Robotic Anterior Mediastinal Mass Resection: Belgium

7

Jeroen M.H. Hendriks, Patrick Lauwers, Rudy Mercelis, Senne Van Donink, Pieter Mertens, and Paul E.Y. Van Schil

Abstract

Tumors of the anterior mediastinum are relatively rare and most of them are thymic tumors, lymphomas, germinal cell tumors and thyroid tumors. As a reference centre for these tumors, both open and VATS techniques are used for surgical resection for more than three decades. Since 2004, these tumors are removed with the da Vinci robot as a minimal invasive procedure. Initially with the 3-arm da Vinci S and since 1 year with the 4-arm da Vinci Xi. Technique and results are presented in this paper. Outcome is excellent and robotic resection will stay our technique of choice.

Keywords

Anterior mediastinum • Thymic tumors • Thymoma • RATS • Robotic, da Vinci • Myasthenia gravis

7.1 Neurological Aspects of Anterior Mediastinal Tumors

Tumors of the anterior mediastinum are relatively rare. Most of them are thymomas, lymphomas, germinal cell tumors and thyroid tumors [1, 2]. The diagnosis is suspected on medical imaging with contrast enhanced computed tomography (CT) being the preferred method [3], while magnetic resonance imaging (MRI) and positron emission tomography (PET) may provide additional information in selected cases [4].

A particular phenomenon of thymomas is the association with autoimmune diseases. This has not only been described for several neurological disorders such as myasthenia gravis, Lambert-Eaton myasthenic syndrome, neuromyotonia, stiff person syndrome, rippling muscle disease, autonomic neuropathy and inflammatory myopathy, but also for hematological syndromes as pure red cell aplasia, pancytopenia, thrombocytopenia and hypogammaglobulinemia or Good syndrome, dermatologic disorders such as alopecia, vitiligo and pemphigus, and other diseases as systemic lupus eythematosus, glomerulonephritis and ulcerative colitis [5, 6].

While the association of most of these conditions with thymoma is rare, a lot of information is available about the association with myasthenia.

In patients with myasthenia gravis, a thymoma is discovered in about 15% including both young adults and late onset patients above the age of 60. Patients with thymoma generally have a more severe form of myasthenia than non-thymoma patients and almost all of them have detectable antibodies against the acetylcholine receptor [7, 8].

On the other hand, a diagnosis of myasthenia gravis can be made in about 50% of thymoma patients. While most patients have already symptoms and signs of myasthenia at the time of diagnosis, others develop myasthenia months to years after thymectomy. In most of them, the presence of acetylcholine receptor antibodies can already be detected at the time of the operation [5].

J. M. H. Hendriks, M.D., Ph.D. (✉) • P. Lauwers • S. Van Donink
P. E. Van Schil
Department of Thoracic and Vascular Surgery, Antwerp University Hospital, Wilrijkstraat 10, 2650 Edegem, Belgium
e-mail: jeroen.hendriks@uza.be

R. Mercelis
Department of Neurology, Antwerp University Hospital, Edegem, Belgium

P. Mertens
Department of Anesthesiology, University Hospital Antwerp, Edegem, Belgium

© Springer International Publishing AG, part of Springer Nature 2018
K. Kernstine (ed.), *Atlas of Robotic Thoracic Surgery*, https://doi.org/10.1007/978-3-319-64508-7_7

The high incidence of myasthenia in thymoma patients and the special care required by myasthenia patients during anesthesia and postoperative period, make that every thymoma patient should be evaluated by a neurologist familiar with myasthenia before surgery [2].

Myasthenia most often begins with ocular symptoms as diplopia and ptosis. In almost all patients symptoms are variable and more pronounced with visual fatigue, e.g. after car driving for a long time. Typically, symptoms are more severe in the evening than in the morning.

A second group of patients present with bulbar symptoms: dysarthria, chewing difficulties and dysphagia. Also in this instance symptoms are aggravated by fatigue, e.g. dysarthria increases while the patient is speaking aloud for some time or chewing is still possible at the beginning of a meal but after some time the chewing muscles get weak and the chin drops. Patients with pronounced bulbar symptoms are at high risk for respiratory problems and should be treated for their myasthenia before surgery. Generalized weakness without ocular or bulbar symptoms is rather unusual. Weakness is also induced by exercise and is most common in the proximal arm muscles but can involve individual finger extensors. Fatigue as only complaint is not specific for myasthenia.

