Kyphosis is a spinal deformity characterized by anterior flexion of the vertebral column [1]. This skeletal deformity of the spinal column is known to be associated with cardiac and pulmonary dysfunction, which may result in abnormal postoperative performance of the cardiopulmonary system [2]. However, a few reports describe the anaesthetic management of patients with severe thoracolumbar kyphosis. We herein describe our recent experience and review the literature.

CASE REPORT

A 71-year-old male patient, who was 144 cm tall and weighed 49 kg, was scheduled for low anterior resection of rectal cancer using minimally invasive robotic surgery with the da Vinci surgical system (da Vinci® surgical system, Intuitive Surgical Inc., CA, USA). He had a history of untreated back trauma at the age of 3 years, which resulted in a progressive thoracic kyphosis. Otherwise, the patient’s medical history included only a 40 pack-year history of remote tobacco use and benign prostatic hypertrophy.

Preoperative chest radiography revealed a severe kyphotic deformity of the thoracolumbar spine (Fig. 1 and 2), and computed tomography showed centrilobular emphysema in the upper lobes of both lungs. The posterior angle of the thoracolumbar kyphosis, measured according to the method described by Dickson, was approximately 130 degrees [3]. The patient complained of mild dyspnea (NYHA class II) in a daily activities and the results of preoperative pulmonary function tests showed a mild restrictive pattern [forced expiratory volume in 1 second (FEV1): 2.33 L (62%); functional vital
Fig. 2. Plain chest radiograph (lateral view) shows severe kyphotic changes from T9 to L1 (arrow). By Dickson’s method, measurement of this kyphotic angle is made by lines drawn along the posterior margins of the vertebral bodies above and below the lesion, and is approximately 130 degrees.

Fig. 3. Position of the patient during the operation. The anteroposterior diameter is elongated because of the kyphotic spine. Multiple supportive rolls are used to support the head and upper back.

Fig. 4. Plain chest radiograph (anteroposterior view) shows atelectasis of the lungs bilaterally.

capacity (FVC): 1.76 L (67%); FEV1/FVC ratio: 76%), and preoperative echocardiography revealed normal findings, with normal right ventricular size and preserved right ventricular contractility. The patient had no preoperative medications prescribed.

In the operating room, intraoperative monitoring included 3-lead electrocardiography, pulse-oximetry, end-tidal carbon dioxide (CO₂) detection, and invasive arterial blood pressure monitoring at the radial artery. The patient was placed in a supine position with supportive rolls under the head and upper back (Fig. 3). Induction of anaesthesia was performed with intravenous lidocaine (40 mg), propofol (80 mg), and rocuronium (30 mg), and a target-controlled infusion of remifentanil (Orchestra® Base Primea, Fresenius Kabi Inc., Bad Homburg, Germany) was given at 2−3 ng/ml of effect site concentration. The patient’s lungs were ventilated with oxygen, medical air, and desflurane. After intubation with a #8.0 endotracheal tube (ETT) and temporary fixation at 18 cm from the incisor teeth, the depth of the ETT was identified by fiberoptic bronchoscopy. Fresh gas flow was maintained at 2 L/min with 50% fraction of inspired oxygen and 6% volume of desflurane. Target controlled infusion of remifentanil was continued until the end of surgery.

The surgical procedure itself was initially attempted with robotic assistance; however, movement of the robotic arm of the da Vinci® system proved difficult given the small intraperitoneal space due to the severe thoracic deformity. Moreover, peak inspiratory pressure of the patient was steeply increased from 11 mmHg to 22 mmHg. As a consequence, the surgery was converted to an open procedure, which was then completed without any complications. Peak inspiratory pressure also dropped down to 11−15 mmHg after laparotomy. Airway pressure parameters such as peak inspiratory pressure and plateau pressure of the patient were normally maintained and oxygen saturation also 99−100% during the operation. After the surgery, the patient was fully awakened and showed no respiratory distress signs. Hence, we decided to extubate and
transfer to recovery room after discussion with the operator despite the patient was planned to go to intensive care unit preoperatively.

