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Research Article

Anaesthesia in Robotic Myasthenic Thymectomy: Evaluation of Our 8-Year Experience

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Abstract

Robotic thymectomy in myasthenic patients is rapidly gaining more widespread interest, albite only a few centres use this approach, although only recently it has been established as a routine procedure performed in various centres. The use of minimally invasive techniques to perform thymectomies ensures minor trauma. In particular, the robotic approach allows safely performing radical thymectomy, providing good clinical outcomes to the patients, similar to an open approach. We present a retrospective analysis of our experience during the last 8 years in performing robotic thymectomy in myasthenic patients. We strongly believe that a dedicated team prepared to follow and guide the myasthenic patients in the perioperative period is paramount; this empathy together with the reduced traumatism and radicality ensured by the robotic approach can contribute to obtaining the best therapeutic result.

Keywords: *Myasthenia; Robotic Thymectomy; Thoracic Anaesthesia; Human Factors*

Introduction

The management of myasthenia gravis (MG) during surgery is commonly considered as challenging for the anaesthetist due to its involvement with the pulmonary and muscular systems as well as with drug interactions [1]. In the latest years, advantages have been brought since the introduction of fast track techniques and new drugs such as the neuromuscular relaxant antagonists [2].

MG is a chronic autoimmune disorder characterized by a decrease in acetylcholine receptors at the neuromuscular junction secondary to their destruction or inactivation by circulating antibodies, resulting in loss of strength and severe exhaustibility of striated muscles, which can even bring to an impairment of vital functions [3]. The abnormal antibody production is triggered mainly in the thymus. Conjointly with medical therapy, thymectomy in MG is a universally recommended procedure, especially in myasthenic patients with positive anti-acetylcholine receptor antibodies (AchRAb), with the intent to improve symptoms and, in many cases, to achieve the complete remission of the disease [4-6].

Anticholinesterase therapy is the standard symptomatic treatment in myasthenia gravis, and the most commonly used one as the initial therapeutic approach [7]. The anticholinesterase drugs are efficacious in myasthenic patients with positive anti-acetylcholine receptors antibodies, but the result rarely efficacious in the seronegative cases [8].

Corticosteroids are generally used as the etiologic treatments that act on the pathologic autoimmune mechanisms responsible for the disease. However, when steroid treatment is not sufficiently effective or when it is contraindicated, a number of cytotoxic immunosuppressive drugs, monoclonal antibodies, intravenous immunoglobulins (IVIG), plasma exchange can be used to control the disease [9].

Thymectomy is the only truly strategic intervention capable of modifying the natural history of the disease. It increases significantly the possibility of success in the treatment of MG: only 10% of the non-thymectomized patients achieve remission from the disease, while the percentage increases significantly in those patients who undergo thymectomy, particularly young individuals with a recent onset of MG [10].

Although various surgical approaches have been described for thymic resection, robotic thymectomy is considered one of the most innovative approaches for this type of operation.

The robotic system features, such as the 10 times magnification, 3-dimensional high definition vision of the operating field, the wrist like manoeuvre ability with 7 degrees of freedom and the physiological tremor filtration, give to the surgeon the advantage of a better vision of the surgical field and articulation of the surgical instruments within the chest cavity, allowing precise isolation of anatomical structures, safe manipulation of the tissues, and also guarantee a complete radical excision of the thymus and the entire peri-thymic adipose tissue [11-13].

Moreover, this technique offers a better aesthetic result and is therefore preferred by young and mostly female patients, as generally are these patients affected by MG. In addition, this surgical approach is usually associated with a rapid and favourable postoperative course, making it a more appealing option than median sternotomy, not only for younger patients but also for older ones. The aesthetic result and the rapid functional recovery are also important elements to convince those patients concerned about the thymectomy through a median sternotomy.

Robotic surgery, after its application for lung cancer treatment, has been adopted to perform thymectomy in Pisa since 2002 and with the standardization of the technique, it has become a routinely performed procedure In our centre we have developed a dedicated multidisciplinary approach realized with the collaboration between neurologists, thoracic surgeons and anaesthetists in order to choose the better therapeutic window in which to plan the surgery and so in reducing perioperative complications [14,15].

Materials and Methods

We retrospectively analyzed the results of 214 patients affected by Myasthenia Gravis (MG) who underwent extended thymectomy from January 2011 to December 2019. All patients underwent a pre-operative multidisciplinary board consultation, consisting of thoracic surgeons, neurologists and anaesthetists specialized in the treatment of MG patients.

