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Research Paper

FAT EMBOLISM SYNDROME IN SINGLE LONG BONE FRACTURE OF LOWER LIMB – A CLINICAL EXPERIENCE

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Background: Fat embolism is the most frequent cause of death after fracture of long bones. Fat embolism were first described by Zenker (1862). The most common clinical situation in which Fat Embolism Syndrome (FES) may develop is orthopedic or general trauma. The purpose of this study was to review the FES experiences in a tertiary referral center between May 2005 and May 2007. Methods: Over 2 years period, 210 patients with single long bone fracture of lower limb (femur or tibia) admitted to our tertiary care centre were prospectively evaluated. FES was diagnosed clinically among those patients showing one or more signs of Lindeque's criteria. Results: among 210 patients, 4.76% developed clinical FES. The incidence of fat embolism in patients with fracture femur was significantly higher ($p = 3.63 \times 10^{-18}$) than that with tibia. Majority of patients belong to age group of 25-34 years, 3 presented with petechiae, 11 with thrombocytopenia. Statistically significant association found between FES with PaO_2 less than 60 mmHg as well as more time taken to admit patient to hospital after injury. Conclusion: The incidence of clinical FES is seen more with femur fracture and delay admission to hospital. As it is tertiary and trauma care centre, many patients had road traffic accidents.

Keywords: Fat Embolism Syndrome, Lindeque's criteria, Long bone fracture

INTRODUCTION

Fat embolism syndrome is fat in circulation associated with respiratory, hematological, neurological and cutaneous symptoms and signs (Mellor and Sony, 2001).

Although pulmonary fat embolization occurs in almost all patients with long bone fracture (Emson, 1958; Evarts, 1970), only 1% to 30% (Herdon, 1975) of patients developed the full, clinical Fat embolism syndrome that consists of petechial rash, diffuse pulmonary infiltrates, hypoxemia, confusion, pyrexia, tachycardia and tachypnea, 24 to 48 h after trauma. Indeed, the syndrome may include a spectrum of diseases, ranging from minor symptoms and signs to overt respiratory failure and may progress to frank respiratory failure, often enough to be a major cause of morbidity and mortality in patients with otherwise uncomplicated fractures.

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Fat embolism is the most frequent cause of death after fracture of long bones (Warthin, 1913). Fat emboli were first described by Zenker (1862). The most common clinical situation in which Fat embolism syndrome may develop is orthopedic or general trauma. Most cases have been reported with femoral, tibia and pelvic fractures. A high association with multiple long bone fractures also is found (Richard, 1993).

Richard (1993), in his study of isolated femoral and tibial fracture of healthy young skiers, demonstrated that Fat embolism syndrome occurs more commonly than previously thought, is not associated with mortality and causes little morbidity. Treatment should consist of supportive care only with specific care directed towards the underlying injury. In his study overall incidence was 23%, 19% among fracture tibiae and 75% among fracture femur. Symptoms included a mean PO_2 of 45 mm of Hg and temperature of 39ºC. 40% of patients had petechiae. The mean patient age was 26 years. None of the patients received mechanical ventilation. All patients had developed Fat Embolism Syndrome (FES) by the third day of hospitalization and duration of syndrome was less than four days in 86% of patients. The mortality was 0%. There were no complications.

Garner *et al*. conducted a study and showed that petechial hemorrhages characteristic of fat embolism syndrome are a manifestation of increased capillary permeability. They used petechiometer to demonstrate the petechiae. They also showed that there is direct relation between petechiae and severity of disease, but no correlation between number of petechiae and degree of serum lipase activity.

