doi:10.1510/icvts.2005.111807

INTERACTIVE CARDIOVASCULAR AND THORACIC SURGERY

Interactive CardioVascular and Thoracic Surgery 4 (2005) 583–587

www.icvts.org

Institutional report - Thoracic general

Surgical versus conservative treatment of flail chest. Evaluation of the pulmonary status

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Received 21 April 2005; received in revised form 28 July 2005; accepted 2 September 2005

Abstract

Through a prospective randomized comparative study, treatment of flail chest by a non-surgical method of packing, strapping, and mechanical ventilation vs. surgical fixation were compared. After management, stability of the chest wall occurred in 85% of the patients in the surgical group. Forty-five percent of patients in this group required ventilatory support after fixation for an average of 2 days. Whereas in the conservative group, stability occurred in 50% of their patients, and 35% of patients required ventilatory support for an average of 12 days. Chest wall deformity in the form of stove-in chest and crowding of ribs was still obvious in 9 patients among the conservatively treated group, compared to only one patient who developed chest wall deformity in the surgically treated group. The pulmonary functions tested two months after management indicated that in the surgical group the patients had a significantly less restrictive pattern. Thus, surgical fixation of a flail segment is a method of great value in the treatment of flail chest, in which stability is achieved without deformity of the chest wall and patients have less restrictive impairment of pulmonary functions.

Keywords: Flail chest; Pulmonary function tests, Chest injuries

1. Introduction

The management of flail chest has been the subject of controversy for many years. An individualized treatment approach putting into consideration the patient's post-traumatic cardio-pulmonary status and the extent of trauma to other organ systems is generally supported. Fractured ribs treated conservatively undergo progressive displacement during the healing phase, which results in considerable deformity, volume loss, and atelectasis. Endotracheal intubation and ventilation may not be able to prevent rib cage distortion. Early reduction and fixation of the fractured ribs restores the chest wall integrity, and forestalls the development of permanently damaging sequelae, but is usually reserved to that small group of patients who are submitted to surgery anyway due to continuous bleeding [1,2].

The aim of this study is to compare two methods used for stabilization of the chest wall: the conservative method by packing and strapping, and the method of surgical fixation of the flail segment. Through a prospective randomized comparative study, the early results and the results at two months after trauma of both modalities of treatment will be compared with special emphasis on pulmonary functions and chest wall deformity.

2. Patients and methods

Forty patients with flail chest were included in this randomized clinical trial.

Inclusion criteria: All patients with flail chest including fracture of three ribs or more with paradoxical movement.

Exclusion criteria:

1. Head trauma with disturbed conscious level.
2. Associated injuries as myocardial contusion that might be adversely affected by general anesthesia.
3. Severe associated trauma to other systems.
4. Fractures of the upper three ribs only, as immobilizing bandages are inefficient in fractures of the upper ribs for anatomic reasons.

On arrival at the clinic, all the patients were admitted to the intensive care unit and received general, local, radiological and laboratory assessment including arterial blood gases (ABGs). This was followed by routine medical care of severe chest trauma. The same assessment was repeated 24 h after management of the flail chest.

Patients were randomized either for conservative treatment (Group I) or for surgical treatment (Group II). The random assignment was carried out using random numbers

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Table 1
Pre-management data of 40 patients with traumatic flail chest on admission

Pre-management variables	All (N=40)	Conservative group (N=20)	Surgical group (N=20)	P-value
Age range at operation (year)	12–60	12–60	24–55	
Mean±S.D.	38.2±11.5	36±14.9	40.5±8.2	P<0.001
Sex				
(Male: Female)	31:9	14:6	17:3	n.s.
Shock (%)	12 (30%)	4 (20%)	8 (40%)	n.s.
Associated Injuries:				
None	33 (82.5%)	15 (75%)	18 (90%)	n.s.
Fracture clavicle (%)	3 (7.5%)	2 (10%)	1 (5%)	
Fracture humerus (%)	1 (2.5%)	1 (5%)	0 (0%)	
Liver injury (%)	1 (2.5%)	1 (5%)	0 (0%)	
Splenic injury (%)	2 (5%)	1 (5%)	1 (5%)	
Hemothorax	20 (50%)	9 (45%)	11 (55%)	n.s.
Pneumothorax	3 (7.5%)	1 (5%)	2 (10%)	
Hemo-pneumothorax	4 (10%)	2 (10%)	2 (10%)	
Injury severity score	16–32	16–32	16–32	
Mean±S.D.	17.4±4.4	18.0±5.1	16.8±3.5	P=0.043

Not significant (n.s.).

