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Robotic Assisted Thoracoscopic Repair of Iatrogenic Tracheal Rupture

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Rezumat

Reparația rupturii iatrogene de trahee prin toracoscopie asistată robotic

Introducere: Ruptura traheală este o afecțiune rară, cel mai frecvent întâlnită în traumatismele capului şi gâtului. Ruptura iatrogenă a traheei este extrem de rară şi are multiple cauze dintre care intubația orotraheală este cea mai frecventă (1). Importanța acestor leziuni derivă din complexitatea solutiilor terapeutice, morbiditatea şi mortalitatea ridicată asociată. Algoritmul terapeutic considera tratamentul conservator sau chirurgical, calea de ales fiind toracotomia postero-laterală sau chirurgie toracică video asistată (VATS). Utilizarea platformelor robotice pentru tratarea rupturii traheale iastrogene post-intubație pentru chirurgie electivă nu a fost comunicată în literatură până la data scrierii acestui articol.

Prezentare de caz: O pacientă în vârstă de 54 de ani fără antecedente personale patologice semnificative, prezintă la mai puțin de 24 de ore de la intervenția chirurgicală pentru hernie de disc L5-S1, emfizem subcutanat la nivelul foselor supraclaviculare. Examenul CT şi bronhoscopic confirmă suspiciunea de ruptură traheală în aria membranoasă, demonstrând o leziune de peste 5 cm, cu minime şanse de vindecare printr-o atitudine conservatoare. Se decide intervenție chirurgicală prin abord toracoscopic asistat robotic de către o echipă cu experiență în utilizarea acestei tehnologii pentru patologia toracică/mediastino-pulmonară. Utilizând platforma DaVinci Xi se realizează disecția mediastinului cu evidențierea breşei traheale de 5 cm la limita laterală a membranoasei, a venei azygos şi a nervului vag, urmată de sutură simplă surjet a leziunii cu fir monofilament resorbabil PDO 4-0 şi aplicarea de adeziv co-polimeric (Coseal) pe tranşa de sutură. Durata intervenției a fost de 220 de minute iar sângerarea intra-

operatorie a fost minimă, sub 50 ml, fără complicații intraoperatorii. Abordul robotic a demonstrat avantajele unei expuneri generoase a câmpului operator, cu o vizibilitate clară a structurilor disecate minuțios şi a facilitat sutura eficientă a defectului traheal. Evoluție postoperatorie favorabilă clinic şi paraclinic. Atât bronhoscopia cât şi radiografiile de control ulterior nu au arătat semne de recidivă.
Concluzie: Cazul presentat demonstrează avantajele utilizării eficiente a chirurgiei toracoscopice asistat robotic pentru a trata o complicație foarte rară, ruptura iatrogenă a traheei. Deşi rezultatele bune sunt evidente, aplicarea technologiei robotice pe scară largă pentru chirurgia traheei necesită studii comparative analizate prospectiv.

