Case Report

A Case of Fat Embolism Syndrome after Fracture of Tibia Fibula

Mithun Kumar Mondal[1], Nur Takia[2], Naser Ahmed[3], Sadat Bin Siraj[4], Masudul Alam Mazumder[5]

Abstract:

Fat embolism syndrome is a fatal condition that affects several organs. It often occurs after trauma or orthopedic surgeries. Most are unnoticed, and treatment of it is primarily supportive, with early fracture repair as a preventative measure. This case report describes a patient who had a left tibia fibula fracture diagnosed using Gurd's criteria and verified by a CT pulmonary angiography and MRI, and was treated with supportive care.

Key Words: *Fat Embolism Syndrome, Steroid, Heparin, Early Fixation.*

Introduction:

Fat embolism syndrome (FES) is a life-threatening systemic inflammatory cascade impacting several organ systems that occurs after trauma and orthopedic surgeries but rarely in non-traumatic patients, resulting in substantial morbidity and mortality. Fat emboli occur in many people with bone fractures but are typically asymptomatic. Many individuals acquire signs and symptoms of organ system malfunction due to mechanical capillary constriction caused by fat emboli or fat hydrolysis into fatty acids. Treatment of FES is supportive and, in most cases, can be prevented by early fixation of large bone fractures. We provide a case of FES in a patient with a left tibia & fibula fracture, initially diagnosed using Gurd's criteria and later confirmed by typical findings on a CT pulmonary angiography and MRI findings. The patient was given supportive care and a short course of intravenous hydrocortisone and heparin.

Case Report:

The patient was a 28-year-old male who presented to the Emergency Department of a local hospital with bleeding & severe pain in his left leg following a road traffic accident. He had experienced immediate left leg pain, swelling, and inability to ambulate the limb. Upon physical examination,

1. Specialist in Charge, Emergency Casualty Centre, Combined Military Hospital (CMH), Dhaka

2. Graded Specialist, Critical Care Centre, CMH Dhaka

3. Specialist in Charge, HDU Complex, CMH Dhaka

4. Specialist in Charge, Critical Care Center, CMH Dhaka

5. Adviser Intensivist, Critical Care Centre and Emergency Casualty Centre, CMH Dhaka

Corresponding Author:

Dr. Mithun Kumar Mondal
MBBS, MD (Critical Care Medicine)
Specialist in Charge, Emergency Casualty Centre
CMH Dhaka
Dhaka Cantonment, Dhaka
E-mail: m1989n.k64@gmail.com

there was an open fracture in the shaft of the left tibia& fibula. The sensory & motor function of the distal area of the injured leg was intact. Pedal pulses were present and symmetric bilaterally. Initial vital signs included a blood pressure of 110/60 mmHg, heart rate of 68 beats per minute, respiratory rate of 18 breaths per minute, oxygen saturation of 98% on room air, and oral temperature of 98°F. The patient had no significant past medical history. The patient had no known drug allergies.

Radiographic imaging of the left leg revealed an open fracture (Grade II) of the left tibia & fibula (Figure 1). Orthopedic surgery was consulted, and the patient was scheduled for surgical toileting & long leg back slab. The procedure was done under Sub Arachonoid Block (SAB) on the same day. The Chest X-Ray initially demonstrated no evidence of cardiopulmonary disease or acute pathology. EKG showed sinus rhythm, with a rate of 62 beats per minute, normal axis, normal PR interval, and no acute ischemic changes.
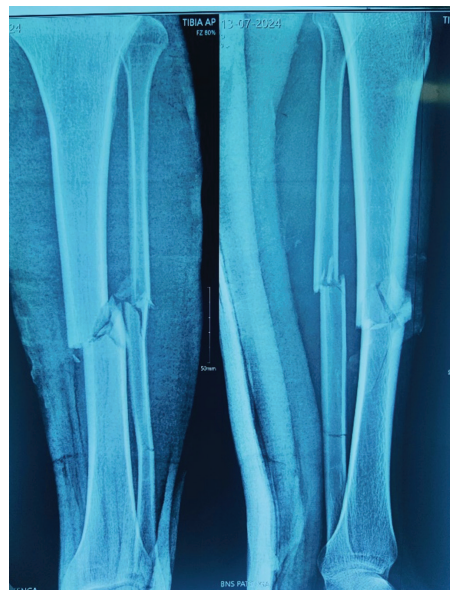

