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Case Report

Challenges in Differentiating Fat Embolism Syndrome and Local Anesthetic Toxicity: A Case Report

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ABSTRACT

Fat embolism syndrome (FES) is a rare but life-threatening condition often associated with long bone fractures, particularly femoral fractures. It typically manifests within 24–72 hours post-injury, presenting with a combination of neurological, pulmonary, dermatological, and hematological symptoms. This case report describes a 48-year-old male who sustained a femoral fracture in a work-related accident and subsequently developed FES during perioperative management. Despite aggressive interventions, including mechanical ventilation, hemodynamic support, and lipid emulsion therapy, the patient's condition deteriorated, leading to cardiac arrest and death. The case highlights the diagnostic and therapeutic challenges of FES, emphasizing the need for early recognition, multidisciplinary management, and advanced diagnostic tools. The possibility of inadvertent intrathecal administration of an incorrect drug or local anesthetic systemic toxicity (LAST) further complicates the diagnosis, underscoring the importance of meticulous documentation and verification of administered medications. This report aims to contribute to the growing body of evidence necessary to address these significant research gaps and advance patient care in high-risk perioperative scenarios.

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Introduction

Fat embolism syndrome (FES) was first described by Zenker in 1861 as a rare but potentially life-threatening condition most commonly associated with long bone fractures, particularly femoral fractures. It usually presents within 24–72 hours post-injury. The syndrome is characterized by a combination of neurological, pulmonary, dermatological, and hematological clinical features, making this a complex and challenging condition to diagnose and manage [1-2]. FES complicating orthopedic trauma in ages 10-39 years, particularly in males, is the highest-risk population [3]. The pathophysiology of FES involves the release of fat globules into the systemic circulation, causing mechanical obstruction and inflammatory responses in the microvasculature of the lungs, brain, and other organs [4]. While the incidence of FES is low, the mortality rate remains high, especially in cases of delayed diagnosis or poor management [5]. Current diagnostic criteria are largely clinical, often leading to delayed or missed diagnoses, especially in perioperative settings where symptoms may overlap with other complications [3]. Local anesthetic systemic toxicity (LAST) classically presents with progressive neurological symptoms, such as seizures and coma, followed by hemodynamic instability and cardiovascular collapse [6]. This case report describes a 48-year-old male who presented to the operating room for surgical intervention following a femoral fracture sustained in a work-related accident. A series of perioperative events ultimately led to his demise. This case underscores the diagnostic and therapeutic challenges associated with managing complex perioperative complications, particularly in the setting of acute trauma. It highlights the critical need for enhanced diagnostic tools and targeted therapeutic strategies to improve outcomes in such high-risk scenarios. By elucidating the complexities of patient management in this context, this report aims to contribute to the growing body of evidence necessary to address these significant research gaps and advance patient care.

Case Report

A 48-year-old male patient was admitted to the emergency department during the previous evening shift following a work-related accident that resulted in a femoral fracture. He was subsequently referred to the orthopedic operating room for surgical stabilization of the fracture. The patient's medical history revealed well-controlled hypertension, managed with losartan, and a remote episode of seizure approximately 15 years prior, the etiology of which remained undetermined. The patient confirmed that he was not currently on any anticonvulsant therapy and denied any history of chronic neurological disorders. On the day of the scheduled surgery, the patient reported the development of a mild headache approximately one hour before being transferred to the operating room. However, he denied experiencing any associated systemic symptoms, such as nausea, visual disturbances, or focal weakness. The anesthesia and surgical team attributed the headache to the patient's nil per os (NPO) time and mild blood loss from the injury. The patient’s preoperative laboratory results revealed a hemoglobin (Hb) level of 12 g/dL. Serum potassium (K^+) was within the normal range at 4.2 mEq/L. Coagulation studies indicated a prothrombin time (PT) of 13.1 seconds (normal range: 11–13.5 seconds), an activated partial thromboplastin time (aPTT) of 32 seconds (normal range: 25–35 seconds), and an international normalized ratio (INR) of 1.1 (normal: <1.2). All values were within the expected ranges, suggesting no underlying coagulopathy. An ECG was performed before the surgical procedure as part of the routine preoperative assessment. The results indicated normal sinus rhythm, with a heart rate of approximately 95 beats per minute. The P-wave, PR interval, QRS complex, and QT interval were all within normal limits, with no evidence of arrhythmia, ischemia, or structural abnormalities. Additionally, no ST-segment or T-wave changes were observed, ruling out preexisting myocardial ischemia or other cardiac pathology at that time. The preoperative ECG findings were unremarkable, confirming stable cardiac function and the absence of significant underlying cardiovascular conditions before the surgery. The patient’s initial vital signs were stable: blood pressure (BP) was 135/80 mmHg, heart rate (HR) was 95 beats per minute, and oxygen saturation (SpO_2) was 98% on room air. A 20-gauge intravenous (IV) line was placed in the left antecubital vein, and normal saline infusion was initiated. Routine preoperative laboratory tests, including complete blood count and metabolic panel, were unremarkable.

