Swamy et al.
Ain-Shams Journal of Anesthesiology (2023) 15:61
https://doi.org/10.1186/s42077-023-00363-1

Ain-Shams Journal of Anesthesiology

CASE REPORT Open Access

Post-pneumonectomy surgery in prone position: a case report

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Abstract

Background Anesthesia in post-pneumonectomy patients is challenging as pneumonectomy is considered "a disease itself" with impaired oxygenation and ventilation. Literary data for prone ventilation in post-pneumonectomy patients is scarce.

Case presentation A 45-year-old female patient with a history of right-sided pneumonectomy 10 years ago with restrictive pulmonary disease underwent uneventful lumbar spine surgery under general anesthesia in the prone position. The lung-protective ventilation using the pressure control mode of ventilation was done.

Conclusions A good understanding of the physiology of the single lung and the concerns of prone ventilation, along with proper preoperative evaluation and optimization, are key to the successful management of such cases.

Keywords Post-pneumonectomy, Spine surgery, Prone ventilation, Lung protective ventilation, Case report

Background

Pneumonectomy (lung resection) is indicated for malignancy, trauma, and chronic conditions like tuberculosis and fungal infections (Doan et al. 2020). Post-pneumonectomy status is linked with various anatomical and physiological changes. Pulmonary disease is a known risk factor for peri-operative pulmonary complications. With increasing 5-year survival rates of more than 75% for benign disease and 40% for malignant disease, post-pneumonectomy patients are expected to undergo other surgical procedures during their lifetime (Sharma et al. 2020). About 45 to 55% of the pulmonary tissue is lost when one lung is completely removed (Öztürk et al. 2014). The post pneumonectomy state is associated with significantly reduced respiratory reserve and adaptations like mediastinal shift towards the side of pneumonectomy with compensatory hyperinflation of the remaining lung (Sharma et al. 2020).

Prone position is a necessity in accessing structures during surgery for spine, neck, etc. The prone position is associated with physiological changes as well as cardiovascular complications, including hypotension, improved ventilation, and endotracheal tube dislodgement (Kwee et al. 2015).

General anesthesia and prone ventilation in a post-pneumonectomy patient pose innumerable challenges in anesthetic management. We would like to present a case report of a post-pneumonectomy patient posted for lumbar spine surgery in the prone position under general anesthesia that was successfully managed in our institute.

Case presentation

A 45-year-old female patient with a history of degenerative disc disease at the L4–L5 level was planned for elective posterior decompression and pedicle screw fixation. The patient underwent a right-sided pneumonectomy and bronchoplasty through a posterolateral thoracotomy because of a fungal infection as a curative procedure 10 years ago.

On examination, the patient had a pulse rate of 80 beats per minute, blood pressure of 130/90 mmHg, and a surgical scar of 8 to 10 cm was present on the right

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posterolateral chest wall, room air oxygen saturation 99%, respiratory rate of 16 cycles per minute, and breath holding time of 20 s. Her weight was 87 kg and height 173 cm. On auscultation, normal vesicular breath sounds were heard with good air entry on the left hemithorax, and no breath sounds were audible on the right. Heart sounds were faint and shifted towards the right side.

Chest X-ray showed hyperinflated left lung with mediastinal shift towards the right side and complete opacification of the right hemithorax (Fig. 1). Preoperative arterial blood gas analysis on room air showed pH: 7.47, pCO_2: 36 mm Hg, pO_2: 91.2 mm Hg, SO_2: 97.2, and bicarbonate of 26.1 meq/l. The pulmonary function test (PFT) showed a forced vital capacity (FVC) of 1.88 L (57% of the predicted value), a forced expiratory flow in 1 s (FEV1) of 1.39 L (49% of the predicted value), and a FEV1/FVC ratio of 91% (Fig. 2). An echocardiogram suggested dextrocardia with no regional wall motion abnormality present at rest, mild tricuspid insufficiency, mildly raised pulmonary artery pressures (27 mm Hg), and left ventricular systolic function of 60% ejection fraction.

Chest physiotherapy and breathing exercises were started preoperatively. After taking a high-risk informed consent in view of the history of pneumonectomy and the challenges of ventilation in the prone position and standard fasting guidelines, the patient was taken up for surgery under general anesthesia.

