Safety of Surgical Treatment for Thoracolumbar Fracture-Dislocations According to Surgical Timing

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ABSTRACT

Introduction: Thoracolumbar fracture-dislocations account for 10% of traumatic spinal injuries and typically occur in the context of high-energy trauma. Our objective is to compare early complications in patients with thoracolumbar fracture-dislocation based on surgical timing, either before or after 24 hours from the trauma. **Materials and Methods:** This is a multicenter, retrospective cohort study of patients surgically treated for thoracolumbar dislocations, from January 1, 2014 to January 1, 2023. We included adult patients (>18 years old) of any gender, surgically treated for high-energy thoracolumbar fracture-dislocations. Patients were grouped based on when they underwent spinal surgery: before or after 24 hours following trauma. Total and grouped complications were recorded. **Results:** Our sample comprised 72 patients, with 64 men (88.9%) and 8 women (11.1%) at an average age of 35.94 years. Occupational health care centers were predominant (n=60; 83.3%). Road traffic accidents (n=42; 58.3%) were the most frequent cause of injury, followed by falls from height (n=26; 36.1%). Furthermore, 86% of patients had one or more associated injuries. In total, 283 complications were recorded, with 67 patients (93.1%) suffering at least one complication, and 26 patients (36.1%) experiencing surgical complications. The median number of complications was significantly higher in late-operated patients (p=0.004). **Conclusions:** Patients with thoracolumbar dislocations who underwent surgery after the first 24 hours following trauma had a significantly higher median rate of complications than those who underwent early surgery.
Keywords: Complications; thoracolumbar dislocations; spinal cord injury; reduction and arthrodesis; spine surgery; safety.
Level of Evidence: IV

Seguridad de la cirugía de luxofracturas vertebrales toracolumbares según la oportunidad quirúrgica

RESUMEN

Introducción: Las luxofracturas vertebrales toracolumbares se producen por traumatismos de alta energía, representan el 10% de las lesiones traumáticas de la columna vertebral y se asocian frecuentemente con otras lesiones. El objetivo de este estudio fue comparar las complicaciones tempranas en pacientes con una luxofractura toracolumbar según la oportunidad quirúrgica, antes o después de las 24 h del trauma. **Materiales y Métodos:** Estudio multicéntrico, analítico, observacional y retrospectivo de una cohorte de pacientes operados por una luxofractura toracolumbar, desde el 1 de enero de 2014 hasta el 1 de enero de 2023. Se incluyó a pacientes de ambos sexos, >18 años, operados por una luxofractura vertebral de alta energía. Se los agrupó según si habían sido operados de columna antes o después de las 24 h del trauma. Se registraron las complicaciones totales y agrupadas. **Resultados:** Se evaluó a 72 pacientes, 64 hombres (88,9%) y 8 mujeres (11,1%), con una edad promedio de 35.94 años. Predominaron las instituciones laborales (n = 60; 83,3%). El mecanismo de lesión más frecuente fueron los accidentes de tránsito (n = 42; 58,3%), seguidos de las caídas de altura (n = 26; 36,1%). El 86% sufrió una o más lesiones asociadas. Se registraron 283 complicaciones en 67 (93,1%) pacientes y 45 complicaciones quirúrgicas en 26 pacientes (36,1%). La mediana de complicaciones fue mayor en pacientes operados tardíamente (p = 0,004). **Conclusiones:** Los pacientes con luxofractura toracolumbar operados después de las primeras 24 h presentaron una mediana de complicaciones totales significativamente mayor que los operados precozmente.
Palabras clave: Trauma vertebromedular; luxofracturas vertebrales; reducción y artrodesis; cirugía de columna; complicaciones; seguridad.
Nivel de Evidencia: IV

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INTRODUCTION

Thoracolumbar fracture dislocations (TLFD) are caused by high-energy trauma. They account for 10% of traumatic spinal injuries and are frequently associated with other injuries (vertebral and non-vertebral).[1-3]

