UPPER THORACIC SPINE FRACTURE ASSOCIATED WITH FRACTURE OF THE STERNUM

FRATURA DA PARTE SUPERIOR DA COLUNA TORÁCICA ASSOCIADA À FRATURA DO ESTERNO

FRACTURA DE COLUMNA TORÁCICA ALTA ASOCIADA A FRACTURA DEL ESTERNÓN

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ABSTRACT

Objectives: The objectives of this presentation are to analyze the kinematics that causes this association, describe the impact of the injury, and evaluate the treatment performed. Methods: Three cases are analyzed by quantifying the displacement and angulation of the sternum, the characteristics of the spinal injury and deformity, treatment, and complications. Results: The mechanism that causes the injury is flexion-distraction, the component of the vertebral body presented is type A, and the most affected region was T5. Two patients had neurological picture E. Sternum injury was caused by direct trauma. Conclusion: The association of these was observed in patients who have suffered from high-energy trauma in a car accident. There was no relationship between the angulation of the sternum and its displacement to the degree of kyphosis and displacement of the thoracic spine. It is important to carry out good radiographic studies that include the sternum when there is suspicion of this relationship.

Keywords: Spinal fractures; Thoracic vertebrae; Sternum.

RESUMO

Objetivos: Os objetivos desta apresentação são analisar a cinemática que causa essa associação, descrever o impacto da lesão e avaliar o tratamento realizado. Métodos: São analisados três casos, quantificando o deslocamento e a angulação do esterno e as características da lesão na coluna vertebral e deformidade, o tratamento e as complicações. Resultados: O mecanismo que provoca a lesão é a flexão-distração, o componente do corpo vertebral apresentado é de tipo A e a região mais afetada foi T5. Dois pacientes tinham quadro neurológico E. A lesão esterno foi causada por trauma direto. Conclusão: A associação destes foi observada em pacientes que sofreram trauma de alta energia em acidente automobilístico. Não encontramos relação entre a angulação do esterno e seu deslocamento com o grau de cifose ou deslocamento da coluna torácica. É importante realizar bons estudos radiográficos que incluam o esterno quando houver suspeita dessa relação.

Descritores: Fraturas da coluna vertebral; Vértebras torácicas; Esterno.

RESUMEN

Objetivos: Los objetivos de esta presentación son analizar la cinemática que ocasiona esta asociación, describir la repercusión de la lesión y evaluar el tratamiento realizado. Métodos: Se analizan tres casos, cuantificando desplazamiento y angulación del esternón y las características de la lesión vertebral y deformidad, el tratamiento y las complicaciones. Resultados: El mecanismo que provoca la lesión es flexo-distracción, el componente del cuerpo vertebral presentado es de tipo A y la región más afectada fue T5. Dos pacientes tenían cuadro neurológico E. La lesión del esternón se debió a trauma directo. Conclusión: La asociación de estas se vio en pacientes que habían sufrido trauma de alta energía durante un accidente automovilístico. No encontramos relación entre la angulación del esternón y su desplazamiento con el grado de cifosis o desplazamiento en la columna torácica. Es importante realizar buenos estudios radiográficos que incluyan el esternón al sospechar esta relación.

Descriptores: Fracturas de la columna vertebral; Vértebras torácicas; Esternón.

INTRODUCTION

The upper thoracic spine is different from the other spinal regions because of the extra stability it provides to the rib-sternum complex. Consequently, a loss of its integrity can diminish that stability. In an experimental study, Watkins et al.[1] demonstrated and quantified this stability.

Isolated fractures of the sternum are considered to be harmless, able to be treated on an outpatient basis. The ribs and the sternum give the thoracic spine a high degree of rigidity. In 1989, Berg[2] described the ribs and sternum as the 4th thoracic spine (supplementing the three spines of Denis), providing greater stability. The sternum can be fractured by either a direct or an indirect mechanism. In turn, the results of direct trauma may be of 2 types: the first occurs in the lower part of the sternum, where it is more flexible and causes an angled fracture at the junction of the manubrium and the body; the second type occurs in the upper part, where it is more rigid, and displacement occurs at the site of the trauma. In both types, the distal fragment is displaced posteriorly and is usually accompanied by fractured ribs and contusions of the intrathoracic organs, which increase morbidity and mortality. (Figure 1) Indirect traumas are produced through a flexion-compression mechanism and it is the proximal fragment that is displaced posteriorly and down, and is usually accompanied by CET and spine fractures, most often of T1 to T6.[3-8] (Figure 2)

