Noninvasive lung recruitment maneuver prevents reintubation and reduces ICU stay

Sir,

Postoperative pulmonary complications after general anesthesia (GA) are common. One of the common causes of postoperative pulmonary complications can be atelectasis. Significant atelectasis can cause ventilation/perfusion mismatch and consequent hypoxemia. Unresolved or neglected collapse can lead to pneumonia.[1]

We report a case of a 10-year-old girl weighing 20 kg, with kyphoscoliosis of the dorsal spine and neurenteric cyst on the right side of thorax. The cyst was excised using standard technique for one-lung ventilation with a bronchial blocker. Manual expansion of the right lung was done at the end of surgery. Postoperative elective ventilation was planned and a single-lumen endotracheal tube (ETT) was inserted. Bilaterally equal air entry was confirmed and ETT was secured. The patient was transferred to intensive care unit (ICU) for further management. In the ICU, decreased breath sounds were noted on the left side and the ETT was pulled out by 1.5 cm, resulting in an improvement in chest expansion. The patient was weaned off from ventilatory support after 12 h of elective ventilation after surgery. Eight hours after extubation, there was inability to maintain oxygen saturation with fraction of inspired oxygen (FiO_2) of 0.5 with a venturi mask. With time the FiO_2 requirement kept increasing along with clinical deterioration [partial pressure of arterial oxygen (PaO_2) 70, partial pressure of arterial carbon dioxide ($PaCO_2$) 60, pH 7.31, FiO_2 0.9]. Increasing levels of dyspnea and hypoxia even with FiO_2 1.0 [PaO_2 60, $PaCO_2$ 73, pH 7.13, respiratory rate (RR) 38 bpm] ensued. Clinical examination revealed decreased air entry in the left hemithorax with concurrent hypotension. A hyperresonant note was found on percussion of the left hemithorax. Needle aspiration confirmed the presence of pneumothorax. Intercostal drain (ICD) was inserted. A gush of air came out under the water seal and X-ray revealed a massive left-sided lung collapse with minimal air in the pleural cavity [Figure 1: collapsed lung (LT) with ICD *in situ*]. The patient's clinical condition improved immediately and the FiO_2 requirement went down to 0.5. The following day the patient again developed hypoxia, fatigue and inability to perform incentive spirometry even with adequate pain relief. Recruitment of the collapsed lung with noninvasive high continuous positive airway pressure (CPAP) recruitment manuever (RM) was used. A noninvasive CPAP mask was applied on the face and airway pressure was sequentially increased by 5 cm H_2O up to a maximum of 30 cm H_2O for 30 s and then set at 5 cm H_2O CPAP for 2 h. The procedure was done under electrocardiogram (ECG), peripheral capillary oxygen saturation (SpO_2), and invasive blood pressure (IBP) measurement. The RM was discontinued if the patient had discomfort, SpO_2 fell below 95%, or there was hemodynamic instability. After 2 h, patient was put on a venturi mask with FiO_2 0.5. The same procedure was followed every day for 5 days. Full expansion of the lung fields was achieved within 1 week [Figure 2]. On the first and second days, RM was done twice a day. From the third day onward, RM was done once followed by 2 h CPAP. Sequential X-rays revealed expansion of the collapsed lung [Figure 2: seventh day after RM] and improvement in gas exchange was seen (PaO_2 92, $PaCO_2$ 38, pH 7.34, FiO_2 0.35, fifth day). Subsequently, the patient did not require CPAP at all. She was discharged from the ICU on the seventh day.

Massive lung collapse may be congenital or acquired. Congenital collapse may be associated with neonatal hyaline membrane disease, laryngeal dysfunction, and obstruction of air passages. Acquired lung collapse may be due to compression or absorption of the alveoli. Thoracotomy itself is a very important cause of atelectasis. Lung collapse should be recognized and treated early. Management involves treating the underlying cause, positioning on the unaffected side to allow reexpansion, bronchoscopic removal of obstruction, provision of adequate pain relief, head-up positioning, deep breathing exercises, incentive spirometry, percussion to loosen out secretions and subsequent removal, tumor resection, postural and gravity-dependent drainage of secretions. Recruitment should be done as an early measure to avoid long-term ventilator dependence in such patients.

Pneumothorax is another common complication that may occur in the perioperative settings. It may be due to bullae rupture because of hyperventilation, barotrauma or volutrauma, undiagnosed one-lung ventilation due to endobronchial intubation with delivery of high tidal volume to the ventilated lung, etc. It can be diagnosed at bedside by percussion when a hyperresonant note is appreciated on the affected side. Mediastinal shift to the opposite side and hypotension may be associated with tension pneumothorax. Chest X-ray shows hyperinflated lung fields on the affected side. Needle aspiration on the affected side leads to release of the trapped air and results in dramatic improvement in the condition of the patient. Definitive management is by ICD insertion.