The morbidity of polytraumatized patients, as well as the usual concomitant neurological injury, may condition the therapeutic window of opportunity of TLFDs.[1-5] This occurs because these are highly unstable injuries that require reduction and surgical stabilization, usually with long instrumentation and through a conventional posterior approach. As a result, the procedure will include the physiological impact of surgery, as well as the risk of second injury and eventual complications.[4-6] As an additional complexity, the definition of 'polytrauma' is highly variable in the literature on the therapeutic approach to patients with thoracolumbar fracture-dislocation. This implies a possible selection bias when including polytraumatized patients, or registration bias when documenting polytrauma as a variable. The Berlin definition was proposed by consensus in 2014 to resolve this conflict; however, it is still not widely used in spinal trauma publications.[1-6] This definition combines the severity of the associated injuries with at least one of five complementary parameters (age, systolic blood pressure, Glasgow scale, APTT value or base excess).[7]

The first 24 hours after trauma represent the crucial interval for decompression in patients suffering spinal trauma and associated neurological injury.[8-12] TLFDs additionally include mechanical instability, which plays an important role in the development of traumatic neurological injury. This leads to a greater difficulty in complying with the critical intervals proposed in the literature, which are related to the need for implants in an emergency.[13] Furthermore, the safety of the procedure is controversial, especially because TLFDs have a higher rate of complications compared to other traumatic spinal injuries of lesser magnitude.[14-16]

Our objective was to compare the rate of early complications (90 days) in patients with thoracolumbar fracture-dislocation according to surgical timing: within or after 24 hours following trauma.

MATERIALS AND METHODS

Analytical, observational, retrospective study of a multicenter cohort of patients operated on for TLFD between January 2014 and January 2023.

Adult patients of both sexes, >18 years old, operated on for traumatic TLFD were included. Thoracolumbar dislocations and fracture-dislocations were considered, according to the definition of the *AO Spine Thoracolumbar Injury Classification System.*[17] This system groups as type C any traumatic spinal injury with segmental involvement of both anterior and posterior structures and translation (potential or evident) beyond the physiological range in any of the three planes of space (coronal, axial or sagittal). Patients with incomplete records, revision surgeries, penetrating trauma or follow-up <90 days were excluded.

The presence of early complications, defined as complications within 90 days of admission, was considered the primary outcome measure. In addition, to facilitate their description, complications were divided into the following subgroups: clinical or systemic, surgical, related to spine and spinal cord trauma, and others. Surgical complications were sub-grouped according to the Clavien-Dindo classification (categories I to V according to severity).[18] Due to the severity of this injury and the frequent complications in patients with spinal fracture dislocations, the variable "major complications" (presence or absence) was defined and dichotomized as the presence of one or more of the following complications: clinical complications (sepsis, hemodynamic shock, multiple organ failure, respiratory distress, nosocomial pneumonia), grade III or greater surgical complications (according to the Clavien-Dindo classification); or complications of the spinal trauma, which resulted in re-intervention, surgical intervention, or death of the patient. Secondly, the time frame of functional and neurological recovery was analyzed. The time elapsed in days from spinal injury to functional independence was considered for rehabilitation, either sitting at the edge of the bed or in the wheelchair in the case of severe neurological injury, or walking for those without injury or mild neurological injury. The evolution of the neurological status was recorded with the *American Spinal Injury Association Impairment Scale* (AIS) at the last available follow-up record.[19]

The following variables were also recorded: age, sex, type of health institution, mechanism of trauma, comorbidities, neurological status on admission, associated traumatic injuries, hemodynamic instability, Glasgow scale, vertebral injury topography, classification, presence of other vertebral fractures, days of hospitalization, days of intensive care, days of mechanical ventilation, type of surgery and instrumentation levels.

Patients were grouped according to surgical timing, before or after 24 h, a cut-off value chosen according to the current literature.[8-12]

This study was conducted in accordance with the Declaration of Helsinki regarding observational research with personally identifiable information. The records were anonymous and confidential.

Statistical Analysis

Categorical variables are expressed as number and percentage, and were analyzed with the χ^2 test or Fisher's test. Numerical variables are described as mean and median, according to their distribution and their measures of dispersion, standard deviation and range. For the comparison of continuous variables, Student's t test or Mann-Whitney's U test were used, according to the distribution expressed. The correlation between the numerical variable 'complications' and the variables 'surgical timing', 'days of hospitalization', 'days in intensive care', and 'days of mechanical ventilation' was studied. Pearson's correlation (parametric variables) or Spearman's rho coefficient (nonparametric variables) was used, according to the result of the normality tests of the variables. The analysis was performed with SPSS Statistics 25.

