J Anesth (2008) 22:317–321
DOI 10.1007/s00540-008-0638-y

Journal of Anesthesia



# Double-lumen tube for ventilation in severe kyphoscoliosis

Pankaj Kundra[1], Anita Joseph[1], Senthil Kumar[1], and B. V. Sai Chandran[2]

[1] Department of Anaesthesiology and Critical Care, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry 605006, India
[2] Department of Cardiothoracic Surgery, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry, India

**Abstract**
The presence of kyphoscoliosis can adversely affect gas exchange because of restriction to gas flow and reduction of lung volume. The effects become more exaggerated during positive-pressure ventilation due to the uneven distribution of ventilation. The use of a double-lumen tube helps to reduce the ventilation perfusion mismatch that occurs because of positive-pressure ventilation. We report a patient with severe kyphoscoliosis who underwent repair of an atrial septal defect, in whom a double-lumen tube was used for ventilation and the conduct of general anesthesia.

**Key words** Kyphoscoliosis · Intermittent positive-pressure ventilation

## Introduction

The institution of positive-pressure ventilation (PPV) in the setting of unilateral lung disease can lead to unique problems [1–3]. When the difference in airway resistance or lung compliance between the two lungs is exaggerated, conventional PPV may lead to preferential ventilation, with the hyperexpansion of one lung and gradual collapse of the other [3]. This ventilation perfusion (V/Q) mismatch between the lungs during PPV can be overcome by directing more gas flow towards the diseased lung, with the help of a double-lumen tube.

## Case report

A 13-year-old girl with severe kyphoscoliosis was scheduled for the repair of an atrial septal defect under cardiopulmonary bypass. She was well nourished (weight, 37 kg; height, 145 cm). Physical examination revealed decreased air entry over the right hemithorax. The spine had convexity to the right. Apical impulse was palpable in the fifth intercostal space (midclavicular line). On auscultation, a grade 3 ejection systolic murmur was heard in the pulmonary area and there was a fixed wide split of the second heart sound. Hematological and biochemical parameters were within normal ranges. Chest radiograph showed severe right-sided scoliosis (U—shaped) with 80° Cobb's angle. Electrocardiogram revealed right bundle branch block. On echocardiography, a 17-mm ostium secundum defect with a large left-to-right shunt was detected, but the pulmonary venous drainage was normal and there was no evidence of pulmonary artery hypertension. Pulmonary function tests (PFTs) confirmed the presence of severely restricted pulmonary disease (Table 1). Arterial blood gas analysis in room air showed a $Pa_{O_2}$ of 60.7 mmHg, $Pa_{CO_2}$ of 36.9 mmHg, and pH of 7.45. The patient was administered 7.5 mg diazepam orally the night before surgery, and 7.5 mg morphine intramuscularly 60 min prior to the surgery.

On the patient's arrival in the operating room, the baseline parameters displayed arterial hemoglobin saturation on pulse oximetry ($Sp_{O_2}$) of 96% in room air, heart rate of 88 beats·min$^{-1}$, and noninvasive blood pressure of 104/70 mmHg, while her respiratory rate was 22 breaths·min$^{-1}$. Peripheral intravenous access was obtained and anesthesia was induced with fentanyl (50 µg), midazolam (2 mg), and thiopentone (125 mg). After the administration of suxamethonium (75 mg) manual bag-and-mask ventilation was started with 100% oxygen through a circle system, when the $Sp_{O_2}$ started falling, from 100% to 88%, despite satisfactory lung expansion and rapid refilling of the reservoir bag. No improvement was observed in $Sp_{O_2}$ until 3 min later, when the patient started breathing spontaneously after recovery from neuromuscular block. Tracheal intuba-

*Address correspondence to*: P. Kundra, D-II/21, JIPMER Campus, Pondicherry 605006, India
Received: January 9, 2008 / Accepted: April 16, 2008

