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Surgical Fixation Compared with Conservative Treatment of Flail Chest Injuries

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ABSTRACT

Background: although the surgical treatment of flail chest has been practiced for many decades, it is still controversial. **Aim:** to compare between conservative treatment and surgical management intervention for flail chest. **Patients and Methods:** The present research is a prospective study; included 71 patients with flail chest, admitted at Al-Azhar University hospital, New Dameitta. The patients were divided into 2 groups according to the treatment they received; 33 patients in surgical fixation group and 38 in conservative management group. The basic patients' clinical characteristics, associated comorbidities, detailed intervention, laboratory investigations, and outcome were obtained. The outcome included total ventilator days, length of stay (LOS) in the intensive care unit (ICU), rate of pulmonary complications, postoperative pain, development of chronic pain, and mortality. **Results:** patients in surgical group had statistically significant low APACHE II score after two weeks postadmission (7.48±1.17 vs. 9.36±1.02) and higher postoperative FEV1 (1.62±0.06 vs. 1.41±0.02). Duration of mechanical ventilation was significantly shorter in surgical group (5.25±1.76 vs. 11.81±2.57 days). Total duration of ICU stay was significantly shorter in surgical group (6.12±1.55 vs. 13.86±2.40 days). No chest deformity was reported in surgical group compared to 34.2% in conservative group; and the respiratory complications were significantly lower in surgical group (30.3% vs. 73.3%). At 6 months, no significant difference between surgical and conservative groups as regard to performing usual activity (18.2% vs. 15.8%) or return to job (45.5% vs. 34.2%). However, the chronic pain was significantly low in surgical group (21.1% vs. 36.8%). No mortality was reported. **Conclusion:** surgical internal fixation was found to be superior to conservative treatment for flail chest.

Keywords: Flail chest; fracture rib; surgery, conservative treatment; internal fixation.

INTRODUCTION

Fractures of multiple ribs are a common and associated with severe pain. When these fractures occur, a greater work of breathing is needed, that can lead to respiratory failure, especially when the underlying lung parenchyma is injured. This is the case in unstable thoracic cage injuries or “flail chest”, which defined as three or more adjacent ribs each fractured in more than one location [(1)]. Flail chest can result in paradoxical chest movements and require ventilator support [(2)]. In addition, flail chest is one of the most severe and complex forms of chest trauma. It is usually associated mortality of up to 33% [(3)]. In addition to acute morbidities, flail chest also leads to chronic pain and disabilities [(4)].

Conservative management of flail chest (analgesics and ventilator support) has been the conventional treatment for flail chest. However, it can entail long hospitalization with immobilization, which leads to complications, such as pulmonary infections, long-term disability and chronic pain [(5)].

For surgical stabilization of rib fractures, a number of new osteosynthetic implants designed specifically had been developed in recent years [(6, 7)]. There are previous studies, which advocated stabilization of rib fractures by such implants; as they had been shown that surgical stabilization of rib fractures could be associated with decreased respiratory movement restriction [(8,9)]. Also, it may decrease the need of intensive care and mechanical ventilation with decreased complications, improved lung function and reduction of overall cost [(10,11,12)]. The correct treatment approach of flail chest is still controversial [(13)]. In addition, since there is a lack of knowledge about the operation indications and benefits from surgery and the new technologies, physicians’ surgery awareness are extremely low [(14)]. Further, there is a lack of prospective studies with a long-term follow-up concerning lung function, mobility and pain [(2)].

Fagevik *et al*. [(15)] in a study of 24 patients with multiple rib fractures, who had undergone stabilizing surgery, found that 50% still had pain after three months and 35% after six

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months. In addition, vital capacity was significantly decreased compared to normal values but there were no significant differences between the injured vs. non-injured side in breathing movements. Physical function decreased with mild to moderate disability at three months and some to mild disability at six months.

It is crucial to find the best treatment intervention to optimize flail chest management, to benefit patient care, and to continue researching the benefits of operative management [(16)].

The present study was designed to compare between conservative and surgical management intervention for flail chest.