RESULTS

Ninety-two patients were included and 20 were excluded after applying the selection criteria. The study sample consisted of 72 patients, 64 men (88.9%) and eight women (11.1%), with an average age of 35.94 years, mostly treated in labor institutions (n = 60; 83.3%). The predominant origin of trauma was traffic accidents (n = 42; 58.3%), followed by falls from great heights (n = 26; 36.1%). Thoracic (n = 34; 47.2%) and thoracolumbar junction (n = 31; 43.1%) fracture-dislocations predominated; less than 10% of the injuries were to the lower lumbar spine. The majority had at least one associated injury (n = 62; 86.1%). Thoracic trauma was the most frequent associated injury (n = 41; 56.9%), followed by traumatic brain injury (n = 31; 43%), and abdominal trauma (n = 20; 27.7%) (Figure 1). Table 1 describes the demographic and clinical characteristics of the entire sample.

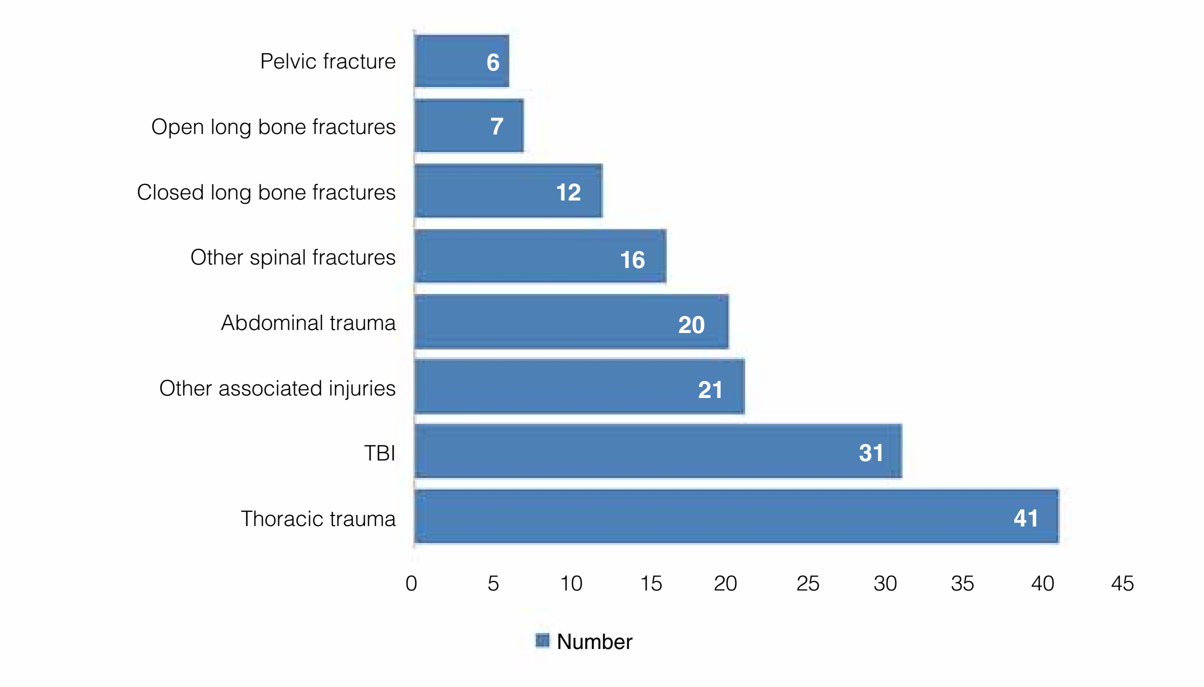

Figure 1. Horizontal bar graph: distribution of the number of associated injuries. The category "Other associated injuries" groups together various injuries that are poorly represented individually.

