Surgical versus nonsurgical management of multiple rib fractures

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Introduction
Significant development in the management of chest trauma has been achieved; however, the proper chosen management, whether surgically or nonsurgically, for each patient is still uncertain. Our study aimed to detect the proper management of rib fracture cases.

Patients and materials
Our prospective study focused on multiple rib fractures in patients admitted to Asyut University hospitals in the period from June 2017 till March 2019. All premanagement and postmanagement variables had been well analyzed, such as the age of the patient, mode of trauma, number and site of rib fractures, type of management whether surgically or nonsurgically, and post proper management outcomes.

Results
Our study included 100 patients who met the inclusion and exclusion criteria. There were 81 male and 19 female patients. The mean age was 39.39±16.21 years. Seventy-six patients were injured by motor vehicle accidents, 19 falls from height, and five from other causes. Hemopneumothorax was the most frequent pleural complications with a percentage of 53% followed by pulmonary contusion (29%). Flail chest was noticed in 24 cases; 14 of them had been managed surgically and 10 nonsurgical. Seven cases of multiple rib fractures, without fail chest, had been managed surgically. The mortality rate was 7%, and all of them were flail chest cases.

Conclusion
Each patient should be selectively managed, whether surgically or nonsurgically, as early as possible after chest trauma.

Keywords:
flail chest, motor vehicle accident, thoracic trauma

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Introduction

Thoracic trauma has been reported to be found in approximately 10% of all traumas. More than 20% of posttrauma mortality has been represented by thoracic trauma [1]. Rib fractures are the major morbidity in cases of chest trauma which have been presented in 18% of the patients with blunt chest trauma [2]. In spite of the dramatic developments in chest trauma management, thoracic trauma remains to be considered as one of the main causes of morbidities in injured pediatric and adult cases [3].

Through history, great advancements in rib fracture management have been achieved. Egyptians were the first ones to describe the management of chest injuries. Edwin Smith papyrus contains significant information about rib fracture management. Hippocrates mentions the treatment of rib fractures and differentiated between types of rib fractures. World War II was the most significant period for a real development in rib fracture management, which saw the first use of local and general anesthesia, bronchoscopic devices, and antibiotic drugs [4].

When the applied force of blunt thoracic trauma exceeds the strength of the thoracic cage, rib fracture occurs. The site and number of rib fractures give an important marker of the severity of the trauma. The most common site of rib fracture was found at 60° rotation from the sternum, from ribs 3 to 10. Ribs 1 and 2 are short and protected by the clavicle, although their injury has a significant possibility of underlying vascular accidents.

Pneumothorax was considered the most common pleural complication in cases of rib fracture, which may be life-threatening in children, followed by hemothorax, pleural effusion, myocardial contusion, diaphragmatic rupture, and sternum fracture down to aortic tear [5].

Severity of the chest injury, numbers and types of rib fractures, associated injuries of other organs,

hemodynamic stability of the patient at the time of admission, the pain intensity scale, age of the patient, and the degree of underlying lung injuries determine the type of rib fracture management.

Management can be categorized mainly in two groups: surgical versus nonsurgical. The main goals of the management are directed toward relieving the pain which is the main complaint associated with rib fractures, correcting conditions of hypoxia and treating morbidities, and prevention complications. The main lines of nonsurgical options include relieving of the pain by good analgesia which is correlated with the severity of the injury, maintaining adequate ventilation, proper fluid replacement, and suitable moods of ventilator support which act as an internal support [6].

The main indications of surgical options include flail chest [7], which can be defined as fractures of two ribs or more at more than one plane, persistence of severe pain in spite of good analgesia [8], failure of weaning from mechanical ventilator [9], and indications of thoracotomy rather than fixation of rib fractures [10].

The protocol of analgesia is to relieve posttraumatic rib fracture pain, which varies from NSAIDs to systemic opioids [11]. Prognosis of the postoperative management depends mainly on number and site of rib fractures, the quality of the surgical technique, age of the patient, mode of trauma, duration of ICU stay, and acquisition of chest infections.

Elderly traumatic patients who present with multiple rib fractures usually have a poor prognosis in comparison with young ones [12].

Patients and methods

Our study focuses on cases with traumatic rib fractures who were admitted to the trauma center of Asyut University hospitals from June 2017 to March 2019. Patients who met the listed inclusion and exclusion criteria were eligible for the study. Informed consent was obtained from all individual participants included in the study . The study was approved by the Ethical Committees of faculty of medicine, Assiut University, Egypt.

The medical records were reviewed, and eligible patients were filtered. The inclusion criteria of the study were all age groups, patients with two traumatic rib fractures or more, all associated organ injuries beside chest trauma, all types of flail chest, recent and old trauma, and intubated and nonintubated patients on admission. Exclusion criteria were single rib fracture, pathological rib fractures, and patients who refused to enroll in this study.

