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Associated thoracic injury in patients with a clavicle fracture: a retrospective analysis of 1461 polytrauma patients

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Abstract

Purpose During primary survey the main goal is to ascertain life-threatening injuries. A chest X-ray is recommended in all polytrauma patients as thoracic injury plays an important role in mortality. However, treatment-dictating injuries are often missed on the chest X-ray. In contrast, clavicle fractures should be relatively easy to diagnose on a chest X-ray. We previously showed that clavicle fractures occur in approximately 10 % of all polytrauma patients in our population. The aim was to compare polytrauma patients, with and without a clavicle fracture, to investigate if a clavicle fracture is associated with concomitant thoracic injury.

Methods A retrospective cohort study of polytrauma patients (ISS $\geq$ 16) from 2007 until 2011. Thoracic injuries were defined as: ribfracture, pneumothorax, lung contusion, sternum fracture, hemothorax, myocardial contusion, thoracic aorta injury and thoracic spine injury.

Results Of 1461 polytrauma patients in 160 patients a clavicle fracture was diagnosed, and 95 % was diagnosed on chest X-ray. Patients with a clavicle fracture had a higher mean Injury Severity Score (ISS) (29.2 $\pm$ 10.1 vs. 24.9 $\pm$ 9.1; $P < 0.001$). Additional thoracic injuries were more prevalent in patients with a clavicle fracture (76 vs. 47 %; OR 3.6; 95 % CI 2.45–5.24) and they had a higher rate of thoracic injury with an AIS $\geq$ 3 (66 vs. 41 %; OR 2.8; 95 % CI 1.97–3.93).

Conclusions The clavicle can be seen as the gatekeeper of the thorax. In polytrauma patients, a clavicle fracture is easily diagnosed during primary survey and may indicate underlying thoracic injury, as the rate and extent of concomitant thoracic injury are high.

Keywords Clavicle fracture · Polytrauma patient · Primary care · Thoracic injury · Associated injury

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Introduction

According to ATLS principles, the main purpose of the primary survey is to ascertain life-threatening injuries. Guidelines recommend that all polytrauma patients should undergo a chest X-ray as an adjunct to the primary survey [1]. Thoracic injuries play an important role in mortality of trauma patients, resulting in 20 % of all trauma deaths [2, 3].

Presence of thoracic injury is also an important risk factor for ICU admittance and may influence the choice of further surgical treatment [4–6]. However, treatment-dictating thoracic injuries such as pneumothorax, rib fractures, sternum fractures and lung contusion are often missed on the primary chest X-ray [7–9]. In contrast, clavicle fractures should be relatively easy to diagnose on a chest X-ray.

Our study group previously showed that clavicle fractures occur in approximately 10 % of all polytrauma patients treated at our level one trauma center. Concomitant thoracic injuries occurred in the majority of polytrauma patients with a clavicle fracture (77 %) [10]. Therefore, clavicle fractures may be used to raise awareness for concomitant thoracic injuries.

The aim of this study was to compare polytrauma patients with and without a clavicle fracture diagnosed on the initial chest X-ray in order to investigate if a clavicle fracture is associated with thoracic injury.

Methods

We conducted a retrospective cohort study of trauma patients admitted to our level I trauma center from January 2007 through until December 2011. Patients with an Injury Severity Score(ISS) $\geq$ 16 as a result of blunt trauma were included in this study. Injury after explosion was considered blunt trauma. Exclusion criteria were patients with penetrating injury, submersion, patients aged $\leq$15, and patients who were dead upon arrival. Patients with and without a clavicle fracture were compared.

Data were collected from the Dutch National Trauma Database (DNTD) for the area Central Netherlands. This database contains patient demographics, description of the traumatic event, primary survey findings, initial treatment, and all injuries diagnosed during initial trauma care, subsequent surgery, or during admission.

