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Case Series

Anaesthetic management of robotic- assisted thoracoscopic thymectomy using the da Vinci system: A case series

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Abstract

Robotic surgeries are revolutionizing thoracic surgeries with their unique advantages, including optimal surgical views and sophisticated, precise manipulation. Minimally invasive thymectomy offers excellent surgical and postoperative outcomes. However, the perioperative management of such cases is challenging due to multiple factors, including difficult airway management, patient positioning, hemodynamic monitoring, coexistent myasthenia gravis, and the need for lung isolation. This case series describes the anaesthetic management strategies used during robotic-assisted thymectomy. It focuses on airway management, pain relief, and monitoring techniques, along with the postoperative complications observed and their successful management, highlighting the importance of adapted perioperative care.

Keywords: Thoracic anaesthesia, Robotic surgery, Thoracic surgery, Human factors.

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1. Introduction

Minimally invasive surgery is increasingly becoming the approach of choice against sternotomy for thymectomy. Since the first robotic assisted thoracoscopic thymectomy (RATT) in 2003, increasing numbers of this procedure is being performed worldwide.[1] While short term surgical outcomes between video-assisted thoracoscopic surgery (VATS) and robot-assisted thoracoscopic surgery (RATS) have been found to be similar in terms of length of hospital stay, post-operative pneumonia and mortality, the operational times for RATS are significantly longer.[2] Minimally invasive surgery has considerably less tissue trauma, comparable efficacy and faster recovery compared to conventional thoracotomy.[3] It also enables more extensive mediastinal fat resection which may impact the long-term outcomes due to ectopic thymic tissue in cases of myasthenia gravis.[4] Majority of cases with thymoma have coexistent myasthenia gravis which make these cases challenging to manage perioperatively. Other unique problems with RATT include open lung ventilation with high intrathoracic pressures and patient positioning. The da Vinci Xi (Intuitive Surgical, Inc) robotic system was used in all our cases. This system consists of three components: a console for the surgeon, patient side cart with four robotic arms, and a vision cart with optical elements for the robotic camera.[4] Here we describe the unique perioperative challenges faced in each of the five cases of RATT and how these were successfully managed.

2. Case Series

This case series presents the experiences of five patients diagnosed with RATT, highlighting the surgical management, anesthesia challenges, and postoperative care. The general characteristics of each case are summarized in **Table 1**.

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2.1. Preoperative management

In all cases, incentive spirometry was initiated two days prior to surgery. Premedication included pantoprazole, and sedatives were avoided. Medications for myasthenia gravis (including anticholinesterase, steroid, and azathioprine) and other comorbidities were continued until the day of surgery. All cases received intravenous hydrocortisone (100 mg) before induction. Surgery was performed via a left-sided approach, with patients positioned in a semi-recumbent position using sandbags, and the left upper limb placed lower than the operating table. Pressure points were padded for comfort and safety.

2.2. Anesthesia management

Induction of anesthesia was achieved with fentanyl, propofol, and atracurium. The average operating time across all five cases was 258 minutes. All patients received thoracic epidural anesthesia, and intraoperative temperature was maintained using warm fluids, a warming blanket, and a mattress. Neuromuscular blockade was monitored with atracurium infusion and titrated based on TOF (Train of Four) values. None of the patients experienced air leaks, atrial fibrillation, thoracic duct fistula, or required conversion to open thoracotomy. Postoperatively, anticholinesterase medications were restarted via nasogastric tube in myasthenia cases to prevent delays in weaning due to muscle weakness. Notably, there were no episodes of myasthenic crisis in the postoperative period.