PATIENTS AND METHODS

The present research is a prospective study that was designed to investigate methods of treatment of flail chest on patients admitted at Al-Azhar University hospital, New Dameitta, during the period from January 2012 to March 2016. Seventy-one patients with flail chest were included in this study. The patients were divided into 2 groups according to the treatment they originally received; 33 patients in surgical fixation group and 38 in conservative management group. The Ethics Committee of Al-Azhar Faculty of Medicine approved this study.

Inclusion criteria:

Inclusion criteria included the following: 1) four or more rib fractures, 2) abnormalities of the thoracic cage and paradoxical breathing, and 3) presence of the six months' postoperative visit results.

Exclusion criteria:

Exclusion criteria included one or more of the following: 1) age <14 or >75 years, 2) severe craniocerebral trauma (Glasgow Coma Scale [GCS] score <8), 3) no spontaneous breathing after high-level spinal cord injury, or 4) history of chronic cardiopulmonary disease.

Study procedures:

All the studied cases were submitted to complete physical examinations, laboratory investigations (including arterial blood gas analysis), and imaging (including chest X-ray and spiral chest CT scanning when indicted). Further, electrocardiogram, intravenous infusion, and ventilator-assisted respiration were performed for patients when needed according to the progress of emergency rescue. In addition, antibiotics, closed thoracic drainage, blood product infusion, wound care, airway secretion clearance, analgesia, sedation, and treatment of complications were performed if necessary. In addition, non-surgical treatments included pressure bandaging and external fixation with pectoral girdle. For the patients in the surgery group, conventional rib fracture plating was performed as described by **Lafferty *et al.*** [(7)]. Briefly, an incision was made at the center of the collapsed area of the thoracic cage after general anesthesia. Separation of the subcutaneous tissues was performed and the fractured ends were exposed along the distribution of the muscles (resection of the muscle fibers was minimized during the process). To avoid damage to the intercostal arteries and nerves, the periosteum was separated carefully. The fractured ends were pulled together and fixed with low-profile titanium-locking plates, and then a surgical drain was subcutaneously implanted.

The outcome of the present study included the total ventilator days, length of stay (LOS) in the intensive care unit (ICU), rate of pulmonary complications (e.g., pneumonia), postoperative pain, development of chronic pain, and mortality.

In addition, acute physiology and chronic health evaluation (APACHE) II score at 7 and 14 days after trauma, rate of tracheostomy, and rate of endotracheal re-intubation were collected and analyzed. APACHE II scores were determined as originally described by **Knaus *et al.*** [(17)]. Injury severity scores (ISS) were calculated as the sum of squares of the highest abbreviated injury scale (AIS) score of three different body regions. The severity was classified according to the guidelines by **Baker *et al.*** [(18)] as the following: ISS <16 was classified as minor injury, ISS 16–24 was classified as severe injury, and ISS >25 was classified as critical injury. As for patients with an AIS equal to 6 in one or more regions, the ISS score was automatically set as 75.

Statistical analysis:

The collected data were coded, tabulated and statistically analyzed using statistical package for social science (SPSS) version 18.0 (SPSS Inc., Chicago, IL, USA). Numerical data were described as means (M) ± standard divisions (SD) and analyzed using the Student's t-test. Categorical data were presented as relative frequency and percent distribution, and then analyzed using the Chi-square (χ^2) test. P-value <0.05 was considered statistically significant for interpretation of data.

RESULTS

As regard to baseline characteristics of studied populations, there were no statistically significant differences between patients treated with surgical or conservative intervention. Males represented 66.7% and 60.5% of surgical and conservative groups respectively. The patients' ages ranged from 25 to 55 years and mean age was 44.39±8.15 and 46.50±5.98 years for surgical and conservative groups respectively. The number of fractured ribs ranged from 4 to 9 ribs; the flail chest was anterolateral in 19 (26.8%) patients and posterolateral in 52 (73.2%) patients; the cause of injury was motor car accident in 77.5%, fall from height in 18.3% and crush injury in 4.2%; the fractured ribs were on the same side (unilateral) in 94.4% and bilateral in 5.6%; ISS score at admission ranged from 17 to 26, while APACHI II score at admission ranged from 10 to 20; again there was no significant difference between both groups (Table 1).

