Data collection: AA, GH, MB
Data analysis and interpretation: MB, BA, RD
Drafting the article: AN, MB
Critical revision of the article: RD
The author (MB, GH, BA, AA, AN, RD) reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Rothberg DL, Makarewich CA. Fat embolism and fat embolism syndrome. J Am Acad Orthop Surg 2019;27(8):346-55.
2. Johnson MJ, Lucas GL. Fat embolism syndrome. Orthopaedics 1996;19(1):41-8.
3. Kosova E, Bergmark B, Piazza G. Fat embolism syndrome. Circulation 2015;131(3):317-20.
4. Luff D, Hewson DW. Fat embolism syndrome. BJA Educ 2021;21(9):322-8.
5. Gurd AR. Fat embolism: An aid to diagnosis. J Bone Joint Surg Br 1970;52:732-7.
6. Vetrugno L, Bignami E, Deana C, et al. Cerebral fat embolism after traumatic bone fractures: A structured literature review and analysis of published case reports. Scand J Trauma Resusc Emerg Med 2021;29(1):47.
7. Shaikh N, Mahmood Z, Ghuori SI, et al. Correlation of clinical parameters with imaging findings to confirm the diagnosis of fat embolism syndrome. Int J Burns Trauma 2018;8(5):135-44.
8. Kainoh T, Iriyama H, Komori A, Saitoh D, Naito T, Abe T. Risk factors of fat embolism syndrome after trauma: A nested case-control study with the use of a nationwide trauma registry in Japan. Chest 2021;159(3):1064-71.
9. Brezic N, Gligorevic S, Atanasijevic T, Zivkovic V, Jovanovic B. Fatal fat embolism syndrome in a young trauma patient with a stable initial presentation: Time to define predictive criteria? A case report. J Trauma Inj 2025;38(3):273-9.
10. Lempert M, Halvachizadeh S, Ellanti P, et al. Incidence of fat embolism syndrome in femur fractures and its associated risk factors over time-a systematic review. J Clin Med 2021;10(12):2733.

11. Caricato A, Russo G, Biasucci DG, Annetta MG. Fat embolism syndrome. Intensive Care Med 2017;43(9):1411-2.
12. Von Bergmann E. Ein fall todlicher fettembolie. Berlklin Wochenscher 1873;10:385.
13. Ihnát Rudinská L, Delongová P, Vaculová J, Silvia FI, Ihnát P. Fulminant pulmonary fat embolism - undetected silent killer. J Forensic Leg Med 2025;114:102918.
14. Eriksson EA, Pellegrini DC, Vanderkolk WE, Minshall CT, Fakhry SM, Cohle SD. Incidence of pulmonary fat embolism at autopsy: An undiagnosed epidemic. J Trauma 2011;71:312-5.
15. Morena D, Scopetti M, Padovano M, Turillazzi E, Fineschi V. Fat embolism: A systematic review to facilitate the development of standardized procedures in pathology. Histopathology 2025;86(6):845-61.
16. Bulger EM, Smith DG, Maier RV, Jurkovich GJ. Fat embolism syndrome. A 10-year review. Arch Surg 1997;132(4):435-9.
17. Tsai SHL, Chen CH, Tischler EH, et al. Fat embolism syndrome and in-hospital mortality rates according to patient age: A large nationwide retrospective study. Clin Epidemiol 2022; 14:985-96.
18. Wilson A, Hanandeh A, Shamia AA, Louie K, Donaldson B. Effective management of femur fracture using damage control orthopaedics following fat embolism syndrome. Cureus 2020;12(3):e7455.
19. Feder D, Koch ME, Palmieri B, Fonseca FLA, Carvalho AAS. Fat embolism after fractures in Duchenne muscular dystrophy: An underdiagnosed complication? A systematic review. Ther Clin Risk Manag 2017;13:1357-61.
20. Hacker A, Irvine DS, MacDougal S, Thornton I. The development of fat embolism syndrome (FES) and multiple small pulmonary emboli following open reduction internal fixation (ORIF) of a left femur fracture: A case report. Cureus 2023;15(9):e45551.
21. Yamafuji Y, Suga M, Fujisawa S, et al. A case of fatal fulminant fat embolism syndrome saved by VA-ECMO in the acute phase of multiple trauma. Trauma Case Rep 2024;51:101028.
22. Sen RK, Tripathy SK, Krishnan V. Role of corticosteroid as a prophylactic measure in fat embolism syndrome: A literature review. Musculoskelet Surg 2012;96(1):1-8.
23. Bederman SS, Bhandari M, McKee MD, Schemitsch EH. Do corticosteroids reduce the risk of fat embolism syndrome in patients with long-bone fractures? A meta-analysis. Can J Surg 2009;52(5):386-93.
24. Silva DF, Carmona CV, Calderan TR, Fraga GP, Nascimento B, Rizoli S. The use of corticosteroid for the prophylaxis of fat embolism syndrome in patients with long bone fracture. Rev Col Bras Cir 2013;40(5):423-6.
25. Baba D, Yamashita Y, Fukuda Y, et al. A case of fat embolism syndrome treated with methylprednisolone. Intern Med 2024;64(13):1993-7.
26. Gholipour M, Salimi M, Motamedi A, Abbasi F. Fat embolism syndrome following femoral shaft fracture: A case report and diagnostic considerations. Radiol Case Rep 2024;20(2):943-8.
27. Velloze S, Holtrop M, Adams TN. A case of diffuse alveolar haemorrhage secondary to fat embolism after long bone fracture. Respir Med Case Rep 2022;39:101735.
28. Calleja L, Chadee P, Naqshband M. A systematic review of prophylactic corticosteroids in the prevention of fat embolism syndrome following long bone fractures. J Orthop Trauma Care 2025;7:1
29. He Z, Shi Z, Li C, et al. Single case metanalysis of fat embolism syndrome. Int J Cardiol 2021;345:111-7.
30. Prashanth N, Neeta PN, Amit RU, Shilpa K. Prophylactic use of corticosteroids in a single long bone fracture of lower limb to prevent fat embolism syndrome - a clinical experience. Indian J Clin Anaesthesia 2015;2(1):63-9.