Premanagement variables in our study included mechanism of injury, presence or absence of dyspnea, number and site of fractured ribs, presence or absence of pulmonary contusion, other associated injuries, and hemodynamic stability at time of admission.

Management variables included nonsurgical options and surgical option. Postmanagement, variable included morbidities and mortality, hemodynamic stability, ICU stays, hospital stays, and outcome at follow-up after 2 weeks.

A trauma specialist, once the patient arrives at the trauma unit, examined the patient clinically to determine the mode of trauma and the injured organs. When blunt chest trauma was detectable, thoracic surgeon assessed it carefully to determine the number and site of rib fractures.

Chest radiography, which is the first line of investigation, is performed to determine the underlying morbidity associated with chest trauma. In doubtful cases, multislice chest computed tomography is requested.

Other investigations such as arterial blood gases, chest sonar, ECG, and echocardiography are reported to exclude underlying cardiac morbidity. Proper management had been chosen selectively for each patient.

Nonsurgical management

Relieve of the pain is the main line of nonsurgical management, and usually more than one method of analgesia was used according to the severity of the pain. Analgesic options included oral NSAIDs, local anesthetics, intravenous opioids, and epidural analgesia. Fluid replacement strategy, especially in cases of severe pulmonary contusion had been put in mind. Pulmonary hygiene, good chest physiotherapy, treating associated pleural complications such as hemopneumothorax, and correcting general condition were achieved in all cases. A mechanical ventilator as a method of internal pneumatic stabilization had been chosen for patients not planned for the surgical option.

Preoperative preparation

We perform multislice computed tomography to determine the site and number of rib fractures. The position of the patient on the table is determined by

the site of fractured ribs; it may be supine, lateral or prone. In our cases, ribs had been fixed by wires or plates.

Operative technique

We aimed to fix only ribs between level 3 and 10, as ribs 1 and 2 are difficult to access and ribs 11 and 12 do not contribute to breathing. Displaced ribs are given priority in our operational planning, and fractured nondisplaced ribs are often not fixed at all. Only fractured ribs between level 3 and 10 were fixed, as 1 and 2 ribs have a difficult access and ribs 11 and 12 have an insignificant role in breathing mechanism. According to the attending surgeon's experience, cases were selectively chosen for fixation either by plates or stainless steel wires.

Instruments used in fixation included 2.5-mm drill bit, quick-coupling 3.5/2.5-mm double-drill sleeve, tap for 3.5-m cortex bone screws, T-handle for quick coupling, small hexagonal screwdriver with holding sleeve, depth gauge for 3.5-mm cortex bone screws, reduction forceps with serrated jaw, 140-mm length (pair) self-centering bone forceps, size 0 (pair), bending pliers for 3.5-mm reconstruction plates, bending template, 22 holes for 3.5-mm reconstruction plates, small air or battery drill, 3.5-mm reconstruction plates (complete set), and – 3.5-mm cortex screws (complete set).

Statistical analysis

Statistical analyses were performed using SPSS program, version 20 (IBM Corporation, Endicott, New York, USA). The data were tested for normality using the Kolmogorov–Smirnov test and for homogeneity variances before further statistical analysis. Categorical variables were described by number and percent, whereas continuous variables were described by mean and SD. Comparative statistics and tests of significance, including the paired Student's test, Mann–Whitney test, χ^2 test, or Fisher's exact test were used. *P* value was considered statistically significant when it was less than 0.05 and highly significant when it was less than 0.001.

Results

Between June 2017 and March 2019, 100 patients were selectively chosen for our study. The age of the patients ranged from 1.5 to 70 years, with a mean 39.39 ± 16.21 years. The number of men cases discussed was 81, and the rest of the cases was female. The main cause of rib fractures was motor car injury in 50%, followed by motorbike accidents in 26% and fall from heights in 19%, in addition to miscellaneous causes, including animal kick and assault from others in 5%. Associated organ injuries, including head and intraabdominal and extremity in addition to vascular injuries, were observed in 75 cases. All the patients were hospitalized with a mean hospital stay of 12.69 days (Table 1).

Rib fractures were detected in all patients, of which 22 patients experienced two rib fractures and 50 patients had more than two rib fractures unilaterally, four patients were documented to have bilateral rib fractures, and 24 patients presented with flail chest (Table 2). Sternal fractures were detected in 10 patients. Five patients arrived with intubation owing to associated head injuries and three patients had undergone an urgent laparotomy owing to intraabdominal injuries with hemodynamic instability.