Table 2
Site and number of rib fractures in 40 patients with traumatic flail chest

Rib fractures	All (N=40)	Conservative group (N=20)	Surgical group (N=20)	P-value
Mean number of fractured ribs	4.6	4.9	4.4	P=0.043
Anterolateral	13 (32.5)	5 (25%)	8 (40%)	n.s.
Posterolateral	21 (52.5%)	15 (75%)	6 (30%)	P=0.01
Costochondral junction with sternum	5 (12.5%)	0 (0%)	5 (25%)	P=0.047
Sternum	1 (2.5%)	0 (0%)	1 (5%)	n.s.

Not significant (n.s.).

Table 3
Stability of the chest wall in 40 patients with traumatic flail chest after management

Stability of the chest	Conservative group (N=20)	Surgical group (N=20)			P-value
		Stainless steel and Kirschner wires	Stainless steel only	All	
Stable	10 (50%)	14	3	17 (85%)	
Unstable	10 (50%)	0	3	3 (15%)	0.041

Not significant (n.s.).

balanced within blocks of 10 patients. Informed consents were obtained from the participating patients or their relatives after our thorough explanations.

Group I Patients were submitted to conservative treatment using strapping and packing in the form of dressing and fixing with elastoplast which was put adhesively to the flail segment within 5 cm anterior and posterior to the flail segment and one rib above and below it. This adhesive plaster was put in place for at least 7 to 10 days, during this period follow up ABGs and chest X-ray was obtained.

Group II Patients were for surgical fixation of the flail segment within 24 to 36 h after admission to the ICU, using Kirschner wires, stainless steel wire, or both. Until the patients were operated upon they were treated conservatively as if they were patients in Group I.

Postoperative assessment: Patients in both Groups were examined for chest wall deformity in the form of stove-in chest, or flail segments as a consequence of the rib fractures on admission, after treatment and two months after discharge. In addition, pulmonary functions were performed two months post-operatively.

The study was approved by the Ethical Committees of the universities involved.

Statistical analysis of the data was performed using the paired Student's test, Mann-Whitney test, Chi-square test or Fischer's exact test. The P-value less than 0.05 ($P<0.05$) was considered significant. Quantitative data were presented as the mean±standard deviation (S.D.).

3. Results

The data of the patients on admission are shown in Tables 1 and 2.

As regards the *methods of fixation* in Group II, in 14 patients (70%) stainless steel wire and Kirschner wires were used in fixation, but in 6 patients (30%) stainless steel wire only was used for fixation.

Table 4
Blood gas analysis in 40 patients with traumatic flail chest

		Before management Mean±S.D.	After management Mean±S.D.	*P*-value
Conservative group	pO_2	63.6±9.1	89.3±7.6	<0.001
	pCO_2	39.7±4.0	30.9±2.5	<0.001
	O_2-Saturation	90.7±1.7	96.2±1.7	<0.001
Surgical group	pO_2	56.2±9.2	98.7±21.0	<0.001
	pCO_2	34.2±6.3	31.2±5.9	n.s.
	O_2-Saturation	88.1±3.4	96.8±3.0	<0.001

Partial pressure of oxygen (pO_2), partial pressure of carbon dioxide (pCO_2). Not significant (n.s.).

Table 5
Post-management data in 40 patients with traumatic flail chest

Post management data	Conservative group (*N*=20)	Surgical group (*N*=20)	*P*-value
Mechanical ventilation Number of patients (%)	7 (35%)	9 (45%)	n.s.
Mean duration of mechanical Ventilation (days)	12	2	*P*<0.001
Mean ICU stay (days)	14.6	9.6	*P*<0.001
Mean hospital stay (days)	23.1	11.7	*P*<0.001

Not significant (n.s.).