Figure 1: Fracture in the shaft of left Tibia-Fibula before fixation

Figure 2: Fracture in the shaft of left Tibia-Fibula after fixation

Approximately 36 hours after the injury, the patient developed fever and respiratory distress. The patient's temperature was 102°F, heart rate 140/min, blood pressure 140/70 mmHg, oxygen saturation decreased from 100% to 85% with high flow oxygen, and respiratory rate 35 breaths/min. The patient was immediately shifted to ICU on 3rd day after admission. The patient's initial lab reports showed hemoglobin 14 g/dl, total WBC 21.52 10^9/L, platelet count 300×10^9/L, and CPK 1899 U/L. The patient's oxygen saturation failed to improve with 15-litre oxygen via a high-flow mask, prompting intubation and mechanical ventilation. Immediate high-resolution computed tomography (HRCT) chest revealed evidence of pulmonary edema & bilateral pleural effusion. Echocardiography revealed moderate TR, severe pulmonary hypertension (PASP: 56mmHg) with reduced Tricuspid Annular Plane Systolic Excursion (TAPSE), and a left ventricular ejection fraction of 60%. Due to no significant improvement in the patient, he was urgently transferred to a higher medical center.

In our tertiary care hospital, he was admitted to the ICU. The patient was intubated on mechanical ventilation with high doses of inotrope & vasopressor support with noradrenaline and vasopressin. Initial venous blood gas (VBG) showed lactic acidosis. CT pulmonary angiogram was done urgently, which revealed a bilateral pulmonary arterial embolism involving lobar and segmental arteries (figure 3, 4). CT scans of the brain were performed and revealed no evidence of acute intracranial hemorrhage, territorial infarction, or intracranial mass lesion.

His initial ICU profile showed Hb% 12.3 g/dl, WBC count 19,300/mm3, Platelet count 1,76,000/mm3, Creatine phosphokinase 5690 u/L, Serum Creatinine 1.46mg/dl, FDP 112.8 umol/L, D-dimer 15.73 umol/L, and CPK 5690 U/L.

Initially, the patient was hemodynamically unstable with inotropic & vasopressor support on mechanical ventilation on FiO$_2$ 1. A heparin drip was initiated in the ICU for the management of embolism at a dose of 1000 units/hr and a target-activated partial thromboplastin time (aPTT) of 60-80 seconds with a high dose of hydrocortisone. Crush protocol was started for rhabdomyolysis, which gradually improved over the next 4 days. The patient maintained stable hemodynamics without any inotropes & vasopressors from ICU day 5.

The extubation trial started from ICU day 6, but the patient became restless during the spontaneous breathing trial. To further evaluate the brain, we did an MRI of the brain in ICU day 8, which revealed multiple small discrete signal intensity change areas of variable sizes noted at the body of the corpus callosum, thalamus-capsule-ganglionic region, and periventricular white matter regions of both cerebral hemispheres. The lesions are hyper-intense on T2W / FLAIR images, all suggesting fat embolism syndrome (figure 5, 6).

Figure 3: Partial filling defect is also noted in the posterior segmental branch of the right upper lobar artery and different basal segments of the right lower lobe artery
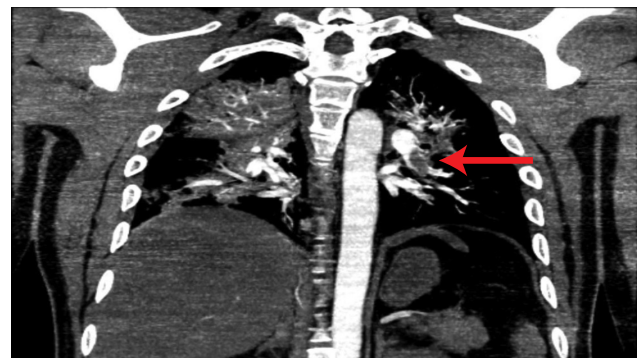

