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The unstable thoracic cage injury: The concomitant sternal fracture indicates a severe thoracic spine fracture

Mario Morgenstern, M.D.[a,b,c,*], Christian von Rüden[a,c], Hauke Callsen[a], Jan Friederichs[a], Sven Hungerer[a,c], Volker Bühren[a], Alexander Woltmann[a], Christian Hierholzer[d]

[a] Department of Trauma Surgery, Trauma Center Murnau, Murnau, Germany
[b] Department of Orthopaedic Surgery and Traumatology, University Hospital Basel, Switzerland
[c] Institute of Biomechanics, Paracelsus Medical University Salzburg, Austria
[d] Department of Trauma Surgery, University Hospital Zürich, Switzerland

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ABSTRACT

Introduction: The thoracic cage is an anatomical entity composed of the upper thoracic spine, the ribs and the sternum. The aims of this study were primarily to analyse the combined injury pattern of thoracic cage injuries and secondarily to evaluate associated injuries, trauma mechanism, and clinical outcome. We hypothesized that the sternal fracture is frequently associated with an unstable fracture of the thoracic spine and that it may be an indicator for unstable thoracic cage injuries.
Patients and methods: Inclusion criteria for the study were (a) sternal fracture and concomitant thoracic spine fracture, (b) ISS $\geq$ 16, (c) age under 50 years, (d) presence of a whole body computed-tomography performed at admission of the patient to the hospital. Inclusion criteria for the control group were as follows: (a) thoracic spine fracture without concomitant sternal fracture, (b)–(d) same as study cohort.
Results: In a 10-year-period, 64 patients treated with a thoracic cage injury met inclusion criteria. 122 patients were included into the control cohort. In patients with a concomitant sternal fracture, a highly unstable fracture (AO/OTA type B or C) of the thoracic spine was detected in 62.5% and therefore, it was significantly more frequent compared to the control group (36.1%). If in patients with a thoracic cage injury sternal fracture and T1–T12 fracture were located in the same segment, a rotationally unstable type C fracture was observed more frequently. The displacement of the sternal fracture did not influence the severity of the concomitant T1–T12 fracture.
Conclusions: The concomitant sternal fracture is an indicator for an unstable burst fracture, type B or C fracture of the thoracic spine, which requires surgical stabilization. If sternal and thoracic spine fractures are located in the same segment, a highly rotationally unstable type C fracture has to be expected.
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Introduction

The thoracic cage is an anatomical entity composed of the upper thoracic spine, the ribs and the sternum [1]. Sternal fractures are rare injuries often associated with thoracic trauma including lung contusion and rib fractures followed by spinal fractures [2–4]. The most common mechanism of injury is a high deceleration trauma caused by motor vehicle collision. In addition to bowel injuries and spinal fractures, sternal fractures are considered seat belt-associated injuries [5–7]. Recent research showed that among the most frequent injury patterns in polytraumatized patients, combined lesions of chest and spinal cord were observed [8,9]. Previous studies stated that sternal fractures can be regarded as an indicator for thoracic spine (T1-T12) fractures and described the combined injury pattern of thoracic spine fracture and sternal fracture as “upper thoracic cage injury” [1,10]. To our best knowledge literature is lacking data that in patients with a thoracic cage injury a highly unstable thoracic spine fracture can be expected.

The aims of this study were primarily to analyse the injury pattern of thoracic cage injuries and secondarily to evaluate associated injuries, trauma mechanism, and clinical course.

The following hypotheses were tested:

(I) The concomitant sternal fracture is an indicator for an unstable T1–T12 fracture: In patients with a thoracic cage injury, more frequently an unstable T1–T12 fracture is

* Corresponding author at: Department of Orthopaedic Surgery and Traumatology, University Hospital Basel, Spitalstr. 21, 4031 Basel, Switzerland.
E-mail address: morgenstern.mario@gmail.com (M. Morgenstern).

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observed compared to patients who suffered a thoracic spine fracture without an associated sternal fracture.

(II) The displacement of the sternal fracture is an indicator for a more unstable and severe T1–T12 fracture in patients with a thoracic cage injury.

