MANAGEMENT OF FLAIL CHEST INJURY: INTERNAL FIXATION VERSUS ENDOTRACHEAL INTUBATION AND VENTILATION

A total of 427 patients with major chest trauma were treated in two major hospitals in Abu Dhabi, United Arab Emirates, during a 10-year period. In 64 of 426 patients, flail chest injury was the dominant factor among other injuries that were insignificant. Among 64 cases of flail chest injury, 26 were managed by internal fixation of ribs, whereas the remaining 38 were managed by endotracheal intubation and intermittent positive-pressure ventilation alone. Of the patients treated by internal fixation 80% (21/26) were weaned from the ventilator within an average of 1.3 days, whereas the remaining 20% (5/26) continued to need assisted ventilation for a longer duration; the total average duration of assisted ventilation for the whole group was 3.9 days. In comparison, among 38 patients with flail chest injury treated by endotracheal intubation and ventilation alone, the average duration of assisted ventilation was 15 days. In the group treated by internal fixation 11% (3/26) of the patients ultimately required a tracheostomy, whereas in the patients treated by intubation and ventilation alone tracheostomy was required in 37% (14/38) of the cases. In the group treated by internal fixation, chest infection was documented in 15% (4/26), septicemia in 4% (1/26), and barotrauma in 0%; in the other group these complications occurred in 50% (19/38), 24% (9/38), and 8% (3/38) of the cases, respectively. The mortality rate was 8% (2/26) in the surgically treated patients, whereas it was 29% (11/38) in the other group. All the deaths in both groups were ascribed to adult respiratory distress syndrome. Average stay in the intensive care unit was 9 days for the patients treated by internal fixation, whereas it was 21 days in the group treated by intubation and ventilation alone. The treatment of flail chest injury in our series by internal fixation resulted in speedy recovery, decreased complications, and better ultimate cosmetic and functional results and proved to be cost effective. (J THORAC CARDIOVASC SURG 1995;110:1676-80)

Zahoor Ahmed, FRCS, FICS, FACA, and
Zahoor Mohyuddin, FRCS, FACS, FICS, FICA,
Abu Dhabi, United Arab Emirates

In the United Arab Emirates the majority of the population belong to the working class and thus chest trauma, by increased morbidity and time lost from work, contributes significantly toward economic loss. Analysis of the various causes of chest trauma showed that motor vehicle accidents and falls related to construction work have been the

major reasons for an increased prevalence of flail chest injury. A motor vehicle accident was responsible for 82% and accidental fall was responsible for 12% of the injuries in our series.

This study describes the cases of patients with flail chest injury who underwent one of two different regimens of treatment. One group underwent internal fixation of the ribs whereas the other group was treated by intubation and ventilation alone. The merits of the two methods of treatment are retrospectively compared.

Patients and methods

During a 10-year period 427 patients with major chest trauma were treated in the Central and Mafraq Hospitals in Abu Dhabi, United Arab Emirates. Of these 427

From the Departments of Thoracic and Vascular Surgery,
Mafraq Hospital, Abu Dhabi, United Arab Emirates.

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Address for reprints: Zahoor Ahmed, FRCS, FICS, FACA, P.O.
Box 28233, Abu Dhabi, United Arab Emirates.

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Fig. 1. Age and sex distribution of patients with flail chest injury.

patients 93 (22%) had flail chest injury but only 64 of these were included in this study because the remaining 29 patients had an associated injury of another system that dominated the outcome. Of the 64 patients included in the study 26 underwent internal fixation of the ribs and 38 were treated by intubation and ventilation alone.

On admission to the intensive care unit (ICU) all the patients received a general, clinical, radiologic, and laboratory assessment. Of particular interest was arterial blood gas analysis while the patient breathed room air and received 35% oxygen by mask.

In both groups of patients there was representation from all age groups between the ages of 20 and 60 years, but the majority were young (Fig. 1).

The flail segments were obvious. The number of ribs broken in each patient ranged between 5 and 8. Four patients from the surgically treated group and nine from the ventilated group had anterolateral flail segments, and in 22 from the surgically treated group and 29 from the ventilated group the location was posterolateral.