Cuvinte cheie: ruptură traheală iatrogenă, toracoscopie asistată robotic

Abstract
Introduction: Tracheal rupture is a rare condition, and its most common cause is head and neck trauma. Iatrogenic rupture is extremely rare and has multiple causes of which orotracheal intubation is the most common (1). Its importance derives from the associated high morbidity and mortality. The specific therapy is either conservatory or surgical, either through a postero-lateral thoracotomy or minimally invasive (VATS). Robotic assisted surgery to repair the post-intubation iatrogenic tracheal rupture after elective surgery has not been described so far in the literature.
Case presentation: We present a 54-year-old female patient with no significant underlying conditions, who presented subcutaneous emphysema of the supraclavicular fossa less than 24 hours after surgery for an L5-S1 disc herniation. The CT and bronchoscopy confirmed the suspicion of tracheal rupture in the membranous area, revealing a lesion of more than 5 cm, with minimal chances of healing through a conservative attitude. Surgery was decided and a robotically assisted approach was offered by a team with experience in applying this technology for thoracic/mediastino-pulmonary pathology. Using the DaVinci Xi platform, the mediastinal dissection was performed, the 5 cm tracheal breach was revealed at the lateral border of the membranousa, azygos vein and vagus nerve, followed by closing the defect with resorbable PDO 4-0 monofilament thread and the application of co-polymer adhesive (Coseal) on the suture line. The operative time was 220 minutes and the intraoperative bleeding was minimal, (50 ml), without intraoperative complications. The robotic approach demonstrated the advantages of a generous exposure of the operative field, with a clear visibility of the meticulously dissected structures and facilitated the efficient suturing of the tracheal defect. Favorable post-operative outcome with both bronchoscopy and follow-up radiographs showed no signs of recurrence.
Conclusion: The presented case demonstrates the advantages of an efficient use of robotic assisted thoracoscopic surgery to treat a very rare complication, the iatrogenic rupture of the trachea. Although the good results are obvious, the large-scale application of robotic technology for tracheal surgery requires prospectively analyzed comparative studies.

Key words: iatrogenic tracheal rupture, robotic assisted thoracoscopy

Introduction

Tracheal rupture is a rare condition, and its most common cause is head and neck trauma. Iatrogenic rupture is extremely rare and has many causes (intubation, tracheostomy,

bronchoscopy, placement of stents, esophagectomy, and others), though orotracheal intubation is the most common (1). Its importance derives from the high associated morbidity and mortality. Diagnosis is based on a high clinical suspicion, thanks to the appearance of clinical signs and symptoms that, although not specific, are highly suggestive-subcutaneous emphysema, respiratory insufficiency, pneumothorax, and hemoptysis. Diagnostic confirmation is made by bronchoscopy, which will reveal the size and site of the lesion. The treatment of choice has traditionally been urgent surgical repair, though the authors of the largest series now tend to advocate conservative treatment whenever permitted by the lesion and state of the patient (2). However, the group of patients who would benefit from surgical treatment has not been fully defined (2).

Orotracheal intubation is a routine procedure that has potential complications. Despite the large number of intubations performed every day, these complications are rare. They include from throat pain, laryngitis, glottic edema, and mucosal ulceration, to laryngeal or tracheal stenosis, necrosis of the tracheal wall, fistulas, aspiration, esophageal intubation, bronchial intubation, atelectasis, and tracheal rupture (3).

Post-intubation tracheal rupture (PiTR) is a very rare condition and we therefore do not have adequate prospective studies to evaluate its incidence. To illustrate this, the first case series of PiTR was published in 1995 (4). Despite these limitations, it was estimated that the incidence of PiTR is of 1/20,000 intubations (5), although these figures vary depending on the publication. However, the incidence estimation in the last decade ranged from 0.05% to 0.37% of all orotracheal intubations performed (6,7). Another characteristic of this condition is that all the information available is based on case reports and small case series; the largest series published to date includes 30 patients (7).

The treatment of choice has traditionally been urgent surgical repair, though the authors of the largest series now tend to advocate conservative treatment whenever permitted by the lesion and state of the patient (8,9). However, the group of patients who would benefit from surgical treatment has not been fully defined (2).

Case Report

A 54-year-old female admitted in Ponderas Academic Hospital for neurosugical treatment of a right L5-S1 hernia, diagnosed through MRI, on which a microdiscectomy was performed with curative intent. Patient is otherwise healthy, non-smoker, does not present any significant former pathologies or risk factors. Within the first 24h postoperative the patient developed subcutaneous emphysema of the supraclavicular fossa, which prompted us to follow up with a chest radiography. This revealed subcutaneous emphysema, but with no sign of pneumothorax (*Fig. 1*).