Table 6
Morbidity and mortality in 40 patients with traumatic flail chest after management

Complications	Group I No. (%)	Group II No. (%)	*P*-value
No complications	8 (40%)	13 (65%)	n.s.
Chest infection	10 (50%)	2 (10%)	*P*=0.014
Empyema	2 (10%)	1 (5%)	n.s.
Pulmonary embolism	1 (5%)	0 (0%)	n.s.
Mediastinitis	0	2 (10%)	n.s.
Wound infection	0	2 (10%)	n.s.
Chest wall deformity	9 (45%)	1 (5%)	*P*=0.008
Scoliosis	5 (25%)	0 (0%)	*P*=0.047
Mortality	3 (15%)	2 (10%)	n.s.

Not significant (n.s.).

Table 7
Pulmonary function tests in the survivors of 40 patients with traumatic flail chest 2 months after management

Pulmonary functions	Group I Mean±S.D.	Group II Mean±S.D.	*P*-value
FVC (%)	66.5±6.5	75.0±5.4	*P*<0.001
FEV_1 (%)	75.0±0.4	75.5±8.7	n.s.
TLC (%)	85.8±11.3	90.7±4.2	*P*<0.001
PEFR (%)	91.8±1.7	92.2±2	n.s.
FEF_{75} (%)	60.4±13.3	65.6±13.8	*P*<0.001

Forced vital capacity (FVC), Forced expiratory volume in the first second (FEV_1), Total lung capacity (TLC), Peak expiratory flow rates (PEF), Forced expiratory flows at 75% of the vital capacity (FEF_{75}), not significant (n.s.).

The assessment of the *stability of the chest wall* in relation to the *methods of fixation* is presented in Table 3, showing a statistically significant advantage of surgical fixation.

A statistically significant improvement in the postmanagement ABGs was found in both groups compared to the premanagement ABGs. This shows that both methods effectively improve the arterial blood gases (Table 4).

The postoperative course, as well as the postoperative morbidity and mortality are listed for both groups in Tables 5 and 6, demonstrating the statistically significant improved results with surgical fixation of flail chest.

As regards the causes of mortality, severe unresolving pneumonia in two patients and pulmonary embolism in one patient were the causes of death of the three patients in Group I, while mediastinitis and septic shock were responsible for the mortalities in both patients in Group II.

The results of the *pulmonary functions* tested two months after management indicated that in the surgical group the patients had a less restrictive pattern than patients in the conservatively treated group (Table 7).

4. Discussion

The treatment of flail chest depends on the severity of the chest wall injury, the condition of the underlying lungs, the degree of hypoxia which is determined by arterial blood gases, the age of the patient, the presence of pre-existing lung disease, and the pain threshold of the patient. The management is directed towards maintaining adequate ventilation, decreasing progressive damage, and preventing complications and sequelae. The function of a fixed bandage (adhesive plaster strapping) is to reduce pain and possibly to render assistance in coughing. This method of fixation however, has a disadvantage, as it definitely reduces ventilation of the half of the thorax in question and in so doing promotes the formation of atelectasis and respiratory insufficiency. For anatomic reasons such immobilizing bandages are inefficient in fractures of the upper ribs [3].

Surgical solutions must be tailored to the individual case. In the case of a very large defect with instability involving the anterolateral part of the chest wall, Carbognani and associates in 2000 suggested that the use of an extrapleural long bar, associated if necessary with other standard devices, can be very useful [4]. The Sea Gull Wing Prosthesis, which is self retaining and easily removable, has been proposed by Actis Dato and associates [5]. Mayberry and his associates reported in 2003 about their preliminary experience with absorbable plates for rib fracture repair with good clinical results as an option for rib fracture repair [6].

Among the disadvantages of operative stabilization is the required general anesthesia which is inherently risky for patients who have sustained multiple and severe trauma, or the presence of associated severe injuries such as myocardial contusion. Techniques of stabilization can be difficult, time consuming, and the additional dissection required to accomplish these repairs may increase local tissue injury. Implanted foreign bodies can contribute to chronic osseous and soft tissue infections [4]. This could be observed in our patients who were subjected to operative fixation, with 2 patients having superficial wound infection, and 2 patients with deep infection in the form of mediastinitis after surgical stabilization of flail sternum and anterolateral rib fractures.