		Pred	Pre	% Pred
FVC	[L]	3.30	1.88	57 %
FEV 1	[L]	2.86	1.39	49 %
FEV1%FVC	[%]	81.31	74.12	91 %
MEF 25	[L/s]	1.90	0.41	22 %
MEF 50	[L/s]	4.37	1.50	34 %
MEF 75	[L/s]	6.15	2.55	41 %
MEF 75-85	[L/s]	-	2.55	-
MMEF	[L/s]	3.69	1.10	30 %
PEF	[L/s]	7.18	2.57	36 %
PIF	[L/s]	-	3.32	-
FET	[sec]	-	7.22	-

Fig. 2 Pulmonary function test showing restrictive pattern

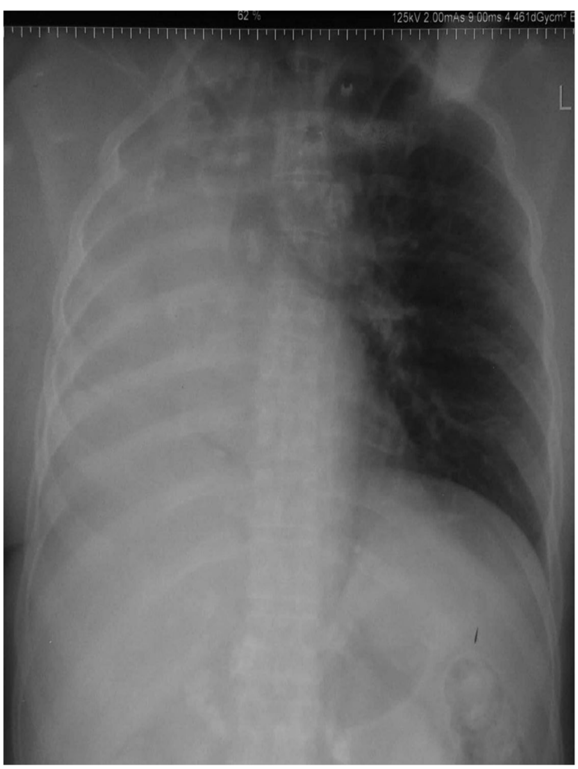

Fig. 1 Chest X-ray AP view showing hyperinflated left lung with mediastinal shift towards the right side and complete opacification of right hemithorax

Patient was wheeled into the operation theater and standard monitors were attached: electrocardiogram, non-invasive blood pressure, oxygen saturation, and temperature monitoring. Anesthesia was induced as per institute protocol and under direct laryngoscopy, a size 7.5 mm ID cuffed PVC oral endotracheal tube was passed easily into the trachea, with cuff placed just below the vocal cords, fixed at 18 cm at the right angle of the mouth. Lung protective ventilation (LPV) was commenced with pressure-controlled mode to achieve a target tidal volume of 5 to 6 ml/kg body weight, and the respiratory rate was maintained at a frequency of 16–18 to achieve an end-tidal carbon dioxide pressure between 35 and 40 mmHg. Peak, plateau, and positive end-expiratory pressures were 19, 18, and 5 cmH_2O, respectively, in the supine position.

After attaining adequate depth of anesthesia, the patient was made prone. The chest was auscultated to rule out airway obstruction, bronchospasm, and accidental extubation. There was a slight increase in airway pressures (peak, plateau, and positive end-expiratory pressures were 22, 21, and 5 cmH_2O, respectively) after proning the patient. Appropriate depth of anesthesia was maintained, hemodynamic parameters remained stable throughout and a restricted fluid regime was followed. The surgical duration was 4.5 h. Our goal of fluid administration was to maintain isobalance; we administered 2 ml/kg/h balanced salt solution (Ringer's Lactate) (720 ml) throughout the surgery, with urine output of about 1 ml/kg/h (350 ml) and a blood loss of 200 ml (well within maximum allowable blood loss).

For analgesia, Inj. paracetamol and local infiltration anesthesia was given, and the patient was made supine. The patient was extubated successfully by reversing neuromuscular blockade and was observed in a high-dependency unit overnight, transferred to the general ward the next day, and discharged on the third postoperative day in a stable condition. Chest physiotherapy and incentive spirometry was continued post operatively.

Discussion

Surgeries in patients with previous pneumonectomy have been reported, like laparoscopic cholecystectomy, hysterectomy, and cardiac surgeries. There is a paucity of data in the literature on the subject of spine surgery in prone position subsequent to a previous pneumonectomy.