The diagnosis of myasthenia is based upon history and clinical findings and can be confirmed by electromyography (EMG) or by the presence of antibodies against the acetylcholine receptor [9]. In some acetylcholine receptor antibody negative patients antibodies against muscle specific kinase (MUSK) are detected. However, MUSK myasthenia appears not to be associated with thymoma [10].

Diagnosis of myasthenia is rather easy in severe generalized disease but can be difficult in limited ocular involvement with intermittent symptoms and no clinical abnormalities. In those cases, single fiber EMG of the facial muscles is the most sensitive diagnostic test [11, 12]. In some patients the response to a rapid acting acetylcholinesterase inhibitor such as edrophonium chloride can be helpful.

The treatment of myasthenia usually starts by symptomatic relief with acetylcholinesterase inhibitors such as pyridostigmine. In our own series, nearly half of the patients do not require any other therapy. Some need immunomodulating therapies with steroids, azathioprine and sometimes other drugs such as cyclosporine, mycophenolate mofetil and tacrolimus [13, 14]. Plasmapheresis and intravenous human immunoglobulins are effective as short term therapy in severely disabled patients with bulbar and respiratory problems. A particular treatment for myasthenia gravis is thymectomy. It is always indicated in patients with radiological suspicion of thymoma, but it is generally accepted that its influence on the course of myasthenia is better in young patients with generalized myasthenia and thymic hyperplasia without the presence of a thymoma [9]. An international controlled trial to confirm the superiority of thymectomy plus prednisolone to prednisolone alone is ongoing [15].

7.2 Thymectomy by Minimally Invasive Techniques

7.2.1 General Principles

Resection of anterior mediastinal masses by thoracoscopic techniques has been introduced in the early 1990s as a minimally invasive alternative for sternotomy [16]. The use of robotic systems for resection of tumors in the anterior mediastinum started at the beginning of the twenty-first century [17]. Most authors describe the use of the da Vinci surgical robotic system for thymic hyperplasia and thymoma in patients with myasthenia gravis [17–20] although resection of other mediastinal tumors has also been reported [21]. Today, there is an ongoing debate whether the da Vinci robotic system really has an added value to thoracoscopic resection of anterior mediastinal masses regarding its high costs, and provides a valuable alternative to obtain a complete resection in case of thymomas when compared to transcervical or transsternal thymectomy or a combination of these approaches. The da Vinci robot is also used by the subxiphoid approach for extended thymectomy. This technique, better described as the trans-subxiphoid robotic thymectomy or TRT, has been evaluated in a human cadaver as an alternative to the lateral thoracoscopic approach in 2009 and evaluated clinically in 2016 by Suda [22, 23]. So far, no randomized controlled trials between different techniques for resection of anterior mediastinal masses have been performed, but advantages of the videoscopic approach include less pain and scarring, less risk of wound infection, fewer transfusions, and shorter hospital stay.

The use of the da Vinci robot for the resection of tumors in the mediastinum, including the anterior compartment, was introduced in the Antwerp University Hospital in 2004 and until now, robotic expertise for this indication is limited in other Belgian centers of thoracic surgery. The robot has been used in our service to resect different kind of mediastinal tumors including neurinomas, neurofibromas, mediastinal cysts, mediastinal metastases, ectopic parathyroid adenomas and thymomas. It is currently also used for pulmonary resections, thoracic selective sympatectomy and aortic surgery.

Size of the tumor is an important parameter to choose between resection by sternotomy or robot-assisted thoracoscopy. Initially 4 cm was our upper limit but larger tumors have been resected. Besides this, histology, previous thoracic surgery, the body habitus of the patient, cardiopulmonary morbidity and the patient's preference also determine the final approach. In general, the da Vinci surgical robotic system provides a superb three-dimensional view of the operative field and gives superior handling of the surgical instruments when compared to the classic thoracoscopic technique. With 7 degrees of freedom in movement of the instrument tip and a possible rotation of 360°, it is even superior to a surgeon's hand in open surgery. Therefore, a precise dissection within a small, fixed and remote area is possible. For this reason, dissection of the upper horns is also possible in most cases of thymectomy without an additional cervical incision.

7.2.2 Anesthesia

The anesthesiologist needs to have a thorough knowledge of thoracic anesthesia since the principles of robotic assisted thoracic surgery are essentially the same as those for thoracoscopic and open thoracic surgery. Single lung ventilation is essential for a successful procedure.

Due to the positioning and necessary working space for the robotic system, patient and table positions are often far from routine. This makes access to the airway of the patient by the anesthesiologist often difficult. Therefore, positioning of the patient and single lung ventilation have to be optimal when the robot is put over the patient. Before draping of the patient, prevention of pressure from the robotic arms upon the patient is of utmost importance. When the exposition of the area of interest is not optimal, CO_2 insufflation is used.

