ELSEVIER

European Journal of Cardio-thoracic Surgery 26 (2004) 373–376

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Management of 150 flail chest injuries: analysis of risk factors affecting outcome☆

Kalliopi Athanassiadi*, Michalis Gerazounis, Nikolaos Theakos

Department of Thoracic Surgery, General Hospital of Nikea-Piraeus, Hellas, Athens, Greece

Received 13 December 2003; received in revised form 7 April 2004; accepted 13 April 2004; Available online 18 May 2004

Abstract

Objective: Flail chest continues to be an important injury with significant complications. The records of 150 patients presenting with flail chest injury were reviewed to determine risk factors affecting morbidity and mortality. **Material and method**: During a 7-year period 150 patients with a flail chest injury were admitted to our trauma center. There were 111 men (74%) and 39 women (26%) ranging in age from 18 to 88 years with a mean age of 56.9. Only 66 (44%) had an isolated flail chest injury on admission. The majority of patients were older than 55 years ($n = 89$, 59.3%), 80 (53.3%) presented with an hemo-, or/and pneumothorax, 36 (24%) sustained a head injury and 25 (16.7%) needed ICU monitoring. The mean ISS score was 38. Age, concomitant diseases, presence of pneumothorax and/or hemothorax, Severity Score (ISS), the need for mechanical support, length of stay and deaths were evaluated by using the *t*-test and χ^2 test where appropriate. **Results**: Sixty-seven patients (44.6%) were conservatively treated, while 80 (53.3%) needed thoracic drainage. Only in 6 cases (4%) thoracotomy was required, while in 9 (6%) laparotomy was performed. Mortality rate reached 5.3%. The main factors correlated with an adverse outcome were: ISS and the presence of associated injuries, while age, hemopneumothorax and mechanical support affected the length of hospitalization but not the mortality. **Conclusions**: (1) Age and hemopneumothorax did not affect mortality. (2) ISS was found to a strong predictor on outcome concerning morbidity and prolonged hospitalization but did not influence mortality rate. (3) Mechanical support was not considered a necessity for the treatment of flail chest.

Keywords: Flail chest; Rib fracture; Blunt chest trauma

1. Introduction

Thoracic injury is the cause of death in approximately one quarter of all trauma victims and influences the morbidity encountered in multiply injured patients [1–4]. Approximately one out of 13 patients with fractured ribs admitted to a hospital will have flail chest with reported mortality rates averaging 10–20% [5,6]. Although there have been many advances in the management of major chest injuries, flail chest continues to be an important injury with significant complications because the paradoxical chest movement causes a decrease in the vital capacity and ineffective ventilation resulting in pulmonary insufficiency [1,5,6].

In the present retrospective study the records of 150 patients presenting with flail chest injury were reviewed to determine risk factors affecting morbidity and mortality and to assess treatment strategies.

2. Material and method

During a 7-year period 150 patients with a flail chest injury were admitted at the department of Thoracic Surgery of General Hospital of Nikea—Piraeus which is a Level I trauma center and a teaching hospital. There were 111 men (74%) and 39 women (26%) ranging in age from 18 to 88 years with a mean age of 56.9. The majority of patients were older than 55 years ($n = 89$, 59.3%). Traffic accident was the leading cause of trauma in the majority of cases. The records of all patients were reviewed and data were collected on patients' age and gender, extent of chest wall injury, presence of pneumothorax and/or hemothorax

☆ Presented at the joint 17th Annual Meeting of the European Association or Cardio-thoracic Surgery and the 11th Annual Meeting of the European Society of Thoracic Surgeons, Vienna, Austria, October 12–15, 2003.

* Corresponding author. Address: Konstantinoupoleos Str., 34A, 15562 Holargas, Athens, Greece. Tel.: + 30-210-6510-388; fax: + 30-210-6547-695.

E-mail address: kallatha@otenet.gr (K. Athanassiadi).

1010-7940/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.ejcts.2004.04.011

requiring chest tubes, types of associated injuries, concomitant diseases, Injury Severity Score (ISS), the need for mechanical support, length of stay and deaths.

Chest pain and dyspnea were the most common symptoms, whereas sensitivity over the chest wall and bone crepitation were the most common findings at presentation. The anamnesis revealed concomitant chronic diseases in 17.3% of hospitalized patients ($n = 26$). Flail chest was diagnosed clinically by evidence of paradoxical motion of a portion of the chest wall on physical examination. This was confirmed by chest radiogram where 3 or more segmental rib fractures were identified. The number of ribs broken in each patient ranged between 3 and 8. CT scan was conducted in order to diagnose pulmonary contusions or to exclude rupture of a great vessel.