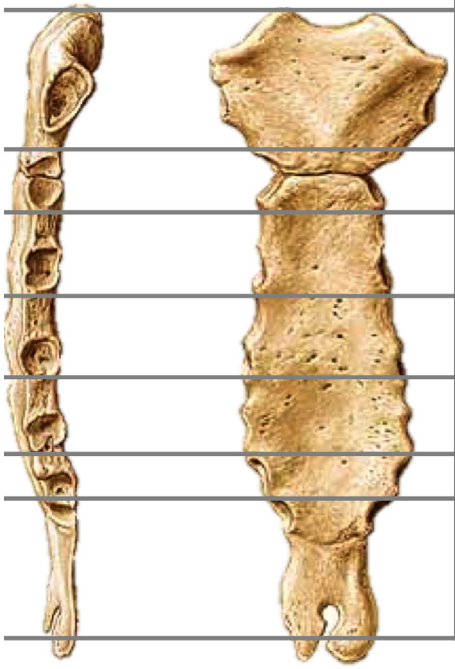
(III) A translational unstable type C fracture can be diagnosed more frequently if the sternal and T1–T12 fracture are located in the same segment, compared to cases in which the sternal and T1–T12 fracture are located in different segments.

Patients and methods

In the period between 2003 and 2012, in a Level-I Trauma Centre a large series of patients with the combined injury pattern of sternal fracture and concomitant thoracic spine fracture was analysed. Inclusion criteria for the study were: (a) sternal fracture and concomitant thoracic spine fracture, (b) Injury Severity Score (ISS) $\geq$ 16, (c) age under 50 years, (d) presence of a whole body computed-tomography (CT-scan) performed at admission of the patient to the hospital. The inclusion criteria for the control group were: (a) Thoracic spine fracture without concomitant sternal fracture, (b)–(d) same as study cohort (see above). By excluding patients aged 50 and more the authors intended to exclude osteoporotic compression fractures in the cohort groups and therefore to obtain a consistent patient collective. The patient data were analysed for the following parameters: Demographic data, mechanism of injury, polytraumatization with corresponding ISS, duration of mechanical ventilation therapy, surgical treatment, and survival. Associated injuries were documented especially with focus on thoracic trauma fractures around the shoulder girdle, and spinal cord injuries. Spinal cord injuries were documented and graded according to the American Spinal Injury Association (ASIA) Impairment Scale (AIS) [11]. Cases with incomplete documentation, incomplete radiographic findings and missing data were excluded from the study.

The analysis of CT-scans was performed by at least three independent investigators including a radiologist, the treating trauma surgeon and one of the authors of the study to detect and grade the extent of the thoracic cage injury and concomitant injury patterns. In case of disagreement on the classification, these cases were discussed until agreement was reached. The investigators analysed injury morphology by screening the CT-scans for existence of the following injury patterns: Displacement or dislocation, integrity of the posterior ligamentous complex (PLC), morphology of vertebral body fracture [12–14]. Based on these the thoracic spine fractures were classified according to the AO/OTA classification by Magerl et al. [14] and the thoracolumbar injury classification and severity score (TLICS) [12]. Burst fractures (AO/OTA type A3 and A4) fractures are unstable fractures. Injuries of the PLC (AO/OTA type B) and displaced fractures (AO/OTA type C) are considered as highly unstable injuries. In addition to the above mentioned injury characteristics the TLICS scoring is based on patients' neurologic status. The affected levels were documented and in case of multi-segmental thoracic spine fractures the fracture with the highest degree of instability (due to AO/OTA classification [13,14]) was selected for statistical analysis.

Sternal fracture was diagnosed when cortical disruption was detected with or without displacement. For the topographic analysis we divided the sternum according to the costo-sternal articulations in seven zones, whereas the manubrium sterni is represented by zone I, respectively the sternal angle (synchondrosis manubriosternalis) by zone II, and the corpus sterni including xiphoid process by zone III–VII (Fig. 1) [15]. Fracture displacement



Level	Number (% of all 72 sternal fractures)
I	18 (25.0)
II	28 (38.9)
III	14 (19.4)
IV	8 (11.1)
V	2 (2.8)
VI	1 (1.4)
VII	1 (1.4)

Fig. 1. Topographic division of the sternum into seven zones, from proximally to distally: I. Manubrium sterni; II. Sternal angle; III–VII. Corpus sterni: division in zones according to articulation with corresponding ribs. Right column: affected zone and prevalence of all 72 sternal fractures in 64 patients with thoracic cage injury (eight patients with two sternal fractures).
(From: Putz R, Papst R. Sobotta, Atlas der Anatomie des Menschen Band 2. München: Urban & Fischer; 2000).

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