Even with only moderate pressures (7 mmHg) significant negative effects on circulation and ventilation might be possible. Reduced venous return can cause hemodynamic instability. Because altering the table position to change filling pressures of the heart is not possible during the procedure, more liberal use of hemodynamic active drugs might be necessary. Ventilation can be impaired by the higher intrathoracic pressure while at the same time absorbed CO_2 has to be eliminated. This might introduce respiratory acidosis and even desaturation, especially when both pleural cavities are opened.

The technique used in our hospital has been described by several authors with specific modifications whenever needed. After general anesthesia is initiated, patients are intubated with a double-lumen tube for selective single-lung ventilation. Standard patient positioning is an incomplete right lateral decubitus with the left side elevated upwards at a 30° angle (Fig. 7.1). The head is also tilted superiorly and slightly to the right. It is important to place the left arm alongside the body but on a lower level than the table not to obstruct movements of the robotic arms. Only patients with myasthenia gravis are transferred to the intensive care unit while all other patients are admitted at the postoperative anesthesia care unit (PACU) and dismissed to the ward several hours later.

Fig. 7.1 Body position for anterior mediastinal mass removal

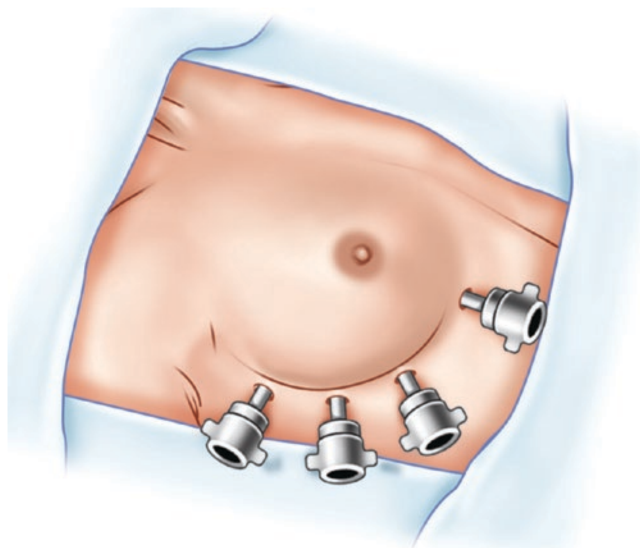

Fig. 7.2 Port placement for right chest approach

7.2.3 Surgical Technique

In our center most resections are performed from the left side of the thorax except for tumors located on the right side of the anterior mediastinum Four trocars are placed as soon as single lung ventilation is initiated by the anesthesiologist: Before 2015 we used the older da Vinci S system with only three ports. These three robotic ports were handled by the first surgeon at the console, while one additional fourth trocar was for the second surgeon at the operating table (Fig. 7.2). For operations on the right side the robot is coming over the left shoulder with ports positioned along the right mammary fold while from the anterior side with the patient in lateral decubitus (Fig. 7.3).