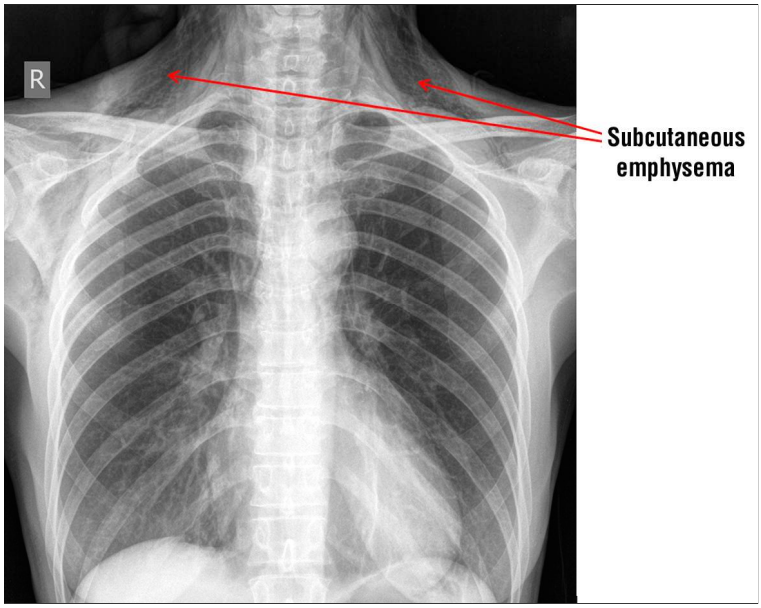

Figure 1. Chest radiography after presentation of subcutaneous emphysema

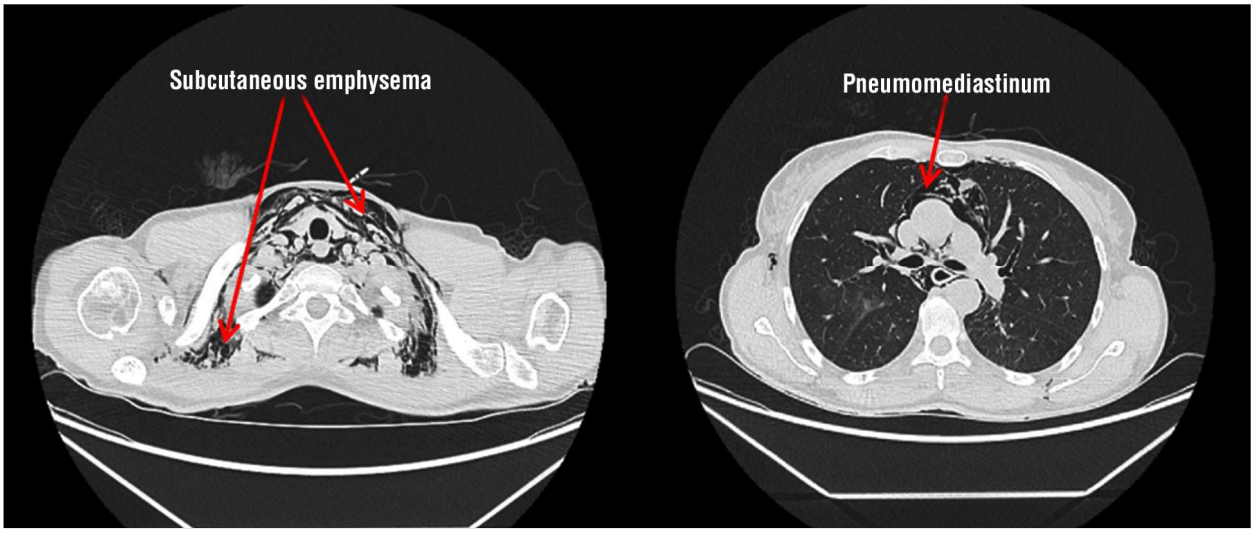

Figure 2. Preoperative CT showing subcutaneous emphysema and pneumomediastinum

We continued investigations using a thoracic computed tomography (CT) which found significant pneumomediastinum and subcutaneous emphysema of the cervical and superior thoracic area (*Fig. 2*) but with no obvious continuity lesion of the trachea.