Chest X-ray imaging was performed in most trauma patients during primary survey. All chest X-rays were performed in anterior-posterior direction in the critical care bay with the patient in supine position. Computed tomography (CT) scan and ultrasound were performed when indicated. Indications for thoracic CT scan included: (1) tenderness on palpation of the thorax, (2) signs of thoracic trauma (e.g., hematoma or excoriation), (3) altered mental status or intoxication, (4) thoracic injury on chest X-ray, (5) high energy trauma. A radiologic resident, a surgical resident, and a trauma surgeon evaluated the imaging studies. All radiological findings were prospectively recorded. If the surgical electronic patient documentation (EPD) or the radiology report did not include the clavicle fracture, it was reported as a missed diagnosis.

All diagnosed injuries were allocated to one of six body regions and coded using Abbreviated Injury Scale (AIS) location codes. The ISS ranges from 0, no injury, to 75, injury resulting in death [11]. The AIS codes of all injuries were used to calculate the ISS to quantify the severity of injury in trauma patients [12]. Patients with a clavicle fracture were selected using the AIS location code 752200.2. Injuries with an AIS $\geq$ 3 were considered serious injuries.

Thoracic injuries included rib fracture, pneumothorax, lung contusion, sternum fracture, hemothorax, myocardial contusion, thoracic aorta injury (dissection or rupture), and thoracic spine injury.

Interventions performed within 24 h of admission were also recorded, which included intubation, chest tube insertion, invasive hemodynamic and pulmonary monitoring on a medium or intensive care unit, thoracic surgery, and epidural analgesia.

Parametric data were reported as means with standard deviation (SD), and non-parametric data were reported as medians with corresponding interquartile range (IQR). To compare proportions, Chi square contingency tables were used when expected frequencies were equal to or greater than five, and Fisher's exact test was performed when expected frequencies were less than five. The independent sample t test was used for parametric continuous variables, and the Mann–Whitney U test was used for non-parametric continuous variables. Odds ratios (OR) were calculated with binary logistic regression analysis and were adjusted for age and ISS. A two-sided p value of <0.05 was considered statistically significant. Data were analyzed with SPSS Version 20.0, (IBM Corp., Armonk, NY) for Windows.

Results

A total of 5357 trauma patients were admitted to the Emergency Room from January 2007 through December 2011. Fifteen patients were found dead upon arrival. A total of 1,461 patients (27.3 %) had an ISS $\geq$ 16 due to blunt trauma and were included in this analysis. A clavicle fracture was diagnosed in 160 patients (11 %). Of these clavicle fractures 95 % were diagnosed by the chest X-ray during the primary survey and the remaining fractures were diagnosed by CT scan. Of the fractures diagnosed at the CT scan, seven fractures were insufficiently visualized on chest X-ray as the entire clavicle was not shown and the remaining fracture was an undisplaced midshaft fracture. All clavicle fractures were included in this analysis.

A thoracic CT scan was performed in 81.2 % of the patients with a clavicle fracture and in 60.5 % of the patients without a clavicle fracture (P < 0.0001). 98.1 % of the patients with a clavicle fracture and 90.5 % of the patients without a clavicle fracture received either chest X-ray or thoracic CT scan. No chest imaging was performed in patients who died at the emergency department or neurotrauma patients who were transferred to our hospital with previous imaging of the head.

There was a significant difference in mean ISS between the patients with a clavicle fracture (29.2 $\pm$ SD 10.1) and patients without a clavicle fracture (24.9 $\pm$ SD 9.1; P < 0.001) (Table 1).

Table 1 Baseline characteristics of the study population

Characteristics	Clavicle fracture ($n = 160$)	No clavicle fracture ($n = 1301$)	P value
Age overall (years)	47.5 (±20.9)	49.2 (±21.6)	0.343
Gender (M/F)	107/53	915/386	0.368
Mechanism			
Motor vehicle accident	70 (43.8 %)	414 (31.8 %)	
Bicycle accident	29 (18.1%)	229 (17.6%)	
Pedestrian accident	8 (5.0 %)	54 (4.2 %)	
Fall >3 m	17 (10.6 %)	120 (9.2 %)	
Fall <3 m	33 (20.6 %)	360 (27.7 %)	
Other	3 (1.9 %)	124 (9.5 %)	
ISS	29.2 (±10.1)	24.9 (± 9.1)	<0.001
Admission at intensive care unit (n)	63 (39.4 %)	446 (34.3 %)	0.202
Admission at medium care unit	40 (25.0 %)	323 (24.8 %)	0.962
Direct transport to operating room	22 (13.8 %)	161 (12.4 %)	0.620
Hospital-LOS (days)	21.5 (IQR 5–30)	16.5 (IQR 3–21)	0.066
Mortality (n)			
At emergency room	2 (1.3 %)	17 (1.3 %)	0.952
Within <24 h	16 (10.0 %)	91 (7.0 %)	0.169
During admission	17 (10.6 %)	123 (9.5 %)	0.658
Total	35 (21.9 %)	231 (17.8 %)	0.203

