Fracture fixation in patients having multiple injuries

Peter J. O'Brien, MD

The concept of early surgical stabilization of long-bone fractures in patients with multiple injuries became firmly established in the 1970s and 1980s. During the 1990s questions were raised about the early total care of all long-bone fractures in these patients. In particular, it was pointed out that patients with severe chest injuries and those with severe head injuries require special consideration. Although patients in those circumstances do require careful attention, most of the literature suggests that continued early surgical stabilization of these fractures, in particular femoral neck fractures, is important for patients who suffer polytrauma. The concept of early temporary surgical stabilization (damage control orthopedic surgery) has recently been suggested. In the majority of cases, femoral shaft fractures can be treated with interlocked intramedullary nailing.

Le concept de la stabilisation chirurgicale rapide des fractures des os longs chez les patients présentant de multiples blessures a été fermement établi dans les années 1970 et 1980. Au cours des années 1990, on a soulevé des questions relativement aux soins intégraux rapides de toutes les fractures des os longs chez ces patients. Plus particulièrement, on a fait remarquer que les patients atteints de graves blessures au thorax ou à la tête doivent faire l'objet d'une attention spéciale. Or, même s'il est vrai qu'il faut accorder une attention particulière aux patients dans cette situation, la plupart des écrits indiquent que la stabilisation chirurgicale rapide et continue de ces fractures est importante chez les polytraumatisés, surtout dans les cas de fracture du col du fémur. On a proposé le concept de la stabilisation chirurgicale temporaire rapide (chirurgie orthopédique pour limiter les dégâts). Dans la plupart des cas, l'enclouage centromédullaire avec verrouillage permet de traiter les fractures de la diaphyse fémorale.

The assessment and early treatment of trauma patients with multiple injuries has improved markedly over the past 2 decades. Some of the major advances include the development of trauma teams, institutional commitment to trauma care and protocols based on prioritization. Early operative intervention has included treatment of immediately life-threatening injuries such as intrathoracic and intra-abdominal bleeding and certain intracranial injuries. Historically, polytrauma patients with major long-bone fractures were treated in traction and in some cases by delayed internal fixation. More recently, the approach to the management of long-bone and pelvic fractures changed. Many centres have undertaken an aggressive approach with early operative stabilization of these fractures.

Over the past 10 years, there has been continued controversy with regard to the timing of fixation of long-bone fractures, especially femoral fractures, in the multiply injured patient. In this paper I discuss some of these controversial issues in 2 sections: first through a general discussion about the timing of surgical stabilization of long-bone fractures in polytrauma patients; second, the timing of fracture fixation in 2 specific subgroups — the patient

From the Department of Orthopaedics, Faculty of Medicine, University of British Columbia, and Vancouver General Hospital, Vancouver, BC

Articles for this issue may be submitted to either of the section editors: Dr. Richard K. Simons, Trauma Services, Vancouver Hospital and Health Sciences Centre, 855 West 12th Ave., Vancouver BC V5Z 1M9; rsimons@vanhosp.bc.ca or Dr. Andrew Kirkpatrick, Regional Trauma Services, Foothills Medical Centre, EG-23, 1403-29th St. NW, Calgary, AB T2N 2T9; fax 403 944-1277; andrew.kirkpatrick@calgaryhealthregion.ca

Accepted for publication Oct. 1, 2002.

Correspondence to: *Dr. Peter J. O'Brien, Broadway Medical Centre,150-943 Broadway W, Vancouver BC V5Z 4E1; fax 604 731-7973; pjobrien@interchange.ubc.ca*

with a significant chest injury and the patient with a significant head injury.

Timing of fracture fixation in polytrauma

In the 1980s and 1990s, a number of groups demonstrated that early stabilization (within 24 h) of femoral shaft fracture is advantageous to the polytrauma patient in terms of both morbidity and mortality.[1–6] Goris and associates,[4] Meek and colleagues[3] and Border and associates[1] all concluded that early stabilization of femoral shaft fractures is a life-saving intervention in the polytrauma victim and should not be delayed. Patients with early fracture stabilization have a lower risk of mortality from adult respiratory distress syndrome (ARDS) and from multiple organ failure. The mechanism by which fracture fixation reduces respiratory failure and late multiple organ failure is complex and multifactorial. Reduction of inflammatory mediators, fat embolism syndrome, analgesic use and forced recumbency are all potential explanations for the benefit of early fracture fixation.