Table 1. Sample description (n = 72)

Variables		Results
Age; mean (range)		35.94 (±12.9; 8-79)
Sex, n (%)	Male	64 (88.9%)
	Female	8 (11.1%)
Type of institution; n (%)	Public	10 (13.9%)
	Private	2 (2.8%)
	Occupational	60 (83.3%)
Mechanism of injury; n (%)	Traffic accident	42 (58.3%)
	Fall from a great height	26 (36.1%)
	Direct trauma	3 (4.2%)
	Other	1 (1.4%)
Topography; n (%)	Thoracic (T1-T9)	34 (47.2%)
	Thoracolumbar junction (T10-L2)	31 (43.1%)
	Lower lumbar spine (L3 to sacrum)	7 (9.7%)
Direction of displacement; n (%)	Anteroposterior	54 (79.4%)
	Lateral	10 (14.7%)
	Rotational	4 (5.9%)
Comorbidities (number); median (range)		2 (0-4)
Associated injuries in number; median (range)		2 (0-8)
AIS at admission; n (%)	A	36 (50.0%)
	B	7 (9.7%)
	C	5 (6.9%)
	D	3 (4.2%)
	E	14 (19.4%)
	Not assessable	7 (9.7%)
Complications, n (%)		67 (93.1%)
Complications (number); median (range)		3 (0-11)
Neurological recovery; n (%)		10 (20.0%)
Deaths; n (%)		1 (1.4%)
Follow-up in days; median (range)		580 (90-4503)

SD = standard deviation; AIS = ASIA Impairmant Scale.

A total of 283 complications were recorded in 67 (93.1%) patients. There were 45 surgical complications in 26 patients (36.1%), 22 of which (48%) were grade III of the Clavien-Dindo classification (complications requiring some surgical, endoscopic or radiographic intervention) (Table 2, Figure 2).

Seventy percent had neurological deficits on admission; 50% of the sample was admitted with a complete spinal cord syndrome (AIS A). Neurological recovery was documented in 10 patients (20%). The 90-day mortality rate was less than 2% (n = 1; 1.4%).

Table 2. Types of complications

Complications	n	(%)
Neurogenic bladder or bowel	53	(73.6)
Urinary tract infection	28	(38.9)
Depression	28	(38.9)
Decubitus bedsores	22	(30.6)
Pneumonia	20	(27.8)
Surgical site infection	15	(20.8)
Other infections	14	(19.4)
Wound dehiscence	12	(16.7)
Neurogenic shock	11	(15.3)
Sepsis	10	(13.9)
Other clinical complications	10	(13.9)
Hypovolemic shock	8	(11.1)
Other complication associated with spinal trauma	7	(9.7)
DVT/PTE	6	(8.3)
Septic shock	5	(6.9)
Empyema	5	(6.9)
Respiratory distress	5	(6.9)
Incomplete reduction	5	(6.9)
Acute renal failure	4	(5.6)
Hematoma at the surgical site	3	(4.2)
Implant loosening/breakage	3	(4.2)
Loss of reduction	2	(2.8)
Nonunion	2	(2.8)
Multiple organ failure	1	(1.4)
Neurovascular injury	1	(1.4)
Progression of neurological status	1	(1.4)
Other surgical complications	1	(1.4)
Cerebrospinal fluid fistula	1	(1.4)