Figure 4: A partial filling defect is noted in the interlobar branch of the left pulmonary artery, extending up to the posterior basal segmental branches.
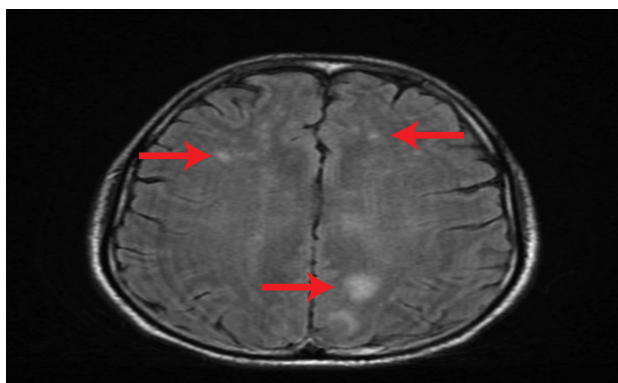
Figure 5:Multiple small discrete signal intensity change areas of variable sizes are noted at the body of corpus callosum, thalamo-capsulo-ganglioic region, and periventricular white matter regions of both cerebral hemispheres (FLAIR)
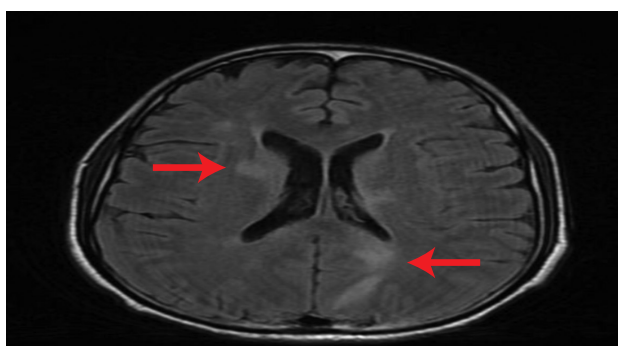

Figure 6: Multiple small discrete signal intensity change areas of variable sizes are noted at thalamo-capsulo-ganglioic region and periventricular white matter regions of both cerebral hemispheres (FLAIR)

On ICU day 9, the patient underwent a tracheostomy for delayed weaning with an altered level of consciousness. On ICU day 12, open reduction and internal fixation were performed (Figure 2). From ICU day 13, the patient was gradually withdrawn from a mechanical ventilator. Echocardiography showed a normal right ventricle with mild TR, PASP 30 mm Hg, normal TAPSE, and LVEF of 60% without any regional wall motion abnormality.

On ICU day 15, the patient became conscious and oriented, maintaining hemodynamics without support and maintaining a saturation of 98% on room air on the tracheostomy filter. On ICU day 16, the patient was shifted to the ward for rehabilitation.

Discussion:

Fat Embolism Syndrome is most typically associated with orthopedic trauma, with the largest frequency occurring in closed, long bone fractures of the lower extremities, including the femur and pelvis.[1] Males aged 10 to 40, multiple fractures, and unstable bone fracture mobility are all risk factors.

Table I: Causes of FES

Trauma-related	Non-trauma related
1. Long bone fracture	1. Pancreatitis
2. Pelvic fracture	2. Diabetes mellitus
3. Fracture of other marrow-containing bones	3. Osteomyelitis and panniculitis
4. Orthopedic procedures	4. Bone tumor lysis
5. Soft tissue injuries (e.g., chest compression with or without rib fracture)	5. Steroid therapy
6. Burns	6. Sickle cell haemoglobinopathies
7. Liposuction	7. Alcoholic liver disease
8. Bone marrow harvesting and transplant	8. Lipid infusion
	9. Cyclosporine A solvent

Due to a lack of standard diagnostic criteria, the incidence of FES varies from <1% to >30%. Mild instances may go undiagnosed. Fat particles or globules are liberated from the major organs and enter the microcirculation, damaging the capillary beds. The disturbance impacts microcirculatory hemostasis in the following organs:

- Brain
- Skin
- Eyes
- Heart

Two main theories try to explain the development of fat embolism syndrome.

Mechanical Theory

According to the hypothesis by Gassling et al., big fat droplets are discharged into the venous system. These fat globules originate in the venous system and are deposited in the pulmonary capillary bed before traveling to the brain via the arteriovenous shunt.[2] Pathophysiological alterations caused by fat droplets include the following:

- Elevated pulmonary artery pressure
- Impairment of oxygen exchange from ventilation-perfusion mismatch
- Systemic effects on end organs such as the brain, kidney, and skin.

The deposition of fat droplets in the brain triggers a chain reaction that results in a systemic inflammatory response syndrome, local inflammation, and ischemia due to microcirculation disruption. Producing inflammatory mediators and vasoactive amines such as histamine and serotonin causes increased vascular permeability and vasodilation, leading to hypotension and hypoperfusion.