3. Case 1

The patient was intubated with a 37 Fr left-sided double lumen tube (DLT). Following positioning, peak airway pressures exceeded 35 cm H_2O when both lungs were ventilated, with tidal volumes inadequate. During one-lung ventilation, pressures surged to 45-50 cm H_2O. The DLT was replaced with a 39 Fr tube, but the pressures remained high. A fiberoptic bronchoscopy (FOB) revealed that the DLT had migrated distally, obstructing the tracheal lumen at the carina. A 9-sized endotracheal tube (ETT) was inserted, followed by the introduction of an EZ blocker for lung isolation. After confirmation with FOB, the peak pressures dropped to below 30 cm H_2O. However, during insufflation at 8 cm H_2O, the patient experienced a sudden drop in blood pressure to 70 mmHg systolic, which was managed with 250 mL IV fluid bolus and 6 mg of ephedrine. Anesthesia was maintained with O2, air, and sevoflurane. At the end of the procedure, the TOF value was 0, and the patient was shifted to the ICU for elective ventilation. Extubation occurred after 3 hours of mechanical ventilation.

4. Case 2

In this case, post-resection, an intercostal drain (ICD) was placed, and closure was initiated. Fifteen minutes after ICD placement, the patient developed tachycardia (124 bpm) and hypotension (78/50 mmHg). Immediate intervention included noradrenaline infusion (0.15 mcg/kg/min) along with 500 mL of Ringer’s lactate and two units of packed cells. The surgical site was reopened, bleeders controlled, and hemostasis achieved. Noradrenaline was tapered and continued at a lower dose (0.05 mcg/kg/min). The DLT was changed to an 8-sized ETT, and the patient was shifted to ICU. After 6 hours, the noradrenaline infusion was discontinued, and extubation occurred. The patient was transferred to the ward 24 hours post-surgery.

5. Case 3

After an uneventful intraoperative course, this patient was extubated on the operating table. Two hours later, the patient became tachypneic, with a respiratory rate of 34 breaths per minute. Ultrasound revealed atelectasis and right-sided pleural effusion. Non-invasive ventilation (NIV) was initiated. The patient remained hemodynamically stable without vasopressors but required high levels of O2 (FiO2 of 50%) via NIV. Pain was managed with epidural infusion and IV analgesics. On postoperative day 2, the patient developed fever, and chest X-ray showed right upper and middle zone consolidation. Antibiotics and antivirals were started, and NIV was continued. A CTPA ruled out pulmonary embolism, and blood cultures were negative. The patient was off NIV on the 5th postoperative day and shifted to the ward on a face mask on the 6th day.

6. Case 4

This patient had restricted mouth opening (less than 3 finger breadth) and buck teeth. An epidural was placed at T5-T6, and induction was performed with fentanyl, propofol, and atracurium. A 39 Fr left-sided DLT was inserted using C MAC, but there was difficulty passing the cuff due to the patient’s dental condition. Upon inflating the cuffs, it was suspected that the tracheal cuff had been damaged during intubation, as tidal volumes were lower than expected. A second attempt with a new DLT also resulted in a damaged cuff. A successful 8.5-sized normal ETT was inserted, and an EZ blocker was placed under FOB guidance. Lung isolation was confirmed, and the procedure proceeded without further complications.

7. Case 5

In this case, following the creation of pneumomediastinum at a set pressure of 8 cm H_2O, the patient experienced sudden bradycardia, with a heart rate of 30 bpm. The gas flow was stopped immediately, ports removed, and 0.6 mg of atropine was administered. The heart rate increased to 102 bpm within 30 seconds. After stabilizing the vitals, pneumomediastinum was reestablished at a lower pressure of 6 cm H_2O without recurrence of bradycardia. The surgery proceeded uneventfully thereafter.

