

# Treatment of Femoral Fractures in the Multiply Injured Patient With Thoracic Injury

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Early fracture fixation in the multiply injured patient has been shown to reduce morbidity and mortality. This premise recently has been questioned when the multiply injured patient has a pulmonary contusion, and also has a femoral fracture stabilized with a reamed intramedullary nail. This put into question whether early stabilization of femoral fractures, especially with a reamed intramedullary nail, should be performed in patients with a pulmonary contusion. A review of the most recent clinical and animal research was performed to help answer this question. This review has revealed that the incidence of pulmonary failure and adult respiratory distress syndrome in multiply injured patients with thoracic injuries who have femoral fractures treated acutely is less than 3%. The morbidity associated with patients with pulmonary contusions is independent of the treatment of the femoral fracture. No difference in the rate of pulmonary failure is found with reamed nails or plate fixation. The pulmonary failure seems to be secondary to the pulmonary contusion, not to the method of fracture fixation.

Treatment of the multiply injured patient with musculoskeletal injuries has evolved during the past 2 decades. Believing that a long bone or pelvic fracture was basically a nonlife threatening injury, the general surgeon in the 1970s generally allowed skeletal stabilization to be performed when the patient was stable enough to do so. This was often days or weeks after injury.

Astute general surgical and orthopaedic trauma surgeons became aware of the improved clinical outcome of these patients when early stabilization of musculoskeletal injuries was performed, usually within the first 24 hours. This was especially true of femoral fractures. Retrospective studies during the 1980s showed a significant and dramatic reduction in adult respiratory distress syndrome and fat emboli syndrome in this patient population with early femoral stabilization.<sup>6,9,11</sup> Early fracture management also was associated with reduction of systemic infection and mortality.<sup>6</sup>

A prospective and randomized study comparing patients with femoral fractures stabilized within 24 hours with those stabilized after 72 hours, showed a significant reduction in the pulmonary complications of adult respiratory distress syndrome, fat emboli syndrome, and pneumonia, when the fractures were stabilized early.<sup>2</sup> This study seemed to have shown conclusively that early stabilization of

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major fractures in the multiply injured patient was beneficial in reducing life threatening pulmonary problems, and reducing the time using a ventilator, time in the intensive care unit, and the cost of hospitalization.

This hypothesis, however, was challenged when the multiply injured patient with a femoral fracture also had an associated thoracic injury (pulmonary contusion, multiple rib fractures, or hemothorax).<sup>7</sup> A retrospective review of severely injured patients who had pulmonary injuries and femoral fractures seemed to implicate the acute reaming of the femoral fracture as the cause of an increased rate of pulmonary failure.<sup>7</sup> This paper led to a great deal of research, clinical and experimental, to help answer the question: Does femoral fracture reaming increase the rate of pulmonary failure in the multiply injured patient with pulmonary injury?<sup>7</sup>

## CLINICAL STUDIES

Pape and coworkers,<sup>7</sup> from Hannover, Germany, became concerned by an increase in adult respiratory distress syndrome and mortality in a group of severely injured patients with femoral fractures and associated thoracic injury, who had early reamed intramedullary rodding of their femoral fractures. A retrospective review of this patient population showed a higher rate of adult respiratory distress syndrome in those patients with early reaming and intramedullary rodding of the femoral fracture. This rate was not statistically higher than for the patients with thoracic injury and delayed rodding of the femoral fracture, but it was significantly higher than for patients without the thoracic injury. Pape et al suggested that patients with femoral fractures and thoracic injuries should not have early fracture stabilization with reamed intramedullary rods. This study reintroduced the controversy over early versus delayed stabilization of musculoskeletal injuries in the multiply injured patient.

This controversy led to a great deal of research into the potentially harmful effects of

reaming of the medullary canal.<sup>5</sup> Echocardiography was used to show that embolization of medullary content to the heart occurred with any manipulation of the femoral fracture.<sup>9</sup> It occurred with introduction of an awl into the proximal femur, during introduction of a 3-mm guide rod, and most dramatically with the initial reaming of the medullary canal.

Numerous retrospective clinical studies followed the Hannover work.<sup>1,3,4,13-17</sup> Bone et al<sup>1</sup> looked at the multiply injured patient with thoracic injuries, with and without femoral fractures. The patients with femoral fractures were grouped into those who had reamed femoral rodding and those who had stabilization of the femoral fracture with plates, that is, usually proximal and distal third fractures. There was no increase in adult respiratory distress syndrome with femoral reaming; in fact, the adult respiratory distress syndrome and mortality rates were lowest with early fracture stabilization with reamed rods (Table 1).