Spinal anesthesia was administered in the sitting position using 4 mL of 0.5% hyperbaric bupivacaine (Marcaine). The procedure was performed under strict aseptic conditions, and clear cerebrospinal fluid (CSF) flow was observed, indicating accurate needle placement. Following the injection, the patient reported warmth and tingling sensations in the lower extremities, consistent with an effective sensory block.

Approximately three minutes post-procedure, the patient complained of nausea, dizziness, and a sensation of impending fainting. His complexion became pale, and vital signs revealed progressive hypotension (BP 95/63 mmHg), tachycardia (HR 125 bpm), and declining SpO_2 (90%). The anesthesiology team suspected compromised IV access due to patient positioning and initiated attempts to establish a new IV line. Ephedrine (10 mg IV) was administered.

Shortly after the re-establishment of intravenous (IV) access, the patient exhibited a generalized tonic-clonic seizure, which persisted for approximately two minutes. The seizure was promptly terminated following the administration of diazepam (10 mg IV). During the event,

noninvasive blood pressure (BP) monitoring indicated severe hypotension (65/35 mmHg). Upon clinical assessment, the anesthesiologist characterized the carotid pulse as weak and thready. Additionally, limited petechiae were observed on the patient's chest (Figure 1). In response to the hemodynamic instability, ephedrine (30 mg IV) was administered to address the hypotension. Furthermore, dexamethasone (8 mg IV) was administered to mitigate potential inflammatory or vasodilatory responses.

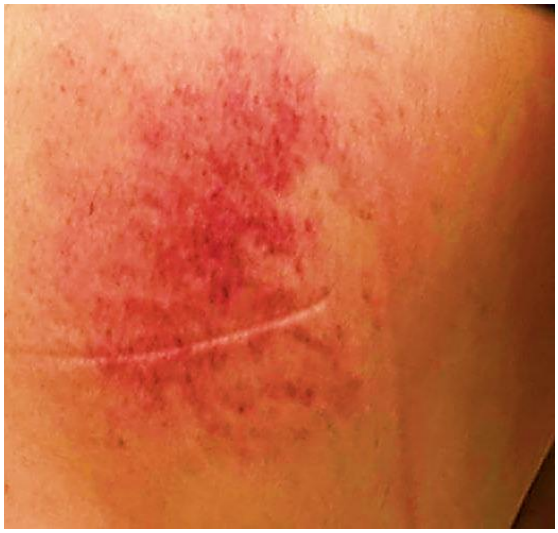

Figure 1- Petechiae on the patient's chest.

Postictally, the patient's electrocardiogram (ECG) demonstrated sinus tachycardia (HR ~190 bpm) with nonspecific ST-segment depression and T-wave inversion, suggestive of myocardial ischemia or stress-induced cardiac strain. The SPO2 level also reached 88%. His breathing became progressively irregular and shallow, necessitating endotracheal intubation and mechanical ventilation.

Persistent hypotension (BP 63.44 mmHg) and refractory hypoxemia (SpO_2 ~85%) raised concerns about systemic complications. Epinephrine was administered to support hemodynamics.

Although systemic local anesthetic toxicity (LAST) was considered unlikely, lipid emulsion therapy (Intralipid 20%) was initiated as a precautionary measure. A bolus of 1.5 mL/kg was administered, followed by a continuous infusion at 0.25 mL/kg/min. The patient underwent arterial blood gas (ABG) analysis, which demonstrated profound hypoxemia and metabolic acidosis, with the following partial results: pH 7.11, PaO2 55 mmHg, PaCO2 46 mmHg, and bicarbonate 14 mEq/L.

