Dedicated orthopedic trauma theatres: effect on morbidity and mortality in a single trauma centre

David Lemos, MD*
Eric Nilssen, MD*
Bikalpa Khatiwada, MD*
Graham M. Elder, MD†
Rudolph Reindl, MD*
Gregory K. Berry, MD*
Edward J. Harvey, MSc, MD*

From the *McGill University Health Centre/McGill University, Montréal, Que., and the †Northern Ontario School of Medicine, Sault Hospitals, Sault Ste. Marie, Ont.

Study conducted at the McGill University Health Centre/McGill University, Montréal, Que.

Accepted for publication
Mar. 20, 2007

Correspondence to:
Dr. E.J. Harvey
Division of Orthopaedic Surgery
MUHC — Montreal General Hospital
1650 Cedar Ave., Rm. B5.159.5
Montréal QC H3G 1A4
fax 514 934-8394
edward.harvey@muhc.mcgill.ca

Background: A general trend in orthopedic traumatology is the advent of daily, dedicated orthopedic trauma theatres. Availability of trauma theatres is believed to decrease morbidity and mortality, but this remains unproven. We performed a retrospective review comparing morbidity and mortality outcomes at a single institution before and after the establishment of a dedicated trauma room. The purpose was to determine whether a change in outcomes occurred for a single routine procedure with known outcome expectations (hemiarthroplasty of the hip after femoral neck fracture) with the implementation of a designated trauma theatre.

Methods: We examined a cohort of 457 elderly patients (245 before and 212 after trauma theatre implementation) who underwent hemiarthroplasty for displaced low-energy subcapital hip fractures.

Results: Patients in both groups were similar in terms of age, sex ratio and ASA classification. We found statistically significant differences favouring the dedicated trauma room system for postoperative morbidity. Despite this outcome, the average time to surgery for these patients significantly increased. We noted no difference in mortality between the 2 groups.

Conclusion: The hip fracture population can be treated safely in the context of dedicated trauma room time; however, there needs to be prioritization of hip fractures in a tertiary care centre or other trauma cases will tend to take precedence.

Contexte : En traumatologie orthopédique, l'accès sur une base quotidienne à des salles de traumatologie orthopédique devient une tendance générale. Selon certains, l'accès à des salles de traumatologie réduirait la morbidité et la mortalité, mais cela reste à démontrer. Nous avons réalisé une revue rétrospective afin de comparer les résultats obtenus sur le plan de la morbidité avant et après l'implantation d'une salle réservée à la traumatologie, dans un seul établissement. Le but était de vérifier si les résultats généralement attendus d'une intervention courante (l'hémiarthroplastie de la hanche après fracture du col du fémur) avaient changé après la mise en place de la salle de la traumatologie.

Méthodes : Nous avons étudié une cohorte de 457 patients âgés (245 avant et 212 après la mise en place de la salle de traumatologie) soumis à une hémiarthroplastie pour fracture de la hanche sous-capitale de faible énergie.

Résultats : Les 2 groupes présentaient les mêmes caractéristiques pour ce qui est de l'âge des patients, du rapport hommes:femmes et de la classification de l'ASA. Nous avons observé des différences statistiquement significatives en faveur du système de salle de traumatologie pour ce qui est de la morbidité postopératoire. Malgré ce résultat, le temps d'attente moyen pour la chirurgie a augmenté considérablement pour ces patients. Nous n'avons observé aucune différence quant à la mortalité entre les 2 groupes.

Conclusion : La population sujette aux fractures de la hanche peut être traitée de façon sécuritaire dans les temps dévolus à une salle de la traumatologie; toutefois, il y aura lieu d'établir un ordre de priorité pour les fractures de la hanche dans les centres de soins tertiaires, faute de quoi d'autres cas de traumatologie pourraient tendre à avoir préséance.