As respect to associated injuries (comorbidities), they were in the form of splenic rupture in 1 (1.4%), subarachnoid hemorrhage in 1 (1.4%), sternal fracture in 1 (1.4%), pulmonary laceration in 3 (4.2%), and myocardial injury in 1 (1.4%) subject. All previous injuries were confined to the surgical intervention group. On the other hand; pneumothorax was reported in 25 (35.2%) subjects (10 in surgical and 15 in conservative group), limb fracture in 18 (25.4%) subjects (8 in surgical and 10 in conservative group), pelvic fracture in 10 (14.1%) subjects (4 in surgical and 6 in conservative group), clavicle fracture in 13 (18.3%) subjects (8 in surgical and 5 in conservative group), mediastinal emphysema in 6 subjects (3 in each group), shock in 10 subjects (4 in surgical and 6 in conservative group), and finally tracheal rupture in 2subjects (2.8%) (1 in each group). There was no statistically significant difference between surgical and conservative groups as regard any of these comorbidities (Table 2).

Regarding outcome, patients in surgical group had statistically significant low APACHE II score after two weeks postadmission when compared to conservative group (7.48±1.17 vs. 9.36±1.02, respectively) and higher postoperative FEV1 (1.62±0.06 vs. 1.41±0.02, respectively). The duration of mechanical ventilation (MV) was significantly shorter in surgical group (5.25±1.76 vs. 11.81±2.57 days). In addition, the total duration of ICU stay was significantly shorter in surgical group (6.12±1.55 vs. 13.86±2.40 days). No chest deformity was reported in surgical group compared to 34.2% in conservative group; and the respiratory complications (mainly pneumonia) were significantly lower in surgical group (30.3% vs. 73.3%, respectively). Finally, at 6 months, no significant difference between surgical and conservative groups as regard to performing usual activity (18.2% vs. 15.8%, respectively) or return to job (45.5% vs. 34.2%, respectively). However, the chronic pain was significantly low in surgical when compared to conservative group (21.1% vs. 36.8%, respectively) (Table 3).

DISCUSSION

The aim of the present work was to compare between surgical and conservative treatment for flail chest injury. Results of the present work showed that both groups were comparable as regard to patients' characteristics and associated injuries or comorbidity and severity score at admission, performing usual activities at 6 months and return to original job at 6 months postoperatively. On the other hand, clinical outcome was better in the surgery group, such as need for mechanical ventilation, total days of mechanical ventilation time, total ICU stay (days), pulmonary complication rate (mainly pneumonia), and APACHE II scores after 2 weeks postadmission. In addition, surgical treatment was associated with low development of chronic pain and. These results suggest that surgical treatment of severe flail chest resulted in improved outcomes compared with a conservative treatment. **Xu *et al.*** [19] studied the difference between surgical and conservative treatment for flail chest and reported that the ventilation time was 13.7±4.4 days in the conservative group, while it time was significantly shorter in the surgical group (10.5±3.7 days). This result is going with this of the present work. In addition, **Tanaka *et al.*** [20] conducted a prospective randomized clinical trial, to compare between surgical and conservative treatment, and reported that the mean ventilation time (10.8±3.4 days) in the surgical treatment group was significantly shorter than in the conservative treatment group (18.3±7.4 days), and that ventilator weaning could be successfully performed 2.5±3.2 days after operation for patients in the surgical treatment group. Results of the present work also consistent with recent meta-analysis done by **Schuurmans *et al*.** [16] and demonstrated that operative management of flail chest improves the outcome of patients concerning pulmonary infection (pneumonia), days of mechanical ventilation, ICU stay, days in hospital, tracheostomy rate, functional vital capacity, and treatment costs. In addition, **Granetzny *et al*.** [9] demonstrated the same short-term results, but also with reduced total hospital length of stay, and **Marasco *et al*.** [10] found ICU length of stay, rate of pneumonia, and length of noninvasive mechanical ventilation to be reduced significantly with surgical repair.