In general, the polytrauma patient is in the best condition for operative fracture stabilization in the first 24 hours after injury. Multiply injured patients frequently have a predictable course of general, and in particular respiratory, deterioration during the first few days after injury. Respiratory deterioration can be exacerbated by the presence of unstable long-bone fractures. The respiratory dysfunction may preclude orthopedic surgical intervention for a number of days. Some of these patients will continue on a steady downhill course and will die before the long-bone fracture can be stabilized. There is documented evidence of up to a 5-fold increase in the death rate in patients who do not have early surgical stabilization of a femoral fracture.[3,4] This has led most orthopedic trauma surgeons to adopt a policy that operative fixation of femoral fractures should be performed within the first 24 hours after injury, provided that hemodynamic stability has been achieved.[2]

Morbidity has also been reduced in the multiply injured patient by early fixation of long-bone fractures, in particular those of the femoral shaft. A number of authors have demonstrated that fracture fixation within 24 hours of injury in the face of multiple trauma will result in a decreased duration of ventilation, decreased time in the intensive care unit, decreased rates of ARDS, fat embolism syndrome, multiple organ failure and late sepsis, a decreased overall length of hospitalization, and reduced cost of medical care.[1–7] In addition, there is evidence that early fracture fixation reduces the incidence of fracture-related complications and improves fracture outcome.

However, there is only one prospective randomized trial comparing early versus delayed stabilization of femoral fractures. The study by Bone and colleagues[2] included a subgroup of 83 patients with an injury severity score greater than 18. When comparing patients who had femoral fracture stabilization within the first 24 hours to patients who had delayed stabilization of femoral fractures, they found that a group with early stabilization had fewer pulmonary complications, shorter hospital stay and days spent in the intensive care unit and on a ventilator, and a substantial cost savings.

Some investigators have questioned whether early stabilization of long-bone fracture in the face of polytrauma is necessary.[8–10] Based on the information available, the large number of retrospective reviews and the prospective randomized comparison,[2] the standard treatment in most institutions remains that multiply injured patients should have femoral fractures surgically stabilized within the first 24 hours after injury. It would appear that this policy will lead to lower morbidity and mortality.

Chest injury

Polytrauma patients with a femoral fracture and a severe chest injury require special consideration in terms of timing of fracture stabilization. The standard form of surgical management for femoral shaft fractures has been closed reamed interlocked intramedullary nailing. Pape and colleagues[11] were the first to question the safety of this surgical intervention in patients with associated lung contusion. They performed a retrospective review of 106 patients with multiple injuries. In those without severe chest injury, early reamed intramedullary nail fixation of femoral fractures was associated with a reduced risk of morbidity. However, they found that in their patients with severe chest injury, early intramedullary nail fixation was associated with an increased risk of both ARDS and death. They suggested that another form of fixation or delayed nailing be considered in the polytrauma patient with a severe chest injury (Abbreviated Injury Scale > 2).

The results of that study were not in keeping with the clinical experience of most orthopedic surgeons in North America. Many basic science[12–20] and clinical studies[21–30] were then undertaken in an attempt to find the optimum timing and technique for fixation of femoral fractures in the multiply injured patient with a serious chest injury. The basic science studies have clearly shown that reamed intramedullary nailing of the femur is correlated with embolization of fat and marrow contents into the venous circulatory system. Many laboratory studies in animal models with and without simulated thoracic injury have demonstrated that reamed intramedullary nailing of long-bone fractures has definite negative effects on pulmonary physiology. Different studies have conflicting results; however, it appears that the effect on pulmonary function is generally small and transient. There is no evidence in basic physiology research to suggest that reamed intramedullary nailing would have a significant negative effect on pulmonary function in the clinical setting.

Numerous clinical studies have also been done to further document the effects of surgical fixation of femoral fractures and pulmonary function. Charash and associates[21] repeated the study design of Pape and colleagues[11] and arrived at opposite conclusions. In a retrospective review of 138 patients with multiple injuries, the patients with significant pulmonary injuries had a 56% complication rate when fixation was delayed compared with a 16% complication rate for those who had early stabilization. The authors concluded that a delay in fixation in patients with femoral shaft fractures and thoracic injuries did not protect against pulmonary dysfunction, and rather increased the risk of it. A number of other retrospective reviews of this issue reached the same conclusions. In general, the studies would indicate that pulmonary function in multiply injured patients with a serious thoracic injury depends principally on the pulmonary injury. Early fixation of a femoral fracture reduces the pulmonary compromise. Bosse and associates[30] studied the method of fixation used to manage femoral shaft fractures. They compared early reamed intramedullary nailing to open reduction and internal fixation. No difference was noted between the plating and nailing groups in terms of mortality, the occurrence of ARDS, pulmonary embolism or pneumonia. In their study, the incidence of ARDS was only 2%.