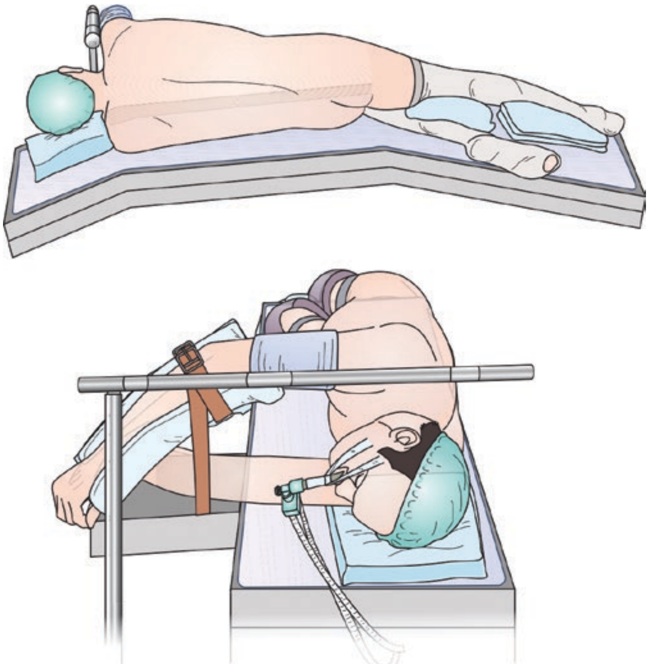

Fig. 7.3 Right chest approach, left lateral decubitus position

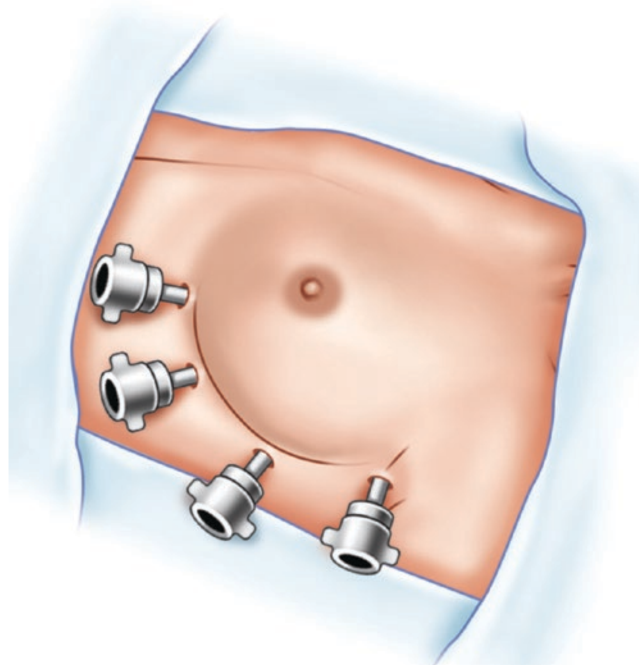

Fig. 7.4 Port placement for left chest approach

Since 2015, we use the da Vinci Xi four-arm surgical robot. This makes handling of all four 8 mm ports possible at the console by the first surgeon. The robot can access the patient from the lateral side (instead of the shoulder approach) and easily rotated once over the patient. Arms will be corrected a second time after the target is defined with the camera inside the patient. This makes the approach easier while not obstructing the working space of the anaesthesiologist. The camera can also be changed easily between ports during the procedure whenever necessary. The second surgeon or table surgeon can choose between placing all robotic ports in the left pleura around the breast with one hand's breadth between them (Fig. 7.4) or placing three ports around the breast while the fourth port is placed more posteriorly, outside this circle as used with the older da Vinci system. In the latter case, the fourth arm is not placed. When all four da Vinci ports are used, the fourth port is also used by the console surgeon but can be easily disconnected whenever the second surgeon needs to suction blood, to apply clips, and for removal of the specimen. Afterwards, the fourth arm is reconnected. The table surgeon is also present to change the instruments and stays at the operating table during the whole procedure in case urgent conversion to a sternotomy or anterior thoracotomy is needed. Since we usually operate close to the phrenic nerve, bipolar cautery is always installed. All non-thymic tumors are resected by a direct approach unless they are not visible within the thymic fat in which case they are resected by an extended thymectomy. Mostly, a 30° camera is used. Once CO_2 insufflation of 7 mmHg is installed, dissection starts at the left lower corner, anterior and medial to the phrenic nerve, and from here upwards alongside the nerve into the cervical region. Special attention is paid to the left innominate vein and its thymic tributaries. These small veins are usually clipped through the fourth port by the second surgeon. The upper thymic poles are mobilized from the left to the right side of the mediastinum and during this dissection, the innominate vein is compressed downwards by the second surgeon in order not to hurt it during dissection. In most cases, the right pleura is opened in order to locate the phrenic nerve at the other side and to accomplish a complete extended thymectomy. The lower parts are dissected at the end and subsequently, the resected specimen is placed in an endobag and removed through the fourth trocar incision. A pleural drain is inserted through one of the ports crossing the mediastinum from the left side with its tip in the right pleura, draining both thoracic cavities and the mediastinum. After re-inflation of the left lung, trocar incisions are closed and patient is extubated immediately on the table whenever possible.

7.3 Outcomes

From 2004 to April 2016 a total of 75 robotic assisted operations for tumors in the anterior mediastinal compartment were performed in the Antwerp University Hospital, Belgium. These represent 70% of our total of robotic assisted operations for mediastinal tumors.

Median age was 42 years (range, 14–79 years). Myasthenia gravis was present in 37 patients (61%). The majority of patients (n = 69) were operated through the left hemithorax (64%). A CO_2 insufflation was used in all patients since 2006. Resection of the tumor was macroscopically complete in all patients. There was no significant intra-operative blood loss in any of the patients and no major surgical complications occurred except for a phrenic nerve paresis in 3 patients. The robotic system itself did not show any technical failure. Chest tubes were removed on postoperative day 3 (range, 1–6). Pathology revealed 17 thymomas (five type A, three type B1, nine type B2), 41 thymic hyperplasias, and three thymic cysts. Other resections included pericardial cysts and parathyroid adenomas.