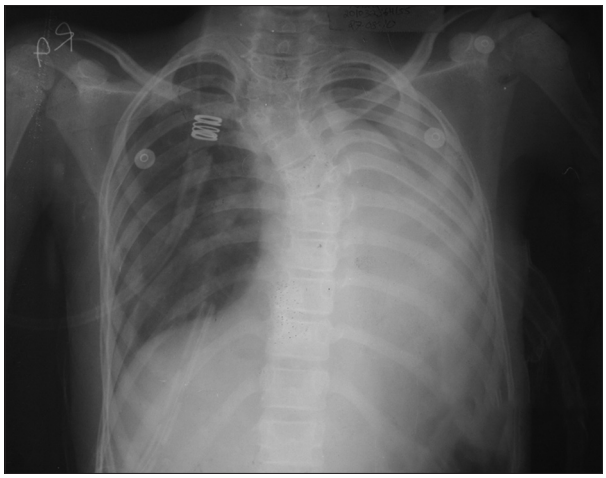

Figure 1: Collapsed lung (LT) with ICD *in situ*

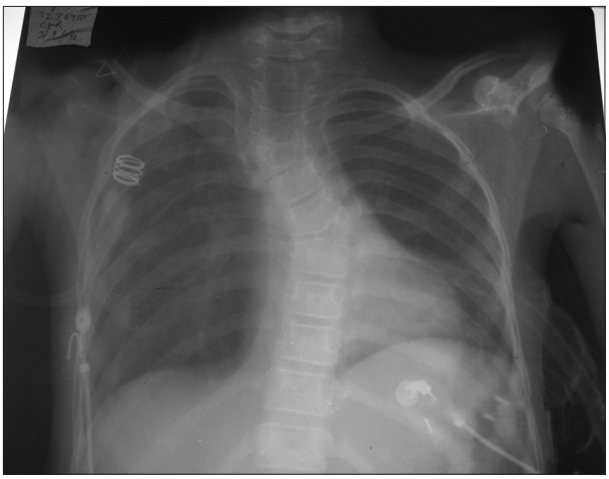

Figure 2: Seventh day after RM

Other causes of decreased air entry may be ruptured bulla, foreign body, tumor, tubercle, lymph node, pleural effusion, pneumothorax, surgical pleural tears, hemothorax, endobronchial intubation, bronchospasm, blockage of main bronchus, pulmonary embolism, inadequate pain relief after thoracotomy, high FiO_2 administration for prolonged duration leading to absorption atelectasis, laparotomies or laparoscopic surgery under GA (especially in morbidly obese patients), pneumonia and post-lung expansion pulmonary edema, etc.

In this case, there was no perioperative bronchospasm. Adequate analgesia was provided with epidural top-ups and intravenous paracetamol. The short period (30 min) of endobronchial intubation of the right side may have led to underventilation of the left lung, leading to collapse, which was corrected in time by withdrawing the ETT and reconfirming bilaterally equal air entry. This, however, does not explain the pneumothorax. A ruptured bulla of the left side may have led to the pneumothorax, which in turn may have caused underlying lung tissue collapse. Needle aspiration confirmed the diagnosis and ICD insertion led to the resolution of pneumothorax. However, underlying lung tissue did not expand merely by drainage of pneumothorax. The collapsed lung had to be reexpanded with RM.

RM including manual hyperinflation of lungs with 40 cm H_2O CPAP for 15 s followed by positive end-expiratory pressure (PEEP) 10 cm H_2O for 30 min and then 10 cm H_2O CPAP from the return of spontaneous breathing until extubation,[2] 40 cm H_2O CPAP over 30 s immediately after intubation, and then PEEP at 5 cm H_2O throughout,[3] sequential increments in inspiratory airway pressures in 5 cm H_2O steps until detection of PaO_2 + $PaCO_2$ > 400 mmHg,[4] using PEEP or high tidal volume (vital capacity maneuver),[5] and CPAP of 40 cm H_2O for 40 s[6] have been described in intubated patients.

Noninvasive RMs include deep breathing exercises with incentive spirometry, noninvasive CPAP and noninvasive positive-pressure ventilation [PPV: pressure support ventilation (PSV)+PEEP].[7] Randomized trials comparing either CPAP or PSV + PEEP to standard medical therapy have found similar results with both techniques in terms of improvement in arterial blood gas (ABG) and respiratory frequency.[8] RMs significantly reduce the need for ET intubation,[9] ICU stay, hospital mortality, and complication rate.[10,11]

In this patient, the noninvasive high CPAP RM was used. Its efficacy was evident on serial chest radiographs and ABG.

Previously, de Matos and colleagues have studied the effects of PEEP and RM under computed tomography (CT) guidance,[12] but here in this case, as the CT facility was not available, we monitored recruitment by keeping close watch on the clinical condition of the patient, ABG analysis, and serial chest X-rays.

To conclude, noninvasive RM application can go a long way in avoiding reintubation and associated complications of ventilatory support, and hence reducing the length of ICU stay and related morbidity. Early recognition and institution of appropriate strategy under efficient monitoring should be done. Close clinical condition monitoring and serial chest X-rays with ABG are reliable guides to monitor the recruitment if CT is not available.

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Conflicts of interest
There are no conflicts of interest.

Jai Prakash Sharma, Rashmi Salhotra[1], Surendra Kumar[2], Asha Tyagi[1], Ashok Kumar Sethi[1]

Departments of Anaesthesiology, All India Institute of Medical Sciences (AIIMS), Bhopal, Madhya Pradesh, [2]Delhi State Cancer Institute, [1]Department of Anaesthesiology and Critical Care, University College of Medical Sciences UCMS, Guru Teg Bahadur (GTB) Hospital, Delhi, India
E-mail: rashmichabra@yahoo.com

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