Tachakra *et al.* (1967) studied relation between hypoxia and fractures of femur and tibia. They studied fifty patients with fractures. Arterial blood gas analysis showed a phase of primary hypoxia in 32 out of 50 fracture patients without head, chest or abdominal injury. The incidence was greater in those with fracture femur, i.e., 9 out of 11, and that of tibia 7 out 29, or both than in those with fracture hips and was related to severity of injury. The PO_2 in this primary hypoxemia was between 60 to 70 mm of Hg. There was second episode of hypoxemia which followed fracture operation or manipulation. He concluded that pulmonary fat embolism is the most likely explanation of the primary episodes of hypoxemia. 16 patients developed second attack of hypoxia. One patient had 4 attacks of hypoxia, which followed some surgical manipulation showed that pulmonary fat embolism is the most likely explanation for hypoxemia after fractures.

Fat embolism syndrome is diagnosed using

1. Gurd´s criteria (Gurd, 1970).
2. Lindeque´s criteria (Lindeque *et al.,* 1987).

Gurd´s criteria for diagnosis of fat embolism syndrome have been criticized for being unreliable because fat droplets can frequently be found in the blood of healthy volunteers and trauma patients, without clinical evidence of fat embolism syndrome (Nolte *et al.,* 1974). Lindeque suggested that Gurd´s criteria may under diagnose the syndrome and proposed his criteria based on respiratory parameters (Lindeque *et al.,* 1987). Lindeque´s criteria involved arterial blood gas study which is gold standard for detection of hypoxia. Gurd´s criteria do not use arterial blood gas analysis as criteria.

The diagnostic value of determining hypocalcaemia, hypoalbuminemia, anaemia,

thrombocytopenia, fat globules in the blood, urine or sputum and elevated serum lipase levels all have been questioned (McCarthy *et al*, 1973; Lepisto and Alho, 1975; Murray and Racz, 1974; Meyers and Taljaard , 1977). Many patients having abnormal values as mentioned earlier have been shown not to have Fat embolism syndrome (McCarthy *et al*, 1973; Home, 1974; Shier *et al.,* 1977).

We thought Lindeque's criteria to be more practical and clinically applicable so we used it for defining fat embolism syndrome in our patients.

As times have changed, the increased severity of motor vehicle injury and advances in supportive care may be supposed to influence the epidemiologic results of FES in long bone fracture. Therefore, the purpose of this study was to review the experiences of FES in a tertiary referral center in Karnataka in this study period.

MATERIALS AND METHODS

The present study was conducted from May 2005 to May 2007, in a tertiary care centre especially for trauma in Bangalore, Karnataka, India. In this period 210 patients with single long bone fracture of lower limb (femur or tibia) fulfilling our criteria were attended in the casualty and evaluated for subclinical fat embolism by peripheral oxygen saturation using pulse oxymeter and arterial blood gases.

Inclusion Criteria

a. Patients with closed fracture long bone in lower limb.

b. ASA – I

c. Age- < 45 years

Exclusion Criteria

a. Patients with polytrauma.

b. Patients with head injury and sepsis.

c. Patients associated with fracture ribs and lung contusion.

d. Patients with ischemic heart disease, congenital heart disease, hypertension and valvular heart disease.

e. Patients with blunt injury to thorax, abdomen, head and neck.

f. Patients with cervical spine injury and facio maxillary injuries.

g. Patients with shock – hemorrhagic, septic, cardiogenic and neurogenic.

h. Patients with vascular injuries.

i. Associated with respiratory system and other medical illness like chronic obstructive airway disease, pneumonia (Aspiration) or lower respiratory tract infection.

Institutional ethical committee clearance was obtained and written informed consent was obtained from all patients or their relatives. Patients were subjected to further investigations like Haemogram, which include Hemoglobin, total leukocyte count, differential count, platelet count, prothrombin time, activated thrombin time, erythrocyte sedimentation rate, D-Dimer, electrocardiogram, chest X-Ray, temperature and urine for fat globules. All the patients underwent surgical fixation of bones i.e. intramedullary nailing within 12 h. The patients were followed up and assessed for development of signs and symptoms suggestive of clinical "FES" using clinical monitoring and serial investigations like pulse oximetry, arterial blood gases, urine fat globules, platelet count, fibrin degradation products (D-Dimer), altered sensorium and chest

x ray. All the patients monitored clinically for fat embolism syndrome. Arterial blood gas analysis was done in some patients who had hypoxia intra operatively and FiO_2 increased accordingly.