Anaesthetic considerations

Pre-assessment: The role of the anaesthetists is to conduct an accurate preoperative evaluation in order to evaluate the right moment in which to perform the operation. Preoperative evaluation includes pulmonary function testing, ECG, X-Ray, blood exams. Anxiolytic, sedative, and opioid pre-medications are not recommended for myasthenic patients. We normally administer 8 mg dexamethasone the morning of the surgery according to the neurologist indications as a continuation of MG therapy [16].

Anaesthesia: In the preoperative holding area, a peripheral 18-gauge intravenous catheter is inserted in the right hand and they are warmed with active warming system.

Once in the operating room, routine monitoring includes a 3-lead electrocardiogram, pulse oximetry, and non-invasive blood pressure, bispectral index (BIS), degree of neuromuscular blockade (TOF guard), temperature monitoring.

The patient is placed supine and pre oxygenated with 100% fraction of inspired oxygen for 3 minutes. Induction of anaesthesia is conducted with a propofol bolus of 2 mg/kg, fentanyl 1 microgr/Kg and after mask ventilation is checked, a dose of 0.6 mg/kg of rocuronium is administered. After successful muscle relaxation, a left double-lumen tube is placed, and pressure control mechanical ventilation is executed. The correct position of the tube is checked via bronchoscope.

Anaesthesia is maintained by continuous intravenous infusion of propofol (4 - 6 mg/kg/h) and remifentanil (0.3 - 0.5 μg/kg/min). The patient's response to surgical stress and sedation is based on hemodynamic changes and the bispectral index (BIS) [17,18].

Patient positioning: In the execution of robotic thymectomy the patient is usually placed in semi-recumbent position at the left edge of the operating table with his left side upwards, maintaining the position using sandbags.

Once the robot is docked, for the anaesthesiologist becomes extremely challenging to reach the arms, hence it is absolutely necessary to close every preparation, such as all narcotic operations, including the establishment of an invasive arterial pressure catheterization if necessary, before the docking process and the start of the surgery [19].

Management of one-lung ventilation (OLV): During robotic thoracic surgery OLV is essential and the most commonly used methods include double-lumen endotracheal intubation. For patients with difficult intubation, we advise using a single-lumen tube with bronchial occlusive cuff (e.g. a Univent catheter). Adequate minute ventilation should be ensured as much as possible both via volume-controlled ventilation, both via pressure-control ventilation. Our strategy is to use pressure control ventilation to maintain and limit airway pressure at 25 - 30 mmHg and to avoid CO_2 accumulation, consequently the close monitoring of SpO_2, $ETCO_2$ becomes essential and when necessary is advisable real-time monitoring of arterial blood gases. Once hypoxemia or CO_2 accumulation occurs, the respiratory parameters should be actively adjusted: the respiratory rate is usually modified to a level 20% higher than that for double-lung ventilation and, if SpO_2 continuously decreases, we can add a fresh flow of O_2 on the non-ventilated lung [20-22].

Hemodynamic management of CO_2 pneumothorax: Robotic thoracic surgery requires not only OLV but also continuous CO_2 insufflation into the ipsilateral chest, producing an artificial pneumothorax to facilitate lung collapse and increase mediastinal space, thus revealing the surgical field. The pressure of the artificial pneumothorax is usually 5 - 10 mmHg, which may cause increased CO_2 levels in the blood. CO_2 insufflation may sometimes lead to a significantly decreased venous return and hypotension [23]. The risks of CO_2 pneumothorax also include venous air embolism, reduced blood amount in the right side of the heart and acute cardiovascular collapse (i.e. hypotension, hypoxemia, arrhythmia, etc.) [24,25]. To minimize the impact of CO_2 insufflation during robotic thoracic procedures, CO_2 should be slowly applied (starting with a pressure of 5 mmHg and low flow), and its blowing speed should be adjusted according to hemodynamic changes. Although it has been demonstrated that CO_2 pneumothorax can reduce cardiac output by 10% to 30% [26], patients are generally well tolerant of hemodynamic changes during CO_2 insufflation. Normally, it is enough to apply a rapid fluid replacement to increase blood pressure or administer phenylephrine. To counteract the heeling on the mediastinum, in our experience, before the exclusion of the left lung, and the induction of pneumothorax with 5 mmHg of CO_2, a 500 ml of volume preload should be administered and 5 of PEEP on the ventilated lung applied.