The implication of the clinical studies is that, even in patients with significant pulmonary injury, early surgical stabilization of the femur fracture is advantageous, and there is no clear evidence that the form of fracture stabilization is a major determinant of pulmonary dysfunction. Therefore, the best treatment for the fracture — closed reamed interlocked intramedullary nailing — would appear to be the appropriate treatment for patients in this subgroup. The basic science and clinical studies, however, have not provided us with unassailable information. The patient with a serious chest injury and a femoral fracture needs to be closely monitored during fracture fixation and must be managed with extreme caution. More studies are required to determine whether there is an identifiable subgroup of trauma patients who are in fact adversely affected by reamed intramedullary nailing.

Head injury

Patients having a serious head injury make up the other subgroup in which careful evaluation and caution are required with respect to managing orthopedic injuries. It has been clearly shown that secondary brain injury will occur in patients with severe head injuries exposed to hypotension, hypoxemia and increased intracranial pressure or reduced cranial perfusion pressure. It follows, therefore, that operative intervention for orthopedic stabilization of long-bone fractures may cause secondary brain injury if intraoperative hypotension or hypoxia are allowed to occur. A poorer neurologic outcome could be the result. Appropriate resuscitation and careful monitoring of blood pressure, oxygenation and intracranial pressure are essential for these patients.

Some clinical studies that have raised concern about the potential deleterious effect of early fracture fixation after head injury.[31,32] Jaicks and associates[31] retrospectively reviewed 33 patients with blunt trauma. In the subgroup of patients who had early fracture fixation, the fluid requirements were greater, more suffered from hypotension and intraoperative hypoxia and the Glasgow Coma Scale score was lower on discharge than in patients who had delayed fracture fixation. The latter group, however, had more neurologic complications, more neurologic deterioration and longer stays in the intensive care unit and the hospital. Based on their data, however, the authors believed that early fracture fixation exposed their patients to an unacceptable risk of secondary brain injury. Townsend and colleagues[32] retrospectively reviewed 61 patients with severe or moderate closed head injury and femoral fracture. They demonstrated an 8-fold increase in the risk of intraoperative hypotension if the operation was carried out within 2 hours of admission to hospital and a 2-fold increase if the operation was carried out within 24 hours of admission. They found that the risk of low intraoperative cerebral perfusion pressure lasted even longer than 24 hours.

On the other hand, a number of studies have concluded that early fracture fixation in patients with severe head injuries simplifies patient care and does not worsen head injury outcomes.[33–37] Some have even demonstrated reduced mortality and improved neurologic outcome. Smith and Cunningham,[33] in a retrospective review of 77 patients, compared early fixation (< 24 h) with late fixation in head-injured patients. The early fixation group had higher intraoperative fluid requirements and a higher incidence of hypotension. Patients having late fixation, however, had longer stays in the intensive care unit and in hospital. That group also experienced more pulmonary and neurologic complications. The authors concluded that early fracture fixation did not increase the likelihood or severity of neurologic complication. Similarly, Starr and colleagues[34] reported a 45-fold increase in pulmonary complications with delayed femoral fixation compared with immediate fixation. They also demonstrated that the risk of central nervous system complications and death was increased in the delayed fixation groups. Hofman and Goris[37] in their retrospective review of head injured patients with long-bone fracture found that mortality was more than 3 times higher in patients with delayed or no fracture fixation and that the neurologic outcome, based on the Glasgow Outcome Score, was

better in patients who had early fracture stabilization.

It is essential to prevent hypotension, hypoxia and increased intracranial pressure to reduce secondary brain injury in patients with severe closed head injury. Adequate resuscitation and monitoring are essential regardless of the timing of fracture fixation. All of the studies published on the timing of fracture fixation in the head-injured patient are retrospective and have significant methodologic problems. The conclusions of the various studies are conflicting. There is, however, no strong evidence that delaying fracture fixation improves neurologic outcome. In view of the benefits of femoral fracture fixation on pulmonary function and overall mortality, early fracture fixation should probably continue to be performed on patients with head injury. Polytrauma patients with head injury, however, do require special consideration and monitoring. Fracture fixation should proceed as soon as possible after complete assessment and resuscitation.

