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Timing of definitive fixation of major long bone fractures: Can fat embolism syndrome be prevented?

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ABSTRACT

Fat embolism is common in patients with major fractures, but leads to devastating consequences, named fat embolism syndrome (FES) in some. Despite advances in treatment strategies regarding the timing of definitive fixation of major fractures, FES still occurs in patients. In this overview, current literature is reviewed and optimal treatment strategies for patients with multiple traumatic injuries, including major fractures, are discussed. Considering the multifactorial etiology of FES, including mechanical and biochemical pathways, FES cannot be prevented in all patients. However, screening for symptoms of FES should be standard in the pre-operative work-up of these patients, prior to definitive fixation of major fractures.

Introduction

Fat embolism is very common in femoral shaft fractures, with an incidence of 95% [1]. In some patients this results in fat embolism syndrome (FES), a severe complication that occurs in 1–10% of patients in isolated femoral fractures and even more frequently in bilateral fractures [2]. The exact etiology of FES remains controversial. A mechanical explanation describes that FES results from fat and intramedullary contents that are released from the fracture and entered into the circulation. Due to embolisation of these particles respiratory dysfunction and severe neurological complications can occur [3]. Some authors claim that the emboli can be released from the medullary cavity directly from the fracture, whereas others suggest a relation with increased intramedullary pressure during reaming or insertion of an intramedullary nail [4]. A biochemical theory states that FES results from a proinflammatory state. This, in turn, is evoked by products from bone marrow fat, leading to end-organ dysfunction [3,5]. The combination of mechanical and biochemical phenomena is likely to occur, and explains the diverse onset of symptoms as well as the combination of venous and arterial symptoms [6].

Timing of definitive intramedullary fracture fixation in the context of FES remains a controversial subject. Especially in patients with multiple traumatic injuries the discussion focusses on early total care versus damage control orthopaedics. The arguments in this discussion are the advantages of early fixation (less blood loss, fat embolism) versus the risk of serious complications in early definitive fixation (the 'second hit'). Especially the intramedullary fixation of femur fractures is subject of discussion, as these fractures are associated with high energy trauma as well as with a relatively high rate of systemic complications. This overview aims to describe trends in timing of fixation over the last decades and to illustrate the contemporary state of the art. The focus will be on the relation between timing of definitive fixation and incidence of systemic complications, in particular the fat embolism syndrome.

Historical perspective

In the beginning of intramedullary fixation, early nailing of long bone fractures in multitrauma patients was associated with mortality rates up to 50%. For this reason early definitive fixation was abandoned and replaced by delayed fixation at day 10–14. Following these insights it was Küntscher himself [7] who recommended to delay nailing as long as symptoms of fat embolization are present, and to wait a few days in any definitive major fracture fixation. However, delayed fixation leads to prolonged immobilization, which is associated with complications

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such as decubitus and pneumonia. In fact, delayed fracture fixation was shown to induce longer ICU admissions [8].

In the early 1980s the treatment protocols began to change. Following several well-documented prospective studies on early fracture fixation [9,10] general practice changed into fixation of fractures in the first days after trauma, both for major and minor fractures. Early mobilization and a decrease of ARDS incidence were achieved, but the more aggressive approach resulted in a shift towards very early fixation of all fractures, in the first 24 h after injury. This, in turn, evoked a higher incidence of complications, due to increased blood loss and the phenomenon we now know as the second hit; a challenge to the patient's physiology by aggravating the inflammatory response to trauma [11,12]. Specifically, in the multitrauma patients the very early definitive fixation of major fractures resulted in life threatening complications; ARDS and multiple organ failure.

The introduction of damage control orthopedics followed the insights obtained from analysis of the aggressive approach. In selected patients, life-saving procedures are performed timely and as minimally invasive as possible, followed by resuscitation in the intensive care unit and definitive fracture fixation when the patient's physiology allows. This damage control orthopedics strategy has now been widely adopted and several publications show improvement of patient outcome parameters, especially in inflammatory parameters, in this staged approach [10,13–15]. Other studies, however, have not been able to reproduce these results [16] and show limited effectiveness. Still, the staged approach has not shown the high incidence of complications associated with early definitive fixation of fractures that was observed previously. Demonstrating the effectiveness of damage control orthopedics may therefore well be limited by the acute and urgent nature of the patient population.