Given the high suspicion of tracheal rupture we decided to perform a bronchoscopy which confirmed our clinical suspicion, a 5 cm rupture of the posterior wall of the trachea with the development of a local hematoma. (*Fig. 3*).

After the diagnostic's confirmation, we considered that, given the size of the rupture, a conservative approach is not a viable option, so we have decided towards surgical repair. As the bronchoscopy revealed a blood clot and a small bleeding source at the lesion's site, the patient remained in the ICU under sedation and orotracheal intubation, to prevent the distal airways obstruction. The preoperative work-up was completed by parenteral feeding and large spectrum antibiotic therapy. We discussed the different surgical approaches, postero-lateral thoracotomy or minimally invasive either VATS or RATS. Given the position of the tracheal rupture, in close proximity to the carina, and the potentially much better exposure offered by the robotic assisted surgery, we went ahead for the RATS repair. Due to the patient being sedated, a medical multidisciplinary committee was set-up to indicate and approve the surgery, while the informed consent was signed by the patient's next of kin.

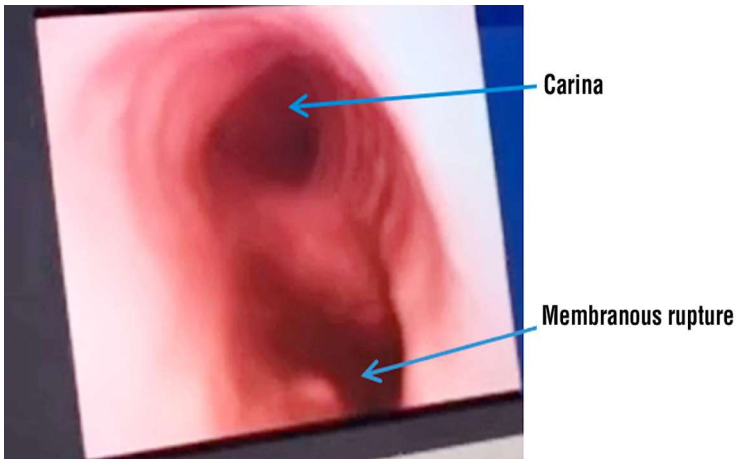

Figure 3. Rupture of the membranous tracheal wall

Surgery was performed under general anesthesia and oro-tracheal intubation. After dissecting the medium mediastinum starting from the azygos vein and going superior we found a large hematoma. After