As regards the pulmonary functions, we observed in this study that the conservatively treated group, had a mean percentage of forced vital capacity (FVC) of 66.5%, a mean percentage of forced expiratory volume (FEV_1) in first second of 75.0%, a total lung capacity (TLC) of 85.8%, and a mean percentage of peak expiratory flow rate (PEFR) of 91.8%. This was in agreement with the results of Landercasper and his colleagues who treated their patients conservatively by strapping of flail segment with physiotherapy and analgesia [7]. They noted that the majority of patients tested in their study had impairment of pulmonary functions, in which FVC was 68.5%, FEV_1 was 73.5%, FEV_1: VC was 88.5% and PEFR was 3.6 L/S. Kishikawa and associates in 1991 studied the pulmonary functions of patients with flail chest managed conservatively, using spirometry at 2 months after injury. They suggested that flail chest causes respiratory dysfunction as their results revealed that the VC was 70.5%, FEV_1 was 78.6% and PEFR was 86% (4.3 L/S) [8].

Lardinois et al. in 2001 stated that early restoration of the chest wall intergrity and respiratory functions prevents restrictive impairment of pulmonary functions, as proved by the total lung capacity (TLC) values their surgically treated patients presented six months postoperatively, which were all significantly higher than 85% of predicted, which is correlating with our results with a TLC of 90.7% [9]. So it seems that surgical fixation of flail segments allows the maintenance of the lung function or at least less impairment of pulmonary status.

As regards the stability of the chest wall after surgical fixation, our results with 85% stability were coinciding with those reported in the literature. Fabbri and associates in 1996 managed flail chest surgically by osteosynthesis of the ribs using small plates and reported that 87.5% of their patients were stabilized as regards paradoxical motion of the chest wall [10]. In 1995 Ahmed and Mohyuddin used Kirschner wires for fixation of the flail parts achieving stability in 87.5% of their patients [11]. Reber and his colleagues in 1993 used plates for fixation of the flail segment and the stability was achieved in all patients without secondary dislocation [12].

Chest wall injury may result in a variety of delayed sequelae. The most common late problems are chronic pain and chest wall deformity (Stove-in chest) which lead to long-term impairment in pulmonary function tests [13].

In our study, two months after discharge, a chest wall deformity in the form of stove-in chest and crowding ribs was obvious in 9 patients (45%) among the conservatively treated group; Beg and his colleagues in 1990 stated that 56% of the patients who were treated with pad and strapping had stove-in chest [14]. In the surgically treated group of this study however, only one patient (5%) developed chest wall deformity. This was in agreement with Reber and his associates in 1993 who reported that stability of the chest wall without chest wall deformity was achieved in all the survivors with flail chest who were surgically fixed [12]. In 1995 Ahmed and Mohyuddin stated that 12.5% of their patients who were surgically treated had minimal chest wall deformity [11].

The mortality rate was 15% in our patients who were treated conservatively. Similar results were reported in the literature with a 21% mortality rate among the patients who were treated conservatively and required ventilatory support [15]. On the other hand, mortality rate in our surgically treated patients was 10%. This coincided with the results of other centers, who reported an 8–12% mortality rate in surgically treated patients [1,11].

In conclusion we suggest that surgical fixation of a flail segment with an individualized management approach is a method of great value in the treatment of flail chest. In this modality of treatment, stability without deformity of the chest wall is achieved, and patients have less impairment in pulmonary functions. Patient's age, post-traumatic cardio-pulmonary status, and the extent of trauma to other organ systems should be considered, when choosing the appropriate patients for this treatment modality. Patients surgically stabilized had a significantly smoother course during the intensive care unit and hospital stays, had a significantly decreased rate of complications, and had almost no residual chest wall deformity with its resulting restrictive impairment of pulmonary functions, as compared to the conservatively managed patients.

Acknowledgments

The work was performed at the Cairo University and Zagazing University Clinics.

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