Today in Canada, despite universal health care, patients may wait days for "emergency" surgery.[1] This contrasts with countries employing a privatized system where it is perceived that orthopedic trauma/fracture patients can receive their definitive surgical treatment within hours of arrival in hospital. A general trend for orthopedic traumatology in all health care systems is the advent of regular, dedicated daytime orthopedic trauma theatres

allowing timelier and, theoretically, more effective care for these patients.[2,3]

Although it is generally assumed that dedicated trauma theatres decrease morbidity and mortality, and perhaps length of stays in hospital and costs, there is little supporting evidence in the literature. We reviewed the cases of patients with displaced intracapsular hip fractures to study this issue. We chose this cohort because these patients usually present to the average orthopedic centre as a homogeneous group with similar medical problems.[3–5] We hypothesized that availability of regular daytime orthopedic trauma operating theatres in a tertiary trauma care centre would decrease in-hospital morbidity and mortality in a group of elderly patients undergoing hemiarthroplasty for displaced femoral neck fractures. This policy change in one institution may allow for control of certain confounding factors (e.g., different anesthesia techniques, different discharge criteria, surgeon technique) that had clouded the message of other similar publications on this subject.[3]

Methods

We reviewed demographics and outcomes for all patients with displaced low-energy femoral neck fractures treated by hemiarthroplasty in a tertiary care trauma centre serving an urban community setting. We retrieved patient charts from 2 distinct time periods. The first cohort (PRE) comprised patients whose procedures occurred before a dedicated trauma room was in place (June 1994–May 1998). These patients were placed on a general emergency list in the operating room, and surgeries occurred when operating time was available, generally on evenings and weekends. The second cohort (POST) comprised patients whose procedures took place at a time in which there were 4 dedicated orthopedic trauma rooms per week (September 1998–August 2003). We excluded surgeries that took place between June 1998 and September 1998 to allow for a transition period in which the trauma room was gradually implemented as a regular resource. The inclusion and exclusion criteria are noted in Box 1. The McGill University Heatlh Centre institutional review board approved our study.

The institution was a level-1 designated trauma centre. It was a university-affiliated teaching institution with an orthopedic surgery residency program. A senior resident guided by a staff orthopedic surgeon typically performed the surgical procedures. Similarly, a resident with close staff supervision administered anesthesia. Medical management, both pre- and postoperatively, was generally directed by internal medicine staff familiar with orthopedic patients. During the postoperative period, both groups received prophylactic antibiotics consisting of at least 1 dose administered intraoperatively followed by 1–5 doses administered postoperatively, depending on the attending physician's preference. All patients received low molecular weight heparin as perioperative anticoagulation. If patients were taking warfarin preoperatively for other indications they were switched to the oral medication on day 2 after surgery.

We performed our statistical analysis using SPSS 10.0 software (SPSS Inc.). We used the Student t test for continuous variables and the χ^2 test for discontinuous variables. We set statistical significance at the α level of 0.05.

Results

In the PRE group, we identified 281 eligible patients through medical records from a computerized discharge summary database encompassing the study period. After reviewing the charts, we excluded 46 patients, leaving 235 patients in the study group. Ten of these patients had bilateral hemiarthroplasties during this same time period, giving a total of 245 hemiarthroplasties for 235 patients.

In the POST group, we identified 291 eligible patients through a computerized trauma database for the study period. We excluded 79 fractures according to the exclusion criteria listed in Box 1, leaving 212 fractures for analysis. Two patients in this group had bilateral hemiarthroplasties, giving a total of 212 hemiarthroplasties for 210 patients. Patient demographics in the PRE and POST groups were statistically similar: at the time of admission, both groups were similar in terms of age (mean 81 yr in both groups), sex ratio (77% women in the PRE group v. 75% women in the POST group) and ASA classification (mean 2.7 in the PRE group v. 2.64 in the POST group).