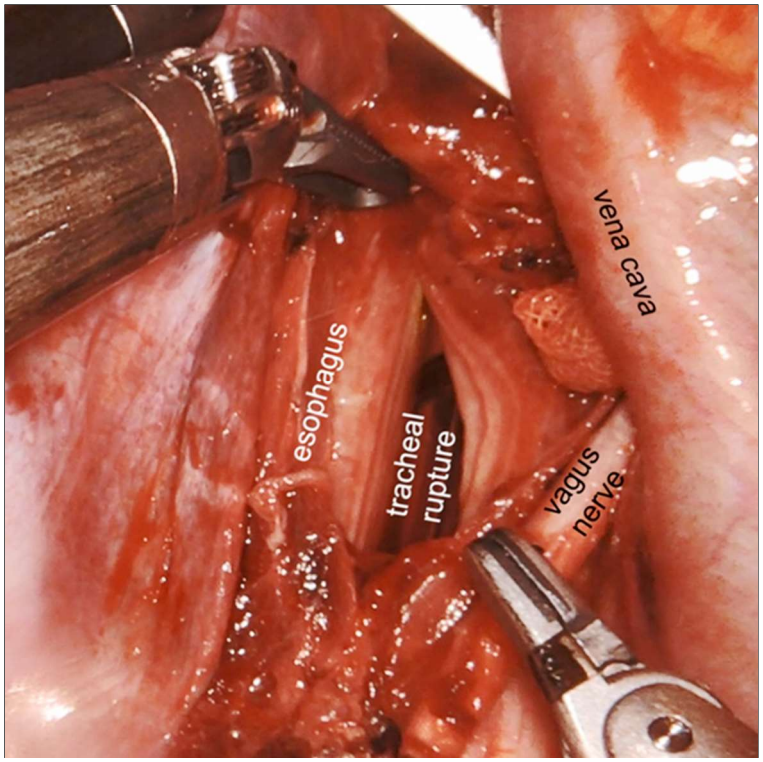

Figure 4. Intraoperative confirmation of membranous trachea rupture

removing it, we continued with the dissection revealing the lateral wall of the trachea, the tracheal rupture, the vagus nerve and the azygos vein. The tracheal rupture was right on the edge of the membranosa, was 5 cm long and it ended at approximatively 1 cm from the emergence of the right main bronchus (*Fig. 4*). The rupture was than sutured with 4-0 monofilament surjet suture under both robotic and bronchoscopic control. After verifying the suture for no air leaks by submerging it in saline solution we applied Coseal surgical sealant (*Fig. 5*).

Total surgical time was 220 minutes with a minimal blood loss of less (50 ml), with no intraoperative complications.

We performed another bronchoscopy 48h postoperative which confirmed the trachea was intact, at which point the patient was extubated (*Fig. 6*). Chest radiography performed on the 5th day postoperative (*Fig. 7*) revealed a right pneumothorax which was resolved by using a 14CH chest drain, the cause being one of the robotic ports used during surgery which had opened. After placing the chest drainage drain we have discovered the assistant port that was placed through the 7th intercostal space, through which the initial chest drain was placed, had opened and required one extra stich. Patient was discharged 7 days postoperative and has made a full recovery, with bronchoscopy and radiology evaluation 6 months postoperative showing no signs of recurrence (*Fig. 8*).

Discussion

The exact mechanism underlying the lesion is uncertain. There is a series of risk factors that contribute to PiTR; these factors may be divided into mechanical and anatomical. Mechanical factors include multiple forced

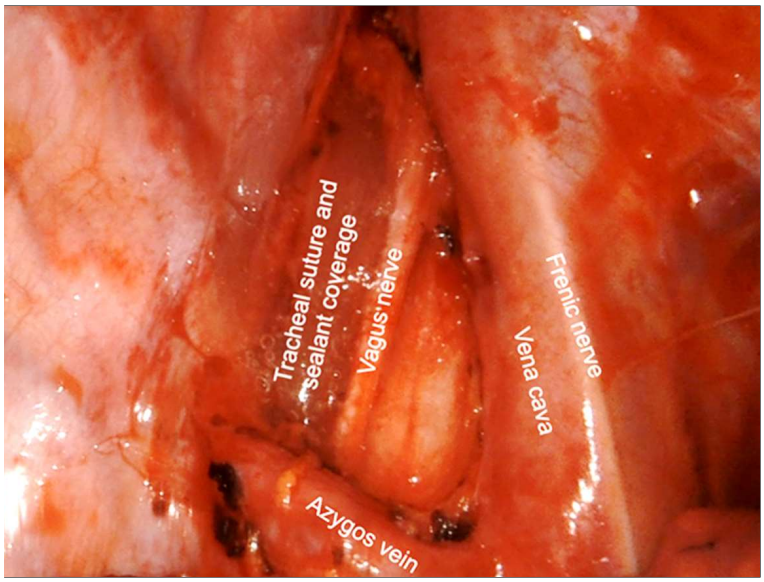

Figure 5. Intraoperative view of the repaired tracheal rupture covered with Coseal sealant agent