Management of fluid balance and body temperature: During robotic thymectomy, fluid balance is essential. Adequate intravascular volume is the prerequisite to hemodynamic stability and adequate organ perfusion. We normally adopt a near to zero balance of fluid [26]. We normally monitor body temperature to avoid the adverse effects caused by intraoperative hypothermia. To prevent hypothermia, appropriate operating room temperature should be maintained, as well as the application of warmth with active warming system [27].

Emergency responses: Bleeding is the most serious complication in robotic thoracic surgery. The entire surgical team must always be prepared for the emergency of converting the procedure to open surgery. The team, made by surgeons, anaesthetists and scrub nurses need regular and clear communication and cooperation. The anaesthetists must ask that the artificial pneumothorax is removed and must restore double-lung ventilation. Undocking and removing the robot is the first step to be taken in the case of a sudden conversion to open surgery. Each member of the team should be familiar with this operation, ensuring that the robot can be undocked and removed within 1 minute in case of necessity. At the same time, the entire team should have acquired the basic skills of CPR training and knowledge of advanced life support.

Reversal of neuromuscular block: The decision to reverse residual neuromuscular blockade at the end of surgery is controversial. Some argue that the presence of anticholinesterases and antimuscarinics will confuse efforts to differentiate weakness due to inadequate neuromuscular transmission from the cholinergic crisis in the recovery room. We normally perform, at the end of the surgery, a half dose of pyridostigmine 2,5 mg and 0,5 mg of atropine as a therapeutic dose. In the case of PORC (postoperative residual curarization), sugammadex is administrated at the dose of 2 mg/Kg [28].

Postoperative analgesia: Postoperative analgesia is an important aspect in myasthenic patients to allow the full recovery of lung function and chest movements. Pain after the robot-assisted thymectomy is lesser than in sternotomy. Postoperative analgesia consists in a bolus dose of morphine (0,5 mg/Kg), ketorolac 30 IV and acetaminophen (1 gr) before the end of the surgery plus local wound infiltration with ropivacaine (10 mg/ml) and lidocaine (2%). Then we apply a ketorolac infusion of 90 mg/die via elastometer.

Paracetamol is supplemented in the case of pain.

All patients are recovered in a PACU and transferred to the ward the 1st postoperative day.

Results

We collected data of 214 consecutive patients (79 males and 135 females), with mean age 43 ± 12 years, who underwent robotic thymectomy from January 2011 to December 2019. The mean operating time was 120 ± 64 minutes. No significant intraoperative complications occurred. All patients (99.5%) were extubated at the end of the surgical procedure, with one exception in which one patient was extubated the day after the operation. The mean chest tube duration was 2.2 days (SD ± 1.6) and the mean postoperative hospital stay was 3 days (range: 2 - 5 days). In the analysis of postoperative complications, we observed in 3 cases major complications: in 1 (0.5%) patient we observed a worsening in myasthenic symptoms, requiring re-intubation for respiratory failure two days after the operation, and in 2 patients (0.9%) postoperative chylothorax was recorded the day after the surgery, treated by minimally invasive operation. In addition, transient recurrent laryngeal nerve irritation was observed in 3 patients (1.4%) and pleural effusion in 2 patients (0.9%).

Discussion and Conclusion

Robotic thymectomy represents a safe and effective minimal-invasive procedure in those forms of MG associated with thymic hyperplasia or non-invasive thymoma both as valid alternative surgery to the more invasive median sternotomy approach and both under an anaesthesia management point of view. In our experience, the association of TIVA with Propofol and Remifentanil, rocuronium and the use if necessary of sugammadex showed to be a safe anaesthesia strategy [29].

Myasthenia gravis is a disease where emotional stress can lead to the exacerbation of the symptoms, therefore we strongly believe that a dedicated team prepared to follow and guide these patients in the perioperative period is paramount; this empathy together with the reduced traumatism and radicality obtained by robotic surgery can contribute to obtaining the best therapeutic result. Hence this specific approach is successful not only to reduce the perioperative complications but also to guarantee a better chance for improvement of the clinical condition, allowing in latest years the extension of the indication of robotic thymectomy also to older patients.

The robotic technique is a valid alternative to open surgery, particularly for clinically well-compensated patients, in whom the mini-invasive approach and the rapid postoperative recovery represent an important additional factor for the achievement of an optimal therapeutic result.

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