Bosse et al<sup>3</sup> compared adult respiratory distress syndrome, pneumonia, and mortality rates in patients with multiple trauma with thoracic trauma and femoral fractures acutely treated with either reamed intramedullary rods or plates. In 235 patients the femur was rodded and in 219 the femur was plated. Comparing these two groups, the patients with reamed and rodded femurs had an increase in severity of extremity injuries ( $p < .001$ ) and injury severity scores greater than 40 ( $p = 0.02$ ). The rate of adult respiratory distress syndrome was 2.6% in the patients with rodded femurs, and in the patients with plated femurs. In their multivariate analysis, there was no significant effect of reamed rod fixation of femoral fractures on the pulmonary outcome in the multiply injured patient with a thoracic injury.

Turchin et al<sup>13</sup> compared the outcome of patients with isolated pulmonary contusion versus those with pulmonary contusion and musculoskeletal injuries. Of the 324 patients studied (mean injury severity score, 32.3), the overall mortality was 25%. Of the 242

**TABLE 1. Outcomes of Severe Chest Trauma With and Without Femoral Fracture**

Parameter	Group 1: Reamed Femoral Fracture	Group 2: Plated Femoral Fracture	Group 3: No Femoral Fracture
Number	24	18	55
Average age (years)	36.6	52.9	47.3
Injury Severity Score	38.8	26.3	26.4
Intensive care unit (days)	6.1	13.1	14.8
Adult respiratory distress syndrome	0 (0%)	6 (33%)	15 (27%)
Deaths	1	1	6

survivors, 128 had major fractures. Comparing the patients with pulmonary contusions, with and without femoral fractures, there was no difference in ventilatory days, intensive care unit days, or hospital stay. There was no significant difference in the overall incidence of pulmonary complications or mortality in patients with femoral fractures. This did not change in patients treated acutely with reamed intramedullary rods. This study showed that the morbidity and mortality seen in patients with pulmonary contusion is because of the pulmonary contusion alone, and is not increased by the presence of fractures or the method of fracture treatment.

Charash et al<sup>4</sup> reproduced the clinical study by Pape et al<sup>7</sup> at their institution. One hundred eighteen patients were grouped as per Pape et al (Table 2). This study found that a delay in femoral fracture fixation is a risk for pulmonary failure independent of the thoracic trauma. The pulmonary complication rate was 56% in the T2 group, that is, thoracic injury with delayed fixation. The pulmonary complication rate in the T1 group, thoracic injury with early fixation, was 16% ( $p = 0.007$ ), (Table 2). In this patient population, patients with an injury severity score of greater than 28 had a four-fold increase in pulmonary complications when fractures were treated in a delayed manner. This study agrees with the study by Johnson et al<sup>6</sup> done 10 years earlier. The greater the injury severity score, the greater the importance of early fracture stabilization.

### ANIMAL STUDIES

These clinical studies have been supported by animal models. Wozasek et al<sup>17</sup> at the Clinic of Trauma Surgery, Vienna, Austria, produced a sheep model with a blunt thoracic injury. The femoral fractures were treated with reamed rods, unreamed rods, or plate fixation. Average intramedullary pressures were 256 mm Hg, 185 mm Hg, and 44 mm Hg, respectively, for the fixation types. There was no significant difference in pulmonary hemodynamics with any of the three fixation methods. This study implies that intramedullary rodding, even with reaming, has no detectable effects on the hemodynamics of the lung. The authors state that this corroborates their clinical experience that reamed intramedullary nailing of the femur is a safe procedure when performed immediately, in the patient who is cardiovascularly stable, even if there are thoracic injuries.

### DISCUSSION

Recent clinical and laboratory studies<sup>1,3,4,13,17</sup> seem to support the 2 decades of clinical, retrospective and prospective, studies on early stabilization of the musculoskeletal system. Early stabilization is associated with reduction in adult respiratory distress syndrome, fat emboli syndrome, and pneumonia. The question of whether patients with an associated thoracic injury can be treated safely with a reamed rod seems to be settled. The