Study conducted at the Hospital San Martín de La Plata, Buenos Aires, Argentina.
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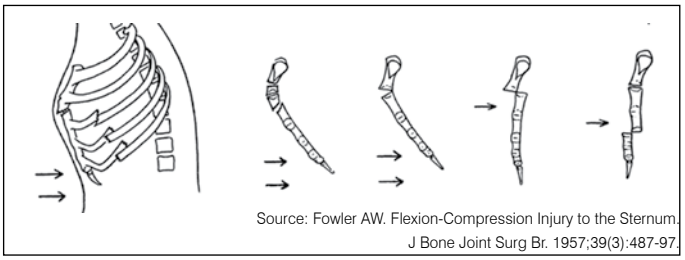
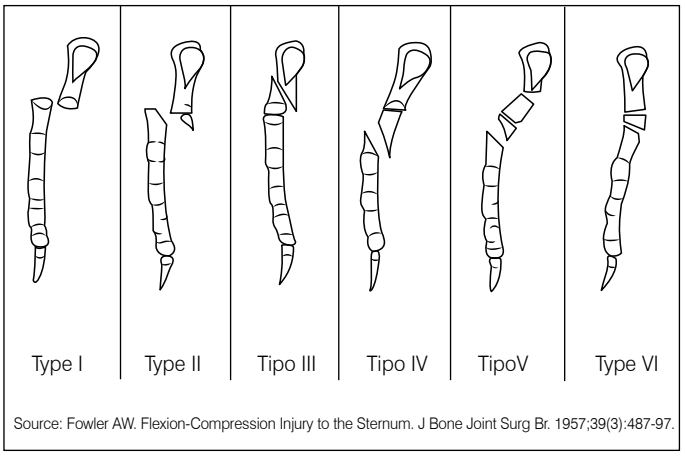
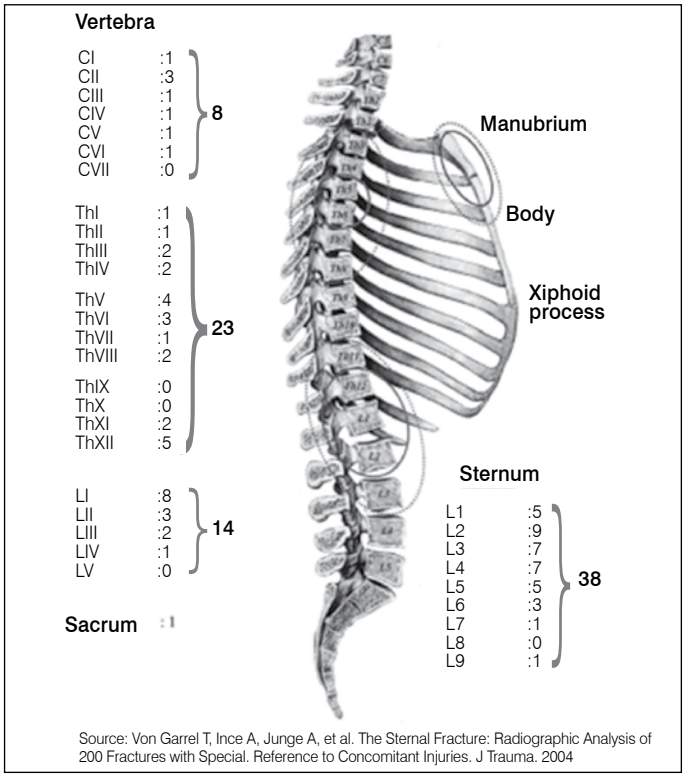

Source: Fowler AW. Flexion-Compression Injury to the Sternum. J Bone Joint Surg Br. 1957;39(3):487-97.

Figure 1. Direct trauma.



Source: Fowler AW. Flexion-Compression Injury to the Sternum. J Bone Joint Surg Br. 1957;39(3):487-97.

Figure 2. Direct trauma.



Source: Von Garrel T, Ince A, Junge A, et al. The Sternal Fracture: Radiographic Analysis of 200 Fractures with Special. Reference to Concomitant Injuries. J Trauma. 2004

Figure 3. Levels of association between fractures of the sternum and the spine.