On postoperative day 1, the patient complained of mild dyspnea while on the general ward and a chest radiograph demonstrated atelectasis of the lung fields bilaterally (Fig. 4). The patient was thus treated for 8 hours with physiotherapy and the administration of supplemental O₂ at 3 L/min via nasal cannula, with subsequent resolution of his dyspnea. On postoperative day 7, the patient was discharged without any surgical or anaesthetic complication.

**DISCUSSION**

Kyphoscoliosis is a progressive spinal deformity characterized by anterior flexion and lateral curvature of the vertebral column. Patients with severe spinal deformities usually have smaller lung volumes and the loss of thoracic elasticity, resulting in increased energy requirements for ventilation. Additionally, in patients with kyphosis, severe deformities of the thoracic cage cause a reduction in vital capacity, lung compliance, and tidal volume, while residual volume and total lung capacity are maintained. Furthermore, the abnormal mechanical properties of the distorted thoracic cage increase the work of breathing and airway resistance. Consequently, patients with kyphotic deformities constantly hyperventilate and are more likely to experience respiratory failure such as hypercapnia, hypoxemia, and respiratory acidosis in case of respiratory insufficiency [4]. During laparoscopic and robotic-assisted surgery, the pneumoperitoneum and Trendelenberg position can significantly affect respiratory function, and postoperatively these patients are at risk for hypoventilation, mismatched ventilation-perfusion and acute respiratory failure [2,5-7].

In our case, anesthetic management was focused to maintain respiratory function in perioperative period. For full awakening and recovery at emergence, we used anesthetic agents such as desflurane and rocuronium which have a rapid onset and short duration. In addition, target -controlled infusion of remifentanil, an ultrashort-acting opioid, is effective to reduce the amount of desflurane in maintaining anesthetic depth and to promote a smooth and rapid emergence [8].

The severity of pulmonary derangement in patients with kyphoscoliosis is related to the angle of deformity [9,10]. In addition, the impairment of pulmonary function in kyphosis correlates with spinal mobility (especially forward flexion) [11] and is notable when the kyphosis angle is greater than 55 degrees [12]. In our case, the kyphosis angle was 130 degrees, such that there was high risk of respiratory insufficiency during the perioperative period. Despite this severe kyphotic deformity, the patient did not have a significant respiratory problem in daily life, and he had a New York Heart Association classification of only II. Perhaps this was because the kyphotic area involved a relatively lower level in the vertebral column, the ninth thoracic vertebra to the second lumbar vertebra, and the patient was chronically adapted to the deformity. Most importantly, the patient’s respiratory function was well maintained during the perioperative period. The resistive pressure, the difference between peak and plateau inspiratory pressure, was maintained normally within 2−3 cmH₂O with peripheral oxygen saturation of 99−100%. For this reason, we did not have to check arterial blood gas analysis intraoperatively. Although the result of blood gas analysis on postoperative day 1 suggested metabolic acidosis, atelectasis on chest radiography and postoperative pain were suspected for the patient’s respiratory compromise. Moreover opioid, meperidine 25 mg intravenously, used for postoperative pain control resulted in further decrease of ventilatory effort.

Finally, chest deformities are known to increase pulmonary vascular resistance by preventing the development of the pulmonary vascular system. When persistent, the increased pulmonary vascular resistance can cause pulmonary hypertension and potentially right heart failure. Although we did not evaluate and monitor the pulmonary arterial pressure of this kyphotic patient in the perioperative period, the results of preoperative echocardiography showed a normal size of the right ventricle, with preserved right ventricular contractility. Patients with severe kyphosis are at high risk for respiratory and cardiovascular complications in the perioperative period. Therefore, a thorough preoperative evaluation and meticulous anaesthetic management are required during surgical procedures. We report this case to describe the careful perioperative management of the patient with severe kyphosis, even after the surgery is complete.

**REFERENCES**