**TABLE 2. Outcome Variables in Four Patient Groups**

Variable	Patient Group			
	N1	N2	T1	T2
Number of patients	48	8	57	25
Thoracic injury	No	No	Yes	Yes
Femur fixation (hours)	< 24	Delayed	< 24	Delayed
Duration of ventilation (days)	2.2 + 0.5	5.8 + 2.7	6.3 + 2.2	10 + 3.0
Mortality	2 (4%)	1 (13%)	2 (4%)	2 (8%)
Pneumonia	5 (10%)	3 (38%)	8 (14%)	12 (48%)*
Adult respiratory distress syndrome	0	1 (13%)	2 (4%)	2 (8%)
Fat emboli syndrome	2 (4%)	0	0	1 (4%)
Pulmonary emboli	0	0	2 (4%)	1 (4%)
Pulmonary complications	7 (14%)	3 (38%)	9 (16%)	14 (56%)**

Pneumonia and overall pulmonary complication rates tended to be greater in Group N2 versus Group N1; however, this was not statistically significant.

Pulmonary and overall pulmonary complication rates were more than three times as great in patients in Group T2 compared with patients in Group T1 (\* $p = 0.002$ ; \*\* $p = 0.007$ ).

(Modified with permission from Charash WE, Fabian TC, Croce MA: Delayed surgical fixation of femur fractures is a risk factor for pulmonary failure independent of thoracic trauma. *J Trauma* 37:667-672, 1994.)

key issue is early stabilization in the hemodynamically stable patient.

To help show why early stabilization is better than delayed stabilization, 106 severely injured patients (average injury severity score, 40.6) were studied prospectively at the Innenstadt Hospital in Munich, Germany.<sup>14</sup> These patients underwent secondary operative procedures 3 or more days after their initial trauma. The secondary procedures were on their musculoskeletal injuries. Group 1, 40 patients, had respiratory, renal, or hepatic failure develop within 2 days of their secondary operation, or had a 20% worsening of preexisting organ dysfunction. Group 2, the 66 remaining patients, recovered uneventfully. The differences in the two groups were: (1) preoperative levels of neutrophil elastase of 92.2 versus 61.3 ng/dl; (2) decreased platelet count of 118,000 versus 236,000; and (3) C reactive protein levels of 12.4 versus 7.6 ng/dl. Thus, secondary surgery may act as a secondary insult, and may precipitate late adult respiratory distress syndrome and multiple organ failure. This may explain why delayed stabilization of femur fractures has a 30% increase in respiratory failure in the multiply injured patient.<sup>2</sup> Values of neutrophil elastase greater than 85

ng/dl, C reactive protein greater than 11 ng/dl, and platelets less than 180,000 are predictive of secondary organ failure with secondary surgery, with a sensitivity of 73% and a specificity of 8%.

The question how to treat multiply injured patients with musculoskeletal injuries, thoracic injuries, and prolonged shock (hemodynamic instability) still exists. These patients still need early fracture stabilization. Plating of the femur has been advocated and has the advantage that medullary pressures will not be elevated and the amount of fat embolization is significantly reduced. Unreamed femoral nails have been shown in animal and clinical studies to reduce the rise in pulmonary arterial pressure, compared with reamed nails, and have been shown to have less fat embolization. In the severely compromised patient, early fracture stabilization with either unreamed intramedullary rodding or plate osteosynthesis seems safer than the use of a reamed intramedullary rod.

Treatment of the multiply injured patient is difficult and challenging. Patients with a pulmonary injury, which already reduces their oxygenation capacity, are especially challenging to treat. The question is, does the

acute reaming of the femoral canal for intramedullary nailing lead to further respiratory embarrassment and adult respiratory distress syndrome? This questions has led some authors to recommend the use of unreamed nails in this patient population.<sup>8</sup> Although this is an acceptable treatment method, the recent literature<sup>3,4,13</sup> has shown only a 3% incidence of adult respiratory distress syndrome in this patient population treated with reamed femoral nailing or with plate osteosynthesis of the femoral fracture. In multiply injured patients with pulmonary injuries, the incidence of adult respiratory distress syndrome is unaffected by the presence of a femoral fracture or the method of stabilization.<sup>1,13</sup> It seems the cause of the pulmonary failure in this group of patients is the pulmonary injury, not the femoral fracture or the method of stabilization.

Multiply injured patients should have femoral fractures stabilized acutely, within 24 hours. Those patients with pulmonary injuries can have reamed femoral nailing safely, as long as they are hemodynamically stable and well oxygenated.<sup>16</sup> In those patients who have had severe shock and whose pulmonary injury results in decreased oxygenation, femoral fracture stabilization is best performed acutely with unreamed nails or plate osteosynthesis.<sup>8,14</sup>

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