Following pneumonectomy, air is injected into the postpneumonectomy space (PPS) (Doan et al. 2020; Sharma et al. 2020). Postoperatively, fluid from hemorrhage and lymphatics and passive transudation replenish the gas in the PPS. The gas resorption and replacement with serosanguinous fluid takes place with most of the gas getting resorbed within 6 months (Doan et al. 2020; Tsukada and Stark 1997). The heart and mediastinum deviate towards the side of the resected lung over time, rotating anticlockwise after left pneumonectomy and translocating after right pneumonectomy. The residual lung undergoes compensatory hyperinflation and herniates across the midline often. An elevated ipsilateral hemidiaphragm causes the liver or spleen to move cephalad (Sharma et al. 2020). In our patient, there was complete opacification of the right thorax with a mediastinal shift to the right. Although diaphragmatic paralysis causes significant decrease in respiratory function, hyperinflation of the residual lung largely compensates (Deslauriers et al. 2011).

Compensatory mechanisms lead to restrictive lung disease characterized by right ventricular overload, tricuspid valve insufficiency, and increased pulmonary artery pressures (Öztürk et al. 2014). Long-term effects after pneumonectomy include a 30% drop in FEV1 and FVC, seen more after right pneumonectomy than left (Sharma et al. 2020). The preoperative PFT in our patient showed restrictive pattern of breathing with decreased FVC (57%) and FEV1 (49%), with normal FEV1/FVC ratio (91%) (Fig. 2).

Post-pneumonectomy restrictive pulmonary disease is a risk factor for the development of acute lung injury (ALI). LPV prevents or reduces ALI. Our current knowledge supports the use of the following preventative measures: maintaining FiO2 as low as possible; routine use of positive-end expiratory pressure with smaller tidal volumes; using lower ventilatory pressures throughout the duration of pressure control ventilation; frequent recruitment maneuvers to prevent atelectasis; maintaining adequate depth of anesthesia; adequate analgesia; avoiding use of non-steroidal anti-inflammatory drugs; minimizing the duration of surgery; and gentle airway handling (intubation and extubation) (Öztürk et al. 2014; Kilpatrick and Slinger 2010). In post-pneumonectomy patients, proper hydration management is crucial. Pulmonary edema in the residual lung may result from excessive perioperative fluid infusions. Therefore, intraoperative fluid balance should be limited as much as possible to minimize the development of postoperative heart failure in post-pneumonectomy patients. Catheterization of the internal jugular vein poses particular dangers in post-pneumonectomy patients due to its aberrant course (Öztürk et al. 2014).

Ventilating the patient in prone position to facilitate the spine surgery is also a challenge. It causes a reduction in cardiac index, decrease in stroke volume with little change in heart rate, and hence, reduced left ventricular compliance (Edgcombe et al. 2008). Our patient, however, had no preexisting cardiac disease, so there was not any significant hypotension. Raised intra-abdominal pressure in prone position pushes blood from the inferior vena cava into the extradural venous plexus, causing increased blood loss and a poor surgical field (Edgcombe et al. 2008). The prone posture reduces pulmonary compliance by squeezing the abdomen and reducing chest wall mobility. A prone position should be provided with proper chest and pelvic support to avoid abdominal compression with adequate padding of all pressure points. Endotracheal tubes need to be properly fixed to prevent tube movement during prone positioning. Distal displacement of the tube may result in endobronchial intubation to the side of the bronchial stump (Kulkarni and Shetty 2021).

Conclusions

In conclusion, prone ventilation surgeries are feasible and can be safely performed in patients with a single lung. A successful anesthetic outcome depends on proper preoperative evaluation, optimization, careful intraoperative positioning, lung-protective ventilatory techniques, optimized fluid balance, and adequate analgesia. A clear understanding of the physiological changes of pneumonectomy and the prone position helped us administer safe anesthesia.

Abbreviations

ALI	Acute lung injury
FVC	Forced vital capacity
FEV1	Forced expiratory flow in 1st second
LPV	Lung protective ventilation
PPS	Postpneumonectomy space
PFT	Pulmonary function test

Acknowledgements
Not applicable.

Authors' contributions
VS: conception, design of the work, interpretation of data, drafted the work. PN: conception, drafted the work, interpretation of data. BK: conception, design of the work, drafted the work, substantively revised. NA: interpretation of data, substantively revised. All authors have read and approved the manuscript.

Funding
Not applicable.

Availability of data and materials
Not applicable.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Competing interests
The authors declare that they have no competing interests.

Received: 9 March 2023 Accepted: 3 August 2023
Published online: 16 August 2023

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