Post operatively also patients were monitored for 24 h. The patients who developed respiratory failure were given ventilator support.

In the study Fat embolism syndrome was described on basis of Lindeque's criteria (1987):

1. A sustained PaO_2 of less than 8 k.Pa (60 mm of Hg) with FiO_2 0.21.
2. A sustained $PaCo_2$ of more than 7.3 k.Pa (55 mm of Hg) or pH of less than 7.3
3. A sustained respiratory rate of greater than 35 breath/min even after adequate sedation.
4. Increased work of breathing judged by dyspnoea use of accessory muscles, tachycardia and anxiety.

Any patient with fracture femur and/or tibia showing one or more of these criteria was judged as having FES.

Data was analyzed and expressed in terms of rates, ratios and percentages. Statistical analysis was done using Pearson's Chi Square test. A probability value (p value) of less than 0.05 was considered as significant.

RESULTS AND DISCUSSION

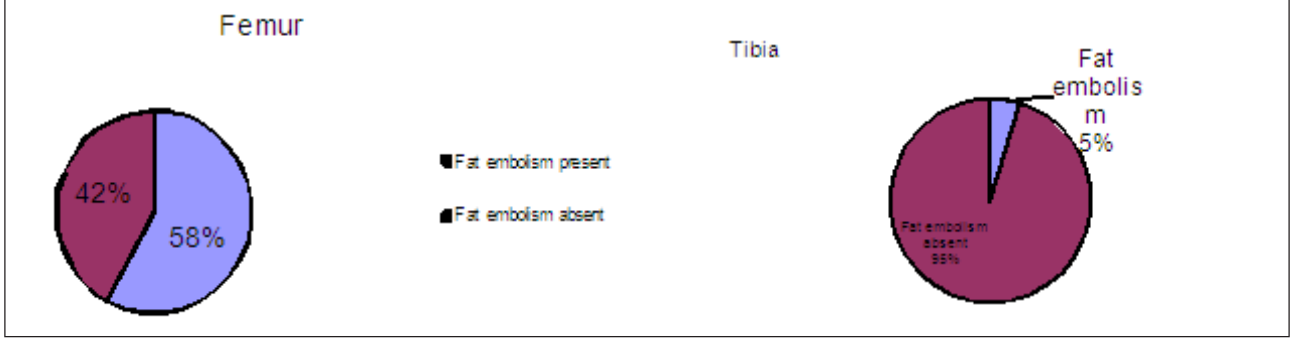
The study was conducted in HOSMAT hospital in the period of May 2005 to May 2007. In the study period, all patients coming to the Casualty with single long bone fractures were evaluated. Fat embolism is the most frequent cause of death after fracture of long bones. (Warthin, 1913).

A total of 210 Patients with closed fracture of tibia or femur and without any other major injuries were screened for sub clinical fat embolism. Out of these 210 patients, majority (83.8%) were male patients. Most of them (69.5%) had fracture of Tibia and 30.5% patients had fracture of Femur.

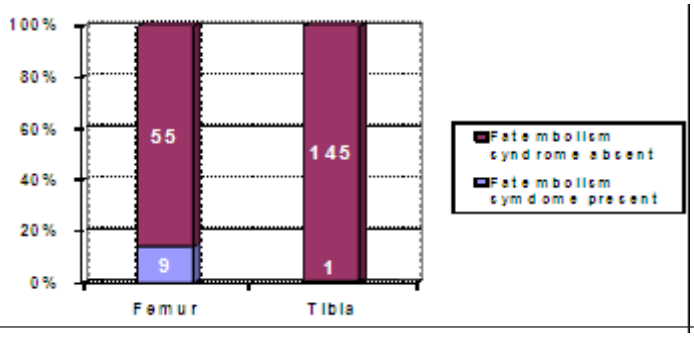
The incidence of subclinical Fat embolism in patients having fracture femur was 57.8 %, i.e., 37 out of 64, while that in patients having fracture tibia was 4.8%, i.e., 7 out of 146 patients (Graph 1).