The classification was done according to the ISS, which is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury allocated to one of six body regions was assigned an Abbreviated Injury scale (AIS) score and the 3 most severely injured body regions have their score squared and added to produce the ISS score [7]. The mean ISS score was 38.

Pulmonary complications such as pneumothorax, hemothorax or hemo-pneumothorax, subcutaneous emphysema and sternal fracture were noted in 119 patients (79.3%), while 36 (24%) sustained head injury (Table 1).

Atelectasis or contusion was developed in 74 patients (49.3%). Twenty-five patients (16.7%) were hospitalized in the Intensive Care Unit (ICU), while 21 of them (14%) developed acute respiratory insufficiency with hypoxemia or hypercapnia ($PO2 < 60$ mmHg, $PCO2 > 45$ mmHg) or suffered from head injury and required intermittent positive-pressure ventilation. The average number of days on the ventilator was 9.6. The rest stayed in the ward and was followed with vital signs, complete blood count and chest X-ray daily. In 25 cases an early tracheostomy (after the 3rd day of hospitalization) in order to facilitate the drainage of bronchial secretions. Fluid administration was carefully managed since it was assumed that everyone had a mild contusion, even if it was not apparent on the first CT scan.

For the management of pain due to fractures, narcotic and non-narcotic analgesics and intercostal nerve block were utilized. Nasotracheal aspiration and fiberoptic bronchoscopy turned to be very helpful to clear secretions. The frequency of the nasotracheal aspiration and bronchial toilet depended on the cooperation of a patient to cough always assisted by the physiotherapists and was used 2–4 times per day.

Operative fixation was performed only in 3 patients among the 6 submitted to thoracotomy due to continuous bleeding.

3. Results

Patients were divided into 2 groups based on the type of associated injuries present. Group A consisted of 66 patients (44%) with an isolated flail chest ($ISS < 20$), while Group B included the rest of cases ($n = 84$, 56%) with extrathoracic fractures or injuries to the brain, to thoracic or abdominal organs requiring thoracotomy and/or laparotomy ($ISS: > 20$) (Table 1).

Sixty-seven patients (44.6%) were conservatively treated, while 80 (53.3%) needed thoracic drainage. The presence of pneumothorax, hemothorax or hemopneumothorax was equal in the 2 groups. Nine patients (6%) required emergency laparotomy, only 6 (4%) were submitted to thoracotomy due to intrathoracic bleeding and synchronous operative stabilization of the chest wall was performed in 3 of them due to cosmetic reasons.

Four patients died within 24 h upon admission, 2 due to serious head injury, one due to intrathoracic bleeding caused by aortic rupture and finally, one due to massive abdominal bleeding caused by hepatic rupture. These four patients were excluded when attempting to determine which factors were associated with a later adverse outcome.

Eight patients died due to pulmonary embolism, myocardial infarction or septic shock at least 11 days after admission. Two of them belonged to Group A and 6 to Group B, while only 3 of them sustained head injury and one was hospitalized in the Intensive Care Unit. Mean hospitalization period was 11.2 days (range 4–21days) and mortality rate reached 5.4%.

In a follow up of 12–38 months no rib dislocation was noted and no death was attributed directly to the sustained chest injury.

Table 1
Associated injuries including pulmonary and vascular complications

Injuries	*N*	%
Associated injuries		
Head injury	36	24
Extremity injuries	38	25.3
Scapula fracture	16	10.6
Abdominal hemorrhage	9	6
Spinal injury	8	5.3
Thoracic cage injuries		
Rib fractures left	57	38
Rib fractures right	51	34
Bilateral rib fractures	42	28
Right hemo- or/and pneumothorax	38	25.3
Left hemo- or/and pneumothorax	35	23.3
Bilateral hemo- or/and pneumothorax	9	6
Subcutaneous emphysema	25	16.7
Sternal fracture	12	8
Thoracic aorta rupture	1	0.7

Concomitant diseases: 26–10.4%.

3.1. Statistical analysis

Statistical analysis was performed for comparison of means by using the Student's *t*-test, whereas, for ratios' comparison the χ^2 test. A *P*-value less than 0.05 was considered significant.

No statistical significance was found comparing the mortality rates of the 2 groups ($P > 0.05$). The main factors strongly correlated with an adverse outcome and higher morbidity were: ISS > 20 and the presence of associated injuries. Conversely, age, hemopneumothorax and mechanical support affected the length of hospitalization and the morbidity, but had no demonstrable impact on mortality.

