



Fat embolism as a complication of lower extremity long-bone surgery

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Abstract

Introduction Fat embolism syndrome (FES) is a formidable complication that occurs with extremity long-bone fractures. Overall, the mortality of FES is estimated to be 10–36 % depending on the severity of the injury. Early detection of complications, selection of optimal methods for fracture fixation and for anesthesia that would prevent FES are essential. The **objective** was to assess the incidence of clinical manifestations of FES in patients with lower extremity long-bone fractures, determine the optimal methods of prevention, methods of anesthesia and surgical intervention in the management of the patients. **Material and methods** The study included 355 patients with lower extremity long-bone fractures treated between 2020 and 2021 at the Trauma Department, State Budgetary Healthcare Clinical N.I. Pirogov Hospital No. 1. Patients were grouped according to different parameters including frequency of occurrence of FES depending on the length of the preoperative period: patients with a long and short preoperative period; treatment strategy: patients treated surgically or conservatively; preoperative use of prophylaxis: patients receiving and not receiving "Essentiale"; anesthetic aidused: general or spinal anesthesia. **Results** Of the 355 patients examined, FES was detected in 8 patients with fractures of the lower extremities, one patient died. FES developed mainly in the first 72 hours of injury. FES occurred in less than 12 hours (n = 1), in 12–24 hours (n = 2), in 24–48 hours (n = 2), in 48–72 hours (n = 3). **Discussion** FES developed in patients with a delayed operative period and in patients treated conservatively. The prophylaxis policy suggests timely diagnosis using Schonfeld's scoring system for FES and taking "Essentiale" early post trauma. Patients who underwent surgery with spinal anesthesia showed a decreased incidence of FES as compared with patients operated on using general anesthesia. **Conclusion** There is a high incidence of FES. Hepatoprotectors can be used on the first days after injury to prevent FES. Osteosynthesis under spinal anesthesia is the preferred method of treatment.

Keywords: fat embolism syndrome, spinal anesthesia, general anesthesia, plating, extrafocal osteosynthesis

For citation: Grankin I.O., Saifullin R.R., Agafonova A.A., Gudalina A.A. Fat embolism as a complication of lower extremity long-bone surgery. *Genij Ortopedii*. 2023;29(4):357-361. doi: 10.18019/1028-4427-2023-29-4-357-361

INTRODUCTION

Fat embolism syndrome (FES) is a formidable complication resulting from traumatic injuries of long bones, characterized by blockage of blood vessels by fat emboli and has a high mortality rate. The incidence of FES depends on the nature of the injury, the general reactivity of the body and concomitant pathologies [1, 2]. Detection and early diagnosis of the pathological process is essential, since the condition develops in the guise of other syndromes and diseases with minimal clinical signs being delayed. Various systems are used to identify FES symptoms and more recently, a quantitative

means of diagnosis of FES has been proposed by Schonfeld. He assigned scores to seven clinical signs: petechial rash, chest x-ray abnormality (Diffuse alveolar infiltrate), hypoxemia, fever (> 38 °C), tachycardia (> 120 beats/minute), tachypnea (> 30 cycles/minute), impaired consciousness, a cumulative score > 5 is required for a diagnosis of FES [3, 4, 5]. The objective was to assess the incidence of clinical manifestations of FES in patients with long bone fractures, identify the optimal methods of prevention, anesthesia and surgical intervention of the patients.

MATERIAL AND METHODS

The findings of 355 patients with long bone fractures of the lower extremities aged 35 to 80 years, median age 57.5 years were retrospectively reviewed. The patients were treated in the Trauma Department of the State Budgetary Healthcare Institution Samara City Clinical Hospital No. 1 named after N.I. Pirogov between 2020 and 2021. There were 145 male (40.8 %

and 210 (59.2 %) female patients. Patients with alcohol intoxication and concomitant pathologies (acute and chronic renal failure, liver cirrhosis, diabetes mellitus) were not included in the study.

The criterion of the frequency of occurrence of FES depending on the duration of the preoperative period was used to identify:

– 273 (76.9 %) patients with a long preoperative period;

– 82 (23.1 %) patients with a short preoperative period.

The criterion of the preoperative prevention of the condition was employed to identify:

– 100 (28.16 %) patients who received hepatoprotector "Essentiale forte N" at a dosage of 300 mg, 1 capsule 3 times/day;

– 255 (71.84 %) patients who received no hepatoprotective agents for prophylaxis.

Depending on the treatment technique used to repair long bone fractures of the lower extremities patients were divided into two groups:

– 248 (69.85 %) patients treated with standard osteosynthesis technologies;

– 107 (30.15 %) patients received conservative

treatment using skeletal traction, plaster immobilization.

Depending on anesthesia applied, patients were divided into two groups:

– spinal anesthesia using local anesthetic Sol. Bupivacaini 0.5 %, 15 mg (n = 238; 67.05 %);

– general anesthesia followed by administration of opioids (Sol. Promedoli 2 %, 1 ml) (n = 117; 32.95 %) patients.

Statistical methods used to determine quantitative characteristics of the statistical population included statistical observation, summary and grouping of statistical observation materials, calculation of absolute and relative values. Quantitative parameters were presented as mean values and the statistical error ($M \pm SE$), qualitative parameters were presented as shares (%).