Plural complications were noted in 77 (77%) patients, of which 10 patients present with pneumothorax and nine patients with hemothorax, and 53 patients were documented with both. Pericardial effusion was detected in nine patients, and the pulmonary contusion was the main pathology of pediatrics, with a percentage of 29% (Table 3). Two patients have been diagnosed by traumatic diaphragmatic rupture at the time of admission; one of them was repaired

Table 1 Age, sex, mechanism of injury, and associated injuries of our study

	n (%) (*n*=100)
Age (years)	
<30	21 (21.0)
30-50	53 (53.0)
>50	26 (26.0)
Mean±SD (range)	39.39±16.21 (1.5-70.0)
Sex	
Male	81 (81.0)
Female	19 (19.0)
Associated injuries	
Head injuries	21 (21.0)
Extremity injuries	47 (47.0)
Intraabdominal injuries	26 (26.0)
Mechanism of injury	
Motor vehicle	40 (40.0)
Motorcycle	26 (26.0)
Falls from height	19 (19.0)
Miscellaneous	5 (5.0)

Table 2 Number and site of rib fractures

Number of rib fractures	*n* (%) (*n*=100)
2 ribs (right)	11 (11.0)
2 ribs (left)	11 (11.0)
3-6 ribs (right)	27 (27.0)
3-6 ribs (left)	23 (23.0)
Bilateral	4 (4.0)
Flail segments	24 (24.0)

by thoracotomy, whereas the other underwent laparotomy during the follow-up period owing to gas under the diaphragm. Thoracotomy was performed in 14 patients.

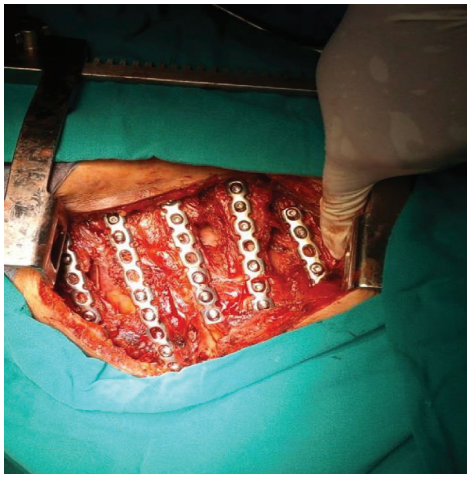
Two patients had undergone spinal fusion, one patient with pelvic injury was managed by pelvic ORIF, 22 patients presented with limb fractures and were managed by limb ORIF, and only one patient was controlled by transarterial embolization.

Six patients out of 10 with sternal fractures had undergone sternal fixation. Management of flail chest surgically had been done in 14 patients, which met the indications of surgical stabilization, and seven patients without flail had undergone surgical stabilization. Ten patients with flail chest had been managed by nonsurgical options.

The main indications of surgical rib stabilization were flail chest, inability to wean from the mechanical ventilator, and pain not responding to analgesia. All surgical stabilizations had been done within 10 days of arrival. Only three patients who had undergone surgical rib stabilization postoperatively had not been transferred to ICU; four patients need a tracheostomy within 28 days postoperative. Two patients complained of chronic pain, and the mortality postoperatively was 5%, mainly owing to pneumonia and respiratory failure, involving two head injuries and five postsurgical rib fixation. Seven patients died in our study, two of them mainly due to head injuries and five owing to postsurgical rib fixation.

Only one patient was readmitted owing to clotted hemothorax, which was managed by video-assisted thoracic-scope technique (VATS) (Fig. 1).

Figure 1



Multiple rib fracture fixation by plates.

Discussion

Age is one of the most important factors determining the outcome among patients with rib fracture. Multiple rib fractures have been detected in all age groups, mainly the young age group [13].

The elasticity of the thoracic cage in children limits the incidence of rib fractures. Elderly patients have a poor prognosis in comparison with young, mainly owing to underlying lung diseases and bad general conditions.

In our study, we found that the age played a insignificance role as a factor in determining the outcome of patients with multiple rib fracture in comparison with the number of rib fractures (Tables 4,5).

Table 3 Pleural complications and morbidities of blunt chest trauma

Complications	*n* (%) (*n*=100)
Pneumothorax	10 (10.0)
Hemothorax	9 (9.0)
Hemopneumothorax	53 (53.0)
Pericardial effusion	9 (9.0)
Pulmonary contusion	29 (29.0)
Diaphragm rupture	2 (2.0)
Sternum fracture	10 (10.0)

Table 4 Age and sex as factors in determining the course of blunt chest trauma patients

	ICU stay (days) [*n* (%)]			*P*
	No	<10 days	≥10 days	
Age (years)				
<30	9 (42.9)	6 (28.6)	6 (28.6)	0.588
30-50	24 (45.3)	13 (24.5)	16 (30.2)	
>50	12 (46.2)	3 (11.5)	11 (42.3)	
Sex				
Male	35 (43.2)	17 (21.0)	29 (35.8)	0.468
Female	10 (52.6)	5 (26.3)	4 (21.1)	
	Hospital stays (days)			*P*
	<10	10-<15	≥15	
Age (years)				
<30	8 (38.1)	8 (38.1)	5 (23.8)	0.627
30-50	21 (39.6)	13 (24.5)	19 (35.8)	
>50	8 (30.8)	10 (38.5)	8 (30.8)	
Sex				
Male	29 (35.8)	27 (33.3)	25 (30.9)	0.581
Female	8 (42.1)	4 (21.1)	7 (36.8)	