Table 1: Summary of the anaesthetic management strategies, airway management, pain relief, monitoring techniques, and postoperative complications observed in each case

Parameter	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Age	37	67	44	74	59
Gender	Male	Male	Male	Male	Male
Height (cm)	168	174	178	169	167
Weight (kg)	61	66	80	71	68
Myasthenia Gravis	Yes	Yes	No	No	No
Comorbidities	Nil	Hypertension	Recent severe COVID-19 treated with antivirals and steroids, hypogammaglobulinemia	Nil	Diabetes Mellitus, Bronchial Asthma
Thymoma size, cm	6.7 x 5.2 x10.4	7.1 x 6 x 8.2	6.4 x 7 x 9.1	11.5 x 9.1 x 12.1	7 x 6.2x 8
Lung isolation technique	ETT 9 with blocker	DLT 41F	DLT 41F	ETT8.5 with EZ blocker	DLT 39F
CVC, side, site	Right IJV	Right IJV	Right IJV	Right IJV	Right IJV
Intra-arterial BP, site	Left radial	Right radial	Left radial	Left radial	Left radial
Patient position	Semi recumbent with 30 degrees left up, left arm lower than the table, supported with padding	Semi recumbent with 30 degrees left up, left arm lower than the table, supported with padding	Semi recumbent with 30 degrees left up, left arm lower than the table, supported with padding	Semi recumbent with 30 degrees left up, left arm lower than the table, supported with padding	Semi recumbent with 30 degrees left up, left arm lower than the table, supported with padding
Epidural anaesthesia	T4-T5, 0.2% ropivacaine 5ml bolus followed by infusion @5ml/hr	T5-T6, 0.2% ropivacaine 5ml bolus followed by infusion @5ml/hr	T5-T6, 0.2% ropivacaine 5ml bolus followed by infusion @5ml/hr	T5-T6, 0.2% ropivacaine 5ml bolus followed by infusion @5ml/hr	T4-T5, 0.2% ropivacaine 5ml bolus followed by infusion @5ml/hr
Insufflation pressures (cm H_2O)	8	8	8	8	8 initially, reduced to 6 due to bradycardia
Peak airway pressure (cm H_2O) during double lung ventilation	35 in DLT, 27 when ETT with EZ blocker was used	28	30	26 on ETT with EZ blocker	28
Approach for RATS	Left	Left	Left	Left	Left
Intraoperative complications	1)Distal migration of ETT causing obstruction of tracheal lumen which led to use of an EZ blocker with a normal ETT 2) Hypotension following creation of capno-mediastinum 3) Residual neuromuscular blockade which led to post op mechanical ventilation.	During closure, post ICD insertion, sudden hypotension due to an arterial bleeder, which was controlled after reopening.	Nil	Buck teeth causing damage to the DLT cuff, intubated with single lumen ETT and EZ blocker was used for isolation.	Sudden bradycardia nearing to 30 bpm post capno-mediastinum creation which was managed successfully.

Table 1 Continued….					
Operative time (hours)	5	4.5	4.5	4	3.5
Intraoperative blood loss(ml)	300	500	250	250	200
Post-operative complications	NIL	Nil	1) Requirement of NIV with FiO_2 of 50% for more than 48 hrs postop. 2) Pneumonia managed with iv antibiotics	Nil	Nil
Intercostal drainage duration (days)	2	2	3	2	2
Post operative ICU stay (hours)	24	24	72	18	18
Post operative day of discharge	4	5	10	5	3

8. Discussion

Anaesthetic concerns in Robotic-Assisted Thoracoscopic Thymectomy (RATT) are distinct, primarily due to the challenges of maintaining one-lung ventilation with high intrathoracic pressures and managing patient positioning. Compared to Video-Assisted Thoracoscopic Surgery (VATS), a meta-analysis has shown that RATT is associated with less blood loss, reduced drainage volumes, and a shorter hospital stay.[5] As the number of RATT procedures continues to rise, it is increasingly important to be aware of the unique perioperative management required to ensure optimal patient outcomes.