Damage control orthopedics

In recent years there has been an evolution of fracture care in multiply injured patients, both in Europe and North America, to the concept of damage control orthopedic surgery. The concept is that with respect to patients with very high injury severity scores and patients with severe thoracic injuries instead of providing early definitive care of all fractures, early temporary fracture stabilization can be employed. This would involve fracture reduction and stabilization using an external skeletal fixator. This type of fixation would be used until the patient's overall condition was improving; then definitive osteosynthesis could be carried out in a secondary fashion.[38] Whether early temporary fracture stabilization followed by secondary definitive management of major fractures will be a benefit to severely injured patients remains to be seen.

Summary

Early fixation of long-bone fractures in multiple trauma has become the standard of care in most centres. Although there is reason for concern about reamed intramedullary nailing of femoral fractures in patients with severe chest injury, at present chest injury is not a contraindication to early intramedullary nail fixation. Patients with severe head injury should also be given special consideration. These patients require careful monitoring and appropriate resuscitation. However, they should be offered the advantages of early long-bone fixation.

References

1. Border JR, Allgöwer M, Hansen SP, Ruedi TP, editors. *Blunt multiple trauma: comprehensive pathophysiology and care*. New York: Marcel Dekker; 1990.
2. Bone LB, Johnson KD, Weigelt J, Scheinberg R. Early versus delayed stabilization of femoral fractures: a prospective randomized study. *J Bone Joint Surg Am* 1989;71:336-40.
3. Meek RN, Vivoda EE, Pirani S. Comparison of mortality of patients with multiple injuries according to type of fracture treatment: a retrospective age- and injury-matched series. *Injury* 1986;17:2-4.
4. Goris RJ, Gimbrère JS, van Niekerk JL, Schoots FJ, Booy LH. Early osteosynthesis and prophylactic mechanical ventilation in the multitrauma patient. *J Trauma* 1982;22:895-903.
5. Johnson KD, Cadambi A, Seibert GB. Incidence of adult respiratory distress syndrome in patients with multiple musculoskeletal injuries: effect of early operative stabilization of fractures. *J Trauma* 1985; 25:375-84.
6. Riska EB, von Bonsdorff H, Hakkinen S, Jaroma H, Kiviluoto O, Paavilainen T. Prevention of fat embolism by early internal fixation of fractures in patients with multiple injuries *Injury* 1976;8:110-6.
7. Pinney SJ, Keating JF, Meek RN. Fat embolism syndrome in isolated femoral fractures: Does timing of nailing influence incidence? *Injury* 1998;29:131-3.
8. Rogers FB, Shackford SR, Vane DW, Kaups KL, Harris F. Prompt fixation of isolated femur fractures in a rural trauma center: a study examining the timing of fixation and resource allocation. *J Trauma* 1994;36:774-7.
9. Fakhry SM, Rutledge R, Dahners LE, Kessler D. Incidence, management, and outcome of femoral shaft fracture: a statement population-based analysis of 2805 adult patients in a rural state. *J Trauma* 1994;37:255-61.
10. Reynolds MA, Richardson JD, Spain DA, Seligson D, Wilson MA, Miller FB. Is the timing of fracture fixation important for the patient with multiple trauma? *Ann Surg* 1995;222:470-81.
11. Pape HC, Auf'm'Kolk M, Paffrath T, Regel G, Sturm JA, Tscherne H. Primary intramedullary femur fixation in multiple trauma patients with associated lung contusion: a cause of posttraumatic ARDS? *J Trauma* 1993;34:540-8.
12. Duwelius PJ, Huckfeld R, Mullins RJ, Shiota T, Woll TS, Lindsey KH, et al. The effects of femoral intramedullary reaming on pulmonary function in a sheep lung model. *J Bone Joint Surg Am* 1997;79: 194-202.
13. Heim D, Schlegel U, Perren SM. Intramedullary pressure in reamed and unreamed nailing of the femur and tibia — an in vitro study in intact, human bones. *Injury* 1993;24Suppl 3:S56-63.
14. Wozasek GE, Simon P, Redl H, Schlag G. Intramedullary pressure changes and fat intravasation during intramedullary nailing: an experimental study in sheep. *J Trauma* 1994;36:202-7.
15. Kröpfl A, Berger U, Neureiter H, Hertz H, Schlag G. Intramedullary pressure and bone marrow fat intravasation in unreamed femoral nailing. *J Trauma* 1997; 42:946-54.
16. Manning JB, Bach AW, Herman CM, Carrico CJ. Fat release after femur nailing in the dog. *J Trauma* 1983;23:322-6.
17. Wenda K, Runkel M, Degreif J, Ritter G. Pathogenesis and clinical relevance of bone marrow embolism in medullary nailing: demonstrated by intraoperative echocardiography. *Injury* 1993;24(Suppl 3):S73-81.
18. Wozasek GE, Thurnher M, Redl H, Schlag G. Pulmonary reaction during intramedullary fracture management in traumatic shock: an experimental study. *J Trauma* 1994;37:249-54.
19. Wolinsky PR, Banit D, Parker RE, Shyr Y, Snapper JR, Rutherford EJ, et al. Reamed intramedullary femora nailing after induction of an "ARDS-like" state in sheep: effect on clinically applicable markers of pulmonary function. *J Orthop Trauma* 1998;12:169-76.
20. Heim D, Regazzoni P, Tsakiris DA, Aebi T, Schlegel U, Marbet GA, et al. Intramedullary nailing and pulmonary embolism: Does unreamed nailing prevent embolization? An in vivo study in rabbits.