The nondominant associated injuries were similar in the two groups (Table I). Arterial blood gas analysis when the patient was receiving 35% oxygen by mask was indicative of respiratory acidosis in 29 patients with carbon dioxide tensions in the range of 52 to 65 mm Hg; in the remaining 35 patients the values were less than 45 mm Hg. Oxygen tensions, however, were less than 60 mm Hg in all patients. All the patients were intubated and supported by a respirator. Inspired oxygen fraction and positive end-expiratory pressure (PEEP) were adjusted so that oxygen saturation of 95% could be achieved along with a carbon dioxide tension of less than 45 mm Hg.

Bilateral prophylactic intercostal drains were inserted in 16 patients who needed a PEEP of more than 10 mm Hg to prevent occurrence of tension pneumothorax resulting from barotrauma caused by high PEEP.

In the patients in the surgically treated group the primary reasons for operative intervention were hemotho-

Fig. 2. Chest x-ray film showing pinned fractured ribs.

Table I. Associated injuries in patients with flail chest

Type of injuries	Intubation ventilation (n = 38)	Internal fixation (n = 26)
Brain concussion	19	15
Clavicle fractures	5	9
Colles' fractures	1	3
Scapula fractures	7	3
Lumbar TP fractures	0	1
Acromial dislocation	0	1
Pubic rami fractures	5	2
Skull fractures	1	1
Femur fractures	1	2
Tibia fractures	1	0
Splenic rupture	0	2

TP, Transverse process.

rax in 10 patients, major air leak in 6 patients, and gross chest wall deformity in 6 patients. In 4 patients who were operated on for associated orthopedic or abdominal injuries the opportunity was availed to stabilize the chest wall as well.

Internal fixation of ribs was done within 12 to 48 hours after admission to the ICU. All the easily accessible noncomminuted fractured ribs were pinned by Kirschner wires. Each wire was passed through the cortex into the medulla 3 to 4 cm from the fracture site and driven across into the other fragment (Fig. 2). In case of costal cartilages particular care was taken because the excessive force used in pinning may lead to their splitting. Of the two fracture sites in a rib, only one was fixed; the idea was to convert the flail segment into a simple rib fracture to overcome the paradoxical movement of the chest wall during the respiratory cycle.

Fig. 3. Comparison of cost effectiveness with two different methods of treatment in flail chest injury.

Results

Although this is a retrospective study, the two groups matched in terms of age, sex, the severity of injury to the chest wall, and the nature of associated injuries.

One important criterion of assessment was the duration of assisted ventilation required in each group and thus the need to stay in the ICU. Patients from the ventilated group required the use of a ventilator for an average of 15 days and the ICU stay averaged 21 days. Against this, patients from the surgically treated group received assisted ventilation for an average of 3.9 days and stayed in the ICU for an average of 9 days. In fact, 21 of the 26 patients from the surgically treated group were weaned from the ventilator in an average of 1.3 days, but the remaining 5 patients needed longer ventilatory support, which caused the average duration to be 3.9 days (Fig. 3). The criteria applied in our hospitals for the discharge of these patients from the ICU are achievement of hemodynamic stability and maintenance of satisfactory spontaneous breathing with oxygen tensions about 80 mm Hg with the patient breathing room air.

Infection was a major problem in patients from the ventilated group. Chest infection occurred in 50% (19/38) of these patients and septicemia with its features of pyrexia and positive blood culture results occurred in 24% (9/38) of the patients. The prevalences of chest infection and septicemia were much lower in the surgically treated group (15% [4/26] and 4% [1/26], respectively). The prevalence of infection in the two groups was related to the

duration of ventilator support required by each group.

Tracheostomy was required in 37% (14/38) of patients in the ventilated group whereas only 11% (3/26) of the patients in the surgically treated group required this procedure. Pneumothorax caused by barotrauma occurred in 8% (3/38) of the patients in the ventilated group because of the need for a higher PEEP to attain adequate ventilation, whereas no patient from the surgically treated group had this complication. The final outcome was much worse in the ventilated group, in which the mortality rate was 29% (11/38) as compared with 8% (2/26) in patients in the surgically treated group (Fig. 4).

Because of a highly mobile population the length of follow-up was limited. The surviving patients could be followed up for a period of 3 to 9 months only. Because no patient had preinjury pulmonary function values available for comparison, the respiratory status was assessed by asking the patient to comment on his or her postinjury respiratory status as compared with the preinjury level. Three patients from the ventilated group and two patients from the surgically treated group had some limitation of respiratory function. All five patients belonged to the older age group and the decline in respiratory function may be related to age rather than the method of treatment.