Biochemical Theory

Baker et al. proposed this notion to explain the development of fat embolism syndrome.[3] According to this idea, the precipitating event, whether traumatic or nontraumatic, causes a hormonal shift in the body system. This causes the release of free fatty acids (FFAs) and chylomicrons. Baker et al. ascribe fat embolism syndrome to FFA. FFA is produced when pneumocytes hydrolyze fat particles, which then move to other organs and induce various organ dysfunction disorders.[3]

FES is characterized by multisystem dysfunction, usually occurring 12 to 72 hours after the initial injury. The traditional trio of FES is hypoxemia, neurological problems, and petechiae. The most common early indications of FES are dyspnea, tachypnea, hypoxemia, and respiratory failure. In one large series of patients with FES, hypoxia was the most common finding, impacting 96% of individuals.[4] Neurological abnormalities are prevalent and often appear following respiratory alterations. Neurological problems include focal deficits, disorientation, lethargy, restlessness, and coma. The petechial rash is typically found in non-dependent areas (conjunctivae, head, neck, anterior thorax, or axillae).[5] Other nonspecific signs include fever and retinopathy. Thrombocytopenia and unexplained anemia are common hematologic symptoms, accounting for 37% and 67% of cases, respectively.[4] Severe cases of FES can be worsened by disseminated intravascular coagulation, which is most likely caused by increased tissue factor expression following trauma. Fulminant FES can cause right ventricular dysfunction, biventricular failure, acute respiratory distress syndrome, shock, and death.

FES is diagnosed by recognizing the typical clinical condition in conjunction with supportive imaging and a predisposing injury. Chest X-rays showing bilateral patchy infiltrates consistent with acute respiratory distress syndrome and may be difficult to distinguish from pulmonary edema or alveolar hemorrhage.[6] Frequently, the chest X-ray is read as normal. Diffusion-weighted brain MRI can reveal a star-field pattern of diffuse, punctate, hyperintense lesions up to day four. Later, the same changes are seen in the Fluid-attenuated inversion recovery (FLAIR) sequence of MRI.[7] In our patient, The MRI was done in ICU day 8, so multiple small discrete signal intensity change areas of variable sizes at the thalamic-capsule-ganglionic region and periventricular white matter regions of both cerebral hemispheres found on the FLAIR sequence, which correlate with fat embolism syndrome. The same findings were seen by Bethany et al. in a case report, in which the MRI was done on day 7 after trauma.[8]

Many authors have proposed clinical diagnostic criteria due to the absence of a gold standard diagnostic test or pathognomonic feature. The most frequently cited are Gurd's Criteria.[9]

Table II: Gurd's criteria (2 major, or 1 major criterion plus 2 minor criteria)

Major criteria 1. Petechial rash

2. Respiratory symptoms with radiographic change

3. Central nervous system signs unrelated to trauma or other conditions

Minor criteria 1. Tachycardia (HR 120 bpm)

2. Pyrexia (temperature > 39°C)

3. Retinal change (fat or petechiae)

4. Acute thrombocytopenia

5. Acute decrease in hemoglobin

6. High erythrocyte sedimentation rate (ESR)

7. Fat globules in sputum

Our patient had respiratory symptoms with radiographic change and central nervous system signs in major criteria. The patient also had tachycardia, fever, thrombocytopenia, and an acute decrease of hemoglobin (8.6 g/dl on 2nd ICU day) in minor criteria. Later, a CT pulmonary angiogram and brain MRI confirmed our suspicion.

Currently, there are no disease-specific therapies for FES. Heparin and corticosteroids have been offered as therapies; however, they have not consistently shown better morbidity or death.[10] Systemic anticoagulation has been investigated as a possible treatment for FES. Heparin boosts lipase activity, which may speed up lipid clearance from the bloodstream, but the resulting increase in free fatty acids may exacerbate the underlying pro-inflammatory mechanism.[11] Furthermore, anticoagulation in the presence of trauma and previous hematologic abnormalities may be hazardous.[12] No randomized controlled trials or comprehensive retrospective evidence support the usual use of heparin or other anticoagulants in FES. Corticosteroids may be used to treat fulminant FES. However, there is inadequate data to recommend routine corticosteroid therapy for the majority of people with FES. We treated our patient with heparin and corticosteroid therapy.

Supportive intensive care unit-level care is common. Most individuals have severe hypovolemia and require fluid resuscitation. While the patient recovers, supplementary oxygen or mechanical breathing may be required to address hypoxemia. Frequent neurological evaluations are essential if central nervous system dysfunction is present, as is intracranial pressure monitoring.[13] Vasopressors may be required. Case reports have revealed that mechanical support devices and extracorporeal membrane oxygenation can be used to bridge the recovery gap in patients with severe FES, which causes refractory systemic arterial hypotension and shock.[14,15] The Echocardiography showed gradual improvement of right ventricular function, so we did not use any pulmonary vasodilators.