Table 5 ICU stays, hospital stay, and according to number of rib fractures

	Number of rib fractures [*n* (%)]			*P*
	2 ribs	3-6 ribs	Flail segments	
ICU stays (days)				
No	14 (63.6)	27 (54.0)	3 (12.5)	0.003*
<10	4 (18.2)	10 (20.0)	8 (33.3)	
≥10	4 (18.2)	13 (26.0)	13 (54.2)	
Hospital stays (days)				
<10	8 (36.4)	23 (46.0)	5 (20.8)	0.124
10-<15	8 (36.4)	16 (32.0)	7 (29.2)	
≥15	6 (27.3)	11 (22.0)	12 (50.0)	

Table 6 ICU stay, hospital stay according to mechanism of injury

	Mechanism of injury [*n* (%)]					*P*
	Automobile	Pedestrian	Motorcycle	Falls from height	Miscellaneous	
ICU stays (days)						
No	8 (23.5)	5 (31.3)	12 (46.2)	16 (84.2)	4 (80.0)	0.003*
<10	12 (35.3)	5 (31.3)	4 (15.4)	1 (5.3)	0	
≥10	14 (41.2)	6 (37.5)	10 (38.5)	2 (10.5)	1 (20.0)	
Hospital stays (days)						
<10	11 (32.4)	3 (18.8)	8 (30.8)	11 (57.9)	4 (80.0)	0.101
10-<15	12 (35.3)	5 (31.3)	8 (30.8)	6 (31.6)	0	
≥15	11 (32.4)	8 (50.0)	10 (38.5)	2 (10.5)	1 (20.0)	

Table 7 ICU stay, hospital stay and outcome according to management

	Management [*n* (%)]		*P*
	Nonsurgical	Surgical	
ICU stay (days)			
No	42 (59.2)	3 (10.3)	0.000*
<10	8 (11.3)	14 (48.3)	
≥10	21 (29.6)	12 (41.4)	
Hospital stay (days)			
<10	31 (43.7)	6 (20.7)	0.063
10-<15	18 (25.4)	13 (44.8)	
≥15	22 (31.0)	10 (34.5)	
Outcome			
Morbidities	68 (95.8)	25 (86.2)	0.089
Death	3 (4.2)	4 (13.8)	

In our study, motor vehicle accidents were noticed to be the main origin of blunt chest trauma followed by falls from height and other causes. Effects of mode of trauma had been illustrated in Table 6.

Associated injuries of other organs should be kept in mind during arrangements for the proper management. Patients present with head trauma GCS = 8 or less will not get a real benefit if surgical management is chosen before certain neurological improvement.

Pneumothorax side by side with hemothorax is the most frequent pleural complications associated with rib fractures [14].

Pulmonary contusion is closely linked to cases present with flail chest [15]. Pulmonary contusion in cases of rib fractures must be managed well, otherwise a lot of respiratory complications may develop, leading up to death. Management of pulmonary contusion depends mainly on proper antibiotic protocol to avoid chest infection plus a good fluid strategy.

Cardiac morbidities such as myocardial contusion, pericardial effusion, and rupture of the aorta may be found in cases of severe blunt chest trauma, and such cases should be managed as early as possible.

An important study was done by Tanaka *et al.*[16] on patients with randomized multiple rib fractures who underwent between surgical and surgical options. They noticed a better prognosis for cases that were managed surgically.

The effect of surgical versus nonsurgical management on duration of ICU and hospital stay, in addition to morbidity and mortality rates, has been illustrated in Table 7.

In our study, 24 of 100 patients had arrived at our trauma unit with flail chest. Another study done by Borman *et al.*[17] showed that the mortality rate is significantly increased in patients with flail chest. In our cases, the mortality rate was seven out of 100 patients, and all of them presented with flail chest.

Study limitations

The topic of surgical versus nonsurgical management had been discussed in many studies before, and no control group could be detected. Therefore, this study also did not include a control group.

Conclusion

Proper management of patients with multiple rib fractures decreases morbidities and mortality rates. The management should be chosen selectively for each patient regarding the number and site of rib fractures, associated injuries of other organs, clinical status of the patient at the time of admission, age of the patient, and absence or presence of flail chest and pulmonary contusion. Early surgical stabilization within one weak has been reported to offer a good prognosis, decreasing ICU stay and mechanical ventilator duration.

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Conflicts of interest

There are no conflicts of interest.

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