Fat Embolism Syndrome in Long Bone Fracture—Clinical Experience in a Tertiary Referral Center in Taiwan

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Background: Fat embolism syndrome (FES) is a potentially fatal complication of long bone fractures. There have been no reports of FES in long bone fractures in this decade in Taiwan. The purpose of this study was to review the FES experiences in a tertiary referral center between January 1997 and February 2008.

Methods: Between January 1997 and February 2008, 13 patients with long bone fractures with documented FES in our institution were reviewed. FES was diagnosed clinically by at least 2 major criteria or 1 major with at least 4 minor signs of Gurd's criteria.

Results: The incidences of FES, less than those reported in the literature, were 0.15% in fracture of the tibia, 0.78% in fracture of the femur and 2.4% in multiple fractures. The mortality rate of FES, similar to other available results, was about 7.7%. All cases were less than 35 years old, except for 1 70-year-old male. Fat embolism occurred within an average of 48.5 hours after long bone fracture. Eleven presented with sudden drop in hemoglobin level, dropping 4.2 g/dL on average. Nine presented with thrombocytopenia, and 10 presented with sudden drop in platelet count, dropping 140,000/dL on average. Two had cerebral sequelae without recovery at the last 48-month follow-up.

Conclusion: This 12-year interval retrospective study revealed modern epidemiologic results for FES in long bone fracture. Compared with the available literature in the recent decade, the incidence of FES in long bone fracture in our institution is less and the mortality rate is similar. [*J Chin Med Assoc* 2010;73(8):407–410]

Key Words: complication, fat embolism syndrome, femoral fracture, long bone fracture, tibial fracture

Introduction

Fat embolism syndrome (FES) is a potentially fatal complication of long bone fractures. The mortality rate of FES was 10–20% or higher in the 1960s,[1] but the rate has reduced to less than 10% on account of more aggressive pulmonary therapy.[2] Early diagnosis and appropriate supportive care can reduce the complication and mortality rates of FES.[1] To our knowledge, there were only 2 reports of FES in fracture in Taiwan, reported a decade ago and giving no information about incidence.[3,4] There have been no epidemiologic studies of FES in long bone fracture in Taiwan in this decade. 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 in Taiwan. Therefore, the purpose of this study was to review the experiences of FES in a tertiary referral center in Taiwan in this decade.

Methods

All patients with long bone fracture with documented FES between January 1997 and February 2008 in our institution were reviewed. Informed consent was obtained from all patients prior to enrolment. According to Gurd's criteria,[5] FES was diagnosed clinically by at least 2 major criteria or 1 major criterion with at least 4 minor criteria and high suspicion of FES. All of these patients received reduction with reaming intramedullary nail for fracture fixation. Demographic data,

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clinical presentation, treatment course and prognosis were all reviewed for analysis.

Results

A total of 13 patients in the 12-year period were found with long bone fracture and subsequent FES. Two patients underwent chest computed tomography angiography scan, and 2 patients underwent ventilation/perfusion scan to confirm the final diagnosis. All of these patients were mainly diagnosed according to Gurd's criteria clinically. Eight of the 13 patients were male, and 5 patients were female. In our institution, all femoral shaft fractures and tibial shaft fractures are managed with reaming internal fixation. All 13 patients received reaming system internal fixation also. One patient had tibial shaft fracture only. The other 12 cases had femoral shaft fracture, including 4 with concurrent fracture of the tibial and femoral shafts; 6 had middle third femoral shaft fracture, and 6 had the fracture site over the middle to distal third junction of the femur. Five of the 13 cases had tibial shaft fracture, with all the fracture sites in the middle third. The incidence of FES was 0.15% (5/3,385) in tibial shaft fracture, 0.78% (12/1,541) in femoral shaft fracture and 2.4% (7/294) in multiple fractures during this 12-year interval. The definition of multiple fractures includes having fracture sites over more than 1 bone, excluding segmental fracture of 1 bone and single-side fracture of the tibia and fibula. Regarding the fracture side, 7 were on the right side only, 5 were on the left side only, and 1 involved both sides. As to age, all of the patients were less than 35 years old except for 1 70-year-old male (Figure 1). Fat embolism occurred within an average of 48.5 (11.73–97.5) hours after long bone fracture (Figure 2).

During the time of FES developing, 6 of 13 cases presented with clear lung field on chest X-ray but progressed within 24 hours. All cases progressed from both sides clear, to right lower lobe, to both lower lobes and then bilateral whole lung involvement. The findings of worsening on the chest X-rays of all patients were infiltration in both whole lungs, except for 1 case in both lower lungs and 1 case in the right lower lung (Figure 3).