**Table 1.** Pulmonary function tests

| Parameter | Predicted (l) | Actual (l) | Percent predicted |
|---|---|---|---|
| On admission | | | |
| Forced vital capacity (FVC) | 2.39 | 1.2 | 50 |
| Forced expiratory volume ($FEV_1$) | 2.05 | 0.98 | 48 |
| $FEV_1$/FVC | 86 | 82 | 95 |
| Peak expiratory flow (PEF) | 4.82 | 2.95 | 61 |
| After spirometry (3 weeks) | | | |
| Forced vital capacity (FVC) | 2.39 | 1.4 | 59 |
| Forced expiratory volume ($FEV_1$) | 2.05 | 1.17 | 57 |
| $FEV_1$/FVC | 86 | 83 | 97 |
| Peak expiratory flow (PEF) | 4.82 | 3.16 | 65 |

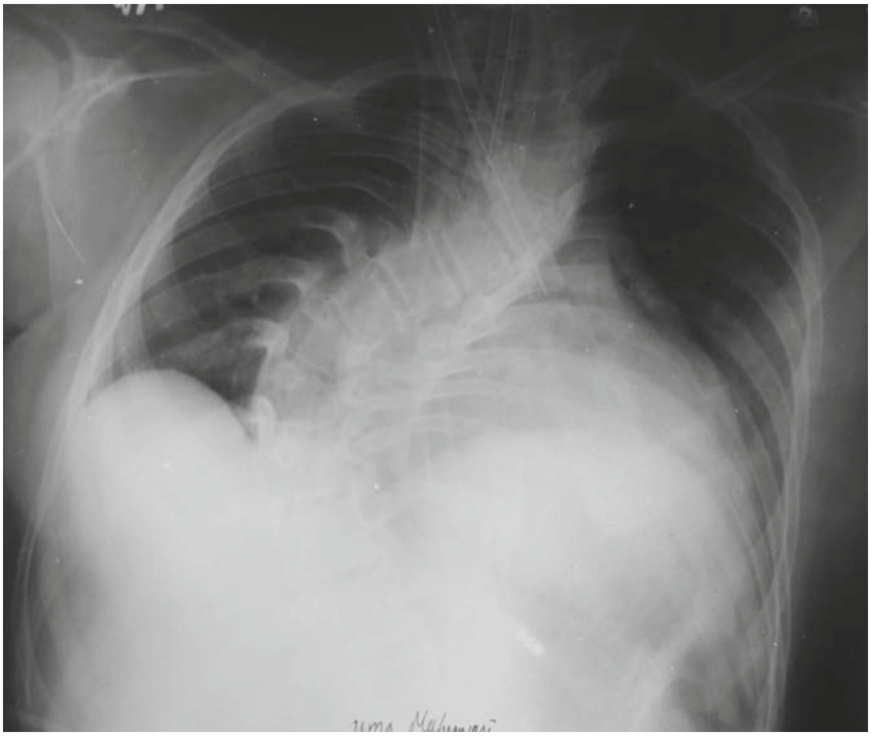

**Fig. 1.** Postoperative chest X-Ray (postero-anterior [PA] view) with trachea intubated shows severe right-sided scoliosis (Cobb's angle, 80°). The lower part of the trachea deviates to the right, with a wide carinal angle. The cardiothoracic ratio is 0.6, and the lung fields appear clear

tion was not attempted and the patient was allowed to wake up, as the $Sp_{O_2}$ improved back to 96% in room air. In view of the V/Q mismatch that worsened with PPV, the surgery was postponed to allow for a thorough workup and for the authors to think of a better strategy for ventilatory management. Chest computed tomography (CT) scan revealed a gross reduction of volume in the right lower lobe, and the patient was prescribed volume-oriented incentive spirometry for 3 weeks.