Severe chest wall deformity was present in 6 patients and a moderate deformity in 4 patients from the ventilated group and in 17 patients the chest wall was normal. In the surgically treated group there was minimal deformity in 3 of the 24

Fig. 4. Comparison of morbidity and mortality in two groups of patients with flail chest injury.

surviving patients. In one patient the Kirschner wire migrated and its tip became palpable under the skin. The wire was pulled out with the use of local anesthesia.

Discussion

Respiratory insufficiency is the most serious physiologic disturbance after chest trauma. Early respiratory support in a patient with such an injury is concerned primarily with maintenance of adequate ventilation, tissue oxygenation, and removal of enough carbon dioxide to maintain a normal pH value.¹⁻³ In flail chest injuries the paradoxical movements and the pain originating from the movements of spiky fractured ribs result in shallow tidal volumes, which may lead to collapse of alveoli, arteriovenous shunting, and hypoxemia, and this continues as long as the causative factors remain operative. The problem is exacerbated by accompanying shock, which interferes with oxygen delivery. Thus patients with flail chest injury, who are unable to breathe adequately on their own, are potential candidates for assisted ventilation.

With the advent of endotracheal tubes with low-

pressure cuffs the trend toward the management of flail chest injury by intermittent positive-pressure ventilation has been further strengthened. However, the prolonged ventilatory support required in these cases has several drawbacks. The fractured ribs need time to become stable and ventilatory support required for long periods is costly and fraught with complications.⁴⁻⁶

The findings in our retrospective study indicate that patients who had internal fixation of flail chest required ventilation for a short duration as compared with the duration in those treated by ventilation alone. This crucial factor influences all parameters, complications, and mortality of patients with this injury.

Fractured ribs treated conservatively undergo progressive displacement during the healing phase, which results in considerable deformity, volume loss, and atelectasis. Thomas and associates⁷ and Moore⁸ have independently reported that progressive chest wall collapse leading to ventilatory insufficiency is particularly common with posterolateral flail injuries. Endotracheal intubation and ventilation may not be able to prevent rib cage distortion. Early

reduction and fixation of the ribs restores the chest wall integrity and forestalls the development of permanently damaging sequelae.

Infection of the underlying contused lung, a common feature, floods the bronchial tree with thick secretions. Their clearance can be best achieved by active initiative in the form of coughing by the patient, and this is neither possible while the patient is supported by the ventilator nor effective with an unstable chest wall in the absence of ventilator support. The frequent suctioning of the bronchial tree by catheters through the endotracheal tubes in patients receiving assisted ventilation, apart from being unsatisfactory, exacerbates the condition by damaging the fragile bronchial mucosa and precipitating the infective process.

Trinkle and associates⁴ treated their patients with flail injury either conservatively or by endotracheal intubation and ventilation. They achieved a mortality rate of 0% in the nonventilated group compared with 21% in the ventilated group. In the series by Dittman, Keller, and Wolff⁵ the average length of ICU stay was 9.8 and 4.5 days in the ventilated and nonventilated groups, respectively. It thus seems obvious that a technique that allows adequate oxygenation, carbon dioxide clearance, and normal blood pH values without ventilatory support will improve the outcome of patients with flail chest injury. The technique of internal fixation practiced by us offers an attractive method of treatment.

The reason for the unusually high prevalence of posterolateral flail injuries in our study is that the anterolateral injuries were found to be much more severe and most often involved vital mediastinal structures or the brain. Therefore the patients either did not survive long enough after reaching the hospital or else had an associated dominating injury of another system that played the pivotal role in the final outcome, and such patients were not included in the study. Anterolateral flail injuries result from

direct impacts in a head-on collision. The injury is central but usually worse on one side and involves sternum, costal cartilages, and anterior ribs. Posterolateral flail injuries are sustained when a person, as a reflex, tries to turn away from the oncoming force, which thus strikes the side of the body. The ribs are fractured anteriorly and in the vicinity of the posterior axillary line.

Because chest wall injury is not a parenchymal lung disease, restoration of normal chest wall contour will maintain the lung function.⁹ Further internal fixation offers the surgeon an opportunity to clear the pleural cavity of all clots and thus to produce full expansion of the lung and prevent the development of an empyema or dense pleural fibrosis.

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