When FES occurred, intubation with mechanical ventilator was necessary in 9 (69.2%) patients, while oxygen support via nasal cannula was enough in 2 (15.4%) patients. One patient received oxygen supplement via a simple mask and another via the biphasic airway pressure system. The average time of oxygen supportive care was about 6 days. Six patients developed

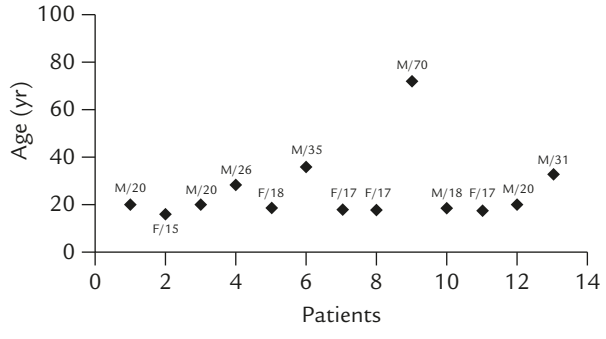

Figure 1. Age distribution of patients. All were younger than 35 years except for 1 70-year-old male. M = male; F = female.

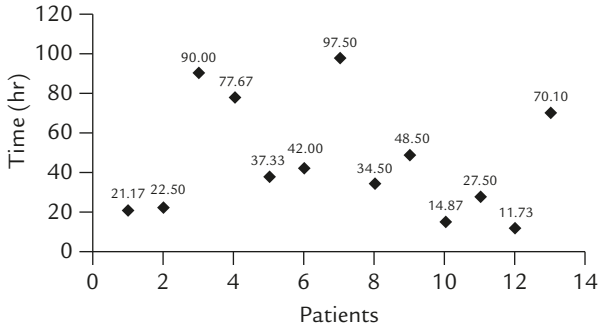

Figure 2. Time from injury to development of fat embolism syndrome (FES). Most of the patients developed FES within 48 hours after long bone fracture.

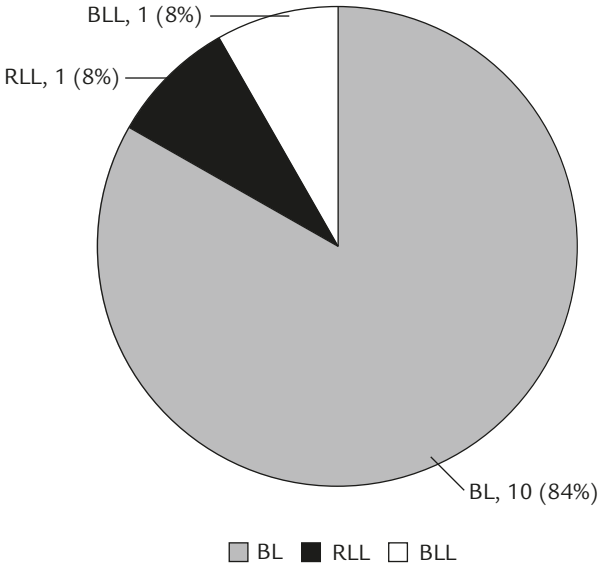

Figure 3. Area of infiltration as seen on chest X-ray. Excluding the 1 patient without any findings of infiltration, the chest X-ray findings of worsening for all patients was infiltration in both whole lungs (BL), except for 1 case in both lower lungs (BLL) and 1 case in the right lower lung (RLL).

FES before receiving operation, and half of those cases were transferred from other hospitals due to FES developing. Excluding this group, another 7 patients developed FES within 24 hours after undergoing operation. The average hospital stay was 19.5 ± 8.6 days, and the mortality rate was 7.7%. Within the 13 cases, 92.3% (12/13) presented with hypoxemia (< 70 mmHg), 92.3% (12/13) presented with general infiltration on chest X-ray within 24 hours of FES occurring, 76.9% (10/13) presented with change of consciousness, and 46.2% (6/13) presented with fever (≥ 38.3°C). Eleven of 13 cases (84.6%) presented with sudden drop in hemoglobin (≥ 2.0 g/dL), dropping 4.2 g/dL on average. Nine of 13 cases (69.2%) presented with thrombocytopenia (< 150,000/dL), and 10 presented with sudden drop in platelets, dropping 140,000/dL on average. After FES occurred, 2 cases were treated with heparin; the durations of treatment were 4 days and 9 days, respectively. Seven cases were treated with steroid, and the average duration of steroid treatment was 6.6 days (2–10 days). Heparin and steroid treatment were stopped before discharge. No associated anticoagulation or antiplatelet drugs were prescribed on discharge.

Concerning cerebral sequelae, excluding 1 case who was diagnosed with diffuse axial injury on arrival, there were 2 cases with poor memory, dizziness and irritability after injury. The cerebral sequelae did not resolve in 57.5 months of follow-up (53 months and 62 months, respectively).

To summarize the predominant characteristics of these cases in our institution, most were male, less than 35 years old, with femoral shaft fracture. According to Gurd's criteria, the most common clinical symptoms were hypoxemia (PaO_2 < 70 mmHg), change of consciousness, infiltration findings on chest plain film, and sudden drop in hemoglobin and platelets. Petechiae, presenting in only 1 case over the anterior chest wall and axillar area, was not a common finding in our database. Most FES developed 24–72 hours after long bone fracture.