We statistically compared between the 2 groups comorbidities that were previously determined to be additional risk factors in emergency or elective surgery by Pedersen and colleagues.[6,7] Specifically, we analyzed 5 preoperative variables: age, type of surgery, congestive heart failure, ischemic heart disease and chronic obstructive pulmonary disease. Pedersen and colleagues reported that these variables constituted the most significant risk factors for both morbidity (cardiopulmonary) and mortality. We observed a significant difference in minor comorbidities ($p = 0.001$). We found that minor comorbidities occurred more fre-

Box 1. Inclusion and exclusion criteria

Inclusion

- Age ≥ 65 years
- Femoral neck fracture resulting from a low-impact accident
- Operative intervention consisting of replacement of the femoral neck and head using either a cemented or noncemented prosthesis
- Fractures occurred during 1 of the 2 collection periods

Exclusion

- Age < 65 years
- Polytrauma or fracture resulting from high-impact accident
- Pathological fractures
- Hemiarthroplasties performed for reasons other than trauma (i.e., avascular necrosis)

quently in the POST group than in the PRE group (2.73 v. 1.91). Major comorbidities were statistically similar (0.64 in the PRE group v. 0.78 in the POST group, $p = 0.09$). There was no difference in the ASA classification among patients in the 2 cohorts. The ASA grading system for comorbidity was described in 1963 and has been shown to predict early mortality following hip-fracture surgery.[8,9] There was no significant difference in ASA (2.7 in the PRE group v. 2.64 in the POST group, $p = 0.32$).

The operative delay (defined as the time from triage in the emergency department until the start of surgery) in the PRE group was 56.5 hours. The POST group had an average delay of 72.1 hours ($p = 0.006$). The mean duration of surgery was 10 minutes longer in the POST group than the PRE group (78.6 v. 89.2 min, $p = 0.006$). The blood loss was similar between groups ($p = 0.06$). In the PRE group, 85.3% of the patients underwent general anesthesia compared with only 61.8% in the POST group. The ratio of implant types changed between PRE and POST groups (PRE: 240 noncemented, 5 cemented v. POST: 160 noncemented, 52 cemented). The specific morbidity data are noted in Table 1.

The length of stay in hospital was not significantly different between the 2 groups ($p = 0.14$), with patients in the PRE group staying in hospital an average of 4 days longer than those in the POST group.

In the PRE group, 25 of 245 patients (10.1%) died during the 30 days after surgery compared with 19 of 212 patients (9%) in the POST group ($p = 0.75$). There was a significant difference ($p < 0.001$) between groups for total and minor complications. Since both major (e.g., life- or limb-threatening complications) and minor (e.g., deep vein thrombosis, pressure sores) complications can significantly influence morbidity and mortality outcome, we grouped them together (Table 1). In examining separate categories, patients in the PRE group experienced significantly more complications than those in the POST group, except for wound complications. Table 2 summarizes the complications of particular importance in the hip fracture population.

Discussion

A dedicated trauma room for the care of musculoskeletal trauma is a large undertaking in the organization of surgical services. Studies that validate the implementation of trauma theatres are lacking. A single recent work has shown that night-time surgery has an increased complication rate.[2] The present study attempts to examine this trauma room allocation for a homogeneous group of patients. Other hip fracture studies looking at morbidity and mortality have included patients with intertrochanteric and femoral neck fractures in their populations.[8,10,11] It has been shown that timing of surgery does not influence morbidity and mortality outcomes for intertrochanteric hip fractures.[6,12,13] To eliminate this potentially confounding variable, we included only patients with displaced femoral neck fractures treated by hemiarthroplasty.

A previous study[3] examined this same type of population in 2 centres: 1 with an assigned trauma room and 1 without. Statistically significant differences favouring the dedicated trauma room system — about half the operative delay and postoperative morbidity — were found. A trend toward decreased mortality was also observed. Owing to some differences in the centres other than operating room resources (i.e., anesthesia type, discharge planning, anticoagulation protocols), the conclusions of the prior study may have been biased. Study of intracapsular low-energy fractures treated with hemiarthroplasty at a single centre may circumvent some of the prior study's shortcomings.