There is a paucity of data on the anaesthetic management of Robotic-Assisted Thoracoscopic Thymectomy (RATT) from the Indian subcontinent. The left-sided surgical approach has been shown to result in fewer complications compared to the right-sided approach and is thus preferred.[6] However, a key issue with the left-sided approach is the limited access to the patient's head and endotracheal tube due to the robot being stationed on the right side, causing the robot arms to cross over the patient's face. As a result, securing the double-lumen tube (DLT) and ensuring proper connections is crucial. In our series, we encountered difficulty ventilating one patient with the DLT, experiencing high airway pressures due to the distal migration of the DLT during patient positioning.

Proper patient positioning is critical, considering the space needed for robot docking and the free movement of its arms. Previous reports have highlighted cases of brachial plexus injury resulting from positioning and recommended intra-arterial blood pressure monitoring in the same arm to detect neurovascular compression.[7] Fortunately, no patient in our series experienced brachial plexus injury. One case experienced transient hypotension and bradycardia, likely due to capno-mediastinum compromising venous return, which was successfully managed with fluid administration and a gradual reintroduction of capno-mediastinum.

Transient episodes of arrhythmia with hypotension are common during thymectomy, occurring in about 75% of cases. This is likely due to direct compression of the heart and major vessels by the surgical instruments or the effects of capnomediastinum.[8] In our series, one patient developed hypotension towards the end of the procedure after the insertion of the intercostal drain (ICD), requiring blood transfusion. Vigilance is essential even after tumor resection, as in this case, where a massive bleed was caused by an intercostal artery.

A central venous line was inserted in all patients, but central venous pressure (CVP) monitoring was not performed in any case, as CVP values are often erratically high (by 6-8 mm Hg) due to capno-mediastinum and compression by surgical instruments during surgery.[7] Fluid therapy was targeted to maintain a urine output of 1 mL/kg/h. Neuromuscular blockade is crucial for maintaining ventilation to help wash out excess carbon dioxide from the capno-mediastinum. This was monitored continuously with end-tidal carbon dioxide and neuromuscular blockade was guided by Train of Four (TOF) monitoring. It is essential to ensure full recovery of neuromuscular blockade before terminating anaesthesia. It should be noted that antagonizing muscle relaxants with Sugammadex may be challenging in patients receiving anticholinesterase therapy.[9] In our series, one patient exhibited delayed recovery from muscle relaxants. Myasthenia gravis (MG) cases, in particular, show greater variability in response to muscle relaxants, making TOF monitoring even more essential.[8]

All patients in our series were ventilated using volume-controlled ventilation. One case report of RATT described a scenario of high airway pressures during one-lung ventilation

(OLV), which was successfully managed by switching to pressure-controlled ventilation.[10] Postoperatively, one patient with hypogammaglobulinemia developed atelectasis and pneumonia, which was successfully managed with non-invasive ventilation.

Thymomas larger than 5 cm are classified as large thymomas for the purpose of surgical resection.[11] Robotic surgery for large thymomas has shown comparable five-year surgical outcomes and postoperative results to those of smaller thymomas, with the main difference being longer operative times for larger tumors.[11] While robotic surgery facilitates finer dissection and reduces the need for postoperative analgesia, epidural analgesia was routinely used in all our cases to ensure early mobilization and adequate pain relief.

Due to the small number of cases in this series, generalizing the results is difficult. However, there is a lack of trials specifically addressing the anaesthetic management of RATT, making such case series highly relevant for practicing anaesthesiologists.

9. Conclusion

In managing a case of Robotic-Assisted Thoracoscopic Thymectomy (RATT), airway management and patient positioning are the two critical areas that require careful attention. Adequate preparation for difficult airway management, along with the availability of adjuncts for lung isolation, is essential, as the successful introduction of a double-lumen tube (DLT) may not always be feasible. Continuous monitoring of airway pressures is crucial for the early detection and management of endotracheal tube dislodgement, particularly during patient positioning and the surgical manipulation performed by the robotic arms. Furthermore, ensuring adequate pain management and the use of neuromuscular monitoring before extubation contribute significantly to improved patient outcomes.

10. Source of Funding

None.

11. Conflict of Interest

None.

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