Results of the present series are consistent with those published by **Leinicke *et al*.** [21] in their meta-analysis. They reported that early ventilator weaning may reduce the stress caused by invasive endotracheal intubation and decrease the use of sedative-analgesic drugs but also significantly reduce the incidence of ventilator associated pneumonia and in turn reduce the ICU stay and overall hospitalization expenses.

Our work is consistent with **Cannon *et al*.** [22]; they reported that pulmonary complications (mainly infection) are the most common during flail chest treatment. It had been reported that pulmonary infection is one of the main factors associated with longer time of mechanical ventilation and ICU stay, as well as with poor prognosis.

In the present study, the rate of pulmonary complications (infection) was significantly lower in the surgical group compared with the conservative group. This could be explained by the following: 1) early ventilator weaning could decrease the incidence of ventilator-associated pneumonia, and allows early ambulation, physical exercise therapy, and autonomous cough and expectoration, that lead to reduction of airway secretions accumulation, and prevent hypostatic pneumonia.

Althausen *et al*. [11] and **Slobogean *et al*.** [23] showed that the requirement for tracheostomy and endotracheal re-intubation could increase in patients needing long-term mechanical ventilation or for patients with weaning difficulties. Therefore, since surgical intervention for flail chest is associated with shorter mechanical ventilation, surgery should decrease the need for tracheostomy and endotracheal re-intubation.

In the present work, no significant differences in APACHE II score were found between the 2 groups at admission and one week postadmission. On the other hand, the scores were statistically difference (lower in the surgical treatment group) at 14 days after admission between the two groups. As the mean time between trauma and surgery was about one week in the present study, these findings could further confirm that surgical treatment could lead to better outcomes when compared to the conservative methods. The improvement of the overall condition could also directly reduce the treatment cost (due to reduction of total days in both hospital and ICU). Similar results were found by **Bhatnagar *et al*.** [24]; who also reported that although additional costs were needed for surgical treatments, the overall hospitalization expenses could still be lower than the expenses for the patients in the conservative group.

Our work revealed that the time of ICU stay was significantly shorter in the surgical group compared with the conservative group, which was in accordance with our results about shorter ventilation time, lower incidence of pulmonary infection, and better overall condition improvement in the surgical group compared with the conservative group. **Leinicke *et al*.** [21] also demonstrated that surgical treatment could shorten the ICU stay by about 3.4 days compared with a conservative treatment.

On the other hand, **Farquhar *et al*.** [3] reported that days on a ventilator, ICU length of stay and hospital length of stay, and rate of pneumonia were all significantly lower in conservatively managed patients than in surgical patients. This can be explained; their prospective work with use of comprehensive conservative methods that would not introduced in the present work during the time of patient management. These results elevate the need for revision of new conservative modalities of treatment and future evaluation in a prospective study.

CONCLUSION

Surgical internal fixation was found to be a good treatment approach for flail chest, providing early stabilization of the loose thoracic wall, correction of paradoxical breathing, reduction of mechanical ventilation and ICU stay, decreasing the possibility of pulmonary complications, prevent residual thoracic deformities, and decreased development of chronic pain.

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Table (1): Baseline data of the studied flail chest patient's characteristics