In our study, at the time of admission, both groups were similar in terms of age, sex ratio and ASA classificaton. We statistically compared between the 2 groups comorbidities that were previously determined to be additional risk factors in emergency or elective surgery by Pedersen and colleagues.[6,7] We observed no difference between the cohorts, particularly for the 5 variables judged most important by these authors. Patients in the POST group experienced more minor comorbidities than those in the PRE group (2.73 v. 1.91). Both groups received similar surgeries (hemiarthroplasty) performed by residents and guided by attending staff in a tertiary care trauma centre. Anesthesia type was different between the 2 groups, with the patients in the PRE group having more general anesthesia than those in the POST group (85.3% v. 61.8%). We considered the increase in regional anesthesia that we observed in the POST group to be a result of more regional block specialists hired when the hospital became a trauma/orthopedic centre. It is documented in the literature that the method of anesthesia

Table 1. Overall in-hospital morbidity and mortality

	Group; complications/patient		
Morbidity	PRE	POST	*p* value
Total	1.18	0.78	0.001
Minor	0.71	0.43	0.001
Major	0.47	0.35	0.06

POST = with dedicated trauma room; PRE = before dedicated trauma room.

Table 2. Specific postoperative complications

	Group; %		
Complication	PRE	POST	*p* value
Pneumonia	12.0	7.1	0.11
Pulmonary embolism	1.6	2.8	0.52
Deep vein thrombosis	5.7	3.8	0.38
Urinary tract infection	36.3	5.2	< 0.001
Pressure sores	6.5	1.9	0.018
Cardiac combined*	15.5	9.0	0.046

POST = with dedicated trauma room; PRE = before dedicated trauma room.
*Myocardial infarction, congestive heart failure, arrhythmia.

does not influence morbidity and mortality in hip fracture surgery.[9,14–18] The exception is the lower rate of deep vein thrombosis seen with spinal anesthesia, which is postulated to result from venodilation.[13,14,18] The rates of deep vein thrombosis and pulmonary embolus in our study did not differ between groups (pulmonary embolus $p = 0.52$; deep vein thrombosis $p = 0.38$).

The major differences included a markedly increased operative delay (56.5 h in the PRE group v. 72.1 h in the POST group, $p = 0.006$). This represents an additional day of waiting for patients in the POST group. This should translate to increased morbidity and mortality.[4,10,19,20] Postoperatively there was no increased mortality in the POST group (10.1% in the PRE group v. 9% in the POST group) despite the longer waits and an increased preoperative comorbidity load. Potential biases that may have influenced these results include choice of implant. Patients in the PRE group mostly received noncemented hip fracture implants (240 noncemented, 5 cemented). There was a perceived unacceptable intraoperative complication rate for fractures with this group (11 femoral calcar fractures, 3 greater trochanter fractures), and at the end of the recruitment time a cemented hip fracture implant was introduced to the hospital. The rate of cemented implants went up accordingly (160 noncemented, 52 cemented) with cemented implants being used for those fractures for which it was felt that placing a cementless implant in a tight canal would risk fracture. There were no intraoperative fractures in the POST group ($p < 0.001$). Cemented implants do take longer to perform.

The increased delay to operation was not expected after the implementation of a dedicated trauma room. The POST group had more preoperative comorbidities. Patients with active medical issues at the time of admission must be stabilized and optimized before surgery.[11] Some medical problems may never be fully stabilized, and although this issue is controversial, surgical intervention within 48–72 hours is still recommended.[8,20,21] The average delay for the POST group was 72 hours. With the advent of the trauma theatres, there was a change in policy in the operating room; only patients with life- or limb-threatening emergencies would receive surgery after midnight. In addition, only 4 trauma theatres were given to orthopedic trauma every week although the caseload indicated that 6 rooms were needed. Acute injuries and complex intra-articular fractures tended to push the hip fractures farther down the surgical priority list. The conclusion was that a daily, dedicated theatre is needed for fracture care or that low-velocity hip fractures may be better served at another institution (not at a level-1 trauma centre).

