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Original article

Early intramedullary nailing for femoral fractures in patients with severe thoracic trauma: A systemic review and meta-analysis

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ABSTRACT

Purpose: Early intramedullary nailing (IMN) within the first 24 h for multiply injured patients with femoral fracture and concomitant thoracic trauma is controversial. Previously published studies have been limited in size and their outcomes have been inconclusive. A meta-analysis was conducted to evaluate the available data in order to guide care and help improve the outcomes for these patients.
Methods: We searched the literature up to December 2011 in the main medical search engines and identified 6 retrospective cohort studies that explored the safety of early IMN in patients with both femoral fracture and chest injury. Our primary outcome was the rates of pulmonary complication (pneumonia, adult respiratory distress syndrome, fat embolism syndrome), multiple organ failure (MOF) and mortality.
Results: We found no statistically significant difference in the rate of pulmonary complications, MOF or mortality in the patients treated with early IMN.
Conclusion: Early IMN for femoral fractures does not increase the mortality and morbidity in chest-injured patients in the studies analyzed.

Introduction

Femoral fractures with concomitant thoracic trauma have become increasing common in industrialized society due to high energy automobile and industrial accidents. Thirty years ago femoral fractures were initially managed in skeletal traction until the patient was considered stable enough to undergo surgery for fracture fixation.[1] However during this treatment, patients often developed adult respiratory distress syndrome (ARDS), infection, and pneumonia leading to death in some patients, especially in those with a high injury severity score (ISS).[2] Several studies examined how to decrease these complications and found that early surgical stabilization lowered the mortality and morbidity of long-bone fractures in the multiply injured patients.[3–6]

It is important to emphasize that immediate and definitive fixation of fractures may not be beneficial for patients who are hemodynamically unstable or hypothermic, have poor oxygenation due to traumatic lung injury, or have coagulation abnormalities.[7] For these patients a “damage control orthopedic surgery” strategy has been advocated and is now widely accepted.[8]

Reamed interlocked intramedullary nailing is the optimal fixation for femoral shaft fractures in adults.[9] Patients with isolated femoral shaft fractures should undergo IMN as soon as possible. However in multiple trauma patients that have a femoral fracture combined with a chest injury the use and timing of IMN is a topic of debate. In some authors' opinion the increased intramedullary pressure caused by IMN can release bone marrow and fat into the venous blood system, which may dramatically raise the incidence of ARDS and multiple organ failure.[10] In contrast, Carlson et al[11] reported that reamed intramedullary femoral fixation did not increase the pulmonary morbidity in chest injured patients. We conducted a systematic review of the literature up to December 2011 to assess the outcome of IMN in patients with femoral fracture and combined chest injury.

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Materials and methods

Search strategy

We searched the Pubmed, Cochrane Library, Embase, and MEDLINE databases (up to December 2011) without language restriction. The main search terms were “blunt chest wall trauma” or “rib fractures” or “thoracic injury” or “chest injury” or “lung contusion” AND “femoral fracture” AND “pulmonary complication” or “mortality” or “multiple organ failure”.

Study selection

To be included, studies must have explored the incidence of severe pulmonary complications such as ARDS, fat embolism syndrome (FES) or pneumonia for patients with femoral fracture and chest injury who underwent IMN fixation within 24 h. Patients included were age 15–55 years with blunt chest trauma (thoracic abbreviated injury score $\geq$3) and ISS $\geq$18. Blunt chest trauma was defined as chest wall contusion, rib fractures, hemopneumothorax or pulmonary contusion. Two researchers analyzed each title and abstract independently and then met to discuss any discrepancies in order to reduce selection bias, and thereafter the complete articles were analyzed followed the same process.[12]

Data collection

Information about study characteristics, study quality, population, sample size, and the incidence of pulmonary complications (ARDS, FES, pneumonia) and other severe outcomes (MOF and death) were extracted by two independent investigators. The data collection procedure was adapted from Heineman.[13]

Quality assessment

The quality of included studies was independently assessed by the two reviewers using a standard scale. A previously designed criteria list was adapted to evaluate the studies' methodological quality.[14] We modified these criteria to a full score of 9 points to cover the topic of our review, and the studies were ranked according to their methodological quality score.

Statistical analysis

The Cochrane Rev-Man software version 5.0 was used for the statistical analysis to investigate the odds ratio (*OR*) with 95% confidence intervals (*95% CI*). Heterogeneity among the included trials was assessed by I^2 statistic using the heterogeneity *Q* statistic test. Combined odds ratios were calculated using Mantel–Haenszel method with a fixed effect model for each outcome measure.

Results

A total of 1291 citations were identified from the electronic databases. 62 citations were retrieved after screening the titles and abstracts. Of these, 6 studies met the inclusion criteria and were selected for the final systematic review.[15–20] Characteristics of the included studies are shown in Table 1.

Complications

The main pulmonary complications we evaluated were pneumonia, ARDS and FES; however only one study compared the rate of FES.