4. Comments

Decelerational thoracic injuries occur when an individual is moving forward and stops suddenly striking some part of the thorax against an obstacle that is either immobile or moving at a much lower velocity [8]. Flail chest is included to the major, often life-threatening decelerational injuries along with aortic disruption, tracheobronchial disruption and sternal fracture serving as a marker of significant intrathoracic injury [6,9]. It is generally agreed that the most common cause is traffic accidents [7].

In the elderly even low energy traumas can cause flail chest due to the fragility of bones, whereas, in the children only 1% of serious impacts result in paradoxical chest motion since their ribs are more flexible [10]. Ziegler et al. [11] reported that in this category of patients, mortality increases though the ISS was lower compared to younger people. Although the authors support the idea that elderly people should be followed closer since they usually have more concomitant diseases, they could not prove that age is an important determinant in mortality.

Pulmonary complications due to flail chest include pneumothorax, hemothorax, pulmonary contusion, pneumonia and atelectasis [4,6,9]. Although the incidence of hemo- or/and pneumothorax is often mentioned its effects on outcome are seldom noted. The rate in our series was 54.6% similar to that described by other authors [4,6,9,11,12] and it did definitely not increase mortality. Atelectasis along with mild contusion (involving one segment only) was present in half of our cases. Like Johnson et al. [13], we did not find any increase in mortality in patients with flail chest and concomitant mild contusion. Concerning ARDS and pneumonia, both complications may occur following flail chest [4] but actually they are common in all polytrauma patients with prolonged ventilation, which was not the case in our series. Finally, it is widely accepted that bilateral thoracic injuries induce profound derangements in pulmonary, chest wall and diaphragmatic mechanics [14] and were found to be associated with higher probability of increased morbidity and hospital stay in our cases.

It is evident while studying different reports [1,4,5,9,15–18] that the treatment of flail chest still remains controversial. Before 1956 it consisted primarily of external chest wall stabilization [9]. From 1956 to 1975 early intubation and ventilatory support or tracheostomy were emphasized, while after 1975 there has been an increasing effort to treat selected patients without ventilatory assistance [1,3,9]. Since Trinkle's classic study [5] describing the pathophysiology of flail chest not on the basis of paradoxical respiration but of the underlying pulmonary contusion the strategy consisted of avoidance of fluid overload, vigorous pulmonary toilet and systematic analgesia.

Pain relief, chest physiotherapy and aggressive removal of pulmonary secretions help people to be managed safely without ventilatory support, since hypoxemia is not induced in flail chest and oxygen administration does not significantly change ventilatory function [16]. Selective ventilation and early tracheostomy have been shown to be beneficial in all polytrauma patients including the ones sustaining flail chest [9,19]. When it appears that ventilatory assistance will be required, early implementation is best, particularly if there is an underlying moderate or severe pulmonary contusion or serious associated injuries [12]. This point of view is also supported by the fact that in 19 patients of Group B in our series needing ventilation, the cause was their instability due to their general condition (hypovolemic shock, associated injuries, such as extrathoracic fractures, severe head injuries along with pulmonary insufficiency), while only 2 patients of Group A required prolonged ventilation because of their chronic comorbid diseases (decreased cardiopulmonary reserve, preexisting limitations in mobility and poor nutritional status).

It is argued in some recent publications [17,18,20,21] that operative fixation lowers the morbidity and mortality rates but this argument is not widely agreed upon. They favor the idea of stabilization of unstable chest wall segments since it reduces the duration of ventilatory support, the intensive care unit stay and the morbidity [18,20]. The authors believe that such an operation could be meaningless if it is done in order to improve lung air volume reduction, since that is caused by the lung contusion and not by the thoracic deformity [22]. It can be performed in selective cases in order to get better cosmetic results. As Sirmali et al. [23,24] indicated in their series, they found reasonable to use operative fixation only in cases where thoracotomy was required for another indication, and so did the authors. However, the decision is based on the experience and judgement of the thoracic surgeon. The goal of minimizing intubation time by operative fixation of fractured ribs has not been proven yet [24]. There are many aspects to be clarified and prospective randomized trials are needed in order to compare conservative and surgical treatment.

Despite many advances in overall trauma care and improvements in ventilatory support the mortality rate has not changed appreciably over the past decades. The majority

of deaths in patients with flail chest is due to associated injuries. Mortality rate varies in different studies from 11 to 40% [4,9,15], while in our series reached only 5.4%, which represents one of the lowest rates published.

