Pneumatic stabilization of iatrogenic flail chest with CPAP: a case report

B. Dutta and L. Kashyap

Abstract: Iatrogenic flail chest following resection of part of the chest wall in postoperative patients is a challenging scenario for the anesthetist. It can lead to long term morbidity and even death, if adequate management is not instituted. We describe the management of postoperative flail chest, following resection of upper two-third of the sternum along with costal cartilages for a malignant thymoma invading the sternum in an adult male with the use of continuous epidural analgesia and continuous positive airway pressure (CPAP), which provided pneumatic stabilization and an excellent recovery.

Key words: Continuous Positive Airway Pressure; Flail chest; Continuous epidural analgesia.

INTRODUCTION

Flail chest usually occurs secondary to traumatic multiple rib or sternal fractures. However, surgical procedures where part of the chest wall is resected can also lead to flail chest and significant morbidity in the postoperative period. Patients with flail chest may develop acute respiratory failure; the traditional management being the use of positive pressure ventilation and prolonged mechanical ventilation to achieve internal pneumatic stabilization of the chest wall (5). Surgical stabilization has also been suggested for severe flail chest, but its use has been questioned due to complications (6). Newer methods of achieving pneumatic stabilization are gradually evolving over the last few years, including the use of mini-invasive (9) and noninvasive techniques (2). These methods of achieving pneumatic stabilization are reliable and hence, there has been a change in attitude and management practice over the years from the traditional invasive methods to the current minimally invasive techniques.

CASE REPORT

A 44 year old male patient, weighing 64 kg, presented with non-exertional chest pain for three and a half months and dyspnea on heavy exertion for one month. There was no other significant comorbidity and his vital parameters were within normal limits. Systemic examination revealed no abnormality. Biochemical investigations and electrocardiogram (ECG) were normal. However, his chest X-ray showed mediastinal widening and contrast enhanced computerized tomography (CECT) of the chest showed homogenous moderately enhancing mass in the anterior mediastinum with invasion of the manubrium sterni, suggestive of thymic carcinoma. Although CT guided biopsy was inconclusive, fine needle aspiration cytology (FNAC) showed malignant cells, suggestive of malignant thymoma. He was diagnosed with ‘malignant thymoma with invasion of the manubrium sterni’ and posted for ‘enbloc resection of upper two-third of sternum and costal cartilages with thymic tumour and chest wall reconstruction’.

Preinduction, epidural catheter was placed at T12-L1 interspace. Monitoring included pulse oximetry, non-invasive blood pressure, ECG, end-tidal CO₂, airway pressure, temperature, neuromuscular blockade, urine output, central venous pressure (CVP) and invasive blood pressure (IBP). A constant operation room temperature, warming blanket and warm intravenous fluids were used for maintenance of the patient’s body temperature. Analgesia was maintained with epidural morphine and bupivacaine (incremental dosing with 3 mg morphine and 12 cc of 0.25% bupivacaine) along with intravenous morphine and paracetamol suppositories.

The duration of surgery was 8 hrs. The surgeons performed enbloc resection of upper two-third of sternum & costal cartilages with thymic tumour (a chest wall defect of 14 cm x 5.5 cm),

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pericardiectomy, excision of the left phrenic nerve and chest wall reconstruction with marlex mesh, reinforced by bilateral pectoralis major advancement flap cover with primary skin closure (Fig. 1a, 1b). The patient lost 2.5 litres of blood, which was adequately replaced.

Following completion of the surgery, it was planned to electively ventilate the patient postoperatively in view of probable instability of the reconstructed chest wall. However, a trial of spontaneous ventilation was tried inside the OR, after reversal of residual neuromuscular blockade. But as soon as the patient was allowed to breathe spontaneously, the reconstructed chest wall started behaving as a flail segment, the patient became tachypneic and desaturated up to an SpO₂ of 89-91% on 100% oxygen (fraction of inspired oxygen (FiO₂) 1.0) along with an increased hemodynamic response. An arterial blood gas (ABG) analysis done at that moment showed a pH of 7.48, an oxygen tension (PaO₂) of 60 mmHg, and carbon dioxide tension (PaCO₂) of 38 mmHg. The patient was immediately sedated and shifted to the intensive care unit (ICU).

In the ICU, the patient was electively ventilated for 48 hours and then put on mask CPAP at 10 cm H₂O which was gradually tailed off to 5 cm of H₂O. As the flail segment started to stabilize, paradoxical motion became minimal. Bronchial hygiene therapy was also continued throughout the stay in the ICU, which included postural drainage with percussion and vibration, coughing and related expulsion techniques and, mobilization and exercise techniques (e.g. frequent turning of the patient, ambulation and exercise as tolerated). There was marked improvement in the patient’s respiratory status and the patient gradually started to breathe unaided. The CPAP ventilator support was initially discontinued for a few hours of the day, the duration of which was increased progressively. On ninth postoperative day, the CPAP support was permanently discontinued. On breathing room air, his ABG analysis showed a pH of 7.46, PaO₂ of 86 mm Hg and PaCO₂ of 41 mm Hg.