Pneumonia Four studies reported the incidence of pneumonia between the two cohorts of patients.[16–18,20] Three of these studies found that early IMN did not increase the rate of pneumonia (Fig. 1). In contrast, Pape et al[18] reported that the early IMN group had an increased risk for development of pneumonia. The combined odds ratio for pneumonia in these studies was 1.63 (*95% CI*: 0.81–3.29). The I^2 statistic of 28% for this meta-analysis indicates a low level of heterogeneity between the included studies and the fixed effects model was used to ascertain the *OR* value. The *Z* result of 1.36 ($p > 0.05$) suggests that the overall effect is non-significant and therefore the odds of pneumonia in patients treated with early IMN is not significantly increased.

ARDS Six studies reported the incidence of ARDS between the two cohorts of patients (Fig. 2).[15–20] The ARDS rates were similar between the early IMN and non-early IMN group (*OR* = 0.93, *95% CI*: 0.54–1.58).

MOF Five studies assessed the MOF rate in a total of 438 patients.[16–20] 185 patients were treated by IMN, while 253 were in the control groups. Because heterogeneity was not significant ($I^2 = 0$), the fixed effects model was used to ascertain the *OR* value, and a statistical analysis showed that this estimate was not statistically significant ($p = 0.86$, *95% CI*: 0.46–1.91), as shown in Fig. 3.

Mortality

Five trials reported mortality data.[15,17–20] The odds of mortality with early IMN was 1.28 (*95% CI*: 0.62–2.64, $p = 0.50$), which demonstrated that patients with femoral fracture and concomitant thoracic trauma treated by IMN did not have a higher mortality compared to patients who did not undergo early IMN (Fig. 4).

Discussion

We found that early IMN fixation of femoral fracture did not increase the risk of a multiply inured patient with thoracic injury developing pulmonary complications, MOF or death compared to those who had chest trauma or femoral fracture only.

Intramedullary nailing fixation is a minimally invasive and effective way to promote femoral fracture healing. However, the surgical procedure can also release bone marrow and fat into the venous blood system and potentially exacerbate pulmonary dysfunction for multiply injured patients with chest injury. For this reason many trauma surgeons have advocated the use of external fixation or skeletal traction in such a situation. In this meta-analysis, only one study showed that primary intramedullary femoral nailing caused additional pulmonary damage and triggered ARDS in the presence of lung contusion.[18] The others studies did not demonstrate a higher risks of pneumonia, ARDS, MOF or mortality in patients treated with early IMN compared to the control patients.

Pape and colleagues[21] have conducted a series of investigations including retrospective reviews, animal experiments, and prospective clinical investigations to explore the influence of thoracic trauma and primary femoral IMN on the incidence of ARDS in multiple trauma patients. They concluded that unreamed IMN was safe in patients with severe injury and associated lung contusion. In an animal study in sheep, Gray et al[22] found that IMN resulted in a significantly high initial pulmonary embolic load; however there was no detectable effect on coagulation, pulmonary inflammation or animal mortality over the first 24 h after injury. So the pathophysiologic changes induced by intramedullary nailing may be not enough to cause clinical symptoms. This is consistent with the original views of Bone et al,[3] who said that the pulmonary failure seems to be secondary to the pulmonary contusion itself and not to the method of fracture fixation.

Table 1
Characteristics of the included studies.

Ref.	Design	Study quality	Year	Subjects		Results
				Study cohort	Control group	
Weninger P	RCT	7	1998–2004	45	107	Study group: 13 pneumonia, 9 ARDS, 8 MOF, 9 death Control group: 32 pneumonia, 26 ARDS, 19 MOF, 22 death
Handolin L	RCT	6	2000–2001	27	34	Study group: 7 pneumonia, 1 ARDS, 1 MOF, 1 death Control group: 6 pneumonia, 2 ARDS, 5 MOF, 3 death
Bone LB	RCT	4	1990–1991	24	55	Study group: 0 ARDS, 1 death Control group: 15 ARDS, 6 death
van der Made	RCT	6	1991–1995	21	22	Study group: 4 ARDS, 1 MOF, 1 death Control group: 3 ARDS, 0 MOF, 2 death
Pape HC	RCT	7	1982–1991	24	33	Study group: 5 pneumonia, 8 ARDS, 2 MOF, 5 death Control group: 1 pneumonia, 1 ARDS, 1 MOF, 1 death
Boulanger BR	RCT	5	1989–1995	68	57	Study group: 10 pneumonia, 3 ARDS, 1 MOF Control group: 4 pneumonia, 2 ARDS, 1 MOF

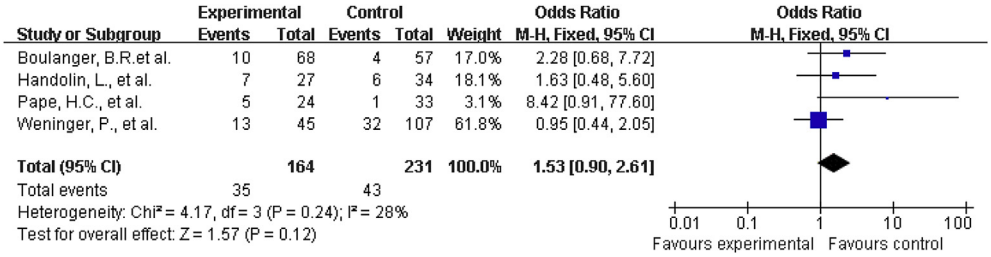

Fig. 1. Forest plot illustrating the odds of pneumonia with 95% confidence intervals for patients with femoral fracture and concomitant thoracic trauma treated by IMN.