The patient was admitted a second time and lung isolation was achieved with a 35-French disposable polyvinylchloride (Rusch; Teleflex Medical Instruments, Limerick, PA, USA) left-sided double-lumen tube (DLT), with the help of a fiberoptic bronchoscope, following 5 min of preoxygenation (Fig. 1). The induction technique was similar to that used earlier. A slight difficulty was encountered in inserting the DLT into the left bronchus, as the carinal angle was widened and it took two attempts (4 min) to correctly position the DLT. The lowest $Sp_{O_2}$ recorded during the intubation process was 88%, and it improved to 97% after the institution of PPV through the DLT. An anesthesia ventilator (Ohmeda 7000; GE healthcare, Madison, WI, USA) was set to deliver 370 ml tidal volume at a frequency of 12 breaths·min$^{-1}$ and an I:E ratio of 1:2. A second ventilator was kept ready to initiate differential lung ventilation (DLV) if the $Sp_{O_2}$ continued to fall after the initiation of ventilation through the DLT. However, the peak airway pressure was maintained at 20 $cmH_2O$ and no further episodes of desaturation were noticed during the entire course of surgery. Anesthesia was maintained with 0.4%–1% isoflurane and 66% nitrous oxide in 33% oxygen through a circle system. Vecuronium bromide and morphine were administered in incremental doses to achieve muscle relaxation and analgesia, respectively, during the course of the surgery. Pericardial patch closure was accomplished under cardiopulmonary bypass, and weaning off the bypass was uneventful. An uneventful extubation was achieved after 12 h of postoperative ventilation, and the patient was transferred to the general ward.

## Discussion

Severe kyphoscoliosis is associated with respiratory complications, often leading to respiratory failure. The progressive nature of the disease limits vital capacity and chest wall compliance, resulting in a combination of both restrictive and obstructive pulmonary disease [4]. The reduced vital capacity and the severity of the scoliosis are the most important predictive factors in the prognosis [5]. The amount of lung that is compressed and squeezed in a compromised small space depends upon the severity of extrinsic restriction imposed by the disease. Expansion in these restricted zones of the lungs is maintained with the help of negative intrapleural pressure during spontaneous breathing, but the institution of PPV offsets the effect of intrapleural pressure on lung expansion and the gas flow preferentially follows the path of least resistance, so a disproportionately large percentage of the tidal volume will be delivered to the compliant lung. Likewise, PPV will also have the greatest change in functional residual capacity (FRC) with positive end-expiratory pressure (PEEP) application [6,7]. Hyperinflation of the more compliant lung compresses intraalveolar capillaries, decreasing perfusion in the compliant lung and simultaneously increasing perfusion to the poorly ventilated injured lung. The cumulative result of these derangements is increased alveolar V/Q mismatching, worsening of gas exchange, and, in severe cases, hemodynamic instability, and barotraumas [6,8]. This seems to be the reason why our patient developed desaturation after bag-and-mask ventilation was started, despite satisfactory lung expansion and rapid refilling of the reservoir bag. Therefore, it may be prudent to use a short-acting muscle relaxant, such as suxamethonium, to minimize the time of PPV through bag-and-mask ventilation before DLT placement.

Improvement in oxygenation following ventilation via a DLT can be a result of more air entering and, hence, the gradual recruitment of the alveoli on the right side. At times, the placement of a DLT can open up an existing stenotic segment or correct the bronchial torsion due to severe kyphoscoliosis and improve oxygenation [4]. In our patient, the lumens of both the major bronchi were nearly at right angles to the trachea when visualized through the fiberoptic bronchoscope during DLT placement, giving the carinal angle a widened appearance. It is likely that the channel for ventilation to the healthy side (left side) was compromised due to partial kinking of the bronchial limb of the DLT after its placement across the carina, because the carinal angle was widened. Secondly, the small diameter of the DLT may have contributed toward an increase in resistance to expiration and this may have contributed significantly toward intrinsic PEEP. Simple methods that can modify the DLT lumen, such as partial clamping of the lumen or the application of a Y—connector of different diameter [9] can be tried to correct V/Q mismatch before setting up the complex equipment for DLV. DLV can be employed if hypoxemia still remains uncorrected (Fig. 2). DLV has been used in disorders where asymmetric lung disease causes severe ventilation–perfusion mismatch and intrapulmonary shunting, leading to hypoxemia. These disorders include emphysema, pneumonia, pulmonary contusion, and bronchial fistulae [10–12]. DLV requires a setup with two sources to deliver independent lung ventilation, and most of the time the provision to perform DLV is not readily available. Under such circumstances, ventilation through a DLT can be a useful alternative for the conduct of controlled ventilation during general anesthesia.

Forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV1) decrease with increasing thoracic curve severity [13,14]. These abnormalities in pulmonary function are usually the result of an abnormal thoracic cage geometry producing a marked decrease in chest wall compliance, rather than resulting from any abnormality in the lungs or respiratory muscles themselves [9]. It is difficult to predict the occurrence of desaturation with the onset of PPV based on PFT, but in the presence of severe restrictive pulmonary disease the possibility of desaturation prediction does exist. The preoperative use of incentive spirometry improves lung function and familiarizes the patient with its use, thus enabling the aggressive use of the spirometry in the postoperative period, to provide optimum benefit.

The morphological features of the trachea and the bronchial tree in severe kyphoscoliosis have led to difficult intubation [4]. Similarly, the placement of a DLT can pose a problem when the anatomy of the tracheo bronchial tree is distorted. In our patient, the carinal angle was widened. Blind insertion of a styleted DLT in such patients can lead to injury to the bronchial mucosa, and bleeding can become troublesome following the administration of heparin. It is therefore prudent to use fiberoptic-guided placement of a DLT in patients with severe kyphoscoliosis. A repeat fiberoptic bronchoscopy is advisable to rule out displacement of the DLT

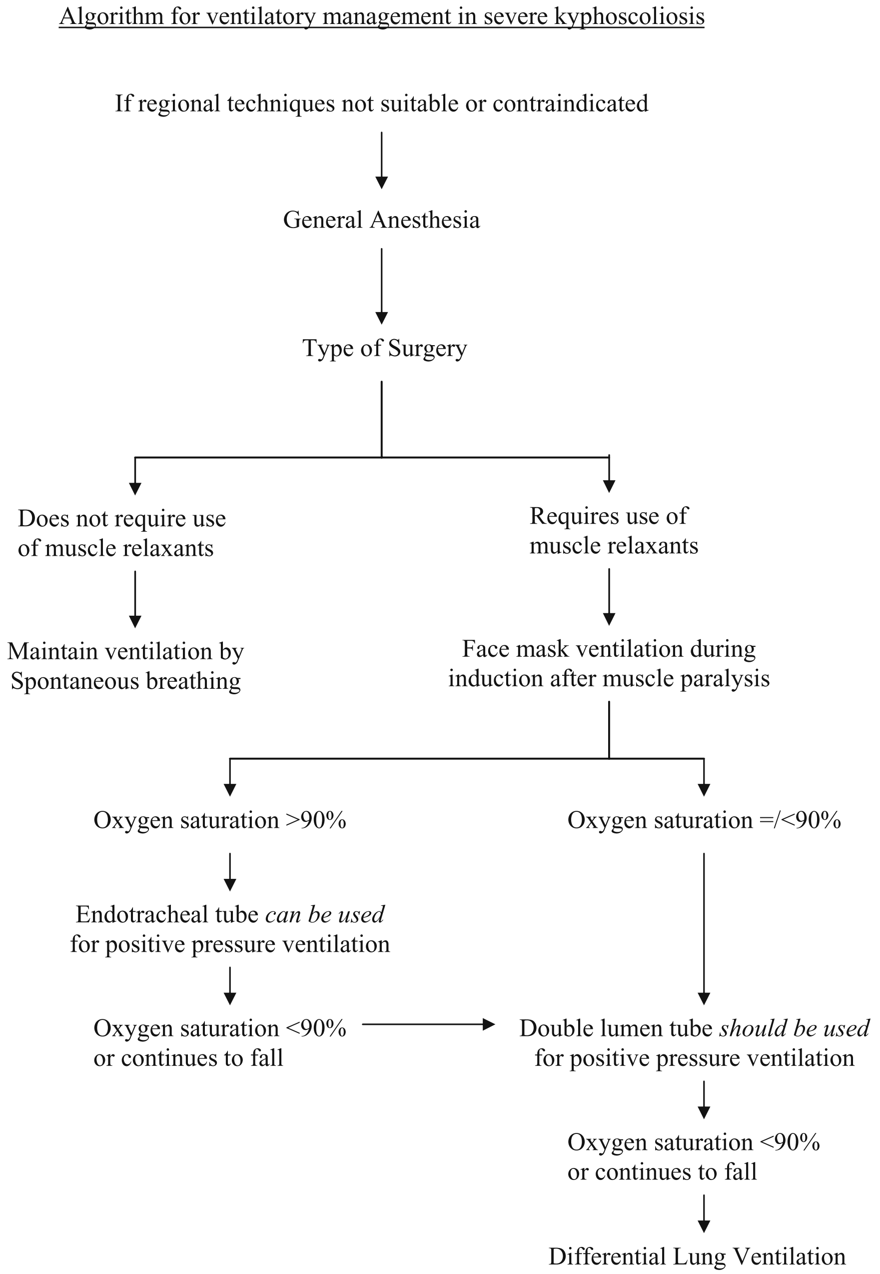


**Fig. 2.** Algorithm for ventilatory management during general anesthesia in the patient with severe kyphoscoliosis

after it has been secured, especially when morphological changes exist in the tracheo bronchial tree.

We therefore conclude that hypoxemia occurring after the institution of PPV in severe kyphoscoliosis can be managed a step ahead of DLV by ventilation conducted through a modified DLT.

## References

1. Hammer GB. Differential lung ventilation in infants and children with lung hyperinflation. Paediatr Anesthesia. 2003;13:373–4.
2. Adoumie R, Shennib H, Brown R, Slinger P, Chiu RC. Differential lung ventilation. Applications beyond the operating room. J Thorac Cardiovasc Surg. 1993;105:229–33.