The clinical presentation—hypoxia, neurological changes (seizure), and cardiovascular collapse—was highly suggestive of fat embolism syndrome (FES). Close monitoring of respiratory and neurological parameters was initiated.

Despite aggressive interventions, including mechanical ventilation, hemodynamic support, and lipid emulsion therapy, the patient's condition continued to deteriorate. Approximately 20 minutes after the onset of seizures, the patient progressed to asystole. In response to the cardiac arrest, the anesthesia team promptly arranged for the echocardiography machine to be transferred to the operating room and urgently requested an emergency cardiovascular consultation. Advanced Cardiac Life Support (ACLS) protocols were immediately initiated. Echocardiography revealed evidence of right ventricular dilatation, raising concerns for potential pulmonary embolism or other cardiopulmonary pathology. Resuscitation efforts were continued in accordance with standard protocols; however, the patient remained unresponsive. After 45 minutes of sustained and exhaustive efforts, further interventions were deemed futile, and resuscitation was discontinued. The patient was subsequently pronounced deceased. Due to the patient's unidentified status, further investigations, including autopsy, were inconclusive, limiting the ability to determine the definitive underlying cause of death.

Discussion

This case underscores the complexity and severity of fat embolism syndrome (FES) as a perioperative complication, emphasizing the need for early recognition, multidisciplinary management, and the implementation of advanced diagnostic and therapeutic strategies to mitigate its high morbidity and mortality rates. FES is a rare yet potentially catastrophic condition, and the presentation of FES in this patient aligns with its known pathophysiology and clinical manifestations, including acute hypoxemia, neurological symptoms, petechial rash, and hemodynamic instability [4]. While these findings are pathognomonic, the diagnosis remains challenging, particularly in atypical presentations or overlapping perioperative conditions. In this case, the sudden onset of neurological deterioration, profound hypoxemia, and cardiovascular collapse shortly after spinal anesthesia highlights the importance of maintaining a high index of suspicion for FES, especially in patients with high-risk trauma profiles such as long bone fractures. The pathogenesis of FES involves the release of fat globules into the circulation, often following traumatic or surgical disruption of bone marrow. These fat emboli can obstruct capillary beds, particularly in the pulmonary and cerebral microvasculature, and trigger an inflammatory cascade that exacerbates organ dysfunction [7]. Although this patient's femoral fracture and perioperative status were consistent with established risk factors for FES, the atypical sequence of events—seizure, hemodynamic collapse, and refractory hypoxemia—complicated early diagnosis. Preoperative symptoms, such as headache [4], may represent subtle prodromal signs of fat embolism, underscoring the need for vigilance in such high-risk scenarios. The generalized tonic-clonic seizure observed in this patient highlights a critical neurological manifestation of fat embolism syndrome (FES) [7], particularly in the perioperative setting. Seizures in FES

are primarily caused by fat globules entering the cerebral circulation, leading to capillary obstruction, blood-brain barrier disruption, and subsequent cerebral edema and inflammation. These processes contribute to neuronal dysfunction, which may present as seizures, confusion, altered mental status, or focal neurological deficits [4, 8]. In this case, the seizure was an early and dramatic neurological event, complicating the perioperative management. While the patient had a remote history of a seizure 15 years prior, the lack of ongoing anticonvulsant therapy or recurrent episodes diminishes the likelihood of pre-existing epilepsy as the underlying cause. Instead, the acute nature of the seizure, combined with the patient's systemic hypoxemia and hemodynamic instability, strongly suggests a direct link to the pathophysiology of FES. Management of seizures in the setting of FES is challenging and requires a multifaceted approach. Immediate cessation of seizure activity through the use of benzodiazepines, as seen in this case, is critical [9].

On the other hand, local anesthetic systemic toxicity (LAST) is a rare but serious complication of regional anesthesia, characterized by dose-dependent neurological and cardiovascular symptoms. Neurological manifestations typically begin with early signs of central nervous system (CNS) excitation, such as dizziness, metallic taste, tinnitus, and perioral numbness, progressing to muscle twitching, seizures, and eventually CNS depression, including coma and respiratory arrest. Cardiovascular symptoms may include arrhythmias, hypotension, and cardiovascular collapse, which can occur concurrently with or independently of neurological signs. Differential diagnosis includes other causes of seizures, hypoxia, or cardiovascular instability, such as hypoglycemia, anaphylaxis, or pulmonary embolism. Prompt recognition and management, including lipid emulsion therapy, are critical to improving outcomes [6, 10].