Despite the longer waiting times, the postoperative complication rate did not increase. However, a healthy patient with a hip fracture should receive surgery as soon as possible.[10,12,19,21–23] The occurrence of decubitus ulcers in orthopedic patient populations has received little attention in the literature. These ulcers have been associated with increased mortality and a much longer length of stay in hospital.[24] Most ulcers have been shown to occur during the preoperative period while a patient waits for surgery. An increased incidence of decubitus ulcers has been associated with longer operative delays.[8] A study by Elder and colleagues[3] supports this finding; the authors reported 3 times more ulcers in their non–trauma room group (6.5% v. 1.9%, $p = 0.002$). In our study, pressure sores dropped significantly in the POST cohort (6.5% in the PRE group v. 1.9% in the POST group). Owing to scheduling ease, the hip fracture patients were no longer kept fasting while more urgent cases were bumped ahead of them. This practice presumably maintained the nutrition and hydration status of hip fracture patients and maintained their nursing care plan of pain relief and position changes until the time of surgery. The combined cardiac morbidity also decreased significantly (15.5% in the PRE group v. 9% in the POST group) and may be attributable to a better medical and nutritional stabilization before surgery.

As a result of pain and urinary retention, urinary tract infections (UTIs) are a common problem in the hip fracture population.[25] We observed almost 6 times more UTIs in the PRE group than in the POST group. These were culture-proven UTIs requiring antibiotic intervention. Although a reproducible break in sterile technique could be an attributable factor in the PRE group, the timing of catheter placement seems to be more important. Nutritional status may play an important role in the prevention of UTIs in these patients,[26,27] and the POST group was probably better optimized.

A major flaw with this study is the implementation of a trauma room only on 4 days of the week. The use of a 7-day-a-week system would probably alleviate the longer waiting times, depending on the backlog of patients for that particular institution. Over the long course of this study there have been improvements in patient care both perioperatively and in the operating room. This may explain some of the changes in morbidity that we observed. Other confounding factors in this study are unfortunately inherent in the retrospective design, which was necessary to obtain sufficient patient numbers for meaningful statistical analysis. We did not use preoperative evaluation protocols to standardize patient health status. Any future studies of trauma room efficiency incorporating a prospective design should address these issues.

Conclusion

Given 2 statistically similar groups of patients, our study has shown that dedicated daily orthopedic trauma theatres do not necessarily decrease operative delay for hip fractures unless priority is given to those patients. Operating time in daylight hours has been shown to decrease morbidity both in our study and in others,[2,3,10] and part of this effect may be related to a more optimal nutrition and

hydration status. Although it cannot be proven conclusively from our results, the availability of trauma rooms was an important contributing factor to decreasing morbidity in the trauma room group. Availability of dedicated orthopedic trauma rooms did not significantly influence 30-day postoperative mortality, despite the statistically significant increase in operative delay. Correcting for this by prioritizing hip fracture surgery or increasing availability of dedicated trauma room time may result in a decrease in 30-day mortality.

Competing interests: None declared.

Contributors: Drs. Lemos, Reindl, Berry and Harvey designed the study. Drs. Lemos, Nilssen, Khatiwada and Elder acquired the data, which Drs. Lemos, Reindl, Berry and Harvey analyzed. Drs. Reindl, Berry and Harvey wrote the article, which all authors reviewed and approved for publication.