Variables		The studied cases (n=71) Surgical (n=33)	Conservative (n=38)	Total (n=71) n (%)	t-test* χ^2-test	P-value
Sex	Male: n (%)	22 (66.7%)	23 (60.5%)	45 (63.4%)	0.28	0.59
	Female: n (%)	11 (33.3%)	15 (39.5%)	26 (36.6%)		
Age (M±SD and range) (year)		44.39±8.15; 25-55	46.50±5.98; 31-55	45.52±7.10	1.25*	0.21
No. of fractured ribs (M±SD & range)		6.42±1.17; 5-9	6.76±1.02; 4-8	6.60±1.10	1.29*	0.19
Type of flail chest	Anterolateral: n (%)	9 (27.3%)	10 (26.3%)	19 (26.8%)		
	Posterolateral: n (%)	24 (72.7%)	28 (73.7%)	52 (73.2%)	0.008	0.92
Cause of injury	Motorcar accident: n (%)	27 (81.8%)	28 (73.7%)	55 (77.5%)		
	Fall from height: n (%)	5 (15.2%)	8 (21.1%)	13 (18.3%)		
	Crush injury: n (%)	1 (3.0%)	2 (5.3%)	3 (4.2%)	0.69	0.71
Laterality of fracture	Unilateral: n (%)	31 (93.9%)	36 (94.7%)	67 (94.4%)		
	Bilateral: n (%)	2 (6.1%)	2 (5.3%)	4 (5.6%)	0.02	0.88
ISS score at admission (M±SD, range)		22.0±2.48;17-26	22.92±2.35;19-26	22.49±2.44	1.60*	0.11
Admission APACHI II score (M±SD, range)		14.63±2.44;10-20	14.39±2.02;11-18	14.50±2.21	0.45*	0.56

Table (2): Associated injuries (comorbidities) in the studied flail chest patients

Variables		The studied cases (n=71) Surgical (n=33) n (%)	Conservative (n=38) n (%)	Total (n=71) n (%)	χ^2-test	P-value
Associated comorbidity	Splenic rupture	1 (3.0%)	0 (0.0%)	1 (1.4%)	1.16	0.28
	Subarachnoid Hge	1 (3.0%)	0 (0.0%)	1 (1.4%)	1.16	0.28
	Sternal fracture	1 (3.0%)	0 (0.0%)	1 (1.4%)	1.16	0.28
	Pneumothorax	10 (30.3%)	15 (39.5%)	25 (35.2%)	0.65	0.42
	Pulmonary laceration	3 (9.1%)	0 (0.0%)	3 (4.2%)	3.60	0.09
	Limb fracture	8 (24.2%)	10 (26.3%)	18 (25.4%)	0.04	0.84
	Pelvic fracture	4 (12.1%)	6 (15.8%)	10 (14.1%)	0.19	0.65
	Clavicle fracture	8 (24.2%)	5 (13.2%)	13 (18.3%)	1.45	0.22
	Myocardial injury	1 (3.0%)	0 (0.0%)	1 (1.4%)	1.16	0.28
	Mediastinal emphysema	3 (9.1%)	3 (7.9%)	6 (8.5%)	0.03	0.85
	Shock	4 (12.1%)	6 (15.8%)	10 (14.1%)	0.19	0.65
	Tracheal rupture	1 (3.0%)	1 (2.6%)	2 (2.8%)	0.010	0.91

Table (3): Outcome in the studied flail chest patients

Variables		The studied cases (n=71) Surgical (n=33)	Conservative (n=38)	Total (n=71)	t-test* χ^2	P-value
APACHE II after 1 week (M± SD)		11.42±2.06	11.15±1.30	11.28±1.68	0.66	0.51
APACHE II after 2 weeks (M± SD)		7.48±1.17	9.36±1.02	8.49±1.44	7.21	<0.001#
Postoperative FEV1 (M± SD, range)		1.62±0.06; 1.5-1.72	1.41±0.02; 1.38-1.72	1.50±0.11	19.24*	<0.001#
MV time (days) (M± SD, range)		5.25±1.76; 3-9	11.81±2.57; 8-17	9.79±3.85	8.01*	<0.001#
ICU stay (days) (M± SD, range)		6.12±1.55;4-10	13.86±2.40;9-18	10.26±4.39	15.83*	<0.001#
Respiratory complications: n (%)		10(30.3%)	28 (73.7%)	38 (53.5%)	13.36	<0.001#
Chest deformity: n (%)		0 (0.0%)	13 (34.2%)	13 (18.3%)	13.82	<0.001#
Postoperative Evaluation after 6 months: n (%)	Usual activities	6 (18.2%)	6 (15.8%)	12 (16.9%)	0.07	0.78
	Chronic pain	4 (21.1%)	14 (36.8%)	18 (25.4%)	5.70	0.017#
	Return to job	15 (45.5%)	13 (34.2%)	28 (39.4%)	0.93	0.33

= Statistically significant difference