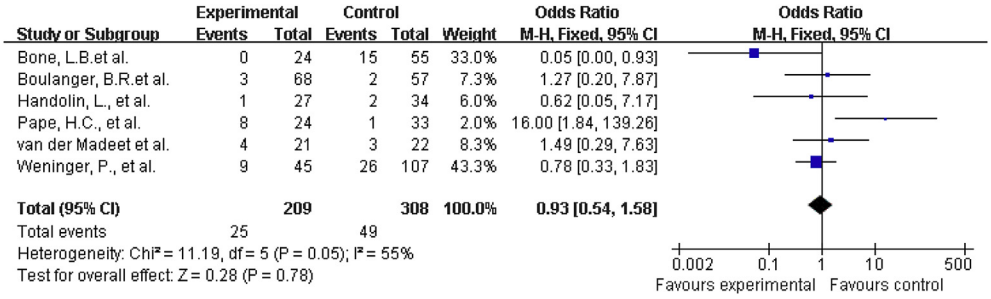

Fig. 2. Forest plot illustrating the odds of ARDS with 95% confidence intervals for patients with femoral fracture and concomitant thoracic trauma treated by IMN.

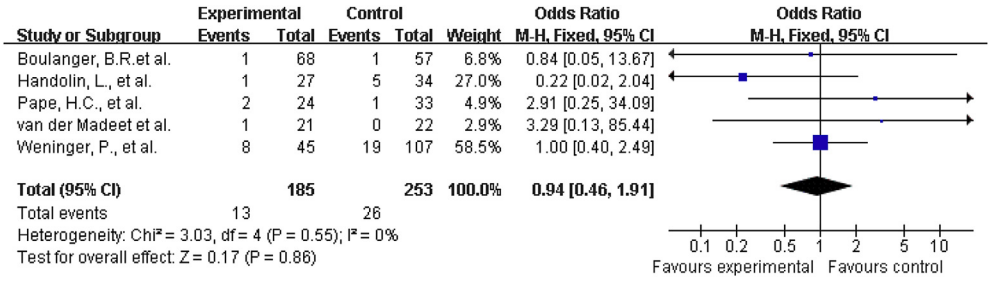

Fig. 3. Forest plot illustrating the odds of MOF with 95% confidence intervals for patients with femoral fracture and concomitant thoracic trauma treated by IMN.

The potential adverse effects from high intramedullary pressure during reaming still warrants close attention. Streubel et al[23] have reported on the use of the reamer irrigator aspirator (RIA) in order to reduce pulmonary complications associated with reaming. In a sheep study, Smith et al[24] developed an alternative approach that uses an intramedullary suction system with multiple evacuation ports combined with a computerized monitoring system to control intramedullary pressure and prevent secondary fat embolization during IMN. Both of these techniques can effectively reduce the intramedullary pressure during reaming compared to conventional reaming.

While we did not find any significant adverse effects of early IMN in the pooled data of multiply injured patients with combined pulmonary trauma, these findings are based on a limited number of retrospective studies. As such, these results should be interpreted with caution. In the six studies reviewed both reamed or unreamed

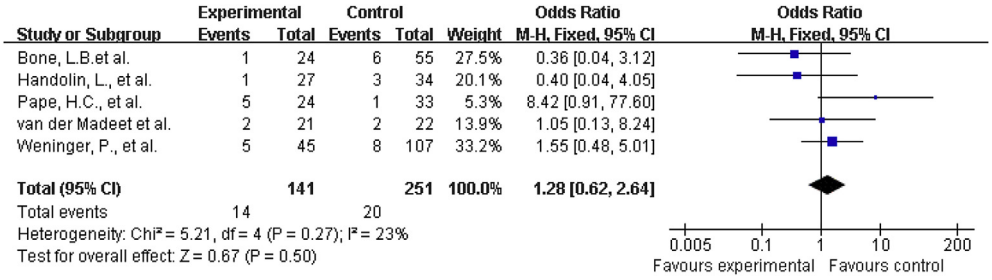

Fig. 4. Forest plot illustrating the odds of mortality with 95% confidence intervals for patients with femoral fracture and concomitant thoracic trauma treated by IMN.

intramedullary nailing techniques were applied and the reaming procedure itself was not considered in the analysis. Additional randomized clinical trials, with larger sample sizes, of reamed or unreamed IMN are needed to definitively determine whether the early IMN should be applied to patients with a femoral shaft fracture and an associated chest injury.

In brief, we cautiously conclude that for patients with a femoral shaft fracture combined with thoracic trauma and stable vital signs, current available evidence supports the use of IMN within 24 h of injury.

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