State of the art: timing of definitive fixation

In 2014, the Eastern Association for the Surgery of Trauma published their guidelines on timing of fracture stabilization in polytrauma patients [17]. For this guideline a critical review of all available literature was performed according to the GRADE criteria. Although the quality of the retrieved studies was rated as limited by these criteria, this guideline addresses the discussion on timing of fixation of femur fractures by analyzing the outcome parameters mortality, infection, venous thromboembolism (VTE), nonunion or malunion and amputation. For mortality, infection and VTE early internal fixation, within 24 h after injury, showed better results than delayed internal fixation. The authors concluded from their extensive literature review that early internal fixation should be considered in all femur fractures in the absence of clear contraindication to surgery or anesthesia. However, their conclusions are conditional, with specific recommendations to use the guideline to inform the decision-making process only. In selecting the studies used for review, studies on damage-control orthopedics were left out as external fixation was not a subject of their analysis. Also, no conclusions can be drawn on other outcomes such as fat embolism and compartment syndrome.

Prevention of fat embolism syndrome?

Most studies, as described above, focus on systemic complications related to major fractures and the fixation of major fractures. The incidence of fat embolism syndrome is often not taken into account, as the number of patients is too low. In the literature most descriptions regarding fat embolism syndrome are given based upon a specific case, such as in a recent overview on fat embolism syndrome by Kosova et al. [6]. The cases often illustrate the onset of symptoms, but more importantly, the relation between treatment and onset of symptoms. Unfortunately, many cases describe the onset of symptoms prior to intramedullary instrumentation [1,18,19]. This phenomenon is consistent with a combined mechanical and biochemical etiology of fat embolism syndrome [3,6], and it means indirectly that the incidence of fat embolism syndrome should not be an argument in the discussion on timing of definitive fixation of fractures. In other words, the cases in the literature support the idea that the fat embolism syndrome will occur in some patients, irrespective of the definitive treatment, and can therefore not be prevented by changing the timing of definitive fixation of major fractures. On the other hand, the presence of clinical signs of fat embolism syndrome should always lead to the decision to delay intramedullary instrumentation in a patient. Fortunately the general prognosis of fat embolism syndrome is good. Mortality has decreased to less than 10% [20], and in patients who survive most symptoms will resolve [21].

Practical consequences

In patients with multiple traumatic injuries the decision on timing of intervention with respect to the fracture care is part of a process called Safe Definitive Orthopaedic Surgery (SDS) [22]. The decision making within the SDS process depends largely on the physiological condition of the patient, but also on other clinical and environmental parameters. For example, has the patient been transferred from a rural area with considerable delay, or did the patient get injured in an urban environment with rapid rescue? The latter patient is expected to deteriorate further within the first hours after presentation, whereas the delayed patient may have reached a more stable physiology. The process is therefore dynamic, including repeated assessment of the patient. Four categories of patients can be used in the decision making [15]; patients can be stable, borderline, unstable or in extremis. For stable patients and patients in extremis the optimal strategy is quite simple; respectively early total care and resuscitation should be initiated. In stable patients with a serious brain injury [23] or borderline patients their condition should be reassessed in the operating room and if the patient remains stable, intramedullary nailing can be performed directly. An unstable patient must be properly stabilized first (correction of acidosis and life-saving operations such as laparotomy or embolization) and then assessed how soon definitive internal fixation is justified [24]. A temporary traction splint can be used to perform definitive fixation the next day. An external fixator is indicated for prolonged immobilization. In patients in extremis life-saving measures are crucial, followed by a damage control approach to their other injuries. Again, this decision making process is dynamic, meaning that repeated assessment of the patient should take place constantly during the first days after trauma (Fig. 1).

Using the SDS approach in severely injured patients helps in restoring the patient's physiology and to improve survival. Whether it can help in preventing FES is another question. Considering the etiology of FES, based on a combination of mechanical and biochemical causes, it is even unlikely that FES can be prevented in all patients irrespective of the chosen strategy. This is underlined by the onset of symptoms of FES as described throughout the literature. Once symptoms have started, however, it appears logical to delay intramedullary instrumentation in these patients, and therefore ruling out FES should be a part of the preoperative workup.

Conflict of interest

None.