The association between fractures of the sternum and the spine was first described by Fowler[1] in 1957, and more recently by Park in 1980. Its incidence is still uncertain. This association is normally only accepted for the upper thoracic spine (T1 – T6), but it has now been shown that it can be found at different levels. (Figure 3) This results in severe instability that can lead to neurological damage, chronic pain, or deformity and kyphosis.[7,9]

Fractures of the upper thoracic spine are for the most part mechanically stable, given the rigidity provided by the 4th spine described by Berg[2] and they usually are treated orthopedically. When they are associated with an injury to the rib-sternum complex, the spine is destabilized to the extent that internal fixation (reduction?) is necessary. Otherwise, this could evolve into a greater degree of kyphosis, neurological damage, and chronic pain.

The objectives of this presentation are: A) to analyze the kinematics that cause this association; B) to describe the repercussions of the lesion, and C) to evaluate the treatment performed.

MATERIAL AND METHODS

We conducted a prospective analysis of three cases of patients who presented the association of a fracture of the upper thoracic spine (T1 – T6) with a fracture of the sternum.

We evaluated the angulation of the lesion and the dispersion of the fragments in the sternum fracture, the wedging and displacement on the upper thoracic fracture, the kinematics of the trauma, the neurological profile pre- and post-treatment, and the severity of the injury according to the Injury Severity Score (ISS).

Because it is an observational case presentation, authorization by the Institutional Review Board was not required.

RESULTS

The mechanism that produces the spinal lesion was predominantly flexion distraction, associated with the compromise of the vertebral body by compression, with T5 being the most affected region of the thoracic spine. In all three cases, the mechanism of trauma was an accident on a public road, involving an overturned vehicle (car) in two of them and a motorcycle-automobile collision in the third. Only one of the three patients was compromised neurologically (Frankel A), the two other patients remaining neurologically intact (Frankel E). According to the classification of Fowler et al., two of the three cases of sternum fracture were Direct Trauma injuries and the third was a Type II Indirect Trauma. (Tables 1 and 2)

The associated injuries were evaluated using the ISS and were not serious. (Table 1)

The surgeries were performed between 12 and 30 days following the incidents, averaging 21 days. (Table 1)

In the individual analysis of the sternum fractures, we found that, in both the measurement of the angulation and the displacement of the fragments, the most significant values were seen in the patient whose fracture was caused by Indirect Trauma (patient II). (Table 3)

Analyzing the thoracic spine fractures separately, we noted that the angulations (kyphosis) range from 29° to 11° (average of 20°) with displacement of less than 1.1 cm in all cases. Our analysis of pre- and postoperative complementary studies showed that kyphosis and displacement had suffered little or no significant change, so the ultimate goal of the treatment was not to achieve an anatomical reduction, but rather to perform a stable internal fixation to prevent further progression of the displacement. Posterior

Table 1. Fractures of the sternum.

	Sternum fracture	CL VF	Kinematics of the trauma	FI	FPOP	Time waiting for surgery	Type of surgery performed	ISS
I	Direct Trauma	A.4	Automobile rollover	A	A	30 days	API T2-T7	5
II	Type II Indirect Trauma	A.2	Automobile rollover with seatbelt	E	E	55 days	API T2-T4	4
III	Direct Trauma	A.4	Motorcycle-automobile collision	E	E	12 days	API T4-T7	4

Cl VF: Classification of the vertebral fracture. FI: Initial Frankel. FPOP: Postoperative Frankel. ISS: Injury Severity Score.

Table 2. Associated lesions.

	Associated lesions
I	Lung contusion
II	Fracture of the left clavicle
III	None

Table 3. Angulation and displacement values found.

Patient I	Admission	Preoperative	Postoperative
Angulation	11°	8°	8°
Displacement	6 mm	7 mm	7 mm
Patient II	**Admission**	**Preoperative**	**Postoperative**
Angulation	27°	26°	26°
Displacement	0 mm	10 mm	10 mm
Patient III	**Admission**	**Preoperative**	**Postoperative**
Angulation	10°	10°	10°
Displacement	0 mm	0 mm	0 mm

approach arthrodesis with pedicle screw and rod instrumentation was performed in all cases.