DVT/PTE = deep vein thrombosis/pulmonary thromboembolism·

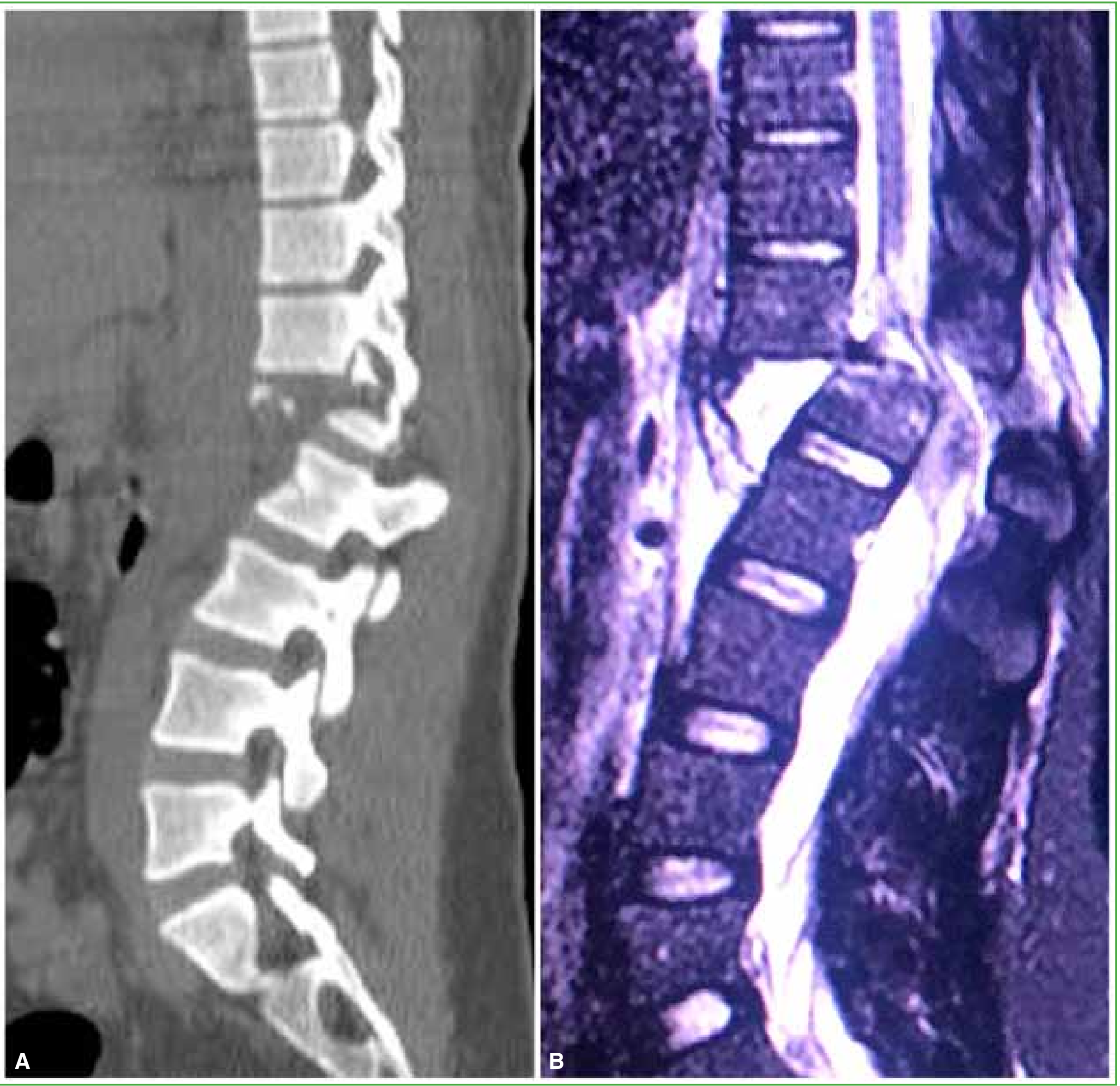

Figure 2. Images of a thoracolumbar fracture-dislocation. A. Computed tomography of the thoracolumbar spine, sagittal view. An L1-L2 fracture-dislocation is observed. B. Magnetic resonance imaging, thoracolumbar spine, sagittal view. The completely severed neuraxis is observed.

Comparison according to surgical timing (before or after 24 h).

Two groups were obtained according to the timing of spinal surgery: before (n = 33) or after the first 24 h (n = 36) following trauma. The median number of total complications was higher in patients operated on late, a statistically significant finding (p = 0.004) (Figure 3). Major complications were more frequent in patients operated on after 24 h, but without statistical significance (p = 0.125).

Other variables with a statistically significant association with surgical treatment after 24 h were: type of institution (p = 0.005; no patient outside the occupational sector underwent surgery within 24 h and, in the public sector, within 14 days from trauma); number of associated injuries (p <0.001), thoracic (p = 0.001), abdominal (p = 0.004) and long bone (p = 0.017) trauma; days in intensive care (p <0.001); and mechanical ventilation (p = 0.006).