The administration of spinal anesthesia, although generally considered safe, may have indirectly contributed to the hemodynamic instability observed in this case. Hypotension following spinal anesthesia is a well-documented phenomenon, potentially compounding the systemic effects of fat embolism by reducing end-organ perfusion and oxygenation [11-13].

Also, the echocardiographic findings in the patient revealed right ventricular (RV) dilation, which is a key indicator of acute pressure overload in the right heart. This finding is highly suggestive of pulmonary embolism (PE), as RV dilation often occurs in response to sudden increases in pulmonary vascular resistance due to obstruction of the pulmonary arteries by emboli [14]. In the context of the patient's clinical presentation, including hypoxemia, hemodynamic instability, and metabolic acidosis, the observed RV dilation strongly supports the diagnosis of acute PE. While RV dilation can also be seen in other conditions such as chronic pulmonary hypertension or RV infarction, the acute onset and associated clinical features make PE the most likely underlying cause in this case [14-15].

A critical point of concern was that the vial containing the drug administered for spinal anesthesia was discarded in the safety box after the drug was withdrawn, raising the possibility that a drug other than Marcaine (bupivacaine)—the intended medication — could have been mistakenly injected into the intrathecal space. The clinical manifestations observed in the patient, including generalized tonic-clonic seizures, hemodynamic collapse, and refractory hypoxemia, are consistent with potential toxicity resulting from the inadvertent administration of an incorrect medication.

Despite the clinical presentation being consistent with FES, the atypical sequence of events — particularly the acute seizure and subsequent hemodynamic collapse — complicates the diagnosis. Furthermore, the absence of definitive documentation regarding the drug vial utilized for spinal anesthesia raises significant concerns that a medication other than Marcaine may have been inadvertently administered, or that local anesthetic systemic toxicity (LAST) could have resulted from the administration of a local anesthetic.

The acute nature of the seizure, combined with the patient's hypoxemia and hemodynamic collapse, suggests that LAST may have been a significant factor in the patient's clinical deterioration.

In this case, the use of lipid emulsion therapy, although rational given the initial suspicion of local anesthetic systemic toxicity (LAST) [16], highlights the diagnostic uncertainty often encountered in acute perioperative crises. Current evidence does not support the efficacy of lipid emulsion therapy in FES, and theoretical concerns about exacerbating the lipid burden have been raised in recent literature [17-18].

The rapid administration of dexamethasone, aimed at attenuating the systemic inflammatory response, aligns with emerging evidence supporting its use in severe FES cases [19]. However, the progression to refractory hypoxemia and asystole despite aggressive interventions suggests that early deployment of advanced modalities, such as extracorporeal membrane oxygenation (ECMO), may have been warranted in this case. Transesophageal echocardiography (TEE) could have provided valuable diagnostic insights, particularly in confirming the presence of fat emboli in the pulmonary vasculature [20-21].

Consequently, in the absence of autopsy results, while fat embolism syndrome (FES) remains a highly probable explanation for the patient's clinical presentation, the possibility of inadvertent intrathecal administration of a drug other than Marcaine or systemic local anesthetic toxicity (LAST) cannot be definitively excluded.

Conclusion

This case underscores the critical importance of early recognition and multidisciplinary management in complex perioperative scenarios, particularly in high-risk patients with conditions such as fat embolism syndrome (FES) or potential local anesthetic systemic toxicity

(LAST). The patient's presentation, characterized by acute neurological deterioration, hemodynamic collapse, and refractory hypoxemia, highlights the diagnostic challenges in differentiating between FES, LAST, and medication errors. The possibility of inadvertent intrathecal administration of an incorrect drug cannot be ruled out, emphasizing the need for meticulous documentation and verification of administered medications to prevent such errors. Key lessons include maintaining a high index of suspicion for FES in trauma patients, the importance of advanced diagnostic tools such as echocardiography, and the potential role of therapies like extracorporeal membrane oxygenation (ECMO) in refractory cases. This case serves as a reminder of the complexities in perioperative care and the critical role of vigilance, accurate diagnosis, and prompt intervention in improving patient outcomes.

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