Out of 210 patients 10 developed clinical fat embolism syndrome with 4.76% involvement. 9 patients with fracture femur developed fat embolism syndrome (14%). One (0.68%) with fracture tibia developed syndrome (Graph 2). The incidence of fat embolism in patients with fracture femur was significantly higher ($p = 3.63 \times 10^{-18}$) than that with tibia.

Graph 1: The Incidence of Sub Clinical Fat Embolism in all Single Long Bone Fracture of Lower Limb



Graph 2: Incidence of Clinical Fat Embolism Syndrome in all Single Long Bone Fracture of Lower Limb



The incidence of fat embolism syndrome in various studies is as follows:

Frequency and Severity of Fat Embolism(Charle M Evartis)

Author		Fat Embolism	Deaths due to Fat Embolism
Robin Smith	789 – Accident	41	29
Newman	89 – Long bone fractures	5	3
Monson	108 – Long bone fractures	9	5
Schutlemeyer	435 – Fractures	92	25
Musselman et al	109 – Injuries	60	6
Saikku	881 – Fractures		8
Sevitt	56 – Fractures	24	1
Emson	44 – Multiple fracture	19	5
Karcher	7,701 – Fracture	96	88

Incidence of Fat Embolism: Variation with diagnostic aids (Mellor, 2001)

First author	Year	Study Design	Incidence	Mortality
Incidence from clinical series:				
Bulger	1997	10 year review of trauma cases	0.9%	7%
Robert	1993	25 year retrospective review	0.26%	20%
Data from Prospective Studies :				
Fabian	1990	96 consecutive long bone fractures	11%	10%
Kallenbach	1987	Randomized trial of corticosteroids; 82 trauma patients	13%	NIL
Lindeque NIL	1987	Randomized trial of corticosteroids 55 trauma patients.	13% by Gurds and 29% by revised criteria	
Chau	1984	80 Consecutive trauma patients	8.75%	2.5%
Schonfield	1983	62 Trauma patients	15% overall No cases in treatment group	NIL
Myere	1977	100 consecutive trauma patients with long bone fracture	17%	1%

The incidence of fat embolism syndrome in various studies is as follows:

Frequency and Severity of Fat Embolism (Charles, 1965):

Incidence of Fat Embolism: Variation with diagnostic aids (Mellor, 2001):

A total of 44 patients out of 210, i.e., 20.95 % confirmed to the inclusion criteria for fat embolism and were hence included for the study after obtaining informed consent. Of these, 37 patients had fracture femur (84.1%) while 7 patients had fracture tibia (15.9%). Among the study patients, most of them (47.7%) belong to age group of 25-34 years, 34.1% belong to 15-24 years, 15.9% belong to 35-44 years and 2.3% belong to 45-54 years age group. Other studies showed similar findings of incidence with age group (Richard, 1993; Tsai *et al.,* 2001; Stein *et al.,* 2008).

One third of patients sought admission to hospital between 6 to 10 h after injury. Majority (93.2%) patients did not manifest petechial hemorrhages. All showed high levels of D – Dimer. More than 50% of the patient's total cell count was increased, i.e., more than 11,000 cells/mcL. 2/3rd (75%) of the patient's platelet count was within normal range, where as 11 patients (25%) presented with thrombocytopenia. In a study they found, nine presented with thrombocytopenia, and 10 presented with sudden drop in platelet count, dropping 140,000/dL on average (Tsai *et al.,* 2001).