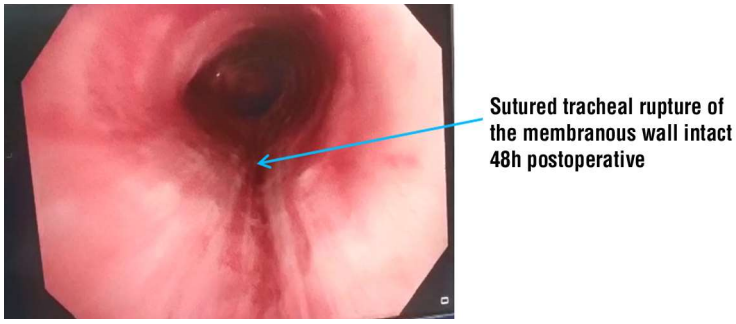

Figure 6. Postoperative bronchoscopy viewing the sutured tracheal rupture before extubation

attempts at intubation, inexperience of the health professional, endotracheal tube introducers that protrude beyond the tip of the tube, overinflation of the cuff (diffusion of nitric oxide into the cuff), incorrect position of the tip of the tube, repositioning the tube without deflation of the cuff, inappropriate size of the tube, significant cough, and movements of the head and neck while the patient is intubated (4,10). In our case intubation was standard with no multiple attempts using a 7.0 flexometalic endotracheal tube performed by an experienced anesthesiologist. The most probable cause for the rupture was due to the repositioning of the patient after intubation in ventral decubitus in order to position for the hernia surgery. The anatomical factors include congenital tracheal abnormalities, weakness of the pars membranosa of the trachea, chronic obstructive pulmonary disease and other inflammatory lesions of the tracheobronchial tree, diseases that alter the position of the trachea (mediastinal collections, lymph nodes, or tumors), chronic use of steroids (11,12), advanced age, and female sex. Our patient did no present any of the anatomical risk factors for tracheal rupture with the exception of female sex.

The most common clinical manifestations of PiTR are subcutaneous emphysema, mediastinal emphysema, and pneumothorax. Other signs include dyspnea, dysphonia, cough, hemoptysis, and pneumoperitoneum (2,13,14). These signs often develop immediately or soon after extubation, though they can take several days to appear. Herniation of the cuff may sometimes be observed on chest radiograph and may contribute to an increase in the size of the laceration (10). We observed the same clinical manifestations in our pacient, with subcutaneous emphysema and pneumomediastinum presenting within the first 24 hours but with no signs of pneumothorax.

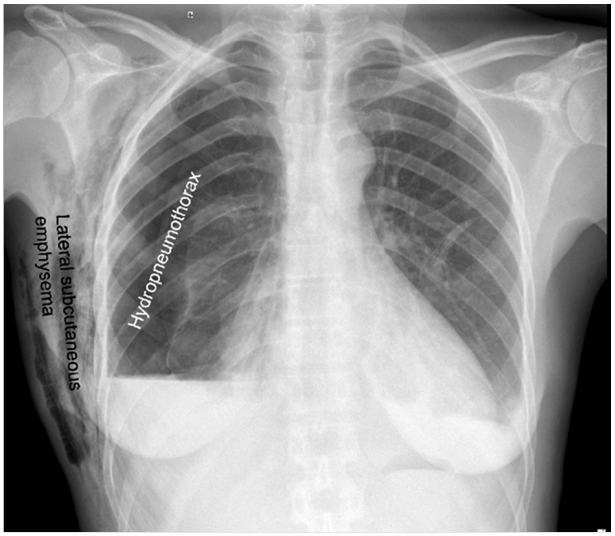

Figure 7. Postoperative chest radiography showing hydropneumothorax and subcutaneous emphysema

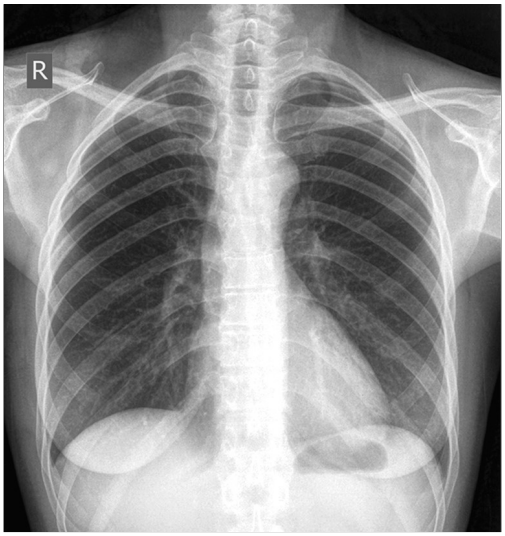

Figure 8. Postoperative follow-up with normal chest radiography with no signs of recurrence