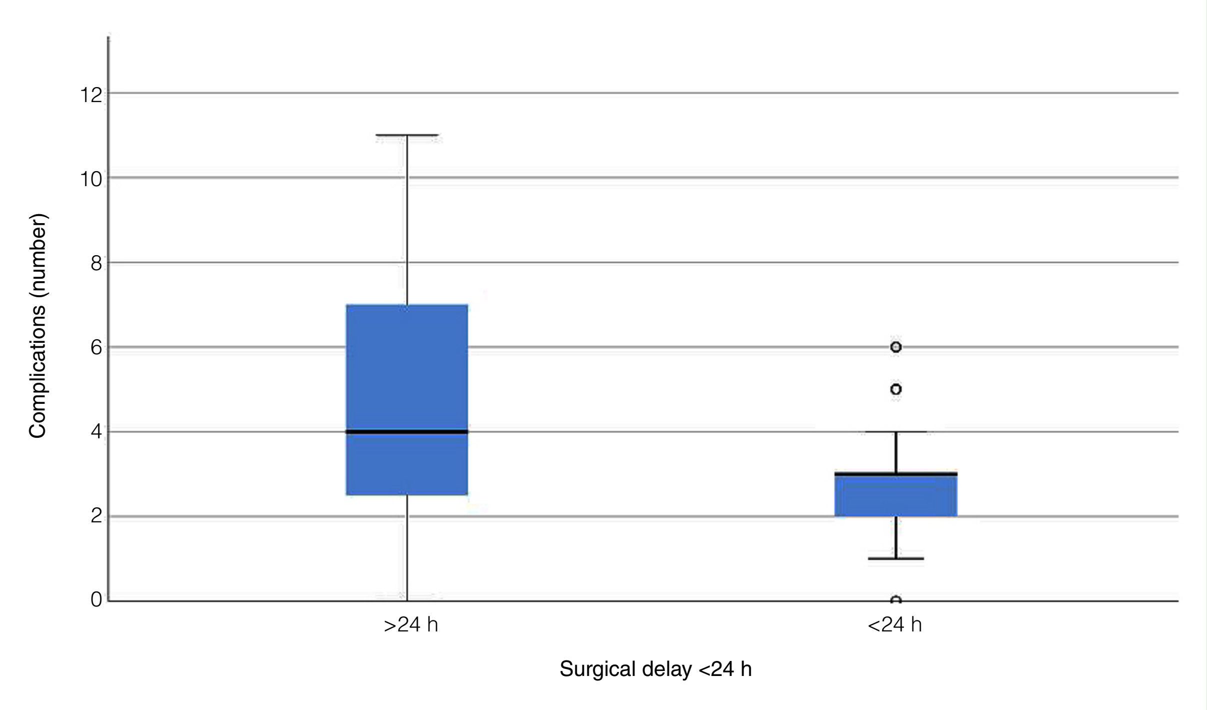

Figure 3. Box plot: distribution of complications according to surgical timing.

There was a positive linear correlation between the number of complications and surgical timing in hours from trauma to surgery (Spearman's rho = 0.403; p = 0.001) and total days of hospitalization (Spearman's rho = 0.423; p <0.001), days in intensive care (Spearman's rho = 0.588; p <0.001), and mechanical ventilation (Spearman's rho = 0.640; p <0.001).

Neurological recovery by at least 1 grade on the AIS scale was more frequent in patients operated on before 24 h; however, the difference was not statistically significant (p = 0.065). The onset of functional recovery was early in patients operated on before 24 h (p<0.001). Table 3 summarizes the results of the comparison.

DISCUSSION

TLFDs are caused by high-energy trauma involving simultaneous and multidirectional forces (flexion/extension, rotation and compression), resulting in a circumferential capsule-disc-ligament injury and the development of spinal injuries with translational instability.[17] These types of severely mechanically unstable injuries should be reduced and stabilized as soon as possible, but surgical timing remains controversial. It is mostly influenced by polytrauma in the patient, as well as vertebral/spinal cord trauma.[7-12]

The magnitude of the first trauma-associated injury is the main prognostic parameter for the clinical outcome of the patient after multiple high-energy trauma.[20] It should be noted that the eventual complications that may ensue during the initial evolution will determine the beneficial or adverse outcome of this group of patients. These secondary events include, among others, septic complications, single or multiple organ dysfunction, and acute lung injury or acute respiratory distress syndrome.[20] The potential unfavorable impact of surgical procedures on the physiologic response to trauma has been estimated; in this scenario, definitive spine surgery is typically associated with higher mortality rates in early operated patients.