In the present study, 68.2% patients experienced high fever with temperature of more than 37^{o} C. A study showed 46.2% patients presented with high grade fever (Tsai *et al.,* 2001). Majority (95.5%) of the patient's urine did not show Fat globules, and 1/3rd of the patient's chest x-ray showed infiltrates. None of the patients had tachypnea. The entire patient's systolic as well as diastolic Blood Pressure was within normal range.

Present study revealed, on admission 1/3rd of the patient's PaO_2 was below 60 mmHg, 34.1% of patients showed P^H of less than 7.3 and 16 patients (36.4%) experienced tachycardia of more than 100, fulfilling Lindeque's criteria, where as the entire patient's $PaCO_2$ was less than 55 mmHg. In Tachakra *et al.* (1975) study 64 % of patients with fractures had PO_2 between 60 and 70 mm Hg immediately after admission. Collins (1969) reported that arterial PO2 fell below 80 mm Hg in one third of 33 patients with comminuted femoral shaft fractures. Bradford *et al*. (1970) found arterial oxygen saturation below 90 % in 8 out of 23 patients in one or more fractures of tibia and femur. McCarthy *et al*. (1973) observed a fall in PaO_2 below 80 mm Hg during first two days after injury in 28 out of 50 patients with fractures of the extremities.

The management of these patients was primarily supportive. Steroids were not administered in any of our patients. All the patients in our study were treated surgically with a standard procedure (intra medullary nailing, by same group of surgeons. Seven patients required ventilator support due to respiratory distress, hypoxia and poor Glasgow Coma Score. The average ventilator days were 8.42. One patient each required ventilator support for 4, 5, 7, 8 and 15 days, 2 patients out of 44 subjects required 10 days ventilator support. Another study showed (Mellor, 2001; Gupta, 2011) average ventilator support for 7.8 days.

The patient's who showed PaO_2 less than 60 mmHg on admission, were more likely develop

Table 1: Association Between the Time Gap From Injury to Admission and Development of Fat Embolism Syndrome

Time gap from injury to admission (in hours)	Clinical FES				Total	
	Yes		No			
	Nos	%	Nos	%	Nos	%
<5	2	16.7	10	83.3	12	100
6 -10	2	13.3	13	86.7	15	100
11 -15	0	0	5	100	5	100
16 -20	5	55.6	4	14.4	9	100
21 – 25	0	0	2	100	2	100
48	1	100	0	0	1	100
Total	10	22.7	34	77.3	44	100

Note: Pearson's Chi square test, P value = 0.01

Table 2: Association Between the PaO2 Levels on Admission and Development of Fat Embolism Syndrome

PaO2 levels on admission	Clinical FES				Total	
	Yes		No			
	Nos	%	Nos	%	Nos	%
<60	7	63.6	4	36.4	11	100
>60	3	9.4	30	90.6	33	100
Total	10	22.7	34	77.3	44	100

Note: Pearson's Chi square test, P value = 0.01

FES, the p value was 0.01 (Table 1). Significant association was found between the development of Fat Embolism Syndrome and more the time gap from injury to admission to hospital, the p value was 0.035 (Table 2).

With the improvement of supportive care, the mortality rate of FES has decreased in the past several decades. The incidence has also declined as the methods of detection and prevention of risk factors of FES have improved. We look forward to a large, multicenter prospective study of modern epidemiologic results of FES in long bone fracture in Karnataka in the future.

CONCLUSION

The present study conducted from May 2005 to May 2007, in a tertiary care centre especially for trauma in Bangalore, Karnataka, India, revealed, incidence of FES in patients with single, lower limb, long bone fracture was 4.76% (10 out of

210 patients). The incidence of sub clinical Fat Embolism overall was 20.95% (44 out of 210 patients). Patients with Femur fractures had higher incidence of FES as compared to patients with fracture tibia. The statistically significant association was found for incidence of FES with PaO_2 less than 60 mmHg as well as more the time gap from injury to admission to hospital.

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