J Trauma 1995;38:899-906.
21. 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* 1994;37:667-72.
22. Van Os JP, Roumen RM, Schoots FJ, Heystraten FM, Goris RJ. Is early osteosynthesis safe in multiple trauma patients with severe thoracic trauma and pulmonary contusion? *J Trauma* 1994;36:495-8.
23. Ziran BH, Le T, Zhou H, Fallon W, Wilber JH. The impact of the quantity of skeletal injury on mortality and pulmonary morbidity. *J Trauma* 1997;43:916-21.
24. Bone LB, Anders MJ, Rohrbacher BJ. Treatment of femoral fractures in the multiply injured patient with thoracic injury. *Clin Orthop* 1998;347:57-61.
25. Boulanger BR, Stephen D, Brenneman FD. Thoracic trauma and early intramedullary nailing of femur fractures: Are we doing harm? *J Trauma* 1997;43:24-8.
26. Behrman SW, Fabian TC, Kudsk KA, Taylor JC. Fixed outcome with femur fractures: early vs. delayed fixation. *J Trauma* 1990;30:792-8.
27. Brumback RJ, Virkus WW. Intramedullary nailing of the femur: reamed versus nonreamed. *J Am Acad Orthop Surg* 2000;8 (2):83-90.
28. Copeland CE, Mitchell KA, Brumback RJ, Gens DR, Burgess AR. Mortality in patients with bilateral femoral fractures. *J Orthop Trauma* 1998;12:315-9.
29. Scalea TM, Boswell SA, Scott JD, Mitchell KA, Kramer ME, Pollak AN. External fixation as a bridge to intramedullary nailing for patients with multiple injuries and with femur fractures: damage control orthopedics. *J Trauma* 2000;48:613-21.
30. Bosse MJ, MacKenzie EJ, Riemer BL, Brumback RJ, McCarthy ML, Burgess AR, et al. Adult respiratory distress syndrome, pneumonia, and mortality following thoracic injury and a femoral fracture treated either with IM nailing or with a plate: a comparative study. *J Bone Joint Surg Am* 1997;79:799-809.
31. Jaicks RR, Kohn SM, Moller BA. Early fracture fixation may be deleterious after head injury. *J Trauma* 1997;42:1-6.
32. Townsend RN, Lheureau T, Protech J, Riemer B, Simon D. Timing fracture repair in patients with severe brain injury (Glasgow Coma Scale score <9). *J Trauma* 1998;44:977-83.
33. Smith JM, Cunningham TJ. Timing of femur fracture fixation in patients with head injuries. *J Orthop Trauma* 2000;14:125.
34. Starr AJ, Hunt JL, Chason DP, Reinert CM, Walker J. Treatment of femur fracture with associated head injury. *J Orthop Trauma* 1998;12:38-45.
35 McKee MD, Schemitsch EH. The effect of a femoral fracture on concomitant closed head injury in patients with multiple fractures. *J Trauma* 1997;42:1041-5.
36. Poole GV, Miller JD, Agnew SG, Griswold JA. Lower extremity fracture fixation in head injury patients. *J Trauma* 1992; 32:654-9.
37. Hofman PA, Goris RJ. Timing of osteosynthesis of major fractures in patients with severe brain injuries. *J Trauma* 1991; 31:261-3.
38. Pape HC, Giannoudis P, Krettek C. The timing of fracture treatment in polytrauma patients: relevance of damage control orthopedic surgery [review]. *Am J Surg* 2002;183(6):622-9.