RESULTS

Of the 355 patients with long bone fractures of the lower extremities, FES was detected in 8 (2.25 %) patients with fractures of the femur and tibia, 1 (0.28 %) patient with a tibia fracture died. FES developed in the patients mainly in the first 12-72 hours after injury. The complication occurred in less than 12 hours (n = 1; 12.5 %); in 12-24 hours (n = 2; 25 %), in 24-48 hours (n = 2; 25 %), in 48-72 hours (n = 3; 37.5 %). FES developed in patients with a delayed operative period who were treated with skeletal traction or plaster immobilization for preoperative preparation. Complications were one third as much as adverse events in patients who primarily were treated with external fixation followed by plating or nailing. FES was diagnosed according to the diagnostic criteria identified by S.A. Schoufeld: fever ($> 38^{\circ}\text{C}$) (n = 4; 50 %), petechial rash (n = 5; 62.5 %),

hypoxemia (n = 5; 62.5 %), chest x-ray abnormality (Diffuse alveolar infiltrate) (n = 4; 50 %), impaired consciousness (n = 3; 37.5 %), tachycardia (> 120 beats/minute) (n = 3; 37.5 %), tachypnea (> 30 cycles/minute) (n = 3; 37.5 %). FES was diagnosed with a cumulative score > 5 . FES was not detected in patients who received "Essentiale Forte N" and FES was diagnosed in individuals who received no hepatoprotector. A two-week follow-up showed a significant decrease in the incidence of FES (2.04 % of cases), confusion and postoperative hypoxia in patients with fractures of lower limbs who underwent surgery using spinal anesthesia (Sol. Bupivacaini 0.5 %, 15 mg) as compared with the group of patients operated on using general anesthesia followed by administration of opioids (Sol. Promedoli 2 %, 1 ml) in the postoperative period (6.45 %).

DISCUSSION

A high risk of FES is reported in patients with a long preoperative period and in patients treated conservatively. Patients with a short preoperative period had a lower risk of FES. There are 3 main approaches in the treatment of long bone fractures [5] (Table 1): 1) conservative methods (plaster cast and skeletal traction); 2) intramedullary nailing or plating osteosynthesis; 3) external fixation using rods, wires, a combination of pins and wires) [6, 7].

Nonspecific prophylaxis of FES includes administration of "Essentiale" early following an injury or introduction of a 33 % solution of ethyl alcohol, 3-4 ml per kilogram of the patient's body weight in the first 3 days after the injury [20].

General condition of the patient, concomitant diseases and the severity, the nature of the injury, age-related changes in the systems and organs are essential for the choice of anesthesia for limb injuries [21, 22]. The use of spinal anesthesia can reduce twice as much blood loss during surgery due to sympathetic blockade and a decrease in systemic arterial pressure. Intraosseous pressure decreases with CA which reduces the risk of FES during surgical interventions on long bones [1, 23]. The use of narcotic analgesics that do not cause pulmonary vasospasm (fentanyl in combination with regional anesthesia (spinal anesthesia) normalizes microcirculation. Appropriate

analgesia reduces hypercatecholaminemia and free fatty acid concentrations. Patients with similar injuries showed no decrease in the total peripheral vascular resistance with Promedol (20 mg three times a day intramuscularly) used as a narcotic analgesic with no regional anesthesia employed [24, 25, 26].

The treatment of FES included adequate oxygenation, lung ventilation, hemodynamic stabilization and prevention of deep vein thrombosis [26]. Corticosteroids, aspirin, heparin, lipostabil, Essentiale were used for treatment with 50 ml of 90 % alcohol in 5 % glucose solution (400 ml), gepasol neo administered intravenously [27, 28].

Table 1

Comparative characteristics of surgical and conservative methods for repair of long bone fractures

Treatment techniques for long-bone fractures		Advantages	Disadvantages
Conservative treatment (plaster cast, skeletal traction)		Minimal risk of tissue trauma and a safe rehabilitation period	Result in complications, fat embolism, since long-bone fractures are sources of enzymatic aggression and excessive afferent impulses [7, 8, 9]. Associated with restricted mobility, bedsores, a decrease in intestinal motility, thrombosis, etc. [9]
Surgical treatment	Intramedullary nailing or plating osteosynthesis	Sources of enzymatic aggression are eliminated, bone fragments are fixed securely, the patient can ambulate early.	The bone marrow is destroyed with intramedullary nailing leading to disruption of trophic processes, and injury to a large area of the bone [10, 11, 12]. Intramedullary nailing or plating osteosynthesis is performed in a compensated or in a subcompensated condition of the patient [13]
	Extrafocal osteosynthesis using external fixation devices and rods, wires, a combination of rods and wires	1) Less trauma; 2) adherence to damage control strategy at all stages of treatment; 3) strength of bone fixation [14, 15, 16]. Advantages of rods over wires include greater rigidity of fixation, ease of design and surgical technique, less trauma to soft tissues, smaller dimensions improve the quality of life of the patient. With less number of fixation components as compared to the standard Ilizarov technique accurate reduction and good bone fixation were achieved could be achieved with rods [1, 17-19]	The complexity of the frame assembly, the need for special training of the surgeon and the duration of the operation up to 1.5 hours

CONCLUSION

The incidence of FES was 2.25 % in the group of 355 people surveyed. The use of the drug "Essentiale forte N" appeared to be the most optimal method of non-specific prevention of FES. External fixation device using rods was shown to be the most optimal technique for repair of long bone fractures at the stage of preoperative preparation to be followed

by intramedullary nailing or plating of the reduced bone. Spinal anesthesia significantly reduced the risk of FES in patients with long bone fractures of the lower limbs in the postoperative period (2.04 % of cases) as compared to general anesthesia and postoperative use of opioids (6.45 % of cases) and can be considered the method of choice.

Conflict of interest The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article

Funding This study was not supported by any external sources of funding.

Ethics approval Not applicable.

Consent for publication Not required.

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The article was submitted 28.03.2023; approved after reviewing 17.04.2023; accepted for publication 20.06.2023.

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All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.