Clinical suspicion must be followed by diagnostic confirmation, which is achieved by direct visualization of the tracheal rupture by bronchoscopy. This procedure provides data on the exact site and extension of the lesion, helps to plan the therapeutic approach, and can be used to reposition the tube or reintubate the patient if this is necessary (14). Tracheal rupture is usually longitudinal and is most frequently located in the membranous part of the trachea, the posterior part of the trachea that lacks cartilaginous support (15). We performed the first bronchoscopy immediately after the results of the thoracic CT scan which confirmed both the presence and the extent of the tracheal wall damage.

There is no consensus regarding treatment yet, with some authors considering early surgical repair as the best course of treatment (6,17) while others prefer conservative treatment in patients with ruptures less than 2 cm (2,17). However, for cases with ruptures longer than 2 cm most authors agree with early surgical repair. We considered that a 5 cm rupture of the membranous wall of the trachea could not be managed conservative and that primary surgical repair was preferable.

The surgical technique used depends on the type and place of rupture. In cases of tracheal section, end to end anastomosis is usually performed, but in cases of lesions of the membranous part of the trachea there are multiple possibilities. Segmental dissection of the trachea and simple suture, anterior transverse tracheotomy, longitudinal tracheotomy or a combination of the two are examples of techniques to treat these lacerations (5,18). For lesions in the upper two-thirds of the trachea cervicotomy is preferred whereas for lesions closer to the carina, the most common approach is through right thoracotomy or videothoracoscopy. We decided that due to the position of the rupture at 1 cm before the emergence of the right main bronchus a right robotic assisted thoracoscopy was the best approach. By using robotic assisted thoracoscopy we can benefit from the better exposure and the finesse this technique provides, allowing us to perform the suture without having to sacrifice the azygos vein or the vagus nerve.

To our knowledge the use of robotic assisted surgery to repair a tracheal postintubation lesion after elective surgery was not described before. Recently, robotic assisted surgery was successfully used for the surgical management of tracheal and left bronchial branch tears during a McKeown esophagectomy for cancer (19). The authors are explaining the intraoperative incident due to repeated double-lumen intubation, the sclerotic changes of esophageal- tracheal muscle fibers after neoadjuvant chemoradiotherapy and the consecutive inflammation and local edema, making esophageal dissection and extended mediastinal lymphadenectomy quite difficult. The case described by Marano A. et al. (19) was an intraoperative situation identified during a robotic assisted procedure and repaired using the same technique.

Robotic assisted surgery was also recently used to repair a large iatrogenic tracheal laceration an 83years-old COVID-19 positive patient, who required orotracheal intubation and mechanical ventilatory support for respiratory failure (20). After intubation she developed subcutaneous emphysema, with rapid progression to universal distribution with tension and she had ventilatory instability. Bronchoscopy findings confirmed the presence of postintubation tracheal lesion, ECMO support was decided, and a robotic assisted surgical repair was performed. In our case, the robotic assisted repair was performed after an elective neurosurgical procedure in a 54-year-old patient with no pre-intubation respiratory condition.

Conclusions

Post intubation tracheal ruptures are very rare occurrences; however, they are associated with a high morbidity and must be immediately managed. Robotic assisted thoracoscopy, although more expensive, has major benefits in repairing the tracheal breach as well as reducing blood loss during surgery and offering a much better exposure than other techniques. Robotic assisted

thoracoscopy allowed us to repair the tracheal rupture without the need to sacrifice the azygos vein or vagus nerve, preserving the anatomy of the mediastinum.

Conflicts of Interests

The authors declared no potential conflicts of interest.

Ethical Statement

The case study was done by following the ethical norms of scientific research and the principles anonymity a confidentiality.

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