3. Zandstra DF, Stoutenbeek CP. Treatment of massive unilateral pulmonary embolism by differential lung ventilation. Intensive Care Med. 1987;13:422–4.
4. Al-Kattan K, Simonds A, Chung KF, Kaplan DK. Kyphoscoliosis and bronchial torsion. Chest. 1997;111:1134–6.
5. Pehrsson K, Bake B, Larsson S, Nachemson A. Lung function in adult idiopathic scoliosis: 20 year follow up. Thorax. 1991;46:478–81.
6. Branson RD, Hurst JM. Differential lung ventilation. In: Stock MC, Perel A, editors. Handbook of mechanical ventilatory support. 2nd ed. Baltimore: Williams & Wilkins; 1997. p. 173–81.
7. Branson RD, Hurst JM, DeHaven CB. Treatment of unilateral pulmonary contusion with synchronous independent lung ventilation. Respir Care. 1984;29:361–7.
8. Banner MJ, Gallagher TJ. Respiratory failure in the adult: ventilatory support. In: Kirby RR, Smith RA, Desautels DA, editors.

Mechanical ventilation. New York: Churchill Livigstone; 1985. p. 236.
9. Mahli A, Coskun D, Izdes S. Recruitment of unilateral atelectasis with double lumen tube having Y—connector of different diameters. Clin Pract Rev. 2006;7:119–24.
10. Mitchell JB, Shaw AD, Donald S, Farrimond J. Differential lung ventilation after single lung transplantation for emphysema. J Cardiothorac Vasc Anesth. 2002;16:459–62.
11. Danbrosio CG, Brienza N, Giuliani, Bruno F, Fiore T, Brienza A. Independent lung ventilation in patients with unilateral pulmonary contusion. Monitoring with compliance and $EtCO_2$. Intensive Care Med. 2001;27:1860–7.
12. Eltzschig HK, Palmer G, Brustowicz R. Colobronchial fistula in a pediatric patient: diagnostic value of isolated single-lung ventilation and intraoperative use of high frequency oscillatory ventilation. Anesth Analg. 2002;95:621–3.
13. Kearon C, Viviani GR, Kirkley A, Killian KJ. Factors determining pulmonary function in adolescent idiopathic thoracic scoliosis. Am Rev Respir Dis. 1993;148:288–94.
14. Weinstein SL, Zaval DC, Ponseti IV. Idiopathic scoliosis: long-term follow-up and prognosis in untreated patients. J Bone Joint Surg Am. 1981;63:702–12.