# Delay in operative stabilization of spine fractures in multitrauma patients without neurologic injuries: effects on outcomes

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**Background:** Optimal timing for surgical stabilization of the fractured spine is controversial. Early stabilization facilitates mobilization and theoretically reduces associated complications.

**Methods:** We identified consecutive patients without neurologic injury requiring stabilization surgery for a spinal fracture at an academic tertiary-care hospital over a 12-year period. Incidences of postoperative complications were prospectively evaluated. We analyzed results based on the time elapsed before the final surgical stabilization procedure. Multivariate analyses were performed to explore the effects of potential confounders.

**Results:** A total of 83 patients (60 men, 23 women; mean age 39.4 yr) met the eligibility criteria and were enrolled. The mean Injury Severity Score (ISS) was 27.1 (range 12.0–57.0); 35% of patients had a cervical fracture and 65% had a thoracolumbar fracture. No statistically significant associations were uncovered between time to surgical stabilization and age, ISS or comorbidities. Comparing patients stabilized after 24 hours with those stabilized within 24 hours, there was an almost 8-fold greater risk of a complication related to prolonged recumbency ($p = 0.007$). We observed similar effects for other types of complications. Delays of more than 72 hours had a negative effect on complication rates; these effects remained significant after multivariate adjustments for age, comorbidity and ISS.

**Conclusion:** This study demonstrates a strong relation between timing of surgical stabilization of spinal fractures in multitrauma patients without neurologic injuries and complications. Further studies with larger samples may allow for better adjustment of potentially confounding factors and identify subgroups in which this effect is most pronounced.

**Contexte :** Le moment optimal pour stabiliser chirurgicalement une fracture de la colonne soulève la controverse. Une stabilisation rapide facilite la mobilisation et réduit en théorie les complications connexes.

**Méthodes :** Nous avons trouvé, pour une période de 12 ans, des patients consécutifs sans lésion neurologique qui ont dû subir une chirurgie de stabilisation à la suite d'une fracture de la colonne à un hôpital universitaire de soins tertiaires. Nous avons évalué prospectivement les incidences des complications postopératoires. Nous avons analysé les résultats en fonction du temps écoulé avant l'intervention de stabilisation chirurgicale finale. Nous avons procédé à des analyses multidimensionnelles pour explorer les effets de facteurs confusionnels possibles.

**Résultats :** Au total, 83 patients (60 hommes et 23 femmes, âgés en moyenne de 39,4 ans) satisfaisaient aux critères d'admissibilité et ont été inscrits. Le score moyen de l'indice de gravité de la blessure (IGB) s'établissait à 27,1 (intervalle de 12,0 à 57,0); 35 % des patients avaient une fracture de la colonne cervicale et 65 %, une fracture au niveau thoracolombaire. Nous n'avons découvert aucun lien statistiquement significatif entre le temps écoulé avant la stabilisation chirurgicale et l'âge, l'IGB ou des comorbidités. La comparaison entre les patients stabilisés après 24 heures et ceux qui ont été stabilisés dans les 24 heures a révélé que le risque de complication reliée à la position couchée prolongée est presque 8 fois plus élevé ($p = 0{,}007$). Nous avons observé des effets semblables dans le cas d'autres types de complications. Les retards de plus de 72 heures avaient un effet négatif sur les taux de complications. Ces effets demeuraient significatifs après correction en fonction de l'âge, de la présence d'une comorbidité et de l'IGB.

**Conclusion :** Cette étude démontre l'existence d'un lien solide entre le moment où une fracture de la colonne chez des patients multitraumatisés qui n'ont pas de lésion neurologique est stabilisée chirurgicalement et les complications. Des études portant sur des échantillons plus importants pourraient permettre de mieux corriger les données en fonction des facteurs confusionnels possibles et de déterminer les sous-groupes où cet effet est le plus marqué.

The optimal timing for surgical stabilization of spine fractures is a controversial topic. Most of the literature focuses on the optimal timing of surgical intervention for acute spinal cord injury.[1–7] Although improved neurologic recovery has been shown with early intervention,[3–5,7] there is comparatively little information presented on the effects of timing of surgery on other clinical outcomes, such as complications in multitrauma patients with spinal fractures. Early surgical treatment in patients with neurologic injuries has been shown to reduce lung failure and sepsis,[3] overall stay in hospital and the intensive care unit (ICU)[8,9] and the number of medical complications, such as deep vein thrombosis (DVT), wound infections and pulmonary emboli.[4,7,10]

Early surgical intervention has been accepted into the standard of care for patients with isolated long-bone fractures[11] and multitrauma patients with long-bone fractures.[12] In patients with multiple musculoskeletal injuries, the benefits of early surgical stabilization are well-established.[13,14] Based on these data, it is reasonable to assume that early surgical stabilization of patients with spinal fractures may also minimize complications and reduce associated postoperative morbidity and mortality. However, as the external fixators commonly used in long-bone fractures cannot be applied to spinal fractures, the initial surgical stabilization procedure is often also the final one. Consequently, it is important to realize that although early stabilization should be performed whenever possible to reduce length of stay in hospital, the timing of any such procedure should be optimized to allow patients with the most severe physiologic derangements to be optimized preoperatively[15] despite the risk of complications that may arise as a result of their prolonged recumbency.[16]

Gaining greater insight into the issue of optimal timing for surgical stabilization of spinal fractures is challenging, as the presence of neurologic injury likely confounds any analysis of the association between timing of surgical mobilization and clinical outcomes. Previous studies[5,17,18] have reported that early surgical intervention can reduce pulmonary and pneumonia complications in mixed neurologic populations, albeit without accounting for potential confounders. Alternatively, Kerwin and colleagues[15,19] reported a trend toward poorer outcomes in patients undergoing early spine stabilization, with an increase in mortality despite similar anatomic and physiologic parameters in the late operative group and a shorter length of stay in hospital almost certainly owing to the higher number of early deaths. Propitiously, there are patients who incur spinal fractures without neurologic injury who still require surgical stabilization to promote mobilization and reduce the number of complications. As such, this group of patients provides a better estimate of the association between timing of surgical stabilization and clinical outcomes following spinal fracture. However, few data are available on these patients.

The objective of this study was to examine the relation between timing of surgical spinal fracture stabilization with subsequent in-hospital complications and length of hospital admission in multitrauma patients presenting without neurologic injuries.

## Methods

We obtained data for this study from the multiple-trauma registry database of an academic regional trauma centre that collects prospective data on all patients who receive spine surgery. We used the database to retrospectively identify patients admitted between January 1995 and March 2007 who met study eligibility criteria. Patients were selected based on International Classification of Diseases (ICD)-9-CM and ICD-10-CM diagnostic codes for spinal fracture as well as procedure codes for related surgical interventions. Inclusion criteria were spinal (C1–L5) fracture and requirement for surgical stabilization. Exclusion criteria were neurologic injury, open spinal fracture or vascular injury related to the spine fracture. Ethical approval was obtained from the hospital's institutional review board.

Spine fracture operative stabilization was performed by spine surgeons with subspecialty fellowship training who worked at the academic centre during the study period; patients were assigned to the spine surgeon on call at the time of their admission. Indications for surgical intervention, as determined by the spine surgeon, were generally based on a mechanically unstable pattern of spine fracture. The timing of surgery varied and was dependent on many factors, including surgeon availability, operating room availability and the severity of the patient's medical condition. The specific reasons for which surgery may have been delayed were not recorded in the database; though this limits the inferences that can be made from these data, associations between delay and outcomes can still be explored. Delay was defined as the number of hours between a patient's arrival in the emergency department and the time at which the final spine surgery began. The time between injury occurrence and a patient's arrival in the emergency department was not recorded, thus no such statistical adjustments could be made.

At the time of admission, the patients' conditions were assessed using a variety of rating scales. Total body injury was measured by the Injury Severity Score (ISS),[20] with a possible range of 0–75. Brain injury was measured by the Glasgow Coma Scale (GCS),[21] with a possible range of 3–15. Associated injuries were measured using the Abbreviated Injury Score (AIS) for the head and neck (AIS1), face (AIS2), chest (AIS3), abdomen (AIS4), extremities (AIS5) and external injuries (AIS6); each had a possible range of 0–5.[20] The total number and type of specific medical comorbidities were documented. The severity of medical comorbidity was graded using the Charlson–Deyo Comorbidity Index,[22] which predicts 1-year mortality according to the presence and severity of various comorbidities based on ICD-9 diagnostic codes. Scores on this index have a range of 0–17, with higher scores reflecting more severe comorbidities.

As required by the provincial trauma registry, the incidence of postoperative complications was recorded by an independent trauma nurse who followed patients throughout their hospital stay and postdischarge by reviewing their charts. The severity of complications was graded according to the Rampersaud postoperative spinal surgery complications model.[23] In this model, complications are scored on a 0–4 scale, where 0 represents no complications, 1 represents a complication that requires minimal treatment, 2–3 represents moderate to major complications that require further hospital admission and potential for long-term sequelae, and 4 represents death.[23] Complications were also classified according to whether they were related to prolonged recumbency (i.e., pneumonia, respiratory failure, DVT and pulmonary embolus). The trauma nurse recorded the length of stay and destination after discharge from the acute care hospital at the time of discharge.

### *Statistical analysis*

We analyzed data using SAS software version 9.1. We used descriptive statistics to describe the baseline characteristics of the study population. Distribution of continuous variables was assessed according to skewness and kurtosis. We performed the Wilcoxon rank sum test[24] for univariate comparisons if there was significant skewness. In multivariate regression analyses, variables that were significantly skewed were logarithmically transformed. Continuous variables were categorized into quartiles using the nearest clinically meaningful number to explore possible nonlinear relationships. We performed a Mantel-Haenszel $\chi^2$ analysis of variance to examine trends between these subgroups.[25] One-way analysis of variance using Duncan's multiple range test to adjust for multiple comparisons was used to determine significant differences between the subgroups.[26] We performed univariate analyses to identify baseline factors that were related to both the delay in surgical stabilization and the outcomes evaluated. Multivariable analysis, as described by Feinstein,[27] and change in estimate technique, as described by Mickey and Greenland,[28] were used to identify potential confounders. We explored interactions between independent variables and performed subgroup analyses if we identified a significant interaction. All independent variables were entered individually in a bivariate analysis, with delay in surgical stabilization considered to be a potential confounder if it changed the estimate of effect by more than 10%. The final multivariate logistical regression model used to adjust for confounders included these independent variables, as well as variables with a moderate statistical relation ($p < 0.1$) on univariate analyses and variables deemed to be clinically important.

## Results

A total of 83 patients who satisfied the eligibility criteria were identified in the database. There were 60 men (72.3%) and 23 women (27.7%) with a mean age of 39.4 years (standard deviation [SD] 17.0, range 17–87 yr). The mean ISS was 27.1 (SD 12.0, range 12.0–57.0). Twenty-nine patients (34.9%) had a cervical spine fracture and 54 (65.1%) had a thoracolumbar spine fracture. Twenty-six patients (31.3%) had 1 or more comorbidities, and 5 patients (6.0%) scored at least 1 point on the Charlson–Deyo Comorbidity Index.

The median delay to final surgical stabilization was 71 hours (range 1 h to 41 d). The delay until final spinal stabilization was significantly skewed (skewness 2.58, kurtosis 9.11). Table 1 defines the subgroups of patients and their characteristics. With the exception of the AIS6 score, there were no significant differences in the baseline characteristics among the subgroups. The Duncan multiple range test demonstrated that the AIS6 score in patients who had surgery 3–7 days after admission to the emergency department was significantly lower than that in the other groups.

Table 2 lists the number of complications classified as moderate or major in each subgroup with a general trend toward more complications with longer delay. Table 3 lists the univariate predictors of overall complications as well as those related to prolonged recumbency. Delay to final spinal stabilization (logarithmically transformed) was significantly related to higher rates of all types of complications. Other variables related to complications included age and cervical spine fracture.

There were significant differences between the different quartiles according to delay of surgical stabilization for complications related to prolonged recumbency ($p = 0.003$, Mantel-Haenszel $\chi^2 = 8.5$) and for overall complications ($p = 0.019$, Mantel-Haenszel $\chi^2 = 5.4$).

For patients with a delay of more than 24 hours before surgical stabilization, the relative risk (RR) of complications related to prolonged recumbency was 7.7 (95% confidence interval [CI] 1.1–53.9). The RR of a moderate to major complication was 2.9 (95% CI 0.98–8.9) when the delay to surgical stabilization was less than 24 hours.

Patients with a delay of more than 72 hours had an RR for complications related to prolonged recumbency of 3.1 (95% CI 1.3–7.2), whereas the RR of a moderate to major complication was 2.0 (95% CI 1.02–3.8) when the delay was less than 72 hours.

Bivariate analysis demonstrated that cervical spine fracture, the most severe regional AIS score, the Charlson–Deyo Comorbidity Index score and the total number of comorbidities affected the relation between delay to surgical stabilization and rate of complication by more than 10%. The final multivariate model, including all of these variables as well as age and ISS (to adjust for potential confounders), demonstrated that the adjusted relation between delay to surgery (logarithmically transformed) and complications related to prolonged recumbency (odds ratio [OR] 1.74 for each logarithmic day delayed, $p = 0.032$) and overall complications (OR 1.66 for each logarithmic day delayed, $p = 0.005$) remained statistically significant. The addition of the confounders in the multivariate adjusted model resulted in an increased estimate of the effect of surgical delay on complications compared with the unadjusted results.

The median length of stay in the acute care hospital after surgical stabilization was 11 (range 1–279) days. The median length of stay after surgery was significantly greater if a complication related to prolonged recumbency (median 38 d, $p < 0.001$) or any moderate or major complication (median 28 d, $p < 0.001$) occurred. However, with the numbers available, there were no significant relations between surgical delay and length of stay after surgery.

Forty-one patients (49.4%) were transferred to another hospital for convalescence or rehabilitation. Patients undergoing surgical stabilization within 24 hours were more likely to be discharged to the community (61.9%, $p = 0.032$, $\chi^2 = 4.6$) compared with those who were stabilized at a later time (43.3%).

## Discussion

Unstable spinal fractures present many of the same hazards to recovery as long-bone fractures in that they all require recumbency until stabilization is achieved. Regrettably, prolonged recumbency has many well-known adverse physiologic effects, including reduced pulmonary function and residual capacity, increased atelectasis, reduction in cardiac output, venous stasis, immunologic effects and muscular deconditioning.[16] As such, a delay in the surgical treatment of a spinal fracture may also result in complications similar to those experienced with delayed femur and hip-fracture stabilization, such as pneumonia and decubitus ulcers.[11,29]

**Table 1. Baseline characteristics of multitrauma patients without neurologic injuries undergoing stabilization of spine fractures in different quartiles of surgical delay**

| Characteristic | Surgical delay ≤ 24 h | > 24 h to < 72 h | ≥ 72 h to ≤ 7 d | > 7 d | *p* value |
|---|---|---|---|---|---|
| No. patients | 23 | 23 | 19 | 18 | |
| Age, mean (SD) yr | 38.1 (17.2) | 41.6 (14.3) | 35.6 (18.2) | 42.6 (18.8) | 0.56 |
| Fracture location, no. (%) | | | | | 0.18 |
| Cervical | 5 (21.7) | 11 (47.8) | 5 (26.3) | 8 (44.4) | |
| Thoracolumbar | 18 (78.3) | 12 (52.2) | 14 (73.7) | 10 (55.6) | |
| Male sex, no. (%) | 17 (73.9) | 17 (73.9) | 14 (73.6) | 12 (66.7) | 0.95 |
| Test, mean (SD) score | | | | | |
| ISS | 27.3 (13.1) | 29.1 (11.4) | 25.2 (12.4) | 26.2 (11.2) | 0.74 |
| Max AIS1 | 1.7 (1.7) | 1.2 (1.7) | 1.0 (1.5) | 1.1 (1.5) | 0.43 |
| Max AIS2 | 1.3 (1.7) | 1.6 (1.9) | 1.0 (1.2) | 1.5 (1.8) | 0.71 |
| Max AIS3 | 0.3 (1.0) | 0.5 (1.3) | 0.5 (1.2) | 0.2 (0.7) | 0.77 |
| Max AIS4 | 1.6 (1.5) | 1.5 (1.6) | 1.4 (1.6) | 1.1 (1.7) | 0.77 |
| Max AIS5 | 3.3 (1.3) | 3.7 (0.7) | 3.8 (0.5) | 3.7 (0.5) | 0.16 |
| Max AIS6 | 0.3 (0.5) | 0.6 (0.7) | 0.15 (0.4)* | 0.5 (0.5) | 0.042 |
| Max severity AIS | 3.9 (0.7) | 4.1 (0.5) | 3.8 (0.6) | 3.9 (0.4) | 0.43 |
| No comorbidity, no. (%) | 13 (56.2) | 15 (65.2) | 16 (84.2) | 13 (72.2) | 0.16 |
| CDC, no. (%) | | | | | |
| 1 | 2 (8.7) | 0 (0) | 1 (5.3) | 1 (5.6) | |
| 2 | 0 (0) | 1 (4.3) | 0 (0) | 0 (0) | 0.68 |
| GCS | | | | | |
| Mean (SD) | 14.8 (0.4) | 13.6 (2.9) | 13.1 (3.7 | 14.8 (0.7) | 0.08 |
| 15, no. (%) | 17 (81.0) | 14 (73.7) | 13 (76.5) | 14 (87.5) | 0.64 |
| Mechanical ventilation, no. (%) | 2 (8.7) | 4 (17.4) | 2 (10.5) | 2 (11.1) | 0.82 |

AIS = Abbreviated Injury Score; CDC = Charlson–Deyo Comorbidity; GCS = Glasgow Coma Scale; ISS = injury severity score; SD = standard deviation.
*≥ 72 h to ≤ 7 days significantly different compared with ≤ 24 h, > 24 h to < 72 h, and > 7 days.

The goal of any surgical intervention should include early mobilization. However, in an unstable severely injured patient with multiple traumas, the aim of the initial surgical intervention is often to re-establish normal physiology[30] before a definitive fixation procedure to repair the immobilizing fracture. Such "damage-control orthopedics" is not practical for spinal fractures as external fixators commonly applied so successfully in long-bone fractures are not viable in the spine. Consequently, controversy remains as to the appropriate balance between the need for early surgical stabilization and mobilization and the need for achieving optimal physiologic conditions for the optimal timing of spinal fractures.

Mirza and colleagues[5] compared early versus late cervical spine fracture fixation at 2 different institutions and found that early fixation was associated with fewer nonneurologic complications. However, the study did not make any adjustments for other confounding factors that may have existed between the 2 institutions. Schlegel and colleagues[18] compared early versus late fixation in 138 patients with spinal injuries and an ISS greater or less than 18. No significant difference was detected in the incidence of medical complications related to timing of fixation in patients who had an ISS less than 18, disregarding the time of fixation, but in the group with an ISS greater than 18,

**Table 2. Number of moderate or major complications among multitrauma patients without neurologic injuries undergoing stabilization of spine fractures for each quartile of surgical delay**

| | Surgical delay, no. (%) | | | |
|---|---|---|---|---|
| Complication | ≤ 24 h, *n* = 23 | > 24 h to < 72 h, *n* = 23 | ≥ 72 h to ≤ 7 d, *n* = 19 | > 7 d, *n* = 18 |
| Pneumonia | 1 (4) | 3 (13) | 2 (11) | 7 (39) |
| Other respiratory (e.g., ARDS, respiratory failure) | 2 (9) | 3 (13) | 5 (26) | 3 (17) |
| Pulmonary embolism | 0 (0) | 1 (4) | 0 (0) | 0 (0) |
| Deep vein thrombosis | 1 (4) | 0 (0) | 1 (5) | 1 (6) |
| Other infections (e.g., UTI, wound infection) | 0 (0) | 2 (9) | 2 (11) | 1 (6) |
| Cardiovascular (e.g., MI, CVA) | 0 (0) | 0 (0) | 1 (5) | 2 (11) |
| Decubitus ulcers | 1 (4.4) | 0 (0) | 0 (0) | 0 (0) |
| Gastrointestinal (e.g., GI hemorrhage, dysphagia) | 1 (4) | 1 (4) | 1 (5) | 0 (0) |
| Intracerebral (e.g., acute hydrocephalus, meningitis) | 0 (0) | 0 (0) | 1 (5) | 1 (6) |
| Acute renal failure | 0 (0) | 1 (4) | 0 (0) | 0 (0) |
| Failure of orthopedic implant | 0 (0) | 4 (17) | 1 (5) | 2 (11) |

ARDS = acute respiratory distress syndrome; CVA = cerebral vascular accident; GI = gastrointestinal; MI = myocardial infarction; UTI = urinary tract infection.

**Table 3. Univariate predictors of recumbency-related and moderate to major complications among multitrauma patients without neurologic injuries undergoing stabilization of spine fractures**

| | Complication related to prolonged recumbency | | Moderate or major complication | |
|---|---|---|---|---|
| Variable | OR (95% CI) | *p* value | OR (95% CI) | *p* value |
| Delay in operating room | | | | |
| By day | 1.04 (0.97–1.11) | 0.21 | 1.04 (0.97–1.11) | 0.27 |
| By Log(day) | 1.68 (1.10–2.59) | 0.013 | 1.57 (1.09–2.26) | 0.014 |
| Age (per decade) | 1.23 (0.91–1.56) | 0.15 | 1.49 (1.11–2.0) | 0.007 |
| Males | 0.94 (0.32–2.83) | 0.92 | 1.94 (0.63–5.96) | 0.24 |
| Cervical spine fracture | 2.68 (0.97–7.41) | 0.05 | 5.45 (1.98–14.7) | 0.001 |
| ISS | 1.01 (0.66–1.53) | 0.97 | 1.11 (0.75–1.65) | 0.60 |
| Max AIS1 | 1.07 (0.78–1.45) | 0.69 | 1.14 (0.85–1.53) | 0.39 |
| Max AIS2 | 1.16 (0.87–1.56) | 0.32 | 1.07 (0.81–1.43) | 0.60 |
| Max AIS3 | 1.25 (0.66–2.33) | 0.30 | 1.13 (0.58–1.34) | 0.56 |
| Max AIS4 | 1.09 (0.79–1.50) | 0.60 | 1.28 (0.93–1.75) | 0.13 |
| Max AIS5 | 1.24 (0.43–1.51) | 0.49 | 0.76 (0.42–1.38) | 0.36 |
| Max AIS6 | 2.0 (0.84–4.76) | 0.11 | 1.92 (0.82–4.34) | 0.13 |
| Max severity AIS | 1.39 (0.59- 3.22 | 0.45 | 1.61 (0.72–3.62) | 0.24 |
| Comorbidities, total no. | 1.75 (1.08–2.84) | 0.018 | 1.88 (1.11–3.19) | 0.015 |
| CDC | 2.39 (0.55–10.4) | 0.24 | 3.41 (0.67–17.5) | 0.13 |
| GCS | 0.92 (0.75–1.11) | 0.39 | 0.96 (0.79–1.17) | 0.66 |
| GCS < 15, *n* = 25 | 1.22 (0.42–3.53) | 0.71 | 1.05 (0.38–2.87) | 0.93 |

AIS = Abbreviated Injury Score; CDC = Charlson–Deyo Comorbidity; CI = confidence interval; GCS = Glasgow Coma Scale; ISS = Injury Severity Score; OR = odds ratio.

early stabilization had a lower rate of complications than late fixation. Although this study mixed patients with and without neurologic deficits, no comparisons of the neurologically intact subgroup were presented. Croce and colleagues[17] compared early versus late stabilization in 291 patients with spinal fractures presenting with and without neurologic deficits, concluding that patients who underwent late fixation (> 72 h) had a significantly higher incidence of pneumonia and longer stays in hospital and the ICU. The incidence of complications was significantly higher in the late fixation group compared with the early group in neurologically intact patients. However, the late stabilization group was generally older and had a higher ISS, which may have confounded the results.