Table 3. Comparison according to surgical timing before or after the first 24 h.

Variables		Surgical timing				p
		More than 24 h after trauma (n = 36)		Within the first 24 h after trauma (n = 33)		
Age; mean (SD; range)		37	15 (8-79)	36 (11; 20-60)		0.814
Sex, n (%)	Male	30	(83.3)	31	(93.9)	0.169
	Female	6	(16.7)	2	(6.1)	
Hospital; n (%)	Public	8	(22.2)	0	(0)	0.005
	Private	2	(5.6)	0	(0)	
	Occupational	26	(72.2)	33	(100)	
Mechanism of injury; n (%)	Traffic accident	23	(63.9)	17	(51.5)	0.269
	Fall from a great height	12	(33.3)	14	(42.4)	
	Direct trauma	0	(0.0)	2	(6.1)	
	Other	1	(2.8)	0	(0.0)	
Topography; n (%)	Thoracic (T1-T9)	18	(50.0)	15	(45.5)	0.931
	Thoracolumbar junction (T10-L2)	15	(41.7)	15	(45.5)	
	Lower lumbar spine (L3 to sacrum)	3	(8.3)	3	(9.1)	
Displacement; n (%)	Anteroposterior	29	(82.9)	24	(75.0)	0.691
	Lateral	4	(11.4)	6	(18.8)	
	Rotational	2	(5.7)	2	(6.3)	
Classification; n (%)	A0/A1/A2	5	(13.90)	6	(15.90)	0.627
	A3/A4	31	(86.10)	27	(81.80)	
Comorbidities (number); median (range)		2	(0-4)	1	(0-4)	0.101
Associated injuries (number); median (range)		2	(0-8)	1	(0-5)	<0.001
Specific injuries; n (%)						
TBI		18	(50.0)	12	(36.4)	0.254
Thoracic trauma		27	(75.0)	11	(33.3)	0.001
Abdominal trauma		14	(38.9)	3	(9.1)	0.004
Closed fractures of long bones		10	(27.8)	2	(6.1)	0.017
Open fractures of long bones		3	(8.3)	2	(6.1)	0.716
Pelvic fracture		4	(11.1)	2	(6.1)	0.457
Other vertebral fractures		10	(27.8)	5	(15.2)	0.204
Other associated injuries		14	(39)	6	(18)	0.058
Hemodynamic instability; n (%)		11	(31)	4	(12)	0.64
Glasgow ≤8;n (%)		6	(17)	4	(12)	0.592
Neurological deficit; n (%)		22	(61)	27	(82)	0.058
AIS at admission; n (%)	A	18	(50)	16	(48)	0.137
	B	1	(3)	6	(18)	
	C	2	(6)	3	(9)	
	D	1	(3)	2	(6)	
	E	8	(22)	5	(15)	
	Not assessable	6	(17)	1	(3)	
Days in ICU; median (range)		14	(0-90)	4	(0-34)	<0.001
Days of hospitalization; median (range)		55	(11-329)	44	(5-205)	0.112
Days of mechanical ventilation; median (range)		0	(0-30)	0	(0-25)	0.006
Complications (number); median (range)		4	(0-11)	3	(0-6)	0.004
Major complications; n (%)		27	(75)	19	(58)	0.125
Neurological recovery; n (%)		2	(9)	8	(31)	0.065
Functional recovery (days); n (%)		23	(4-246)	6	(2-75)	<0.001

SD = standard deviation; TBI = traumatic brain injury; ICU = intensive care unit.