Mean noted with ± , standard deviation; Median noted with IQR

n number of patients, *ISS* Injury of Severity Score, *LOS* length of stay, *IQR* inter quartile range

Table 2 Prevalence of thoracic injuries

Thoracic injuries	Clavicle fracture n (%)	No clavicle fracture n (%)	P value	OR (95 % CI)
Thorax overall	122 (76.2)	615 (47.3)	<0.001	3.6 (2.45–5.24)
Rib fracture	97 (60.6)	378 (29.1)	<0.001	3.8 (2.68–5.28)
Pneumothorax	62 (38.8)	260 (20.0)	<0.001	2.5 (1.80–3.58)
Lung contusion	60 (37.5)	289 (22.2)	<0.001	2.1 (1.49–2.97)
Sternum fracture	20 (12.5)	55 (4.2)	<0.001	3.2 (1.89–5.56)
Hemothorax	8 (5.0)	50 (3.8)	0.479	1.3 (0.61–2.83)
Myocardial contusion	3 (1.9)	6 (0.5)	0.066	4.1 (1.02–16.65)
Thoracic aorta injury	3 (1.9)	8 (0.6)	0.110	3.0 (0.81–11.76)
Thoracic spine injury	44 (27.5)	193 (14.8)	<0.001	2.2 (1.49–3.18)

n number of patients, *OR* odds ratio. 95 %, *CI* 95 % confidence interval

Additional injuries to the thorax were significantly more prevalent in polytrauma patients with a clavicle fracture than in patients without a clavicle fracture in this study population (76 vs. 47 %; OR 3.6; 95 % CI 2.45–5.24) (Table 2). Specific injuries like rib fractures ($n = 97$; 61 %), pneumothorax ($n = 62$; 39 %), lung contusion ($n = 60$; 38 %) and sternal fracture ($n = 20$; 13 %) were more frequently diagnosed in polytrauma patients with a clavicle fracture. 65.6 % ($n = 105$) of patients with a clavicle fracture sustained a thoracic injury with an AIS $\geq$ 3 compared to 40.0 % ($n = 521$) in patients without a clavicle fracture (OR 2.9; 95 % CI 2.03–4.03). Thoracic spine injury was also more common in patients

with a clavicle fracture ($n = 44$, OR 2.2; 95 % CI 1.49–3.18). Of these, three patients had spinal fractures with neurologic deficit, and one patient had only ligamentous injury.

When a clavicle fracture was diagnosed on the initial chest X-ray, 86 % of the patients underwent intervention for their thoracic injury within the first 24 h of admission. 45 % ($n = 72$) of patients were intubated during trauma care, 26 % ($n = 41$) underwent emergency surgery, 29 % ($n = 46$) had a chest tube placed, and 9 % ($n = 14$) required epidural analgesia. 14 % of patients ($n = 22$) had no intervention and were admitted to the surgical ward for non-invasive hemodynamic and respiratory monitoring.

Discussion

Clavicle fractures in polytrauma patients were associated with treatment-dictating thoracic injuries. In our studied population the majority of the clavicle fractures (95 %) were diagnosed on a chest X-ray during the primary survey. Therefore, the presence of a clavicle fracture may indicate underlying thoracic injuries in polytrauma patients during initial trauma care.