The patient was hemodynamically stable throughout his course in the ICU. Postoperative analgesia was maintained with epidural morphine infusion (5 µg/kg/hr) and intravenous paracetamol 1 g 6 hourly. 48 hours following the surgery enteral nutrition was started via Ryle’s tube at 25 Kcal/kg ideal body weight with supplementary vitamins and trace elements. Postoperative investigations were normal except for moderate leucocytosis (20,000/cc), which came down to normal by the eighth postoperative day. Subsequently, the patient was discharged without any complication 3 weeks after the surgery.

**DISCUSSION**

There are few reports on the surgical methods used for reconstruction after sternal resection (11). Marlex is a plastic mesh which does not cause trouble in the presence of infection. It is reported to be easy to handle and has a high affinity for tissues, but it may have a paradoxical chest wall motion because of the lack of rigidity when the defect is large. On the other hand, a metal plate can retain the rigidity and prevent a flail chest, but its affinity to tissue is insufficient and lung injury may occur. BRICCOLI et al. (3) reported that sternal reconstruction with Marlex mesh and a titanium plate after sternotomy resulted in satisfactory surgical treatment without a flail chest. NONAKA et al. (13) has
reported en-bloc resection of a thymic carcinoma which invaded the sternum, where the chest wall was reconstructed by wiring the ribs and double polypropylene mesh sheets were used to close the defect in the chest wall. The patient was extubated immediately after surgery without complications. Since the surgeons decided to use only marlex mesh in our case, development of postoperative flail chest seemed inevitable.

Our patient did not have any lung injury, which was a good prognostic factor, leading to early postoperative recovery. Surgery involved resection of the left phrenic nerve, which meant development of postoperative hemidiaphragmatic palsy of the left side. The functional effects of unilateral phrenic nerve paralysis are less striking than those of bilateral paralysis. An elevated hemidiaphragm compresses the hemithorax and results in a restrictive pattern of lung disease. In the seated position, the patient’s vital capacity and total lung capacity decrease by approximately 20%; in the supine position, vital capacity decreases by nearly 40% (4). Ventilation and perfusion of the lower lobe are also reduced on the affected side. Mismatching may widen the alveolar-arterial oxygen difference and produce mild hypoxemia (7). Generally, adults with healthy lungs tolerate these changes well; however, patients who are obese or have underlying lung disease are more likely to be symptomatic. Our patient did not have any underlying lung injury, and thus, tolerated it well.

Mild flail chest generally requires only supportive therapy. However, positive airway pressure, provided by positive pressure ventilation, CPAP or a combination of synchronous intermittent mandatory ventilation and PEEP is necessary in patients with severe flail chest in order to diminish the paradoxical movements. Avery et al. (1) in 1956 were the first to report treating flail chest with mechanical ventilation and Thomas et al. (17) in 1978 reported on treatment by surgical stabilization. In 1990, Freedland et al. (8) reported that surgical pneumatic stabilization induced complications such as pneumonia, atelectasis, adult respiratory distress syndrome, and sepsis in 47% of flail chest patients, with a consequent mortality rate of 11%. In 2001, Tanaka et al. (16) reported the effectiveness of mask-CAP therapy which revolutionized the management of flail chest. In 2005, Gunduz et al. (10) compared CPAP via a face mask and intermittent positive pressure ventilation via endotracheal intubation in 52 patients with flail chest who required mechanical ventilation and concluded that non-invasive CPAP led to lower mortality and a lower nosocomial infection rate, but similar oxygenation and length of ICU stay. It has also been observed that mechanical ventilation of more than 48 hours’ duration is the most important risk factor for ventilator related pneumonias. Pneumonia is also the commonest infection in patients with flail chest injury, and bronchial hygiene is an important factor in its prevention.

CPAP leads to positive pleural pressures and causes splinting of the airways (keeping it open with positive airway pressure), thereby decreasing chest wall distortion (18). This results in decreased work of breathing. The bronchioles and alveoli are prevented from collapsing at the end of expiration, thus increasing the Functional Residual Capacity (FRC) and improving ventilation/perfusion (or V/Q) mismatch. Bi-PAP is also an excellent non-invasive ventilatory method for flail chest patients. CPAP was used in this patient because of our earlier experience of its successful use in patients with chest wall reconstruction.

 Epidural analgesia with opioids has emerged as the analgesic technique of choice for postoperative thoracotomy pain management. Excellent pain control, less sedation compared to systemic opiates, avoidance of motor blockade, early ambulation with resultant decrease in deep vein thrombosis and improved respiratory function have long been documented as benefits of continuous epidural analgesia in high risk postoperative patients (15). We opted for epidural morphine infusion, which provided excellent postoperative analgesia and aided in chest physiotherapy and early ambulation.

Nutrition is one of the important aspects of postoperative care of high risk patients, which is usually overlooked by many physicians. We started early enteral nutrition as early enteral nutrition lessens the catabolic response to trauma and decreases the incidence of infection, possibly by enhancing mucosal barrier function and reducing bacterial translocation (12). Early enteral nutrition has also been reported (14) as an infection-reducing factor even when administered below the daily patient requirements. Enteral nutrition was also favoured instead of oral nutrition, to allow continuous CPAP.

In conclusion, ventilatory support with analgesia and chest physiotherapy should be the preferred initial strategy for flail chest patients, supplemented with early enteral nutrition in postoperative high risk patients. CPAP provides adequate support to the chest wall, decreasing the work of breathing, improving oxygenation and thereby leading to early recovery.
References