References

1. Robbins JA, Donaldson LJ. Analysing stages of care in hospital stay for fractured neck of femur. *Lancet* 1984;2:1028-9.
2. Ricci W, Schwappach J, Leighton R, et al. Is "after hours" surgery associated with adverse outcomes? In: Tornetta P, editor. *Proceedings of the 2005 annual meeting of the Orthopaedic Trauma Association*; 2005 Oct. 20–22; Ottawa, Ont. Rosemont (IL): Orthopaedic Trauma Association; 2005. p. 181.
3. Elder GM, Harvey EJ, Vaidya R, et al. The effectiveness of orthopaedic trauma theatres in decreasing morbidity and mortality: a study of 701 displaced subcapital hip fractures in two trauma centres. *Injury* 2005;36:1060-6.
4. Braithwaite RS, Col NF, Wong JB. Estimating hip fracture morbidity, mortality and costs. *J Am Geriatr Soc* 2003;51:364-70.
5. Clague JE, Craddock E, Andrew G, et al. Predictors of outcome following hip fracture. Admission time predicts length of stay and in-hospital mortality. *Injury* 2002;33:1-6.
6. Pedersen T, Eliasen K, Henriksen E. A prospective study of mortality associated with anaesthesia and surgery: risk indicators of mortality in hospital. *Acta Anaesthesiol Scand* 1990;34:176-82.
7. Pedersen T, Eliasen K, Henriksen E. A prospective study of risk factors and cardiopulmonary complications associated with anaesthesia and surgery: risk indicators of cardiopulmonary morbidity. *Acta Anaesthesiol Scand* 1990;34:144-55.
8. Parker MJ, Pryor GA. The timing of surgery for proximal femoral fractures. *J Bone Joint Surg Br* 1992;74:203-5.
9. Valentin N, Lomholt B, Jensen J, et al. Spinal or general anesthesia for surgery of the fractured hip? A prospective study of mortality in 578 patients. *Br J Anaesth* 1986;58:284-91.
10. Rogers FB, Shackford SR, Keller MS. Early fixation reduces morbidity and mortality in elderly patients with hip fractures from low-impact falls. *J Trauma* 1995;39:261-5.
11. Kenzora JE, Mccarthy RE, Drennan Lowell JD, et al. Hip fracture mortality: relation to age, treatment, preoperative illness, time of surgery and complications. *Clin Orthop Relat Res* 1984;(186):45-56.
12. Dolk T. Operation in hip fracture patients — analysis of the time factor. *Injury* 1990;21:369-72.
13. Davis TR, Sher JL, Porter BB, et al. The timing of surgery for intertrochanteric femoral fractures. *Injury* 1988;19:244-9.
14. Sorenson RM, Pace NL. Anesthetic techniques during surgical repair of femoral neck fractures. A meta-analysis. *Anesthesiology* 1992;77:1095-104.
15. Sutcliffe AJ, Parker M. Mortality after spinal and general anaesthesia for surgical fixation of hip fractures. *Anaesthesia* 1994;49:237-40.
16. Koval KJ, Aharonoff GB, Rosenberg AD, et al. Functional outcome after hip fracture. Effect of general versus regional anesthesia. *Clin Orthop Relat Res* 1998;348:37-41.
17. Koval KJ, Aharnoff GB, Rosenberg AD, et al. Hip fracture in the elderly: the effect of anesthetic technique. *Orthopedics* 1999;22:31-4.
18. Parker MJ, Unwin SH, Handoll H, et al. Anaesthesia for hip fracture surgery in adults. *Cochrane Database Syst Rev* 2001;(4):CD000521.
19. Bredahl C, Nyholm B, Hindsholm K, et al. Mortality after hip fracture: results of operation within 12 h of admission. *Injury* 1992;23:83-6.
20. Sexson SB, Lehner JT. Factors affecting hip fracture mortality. *J Orthop Trauma* 1987;1:298-305.
21. Lyons AR. Clinical outcomes and treatment of hip fractures. *Am J Med* 1997;103:51S-64S.
22. Hamlet WP, Lieberman JR, Freedman EL, et al. Influence of health status and the timing of surgery on mortality in hip fracture patients. *Am J Orthop* 1997;26:621-7.
23. Villar RN, Allen SM, Barnes SJ. Hip fractures in healthy patients: operative delay versus prognosis. *Br Med J (Clin Res Ed)* 1986;293:1203-4.
24. Versluysen M. Pressure sores in elderly patients: the epidemiology related to hip operations. *J Bone Joint Surg Br* 1985;67:10-3.
25. Hedstrom M, Grondal L, Ahl T. Urinary tract infection in patients with hip fractures. *Injury* 1999;30:341-3.
26. High KP. Nutritional strategies to boost immunity and prevent infection in elderly individuals. *Clin Infect Dis* 2001;33:1892-900.
27. Schneider SM, Veyres P, Pivot X, et al. Malnutrition is an independent factor associated with nosocomial infections. *Br J Nutr* 2004;92:105-11.