In conclusion, we would like to stress that:

1. Age, hemopneumothorax and mechanical support had no demonstrable impact on mortality.
2. ISS was found to be a strong predictor on outcome concerning morbidity and prolonged hospitalization but did not influence mortality rate.
3. Mechanical support was not considered a necessity for the treatment of flail chest, while the maintenance of pulmonary and tracheal hygiene and systematic analgesia along with aggressive treatment of associated injuries were essential.

References

[1] Richardson JD, Adams L, Flint LM. Selective management of flail chest injuries. Ann Surg 1982;196:481–7.
[2] Livingston DH, Richardson JD. Pulmonary disability after severe blunt chest trauma. J Trauma 1990;30(5):562–7.
[3] Basset JS, Gibson RD, Wilson RF. Blunt injuries to the chest. J trauma 1968;8:418–29.
[4] Clark GC, Schecter WP, Trunkey DD. Variables affecting outcome in blunt chest trauma: flail chest vs pulmonary contusion. J Trauma 1988;28:298–304.
[5] Trinkle JK, Richardson JD, Franz JL, Grover FL, Arom KV, Holmstrom FM. Management of flail chest without mechanical ventilation. Ann Thorac Surg 1975;19(4):355–63.
[6] Ciraulo DL, Elliott D, Mitchell KA, Rodriguez A. Flail chest as a marker for significant injuries. J Am Coll Surg 1994;178:466–70.
[7] Baker SP, O'Neil B, Haddon Jr B, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauam 1974;14(3):187–96.
[8] Swan Jr KG, Swan BC, Swan KG. Decelerational thoracic injury. J Trauma 2001;51(5):970–4.
[9] Freedland M, Wilson RF, Bender JS, Levison MA. The management of flail chest: factors affecting outcome. J Trauma 1990;1460–8.
[10] Albaugh G, Kann B, Puc MM, Vemulapalli P, Marra S, Ross S. Age-adjusted out comes in traumatic flail chest injuries in the elderly. Am Surg 2000;66:978–81.
[11] Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma 1994;37(6):975–9.
[12] Velmahos GC, Vassiliu P, Chan LS, Murray JA, Berne TV, Demetriades D. Influence of flail chest on outcome among patients with severe thoracic cage trauma. Int Surg 2002;87(4):240–4.
[13] Johnson JA, Cogbill TH, Winga ER. Determinants of outcome after pulmonary contusion. J Trauma 1986;17(5):322–6.
[14] Dimopoulou I, Anthi A, Lignos M, Boukouvals E, Evangelou E, Routsi Ch, Mandragos K, Roussos Ch. Prediction of prolonged ventilatory support. Intens Care Med 2003;29(7):1101–5.
[15] Shackford SR, Smith DE, Zarins CK, Rice CL, Virgilio RW. The management of flail chest: comparison of ventilatory and non-ventilatory treatment. Am J Surg 1976;132:759–62.
[16] Gyhra A, Torres P, Pino J, Palacios S, Cid L. Experimental flail chest: ventilatory function with fixation of flail segment in internal and external position. J Trauma 1996;40(6):977–9.
[17] Ahmed Z, Mohyuddin Z. Management of Flail Chest injury: internal fixation versus endotracheal intubation. J Thorac Cardiovasc Surg 1995;110:1676–80.
[18] Lardinois D, Krueger T, Dusmet M, Ghisletta N, Gugger M, Ris HB. Pulmonary function testing after operative stabilization of the chest wall for flail chest. Eur J Cardiothorac Surg 2001;20(3):496–501.
[19] Rodriguez JL, Steinberg SM, Luchetti FA, Gibbons KJ, Taheri PA, Flint LM. Early tracheostomy for primary airway management in the surgical critical care setting. Surg 1990;108:655–9.
[20] Mouton W, Lardinois D, Furrer M, Regli B, Ris HB. Long-term follow up of patients with operative stabilization of a flail chest. Thorac Cardiovasc Surg 1997;45:242–4.
[21] Tanaka H, Yukioka T, Yamaguti Y, Shimizu S, Goto H, Shimazaki S. Surgical stabilization or internal pneumatic stabilization? a prospective randomized study of management of severe flail chest patients. J Trauma 2002;52(4):727–32.
[22] Kishikawa M, Minami T, Shimazu T, Sugimoyo H, Yoshioka T, Katsurada K, Sugimoto T. Laterality of air volume in the lungs long after chest trauma. J Trauma 1993;34(6):908–13.
[23] Sirmali M, Turut H, Topcu S, Gulhan E, Yazic U, Kaya S, Tastepe I. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg 2003;24:133–8.
[24] Liman ST, Kuzucu A, Tastepe AI, Ulasan GN, Topcu S. Chest injury due to blunt trauma. Eur J Cardiothorac Surg 2003;23:374–8.