Discussion

With the improvement of supportive care, the mortality rate of FES has decreased in the past several decades.[1,2] The incidence has also declined as the methods of detection and prevention of risk factors of FES have improved. According to the available literature, the overall incidence of FES in long bone fractures is 2–5%,[2] and the mortality rate of FES in long bone fracture is about 5–15%.[6] The incidences of FES were less in the current study: 0.15% in tibia fracture, 0.78% in femur fracture and 2.4% in multiple fractures. The mortality rate was similar, about 7.7%. From the literature, long bone fracture is indeed an important risk factor of FES, especially femur fracture, followed by tibia fracture. However, there is still no available data concerning the incidence of FES in long bone fracture in Taiwan during this decade. There were only 2 systematic reviews published by Hsu et al[3] and Tang et al[4] about 2 decades ago. These reports mainly mentioned clinical presentation, trauma mechanism, associated sequelae and mortality rate, but had no information on incidence. Concerning clinical presentation, only 7.7% had petechiae typically presented on the anterior chest wall and axilla. It was lower in our report than in others, including the 2 previous reports in Taiwan.[3,4]

In our institution, all femoral shaft fractures and tibial shaft fractures are managed with reaming internal fixation. Giannoudis et al[7] reported that the intramedullary pressure increased during surgery with either reaming or non-reaming internal fixation. It is indeed true that reaming may increase intramedullary pressure and increase the risk of fat embolism. However, careful surgical technique can limit the risk of increasing intramedullary pressure.[7] Furthermore, preoperative and postoperative medical management are important factors that impact the outcome. Early fixation with intramedullary nail is beneficial.[1,8,9] All patients with long bone fracture underwent early surgery within 24 hours except for patients with unstable condition on arrival in our hospital. The incidence of FES can be reduced by early surgery, but FES still developed in some patients who had undergone surgery within 24 hours. Therefore, FES should be kept in mind even if early surgery and associated prevention had been performed for long bone fracture.

In the current study, young people were the predominant group of cases, but most of them recovered after adequate intensive supportive care. The only case who died was a 70-year-old male. He was diagnosed with unilateral femoral shaft fracture. During hospitalization, intubation was performed for oxygen supplementation, but pneumonia and acute respiratory distress syndrome occurred and he finally died from sepsis. Two young patients who had poor response to oxygen supplementation via endotracheal tube recovered after support with extracorporeal membrane oxygenation for 6 and 8 days, respectively.

Clinically, some patients present with respiratory symptoms without abnormal findings in the first chest plain film. However, progression on chest X-ray may be noted in the following 24 hours. Regarding the mechanism of FES, the adipose droplets released from the

medulla enter into vessels and travel to the pulmonary vessels.[10] Perfusion is blocked due to creation of a shunt, then respiratory symptoms present. In the following hours, the adipose droplets in pulmonary vessels irritate the lung parenchyma, leading to release of toxins.[10] Because of the chemical injury to lung tissue, the lung tissue is infiltrated, and typical findings of pulmonary edema may be noted on chest X-ray. According to current pathological research,[11,12] FES is classified into 3 phases. The first is the mechanical phase. The fat intravasates into veins during the time point of injury and large droplets circulate to the lung parenchyma. The second is the latent phase. The droplets may cause circulation distress. The third is the chemical phase. The free fatty acid within the lung parenchyma induces chemical influence. Macrophages, eosinophils and neutrophils infiltrate focally, resulting in tissue edema, bronchial epithelial damage and then bronchial lumen obstruction. Finally, focal inflammation results in tissue fibrosis. Tissue edematous change after FES results in hypoxia, and chest X-ray will show general congestion and ground glass opacity. More deposition of collagen and smooth muscle actin is induced by this stress, and the vessel lumen becomes obstructed due to vessel wall thickening. The mismatch of circulation and perfusion results in hypoxia, and positive pressure ventilation is usually necessary clinically. Some studies show that the edema is worse between 2 and 4 days after single-dose injection of free fatty acid. The fat droplets within the lumen will be reduced in size by hydrolysis. The symptoms and signs recover gradually. There are still some pathologic factors in the lung parenchyma 7–11 days later, but the patient is usually asymptomatic clinically. Epithelial damage to lung parenchyma will result in skin petechiae. Paredes et al reported an experimental study that found that not so many fat droplets accumulate in brain tissue.[13] There is also no significant evidence of chemical influence on brain tissue. Therefore, the reason for change of consciousness is suspected to relate to hypoxia.

Pulmonary embolism is an occasional but potentially fatal problem. According to current literature, there is lack of strong evidence that drugs can prevent FES from acute long bone fractures. Therefore, the most important keys to early diagnosis and management are to keep in mind the possibility of FES and Gurd's criteria for FES, to observe the patient's vital signs, and to check if there is desaturation or not.

There were some limitations to this study. This was a retrospective case series study with only 13 cases. However, due to the low incidence of FES in long bone fracture, it would take a long time to collect enough case numbers. Therefore, this retrospective case study has revealed the modern epidemiologic results of FES in long bone fracture. We also had a long period of follow-up (mean, 46.8 ± 30.2 months; range, 8–97 months). We look forward to a large, multicenter prospective study of modern epidemiologic results of FES in long bone fracture in Taiwan in the future.

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