Thoracoscopic Oesophagectomy Using Prone Positioning for Oesophageal Cancer With Right Aortic Arch: A Case Report

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Abstract. *Background/Aim:* Right aortic arch (RAA) is a rare abnormality of the aortic arch that forms a vascular ring. Oesophageal cancer (EC) accompanied with RAA is even rarer, and in such cases, it is very important to understand the anatomical structure in the upper mediastinum in order to perform a safe and curative operation. *Patients and Methods:* A 67-year-old man who presented with pharyngeal discomfort was admitted to our hospital. Further examinations revealed advanced thoracic EC accompanied with RAA and aortic diverticulum. *Results:* After neoadjuvant chemotherapy, we successfully and safely performed thoracoscopic oesophagectomy and lymphadenectomy using the prone positioning. *Conclusion:* There exist only a few reports of thoracoscopic oesophagectomy for EC with RAA. Sufficient preoperative preparation and sharing an adequate strategy for the surgical approach with the surgical team are definitely necessary. Although the thoracoscopic approach for EC with RAA is useful, more considerations are needed for some issues.

Right aortic arch (RAA), which is a rare vascular malformation that forms a vascular ring, has a reported incidence between 0.04 and 0.1% of necropsy cases (1). Consequently, oesophageal cancer (EC) with RAA is extremely rare. Most

cases accompanied with RAA have vessel and nervous system anomalies in the mediastinum; therefore, it is very important to understand the anatomy of these systems in order to perform an operation safely, especially in lymphadenectomy around both recurrent laryngeal nerves. Almost all previously reported EC patients with RAA underwent open left thoracotomy; however, thoracoscopic oesophagectomy was used to treat this disease (2-4). Compared to open thoracotomy, thoracoscopic oesophagectomy delivers better surgical outcomes because of several advantages, such as a good surgical view and less trauma to the thoracic wall (5, 6). Herein, we describe a case of advanced thoracic EC with RAA that was successfully resected with thoracoscopic oesophagectomy using prone positioning.

Patients and Methods

A 67-year-old man visited a local physician with pharyngeal discomfort. Further examinations revealed advanced thoracic EC, and he was admitted to our hospital for surgical treatment. Abnormal positioning of the aortic arch was first suspected based on the chest radiography. Barium radiography revealed a 5-cm irregular ulcerated lesion with marginal elevation in the left middle thoracic oesophagus, and right indentation in the upper thoracic oesophagus at the point of the abnormal aortic arch was suspected. Three-dimensional (3D) computed tomography (CT) definitely showed the presence of RAA and aortic diverticulum (AD) (Figure 1). The oesophagus and trachea were completely encircled by the RAA, AD, and pulmonary artery.

Results

On the basis of these findings, we made a diagnosis of advanced thoracic EC, T3N2M0 stage III, according to the TNM classification of the Union for International Cancer Control 7th edition (7), accompanied with RAA and AD. The

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Table I. Edwards' classification of the aortic arch and Stewart's classification of the right aortic arch.

Edwards' classification					
I	Double aortic arch	A	Double aortic arch patency		
		B	One-sided closure of the aortic arch		
II	Left aortic arch	A	Normal branch		
		B	Aberrant right subclavian artery		Stewart's Classification
		C	Isolation of the right subclavian artery		
III	Right aortic arch	A	Mirror-image branch	A1*	I
		B	Aberrant left subclavian artery	B1*	II
		C	Isolation of the left subclavian artery	C1*	III
IV	Other				

*Each subgroup is classified by the side of the ductus arteriosus: 1: left ductus arteriosus; 2: right ductus arteriosus; 3: bilateral ductus arteriosus.

patient underwent one course of neoadjuvant chemotherapy with docetaxel, cisplatin, and an oral 5-fluorouracil tablet, followed by oesophagectomy with lymph node dissection. He was initially placed in the semi-prone position and converted to the prone position using rotation while under general anaesthesia with a single lumen endotracheal tube. All surgeons stood on the left side of the patient, and a video monitor was set up on the opposite site. Four trocars were arranged as follows: two 12-mm trocars in the fifth and seventh intercostal space (ICS) on the posterior axillary line, a 12-mm one (camera port) in the ninth ICS, and a 5-mm one in the third ICS on the middle axillary line. Carbon dioxide insufflation was achieved at a pressure of 6 mmHg to collapse the left lung and to expand the mediastinum.

As shown by preoperative 3D-CT imaging, the trachea and oesophagus were completely encircled by a vascular ring, consisting of the aortic arch, AD, and pulmonary artery. The left recurrent laryngeal nerve (LRLN), and left ductus arteriosus (LDA) were recognised after dissecting along the left vagus nerve to the foot side. LDA connected the AD and pulmonary artery, and the LRLN passed behind the LDA and ascended posteriorly (Figure 2). After processing the LDA, we performed lymphadenectomy along the LRLN, and we released the upper thoracic oesophagus from the vascular ring and transected it with an autosuture device. We did not perform radical lymphadenectomy around the right recurrent laryngeal nerve (RRLN) because it was difficult to identify. The thoracic duct was identifiable and carefully preserved. The patient was turned to the supine position. Then we performed mobilisation of the stomach and lymphadenectomy around the celiac and perigastric arteries, and created a 3-cm wide gastric conduit intracorporeally. Reconstruction was conducted using the retrosternal route, and subtotal oesophagectomy was completed.

Histological findings showed moderately differentiated squamous cell carcinoma, pT3N0(0/46)M0 stage II, according to the TNM classification of the Union for International Cancer Control 7th edition. The patient's

postoperative course was almost uneventful. On postoperative day 2, right thoracic drainage was performed because of right pleural effusion, but on postoperative day 7, the patient began to consume a clear liquid diet orally. At about 17 days postoperatively, he was discharged.

Discussion

EC is one of the lethal malignancies and known as the sixth cause of cancer-related death worldwide (8). Most patients are often diagnosed at an advanced stage. In such cases, radical surgery combined with chemotherapy or radiation therapy or both is required for treatment. Neoadjuvant chemotherapy also has some benefits, such as downstaging, increasing complete resection, improving the tolerability of chemotherapy, and thus improving the survival outcome (9). It is known that EC frequently metastasises to the lymph nodes along both recurrent laryngeal nerves. Therefore, careful surgical manipulation dependent on a good understanding of anatomy in the upper mediastinum is essential for curability of the disease and prevention of postoperative complications, such as nerve paralysis.

RAA is a very rare intrathoracic vascular anomaly. RAA was first described by Fioratti and Aglietti in 1763 (1). