Time to Surgery for Unstable Thoracolumbar Fractures in Latin America—A Multicentric Study

Alfredo Guiroy[1], Charles A. Carazzo[2], Juan J. Zamorano[7], Juan P. Cabrera[8], Andrei F. Joaquim[3], Joana Guasque[4], Ericson Sfredo[5], Kevin White[9], Ratko Yurac[7], Asdrubal Falavigna[6]

■ OBJECTIVE: **We sought to identify delays for surgery to stabilize unstable thoracolumbar fractures and the main reasons for them across Latin America.**

■ METHODS: **We reviewed the charts of 547 patients with type B or C thoracolumbar fractures from 21 spine centers across 9 Latin American countries. Data were collected on demographics, mechanism of trauma, time between hospital arrival and surgery, type of hospital (public vs. private), fracture classification, spinal level of injury, neurologic status (American Spinal Injury Association impairment scale), number of levels instrumented, and reason for delay between hospital arrival and surgical treatment.**

■ RESULTS: **The sample included 403 men (73.6%) and 144 women (26.3%), with a mean age of 40.6 years. The main mechanism of trauma was falls (44.4%), followed by car accidents (24.5%). The most frequent pattern of injury was B2 injuries (46.6%), and the most affected level was T12-L1 (42.2%). Neurologic status at admission was 60.5% intact and 22.9% American Spinal Injury Association impairment scale A. The time from admission to surgery was >72 hours in over half the patients and over a week in >25% of them. The most commonly reported reasons for surgical delay were clinical instability (22.9%), lack of operating room availability (22.7%), and lack of hardware for spinal instrumentation (e.g., screws/rods) (18.8%).**

■ CONCLUSIONS: **Timing for surgery in this sample of unstable fractures was over 72 hours in more than half of the sample and longer than a week in about a quarter. The main reasons for this delay were clinical instability and lack of economic resources. There is an apparent need for increased funding for the treatment of spinal trauma patients in Latin America.**

INTRODUCTION

Thoracolumbar spine fractures account for almost 80% of all spine fractures.[1] The most frequent injury type is a compression fracture, which accounts for approximately 45%–66% of cases[2,3] while flexion-distraction fractures make up 15%[4] and about 10% are fracture dislocations.[5]

Management of traumatic thoracolumbar fractures can be nonoperative or surgical, depending on the fracture's morphology, neurologic status, and comorbidities. Controversies about management generally occur with compression fractures, but there is consensus that clear unstable fractures require stabilization to reduce postoperative complications and enable early rehabilitation.[6] In patients with neurologic injury, surgery is considered an emergency, with 2 main objectives: 1) decompress the spinal cord and/or nerve roots and 2) stabilize the spine, which may improve final neurologic outcomes.[6,7]

The optimum timing of surgery for thoracolumbar fractures remains controversial. Most studies have demonstrated that early surgery (within 8–72 hours) helps to reduce the length of hospital stay, days in the intensive care unit (ICU), and days on a

Key words
- Early stabilization
- Late stabilization
- Lumbar fracture
- Spinal cord injury
- Spine surgery
- Thoracic fracture
- Timing of surgery

Abbreviations and Acronyms
AIS: American Spinal Injury Association impairment scale
ICU: Intensive care unit

From the [1]Spine Unit, Orthopedic Department, Hospital Español de Mendoza, Mendoza, Argentina; [2]Department of Neurosurgery, University of Passo Fundo, São Vicente de Paulo Hospital, Passo Fundo, Rio Grande do Sul, [3]Department of Neurosurgery, University of Campinas (UNICAMP), Campinas, São Paulo, Brazil, [4]Hospital Universitario Cajuru, Curitiba, [5]Hospital Cristo Redentor, Porto Alegre, and [6]Neurosurgery Department, University of Caxias do Sul, Caxias do Sul, Brazil, [7]Orthopedic and Traumatology, University del Desarrollo, and Spine Unit, Department of Traumatology, Clínica Alemana, Santiago, and [8]Neurosurgery, Hospital Clínico Regional de Concepción, Concepción, Chile; and [9]ScienceRight Research Consulting, Ontario, Canada

To whom correspondence should be addressed: Alfredo Guiroy, M.D.
[E-mail: alfreguiroy@gmail.com]

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mechanical ventilator, as well as hospital costs and related morbidity.[8]

In low-income countries, however, it is common for surgeries to be delayed for a variety of reasons: the high cost of implants to perform spine stabilizations, diagnostic failures during primary care management, delays transferring patients to suitable centers, delays performing the imaging studies required necessary for diagnosis, lack of hospital resources, and the existence of multiple trauma patients who need to be treated first, among others.[9,10]

In recent years, AO Spine, a worldwide organization consisting of surgeons and other health care practitioners and researchers involved in the treatment and study of spinal disease, has published classification guidelines for a range of spinal injuries and diseases including, in 2013, a classification system for thoracolumbar spinal injuries, which was validated in 2016.[11,12] This thoracolumbar spinal injury classification system describes 3 main morphologic patterns of injury: *type A*, consisting of vertebral body compression fractures; *type B*, in which there is tension band disruption; and *type C*, in which there is either rotation or translation. Both A and B type injuries are further subclassified, depending on the severity of spinal instability, from A0 (minor nonstructural fractures) to A4 (complete burst fractures) and from B1 (transosseous tension band disruption) to B3 (band disruption with hyperextension). Pictorial representations of all these classification levels are available elsewhere.[11] Since the management of the vast majority of compression fractures is nonsurgical and controversy exists as to which patients require surgery, for the current study, we were specifically interested in studying noncompression fractures (type B and C fractures), in which there is generally no discussion of its surgical indication.

Considering that delays in surgical treatment may negatively affect patients' final outcome, the aims of this study were therefore to 1) evaluate the delay for surgery in patients with AO Spine type B and C thoracolumbar fractures in Latin America and 2) identify the frequency and main causes of delays.

METHODS

Ethics Statement

This study was conducted in accordance with ethical standards and approved by the Ethics Committee (29857420.0.1001.5342) for multiple centers. All patients were anonymized with an identification number, and the investigators were blinded to their identity.

Trauma Centers and Registry Review

This was a multicenter retrospective study that included 547 patients with type B or C thoracolumbar fractures (from T1 to L5) from 21 spine centers across Latin America. The recruitment process was performed using either an open call or e-mail to contact all active members of the Latin American branch of AO Spine. Before any data collection, 2 informative meetings were held with all the interested centers to clarify study objectives, scope, and inclusion and exclusion criteria.

From each hospital's trauma registry, the following patient data were extracted: demographics, mechanism of trauma, time between hospital arrival and surgery, type of hospital (public vs. private), fracture classification, spinal level of injury, neurologic status, American Spinal Injury Association impairment score, number of levels instrumented, type of surgery performed (minimally invasive vs. open), and the main reason for any time delay between hospital arrival and surgery.

Inclusion and Exclusion Criteria

We recruited patients older than 18 years old who had suffered a type B or C fracture using the AO Spine thoracolumbar classification criteria and received surgery between January 2014 and December 2019.[11,12] All patients younger than 18 years old or having incomplete data were excluded from analysis.

Surgical Delays

Surgical delay was defined as any duration of time between initial hospitalization and surgery in excess of 72 hours. This duration of time was calculated as the time interval between the patient's date and time of physical arrival at the hospital and the date and time of the initiation of surgery.

Causes of delay to surgery beyond 72 hours were subdivided into 7 categories, as follows: 1—clinical instability, 2—lack of surgery approval, 3—lack of stabilization screws/rods, 4—operating room unavailability, 5—surgical team unavailability, 6—lack of an ICU bed, and 7—other reasons.

Statistical Analysis

All data were imported into SPSS version 26 from an *Excel* spreadsheet. Continuous variables were summarized as means, with standard deviations and ranges, while categorical variables were summarized as absolute numbers and as a percentage of the $n = 547$ total subjects.

For continuous variables (patient age and days between hospitalization and surgery), normality of distribution was tested using the Wilk-Shapiro test. Since both of the 2 listed variables were found to be nonnormally distributed, for all univariate comparisons involving dependent continuous variables, nonparametric tests (e.g., Mann-Whitney U test for 2 groups, Kruskal-Wallis test

Table 1. Hospitals and Patients by Country

Country	Hospitals	Patients	Public Hospital	Private Hospital	Male	Female
Brazil	9	274	274	0	208	66
Chile	3	81	49	32	57	24
Argentina	2	45	0	45	29	16
Mexico	2	35	34	1	28	7
Paraguay	1	30	30	0	18	12
Ecuador	1	26	26	0	17	9
Bolivia	1	21	6	15	17	4
Colombia	1	21	21	0	16	5
Venezuela	1	14	14	0	13	1
TOTALS	21	547	454	93	403	144

Table 2. Characteristics of the Sample (n = 547)

Demographics	Number	%, Standard Deviation
Men, number (%)	403	73.7%
Women, number (%)	144	26.3%
Mean age, years	40.6	16.2
Age range	18–84	
Nature of trauma	**N**	**%**
Car accident	134	24.5
Motorcycle accident	104	19.0
Fall	243	44.4
Diving accident	4	0.7
Other	59	11.3

for >2 groups) were used. For intergroup comparisons of categorical variables, Pearson χ^2 analysis was performed. All tests were 2-tailed, with a Bonferroni-adjusted P threshold of 0.005 used to account for multiple comparisons.

RESULTS

We included 547 patients from 9 Latin America countries in our analysis. Distributions by country and hospital type (public vs. private) are shown in Table 1.

The sample included 403 males (73.6%) and 144 women (26.3%), with a mean age of 40.6 years old. The main cause of trauma was falls (n = 243, 44.4%) followed by car accidents (n = 134, 24.5%) and motorcycle accidents (n = 104, 19.0%) (Table 2).

The most frequent pattern of injury was an AO Spine type B2 fracture (n = 255, 46.6%), and the largest proportion occurred at T12-L1 (n = 231, 42.2%). Neurologic assessment at admission showed that 60.5% (n = 331) of the patients were neurologically intact, while 22.9% (n = 125) had complete neurologic injury (AIS A). Only 16.6% (n = 90) had incomplete neurologic injury (AIS B to D). The levels of spine fracture, number of levels involved, AO Spine thoracolumbar spine trauma classification score, and neurologic status at admission are summarized in Table 3.

The time from admission to surgery was >72 hours in more than half the sample (n = 281; 51.4%), while more than 25% of the patients waited longer than a week. Most patients were treated using open surgery (n = 510, 93.2%) and the remainder with minimally invasive fixation techniques (Table 4). The mean time to surgery among incomplete neurologic injury patients was 7.8 days for AIS B, 4.0 days for AIS C, and 6.6 days for AIS D.

Among the 281 patients who had to wait >72 hours for surgery, the most commonly reported reasons for surgical delay were clinical instability (32%), followed by lack of availability of an operating room (18.9%) and lack of implants to perform stabilizations (screws/rods, 13.9%) (Table 5).

When the duration of delay was analyzed by country and hospital type, statistically significant differences in timing were observed between countries (highest for Venezuela and Brazil; lowest for Chile), and public hospitals averaged longer delays than private hospitals (both $P < 0.001$), as shown in Table 6. No other intergroup comparison—by gender, age group, presence/absence of comorbidity, nature of trauma, type of surgery (minimally invasive/open), AO Spine classification, spinal level, number of levels instrumented, or baseline AIS—revealed differences in the duration of delay that met the *a priori* Bonferroni-adjusted P criterion of $\leq$ 0.005. That said, patients younger than age 50 averaged a delay of 6.8 days versus 12.5 days among those 50 and older (P = 0.025), and patients whose fracture was in the upper thoracic spine (T1-T6) waited an average of 13.1 days, versus 5.7 days in those with lumbosacral fractures and 8.7 days in those with lower thoracic (T7-12) fractures (P = 0.025). Interestingly, a baseline AIS A score was associated with an average delay of 14.4

Table 3. Nature of the Original Injury

Level of Fracture	Number	%
T1–T3	21	3.8
T4–T6	76	13.9
T7–T9	55	10.1
T10–T11	86	15.7
T12–L1	231	42.2
L2–L3	52	9.5
L4–L5	26	4.8
Number of fractured levels	**Number**	**%**
1	117	21.4
2	428	78.2
3	1	0.2
4	1	0.2
AO Spine classification	**Number**	**%**
B1	101	18.5
B2	255	46.6
B3	18	3.3
C	173	31.6
ASIA Impairment Scale	**Number**	**%**
AIS A	125	22.9
AIS B	22	4.0
AIS C	31	5.7
AIS D	38	6.9
Intact	331	60.5

ASIA, American Spinal Injury Association.

Table 4. Nature of Surgery (surgical approach used, number of levels instrumented and time from admission to surgery)

Surgical Approach	Number	%
Open surgery	510	93.2
Minimally invasive surgery	37	6.8
Levels of instrumentation	**Number**	**%**
1	20	3.7
2	185	33.8
3	73	13.3
4	196	35.8
5	40	7.3
6	21	3.8
>7	12	2.3
Time from admission to surgery	**N**	**%**
<24 hours	123	23.8
<48 hours	62	12
<72 hours	50	9.6
<7 days	141	27.3
<30 days	113	21.8
≥30 days	27	5.2

Levels of instrumentation 1: one level above and below the fracture.

Table 5. Reasons for Surgical Delay Among (n = 281) Patients Waiting >72 Hours for Surgery

Reason for Surgical Delay	Number	%
Clinical instability	90	32.0%
Surgical authorization	18	6.4%
Availability of implants	39	13.9%
Availability of operating room	53	18.9%
Availability of surgical team	16	5.7%
Availability of ICU beds	3	1.1%
Other reason	61	21.7%
Missing data	1	0.4%

ICU, intensive care unit.

days versus just 6.7 for all 4 other AIS levels; however, this difference in means was driven by 6 versus just 3 patients in the 2 groups who waited more than 3 months for surgery, respectively, so nonparametric (rank) testing (because days of delay was nonnormally distributed) failed to identify any statistically significant difference ($P = 0.38$).

Reasons for delay were evaluated in each country. The reasons most commonly cited in each country were clinical instability (Brazil and Mexico); equipment unavailability (Argentina, Paraguay, and Bolivia); operating room unavailability (Venezuela, Ecuador, and Colombia); and other reasons (lack of UCI beds in Chile). See Table 7.

DISCUSSION

Although the incidence of thoracolumbar spinal trauma has been increasing, and surgery remains the best treatment option, there is still a lack of consensus about the optimum timing to perform reparative surgery. Nevertheless, the vast majority of the evidence generally supports the benefits of early surgery. Glaser et al[13] evaluated the opinion of 31 spine surgeons regarding what they considered to be "early surgery." Eight responded that the ideal time was up to 8 hours, while 24 surgeons claimed that up to 72 hours was appropriate, demonstrating this afore-mentioned lack of consensus in their opinions.[13] The *Surgical Timing in Acute Spinal Cord Injury Study*, which was based on the physiologic mechanisms of secondary spinal cord injury, defined an early intervention as one performed within 24 hours of the injury. This prospective study, which involved 313 patients with cervical spine trauma, demonstrated that intervening within 24 hours was both safe and associated with improved neurologic outcomes, defined as at least a 2 grade AIS improvement at 6 months' follow-up, when compared with late surgery.[14]

Even with discrepant opinions defining early intervention, there seems to be some consensus that, in patients with incomplete neurologic injury, surgery should be performed as soon as possible, preferably within the first 24 hours, despite several

Table 6. Duration of Surgical Delay by Country and Hospital Type

Country	Number	Mean Delay (days)	*P* Value
Venezuela	14	13.2	<0.001
Brazil	274	12.2	
Mexico	35	8.3	
Ecuador	26	6.2	
Argentina	45	5.5	
Colombia	21	5.2	
Paraguay	30	3.9	
Bolivia	21	3.1	
Chile	81	1.7	
Hospital type	**Number**	**Mean delay (days)**	***P* value**
Public	454	9.5	<0.001
Private	93	3.5	

Table 7. Reason for Delay by Country

Country	Clinical Instability	Equipment Availability	Operating Room Availability	Surgical Team Availability	ICU Bed Availability	Other Reason
Venezuela	0.0%	0.0%	85.7%	0.0%	0.0%	0.0%
Brazil	30.5%	1.8%	19.9%	11.8%	1.1%	23.5%
Mexico	40.0%	2.9%	17.1%	0.0%	0.0%	8.6%
Ecuador	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Argentina	4.4%	60.0%	2.2%	0.0%	0.0%	22.2%
Colombia	14.3%	9.5%	47.6%	0.0%	0.0%	19.0%
Paraguay	23.3%	56.7%	3.3%	0.0%	3.3%	3.3%
Bolivia	28.6%	66.7%	0.0%	0.0%	0.0%	4.8%
Chile	12.3%	25.9%	17.3%	3.7%	0.0%	34.6%
Totals	32.0%	13.9%	18.9%	5.7%	1.1%	21.7%

ICU, intensive care unit.

studies showing benefits of decompression for up to 72 hours after trauma.[14-18]

Other benefits of early surgery have been described irrespective of a patient's neurologic status.[19,20] Xing et al,[8] in a systematic review of 10 studies comparing early (<72 hours) versus late stabilization of thoracolumbar spine fractures, discovered that early surgery may reduce the patient's hospital stay, ICU length of stay, ventilator days, level of morbidity, and hospital expenses.

In our study, when we analyzed patients with incomplete neurologic deficits (the subset of patients in whom early surgery might be anticipated to yield greater benefits), the mean delay was still longer than 72 hours in each AIS subgroup (AIS B to D). Fewer than half of the evaluated type B and C thoracolumbar fractures were operated on within 72 hours of hospital admission, and only 23.8% in <24 hours. The most frequent reason given for surgical delay was clinical instability. However, if we group all the other reasons for delay (lack of authorization to perform surgery and unavailability of resources like screws/rods, ICU beds, and operating rooms), most delays were due to economic aspects. In a retrospective analysis of a registry prospectively collected data and a surgeon survey performed in Canada, Glennie et al[21] identified a discrepancy between surgeons' perception of the ideal timing to perform surgery (<24 hours) and the actual timing of surgery for thoracolumbar spinal cord injuries. The authors highlighted the need for strategies to 1) improve knowledge translation among patients and 2) reduce administrative barriers to early surgery.[21]

Comparing delays to surgical stabilization in the public versus private system, those in public hospitals had to wait an average of 6 days longer (9.5 days vs 3.5 days). Latin American health care systems are heterogenous, and there are many different ways to access health care services.[22] Frenk et al described perhaps the easiest way to subdivide health care on the basis of funding, would be as 1) the *public system* (in general, poorly financed, mostly from general taxes and serving the poor nonworking population); 2) *social security institutions* (in general, well financed by those with salaries); and 3) the *private sector* (well financed, paid for by those with the greatest financial resources).[22] To simplify our analysis, we subdivided hospitals into public and private systems because access to technologies and the potential for early surgery are generally considered similar in the social security and private sectors. In *post-hoc* analysis (not shown), when we compared public and private hospitals to potentially explain the longer times to surgery in the former, the only statistically significant differences we identified were in the percentage of patients with at least one comorbid illness, and the country. With respect to comorbid illness, the percentage of patients with at least one such illness was almost twice as high in public as private hospitals (46.4 vs. 26.9%, $P < 0.001$). It is possible, therefore, that one reason for the longer times to surgery at public hospitals is that a larger percentage of patients required surgery-delaying management to stabilize other health conditions. With respect to country, of the six countries with 100% of public healthcare systems, five were among the top six in terms of the longest delay for surgery (the only exception being Argentina, with 100% patients treated in private hospitals, which had the fifth longest mean time to surgery). Also among these six countries, three were rated worst (first through third worst) in terms of equipment availability, while 2 ranked worst (first through second) in operating room availability, suggesting that differences in resources between public and private hospitals might also play a role in determining the difference we observed in delay for surgery.

The main reason reported for surgical delay in our sample was clinical instability, which was considered the reason for 32% of patients waiting more than 72 hours for surgery. This could be explained because most high-speed accidents are polytraumatic and other visceral lesions may preclude early spinal surgery. Consistent with this was the prolonged (albeit non-significant) delay we observed in AIS A grade patients, which may sustained more severe systemic trauma. Nevertheless, studies suggest that polytrauma patients should be operated upon as soon as they are hemodynamically stable, because the rates of complications like pneumonia, thrombosis, and death are reduced once damage-control spine surgery has been performed.[21-23] Of note, 60.5% ($n = 331$) of the patients included in our study were neurologically intact. In such patients, although there is a risk of neurologic deterioration with an unstable spine, surgery might not be considered emergent by all surgeons, instead being scheduled as an elective procedure.

The current study has limitations. First of all, most Level I trauma centers in Latin America are in the public system, and this may bias results because they are generally less-well financed, which itself may be the primary cause of longer delays to surgery. This said, the vast majority of the population in Latin America countries only has access to the public healthcare system. Another limitation is that, although 547 patients might seem like a sizeable number, this is only a miniscule percentage of all the spinal stabilization procedures performed across the nine participating countries. This calls into question the generalizability of our results. This said, although we cannot generalize our results to all Latin American countries, due to their heterogeneity, this is still a good sample of unstable thoracolumbar fractures, considering that we only included types B and C. There also was huge diversity in the number of patients representing different countries, with 274 from Brazil but only 14 from Venezuela, which may bias our interpretation of results according to country origin. In addition, we were unable to objectively verify that the reported reasons for delays were accurate. These limitations notwithstanding, we believed our results provide an initial glance at the problem of and potential reasons for surgical delays for spinal stabilization surgery in Latin America.

CONCLUSIONS

In Latin America, there appear to be appreciable and unacceptable delays for spinal stabilization surgery in patients with clear unstable thoracolumbar fractures, with more than half of patients needing to wait more than 72 hours and 1 in 4 waiting longer than a week. The main causes of delay appear to be clinical instability and lack of economic resources to support early interventions. Novel strategies must be developed to overcome barriers to early stabilization surgery across Latin America.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Alfredo Guiroy: Writing - review & editing, Methodology, Formal analysis. **Charles A. Carazzo:** Writing - review & editing, Methodology, Formal analysis. **Juan J. Zamorano:** Writing - review & editing, Methodology. **Juan P. Cabrera:** Writing - review & editing, Methodology. **Andrei F. Joaquim:** Writing - review & editing, Methodology. **Joana Guasque:** Writing - review & editing, Supervision. **Ericson Sfredo:** Writing - review & editing, Supervision. **Kevin White:** Writing - review & editing, Formal analysis, Language revision. **Ratko Yurac:** Writing - review & editing, Methodology. **Asdrubal Falavigna:** Writing - review & editing, Formal analysis, Supervision.

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