Blunt thoracic trauma is associated with a high rate of mortality [3, 4, 6]. Early detection of sustained injuries, administration of optimal treatment (e.g., chest tube, intubation, fluid administration), and transportation to a center with appropriate resources are essential to achieve the best chance of survival. Moreover, delay in treatment increases the risk of developing acute respiratory distress syndrome (ARDS), which may lead to severe complications such as respiratory failure, long-term morbidity, and higher mortality rates [13, 14].

The results of this study correspond with the results of a study recently performed by Horst et al. [15]. They investigated if a clavicle fracture was associated with injuries of the neck, thorax or upper extremity. In their study, the incidence of clavicle fractures in polytrauma patients was 10.3 %, and there was a higher prevalence of additional thoracic injuries in polytrauma patients with a clavicle fracture. There was also a higher incidence of thoracic injuries with an AIS ≥ 3 in patients with a clavicle fracture. They mainly emphasize that using a clavicle fracture to detect additional injuries can be of value in the secondary and tertiary survey. However, we believe that the greatest potential benefit could be gleaned from primary survey detection of a clavicle fracture by identifying treatment-dictating thoracic injuries.

Gottschalk et al. investigated the relationship between shoulder girdle injuries and concurrent thoracic, head, and great vessel injuries in almost 53,000 trauma patients [16]. In contrast to our findings, their results did not show an increased risk of thoracic injuries in patients with a shoulder girdle injury. This discrepancy may be explained by the broad range of diagnoses included in shoulder girdle injuries. In addition, their relatively large study population consisted of all types of trauma patients, whereas the present study only included polytrauma patients. This is reflected by the lower reported ISS of 17.8 compared to an ISS of 25–28 in the present study.

The additional value of the early thoracic CT scan to the routine chest X ray is unassailable; however, the number of unnecessary CT scans must be minimized due to the risks involved [17]. Additional injuries found on a CT scan vary from 30 to 65 percent [7–9, 18, 19]. The effect on changes in treatment after additional diagnoses by CT scan can be as high as 63 % [18]. In our study population, a thoracic CT scan was performed in 81.2 % of the patients with a clavicle fracture and in 60.5 % of the patients without a clavicle fracture. This difference shows that with our current thoracic CT criteria, in patient with a clavicle fracture a thoracic CT scan was more often indicated. 66 % of patients with a clavicle fracture sustained thoracic injury resulting in an AIS ≥ 3, which indicates serious injury. The number of patients without a clavicle fracture with an AIS ≥ 3 was much lower (41 %). This indicates that thoracic injuries were more severe in polytrauma patients with a clavicle fracture. A decision instrument called the Nexus chest criteria has been developed by Rodriguez et al. to identify patients at risk for thoracic injury and patients who should undergo thoracic CT scan [20]. The Nexus chest criteria are: (1) older than 60 years, (2) rapid deceleration mechanism, (3) chest pain, (4) intoxication, (5) abnormal alertness/mental status, (6) distracting painful injury and (7) tenderness to chest wall palpation. These criteria show a good sensitivity but a low specificity. The clavicle fracture might provide additional value to these existing criteria.

Strengths of this study include the homogeneity and the size of the prospectively collected database. All patients were admitted in the same level one trauma center, and two database managers and one of the trauma surgeons constantly evaluated the accuracy of the database. Limitations of this study include its retrospective design and the retrospectively calculated extend of injury (ISS). Results of this study implicate that a prospective study should be performed in which all patients with a clavicle fracture are evaluated upon presentation to the emergency room.

In patients with a clavicle fracture, it is important to investigate physical exam findings and mechanism of injury to corroborate suspected thoracic trauma. The high rate of concomitant thoracic injury indicates the importance of detecting a clavicle fracture in the primary survey in order to optimize treatment.

Conclusion

The clavicle can be seen as the gatekeeper of the thorax. In polytrauma patients, a clavicle fracture is easily diagnosed during primary survey and may indicate underlying thoracic injury, as the rate and extent of concomitant thoracic injury are high.

This research was performed according to local protocol of the IRB medical ethical standards. Which does not involve informed consent for encoded patient data. Therefore approval by an ethics committee was not applicable.

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