Current research indicates that preventive corticosteroids in patients with long bone fractures may minimize the risk of FES. A recent meta-analysis of 7 small randomized, controlled trials discovered that preventive corticosteroids lowered the incidence of FES by 78%, with a number-needed-to-treat of 8 to prevent one occurrence of FES.[16] Corticosteroids reduced hypoxemia without altering mortality. A large, multi-center randomized trial is required before preventive corticosteroids are widely used in FES.

Surgical timing and technique have also been proven to influence FES. Early surgical fixation (within 24 hours of the trauma) has a decreased risk of FES than delayed fixation. A delayed approach or intermediate technique, such as external fixation, may be performed in patients who face an unacceptable early surgical risk.[17] In our case, a delayed fixation was performed due to hemodynamic instability. If the patient's fixation had been done early before the complication, the patient would not suffer this much disability.

Acknowledgements:

References:

1. Kosova E., Bergmark B., Piazza G. Fat embolism syndrome. Circulation 2015; 131(3): 317–320. doi: 10.1161/circulationaha.114.010835.

2. Gossling H. R., Pellegrini V. D. Fat embolism syndrome: a review of the pathophysiology and physiological basis of treatment. Clinical Orthopaedics and Related Research 1982; 165: 68–82. doi: 10.1097/00003086-198205000-00011.

3. Baker P. L., Pazell J. A., Peltier L. F. Free fatty acids, catecholamines, and arterial hypoxia in patients with fat embolism. The Journal of Trauma 1971; 11(12): 1026–1030. doi: 10.1097/00005373-197112000-00006.

4. Bulger E. M., Smith D. G., Maier R. V., Jurkovich G. J. Fat embolism syndrome. A 10-year review. Arch Surg. 1997;132:435–439.

5. Georgopoulos D., Bouros D. Fat embolism syndrome: clinical examination is still the preferable diagnostic method. Chest. 2003;123:982–983.

6. Akhtar S. Fat embolism. Anesthesiol Clin. 2009;27:533–550. doi: 10.1016/j.anclin.2009.07.018.

7. Ryu C. W., Lee D. H., Kim T. K., Kim S. J., Kim H. S., Lee J. H., Choi C. G., Suh D. C. Cerebral fat embolism: diffusion-weighted magnetic resonance imaging findings. Acta Radiol. 2005;46:528–533.

8. Radin, B., Reynolds, H. N., Bodanapally, U. K., &Dreizin, D. (2014). Cerebral fat embolism syndrome: Diagnostic state of the art: with and without intra-medullary fixation, with and without long bone fractures. International Journal of Critical Care and Emergency Medicine, 1(1). ISSN: 2474-3674.

9. Gurd A. R. Fat embolism: an aid to diagnosis. J Bone Joint Surg Br. 1970;52:732–737.

10. Habashi N. M., Andrews P. L., Scalea T. M. Therapeutic aspects of fat embolism syndrome. Injury. 2006;37 Suppl 4:S68–S73. doi: 10.1016/j.injury.2006.08.042.

11. Mellor A., Soni N. Fat embolism. Anaesthesia. 2001;56:145–154.

12. Kellogg R. G., Fontes R. B., Lopes D. K. Massive cerebral involvement in fat embolism syndrome and intracranial pressure management. J Neurosurg. 2013;119:1263–1270. doi: 10.3171/2013.7.JNS13363.

13. Sarkar S., Mandal K., Bhattacharya P. Successful management of massive intraoperative pulmonary fat embolism with percutaneous cardiopulmonary support. Indian J Crit Care Med. 2008;12:136–139. doi: 10.4103/0972-5229.43684.

14. Webb D. P., McKamie W. A., Pietsch J. B. Resuscitation of fat embolism syndrome with extracorporeal membrane oxygenation. J Extra Corpor Technol. 2004;36:368–370.

15. Bederman S. S., Bhandari M., McKee M. D., Schemitsch E. H. Do corticosteroids reduce the risk of fat embolism syndrome in patients with long-bone fractures? A meta-analysis. Can J Surg. 2009;52:386–393.

16. Bone L. B., Johnson K. D., Weigelt J., Scheinberg R. Early versus delayed stabilization of femoral fractures. A prospective randomized study. J Bone Joint Surg Am. 1989;71:336–340.

17. Pape H. C. Effects of changing strategies of fracture fixation on immunologic changes and systemic complications after multiple trauma: damage control orthopedic surgery. J Orthop Res. 2008;26:1478–1484. doi: 10.1002/jor.20697.