According to the *Advanced Trauma Life Support* guidelines, surgical specialties should prioritize, during the initial hours, damage control surgery procedures and, in the case of unstable vertebral lesions, perform an individual analysis of each case, considering, in the absence of neurological damage, the possibility of delaying the definitive surgical treatment until the inflammatory response associated with the trauma has been overcome.[20] The persistent controversies in this regard, the lack of a specific cut-off point for definitive surgical timing and especially the remarkable mechanical instability of these lesions motivated the authors to describe the results on the safety of TLFD treatment according to surgical timing.

In our series, the predominant mechanism of injury was traffic accidents, followed by falls from great heights. In agreement with previous publications, young adult male patients predominated.[2-7]

Concomitant traumatic injuries are frequent. In a study of 733 patients with traumatic spinal injuries, Reinhold et al. described associated injuries in 66% of the cases.[6] In our sample, 86% of the patients had at least one concomitant traumatic injury, the most frequent being thoracic trauma, followed by traumatic brain injury.

There are differences between countries and regions of the world in the care of vertebral/spinal cord trauma, which has an impact on surgical timing.[13] In a multicenter retrospective cohort of Latin American institutions that included 547 patients with unstable thoracolumbar fractures (type B and type C), Guiroy et al. documented surgical time frames beyond 72 h in more than half of the patients and >1 week in a quarter of the sample. In our series, 50% of patients underwent surgery after 24 hours. It should be noted that patients operated on in occupational accident centers predominated. No patient in the public sector was able to undergo surgery before 14 days of evolution of the trauma.

The high complication rate of thoracolumbar fracture-dislocations has been recorded in previous publications.[3,6,7,13,15,16,21] In our region, Latin America, Guiroy et al. described a rate of 47% in 113 patients with type C fractures.[13] In our series, the complication rate was high, as at least one complication was documented in almost all patients in the sample (n = 67; 93.1%). Major complications occurred in 63.8% and 26 had surgical complications. This could be related to multiple factors specific to our sample, such as the high prevalence of associated injuries (86%) and the linear correlation obtained between the number of complications and the surgical time frame in hours from trauma to surgery, general hospitalization, intensive care hospitalization, and mechanical ventilation. The median number of complications was significantly higher in patients operated on beyond 24 h; however, there were no statistically significant differences in the presence or absence of major complications based on surgical timing before or after 24 h. It is estimated that the early surgery strategy did not significantly increase morbidity in this group of patients, which is consistent with the reported results.[22,23]

The efficacy of early surgery in the recovery of patients with vertebral and spinal cord trauma and neurological deficit has been extensively studied and remains a controversial issue.[8-12,22,23] However, there is consensus on the safety of early intervention (before 24 h) and its recommendation.[22,23] In our sample, 10 patients had neurological recovery in at least one grade of the ASIA scale, and 80% of the cases of recovery occurred in the group of those operated on early. It should be noted that this difference was not statistically significant ($p = 0.065$). The authors assume that the lack of statistical significance of this estimate may be related to the insufficient statistical power of our research for this result. In addition, patients with type C fractures (all fractures in our sample) have a worse prognosis for neurological recovery and the amount of preoperative spinal translation is highly predictive of complete spinal cord injury and the likelihood of postoperative neurological recovery.[24,25] Lambrechts et al. have suggested that preoperative spinal translation >6.10 mm would be predictive of complete spinal cord injury.[25]

The weaknesses of this study are its observational, retrospective nature and the low sample size, which prevent generalization of its conclusions. Additionally, it was not possible to differentiate between the causes that led to surgery after the first 24 hours of trauma. Its methodological design does not allow establishing a cause-effect relationship between surgical timing and the outcome in terms of complications. However, it provides us with an estimate of the safety of early treatment in a multicenter cohort of patients with spinal fracture-dislocations, injuries with frequent severe neurological damage and associated injuries that condition timely treatment. It also provides regional data on a situation that requires the timely allocation of a large amount of human and economic resources and that constitutes a challenge to be resolved in our country and in Latin America.

CONCLUSIONS

Patients with TLFD operated on after the first 24 h had a significantly higher median total complications than those operated on earlier. These findings suggest the importance of considering the timing of surgery before 24 h, without detriment to the safety of the intervention and with the possibility of positively influencing the neurological and functional recovery of patients.

Conflict of interest: no conflicts of interest to declare.

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