DISCUSSION

Most of the injuries associated with upper thoracic spine and sternum fractures occur in roadway accidents from the use of seatbelts or from being thrown from the vehicle.

The injury to the sternum occurs at or near the manubrium-sternum junction and the second rib always remains attached to the manubrium. The degree of displacement of the sternum has been proposed by several authors as an indicator of intrathoracic lesions. There are three mechanisms that transmit the energy of the trauma and damage the sternum: via the clavicle, caused by forces that pull towards the upper limbs; via the ribs, which play the most important role in the transmission of forces, and via the chin, which is more often associated with cervical injuries. The first two ribs act by moving below and behind the manubrium when the thoracic spine produces a flexion-compression movement, a mechanism first described by Fowler[3] in 1957. The spine injury was described as an associated injury, most often found in the upper thoracic spine, and the fracture line most often encountered is wedging.

The incidence of these associated fractures remains uncertain (some authors speak in terms of 1.4%),[5] although over the past several decades an increase from the greater use of seatbelts has been observed. Andrews and McAfee[6] classified the sternum fracture as "the seatbelt syndrome" and described it as "the price of survival". In a study of 250 cadavers, only 13 had fractured the sternum, of which only 3 had associated spinal injuries.

This association of fractures is a diagnostic challenge given their low frequency. They often go unnoticed given the generally poor quality of X-rays of the upper thoracic spine. The gold standard for diagnosis was the chest X-ray (P), even above the CT scan. Currently, 3D reconstruction has surpassed the X-ray study.[3-12]

Watkins et al.[1] (2005), in a study of cadavers (10 trunks with intact rib cages), performed a multidirectional flexibility test. Their goal was to quantify the degree of stability that the rib cage (ribs and sternum) provides to the upper thoracic spine. The results are shown in Table 4.

Horton et al.[13] (2005) carried out three biomechanical experiments on the trunks of 18 cadavers to investigate the effects on the range of sagittal movement by removing structures that are critical to spinal movement. They concluded that radical discectomy provides the greatest increase in the range of movement and that a sternum fracture, with costosternal release, further increases the extension and leading to correction of the kyphosis.

In our study, we evaluated patients with the McCormak scale,[14] obtaining scores higher than 6 points in all three patients, which indicates the need to also provide anterior support for the stability of the fixation, however because of the comorbidities that this type of access to the thoracic spine implies, and even more so in polytraumatized patients, we decided to perform only the posterior approach surgery and this type of fixation has been sufficient to maintain the stability of the arthrodesis in follow-up from the time of the surgery up until the writing of this paper. (Table 5)

Table 4. Watkins et al. (2005) Flexibility values.

	Sternum and ribs	Sternum
Flexion	20.7%	11.2%
Rotation	31.4%	13.4%
Lateral Inclination	35.4%	17.8%

Table 5. Fracture of the upper thoracic spine.

Patient I	Initial	Preoperative	Postoperative
Degree of Kyphosis	29°	29°	26°
Displacement	0.9 cm	1.1 cm	1.1 cm
McCormak	9	9	7
Patient II	**Initial**	**Preoperative**	**Postoperative**
Degree of Kyphosis	5°	10°	10°
Displacement	0 cm	0 cm	0 cm
McCormak	6	6	5
Patient III	**Initial**	**Preoperative**	**Postoperative**
Degree of Kyphosis	10°	10°	10°
Displacement	0 cm	0 cm	0 cm
McCormak	7	7	7

CONCLUSION

The association of these injuries (fractures of the sternum and the thoracic spine) was seen in patients who had suffered high-energy trauma during an automobile accident.

In our analysis of the results obtained for our case series, we did not find a relationship between the angulation of the sternum and its displacement and the degree of kyphosis or displacement in the thoracic spine.

We point out that the sternum, despite being injured, did not suffer great variations of angulation or displacement after those resulting from the initial trauma, and we can relate this to the stability of the undamaged rib cage. For this reason, we can say that surgical stabilization of the sternum was not required when posterior access spine stabilization was performed.

Finally, we note the importance of the evolution of the sternum through complementary studies (X-ray and CT) in patients with a diagnosis or suspected diagnosis of a fracture of the thoracic spine. Moreover do not forget that, in patients with a fracture of the manubrium of the sternum, an investigation of the spine should always be conducted.

All the authors declare that there are no conflicts of interest regarding this article.

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