References

1. Duwe BV, Sterman DH, Musani AI. Tumors of the mediastinum. Chest. 2005;128(4):2893–909.
2. Casey EM, Kiel PJ, Loehrer PJ Sr. Clinical management of thymoma patients. Hematol Oncol Clin North Am. 2008;22(3):457–73.
3. Tomiyama N, Honda O, Tsubamoto M, et al. Anterior mediastinal tumors: diagnostic accuracy of CT and MRI. Eur J Radiol. 2009;69(2):280–88.
4. Endo M, Nakagawa K, Ohde Y, et al. Utility of 18FDG-PET for differentiating the grade of malignancy in thymic epithelial tumors. Lung Cancer. 2008;61(3):350–5.
5. Evoli A, Minicuci GM, Vitaliani R, et al. Paraneoplastic diseases associated with thymoma. J Neurol. 2007;254(6):756–62.
6. Tormoehlen LM, Pascuzzi RM. Thymoma, myasthenia gravis, and other paraneoplastic syndromes. Hematol Oncol Clin North Am. 2008;22(3):509–26.
7. Maggi L, Andreetta F, Antozzi C, et al. Thymoma-associated myasthenia gravis: outcome, clinical and pathological correlations in 197 patients on a 20-year experience. J Neuroimmunol. 2008;201–202:237–44.
8. Maggi L, Andreetta F, Antozzi C, et al. Two cases of thymoma-associated myasthenia gravis without antibodies to the acetylcholine receptor. Neuromuscul Disord. 2008;18(8):678–80.
9. De Baets MH, Oosterhuis HJGH, editors. Myasthenia gravis. Boca Raton: CRC Press; 1993.
10. Pasnoor M, Wolfe GI, Nations S, et al. Clinical findings in MuSK-antibody positive myasthenia gravis: a U.S. experience. Muscle Nerve. 2010;41(3):370–4.
11. Sanders DB. Clinical impact of single-fiber electromyography. Muscle Nerve. 2002;11(Suppl):S15–20.
12. Mercelis R. Abnormal single-fiber electromyography in patients not having myasthenia: risk for diagnostic confusion? Ann N Y Acad Sci. 2003;998:509–11.
13. Sanders DB, Evoli A. Immunosuppressive therapies in myasthenia gravis. Autoimmunity. 2010;43(5-6):428–35
14. Skeie GO, Romi F. Paraneoplastic myasthenia gravis: immunological and clinical aspects. Eur J Neurol. 2008;15(10):1029–33.
15. Newsom-Davis J, Cutter G, Wolfe GI, et al. Status of the thymectomy trial for nonthymomatous myasthenia gravis patients receiving prednisone. Ann N Y Acad Sci. 2008;1132:344–7.
16. Sugarbaker DJ. Thoracoscopy in the management of anterior mediastinal masses. Ann Thorac Surg. 1993;56(3):653–6.
17. Augustin F, Schmid T, Sieb M, Lucciarini P, Bodner J. Video-assisted thoracoscopic surgery versus robotic-assisted thoracoscopic surgery thymectomy. Ann Thorac Surg. 2008;85(2):S768–71.
18. Ismail M, Swierzy M, Rückert RI, Rückert JC. Robotic thymectomy for myasthenia gravis. Thorac Surg Clin. 2014;24:189–95.
19. Jun Y, Hao L, Demin L, Guohua D, Hua J, Yi S. Da Vinci robot-assisted system for thymectomy: experience of 55 patients in China. Int J Med Robot. 2014;10:294–9.
20. Keijzers M, De Baets M, Hochstenbag M, et al. Robotic thymectomy in patients with myasthenia gravis: neurological and surgical outcomes. Eur J Cardiothorac Surg. 2015;48:40–5.
21. Marulli G, Maessen J, Melfi F, et al. Multi-institutional European experience of robotic thymectomy for thymoma. Ann Cardiothorac Surg. 2016;5:18–25.
22. Ishikawa N, Sun YS, Nifong LW, Oda M, Watanabe G, Chitwood WR Jr. Thoracoscopic robot-assisted extended thymectomy in human cadaver. Surg Endosc. 2009;23(2):459–61.
23. Suda T, Kaneda S, Hachimaru A, et al. Thymectomy via a subxiphoid approach: single-port and robot-assisted. J Thorac Dis. 2016;8:S265–71.