It is important to note that this present study controlled for various potential confounders through the use of multivariate analyses and by limiting analyses to patients without neurologic injuries. As noticed with prior studies,[5,17,18,31] early surgical stabilization had a lower risk of recumbency-related and other complications. Patients stabilized after 24 hours from injury were almost 8 times more likely to experience a complication related to prolonged recumbency compared with those stabilized within 24 hours. We observed similar effects for patients stabilized after 72 hours from injury and for any moderate or major complication, with significance remaining after adjustments for age, comorbidity and severity of other injuries. In contrast, Kerwin and colleagues[32] recently reviewed the National Trauma Data Bank and found that out of 16 812 patients who underwent operative fixation, the 59% who were stabilized early after injury (< 72 h) had fewer complications and required fewer resources than patients stabilized later (> 72 h).

Although data for this study were collected through a prospective database, the analysis itself was retrospective based on the information available, which presents some limitations. For example, the specific reasons for delay of spine surgery were not available. Deliberate delays based on low medical necessity (e.g., relatively stable, minor fractures) may therefore be confounded with unintentional delays due to the availability of resources or other factors. Other potential confounders, including the actual timing of injury (as opposed to admission to hospital) and the magnitude of the surgery were not consistently available, consequently limiting the applicability of this study's conclusions. Nevertheless, this observational study was able to explore the associations between delays and outcomes, and multivariate analyses were used to adjust for multiple factors that may have resulted in delay owing to medical comorbidities. These adjustments actually demonstrated a trend toward enhancement of the effect (adjusted OR for complication 1.74 per logarithmic day v. OR 1.68 with the unadjusted models). Although the difference is small, it suggests that delay may be even more detrimental for patients with greater comorbidity, age and/or injury severity. Prospective registries of patients receiving spine surgery may wish to collect additional information to allow for more detailed analyses in the future.

This study found no statistical differences between length of stay in hospital after surgery and delay to surgical stabilization. However, as patients with complications had significantly longer stays in hospital, this lack of relation might be owing to insufficient power, and more patients may be required to show a difference. Moreover, a greater proportion of patients who were delayed were transferred to another hospital, which may have led to bias against length of stay results for the early group.

It is almost certain that "damage-control orthopedics" involving surgical intervention to ensure physiologic optimization, as well as other medical reasons, may account for some of the delays. As such, the conclusions of this study are limited because adjustments for these types of delay, which may increase the risk of complications, could not be made. Resource limitations and nonmedical logistical issues are also likely causes for delay. The present study was unable to clearly identify the definitive source(s) of delay in each case. However, given the significantly reduced number of complications demonstrated with early stabilization, every reasonable effort should be made to avoid nonmedical delays.

## Conclusion

Spine fracture stabilization within 24 hours of hospital admission appears to be beneficial in multiple trauma patients without neurologic injuries. Surgery within 24 hours considerably decreases the risk of complications related to prolonged recumbency as well as overall complications. The negative effect for delaying spinal fracture stabilization persisted after a delay of 72 hours. Although some patients may require delay for medical and physiologic optimization, the results of this study suggest that every reasonable effort should be made to avoid nonmedical delays in treating these patients. Further prospective investigations would better clarify the effects owing to medical, system or logistical delays.

**Competing interests:** None declared.

**Contributors:** Drs. Pakzad, Yelle and Wai designed the study. Drs. Pakzad and Wai and Ms. Knight acquired the data, which Drs. Pakzad, Roffey, Dagenais, Yelle and Wai analyzed. Drs. Pakzad, Roffey and Wai wrote the article, which Drs. Dagenais, Roffey, Yelle and Wai and Ms. Knight reviewed. All authors approved its publication.

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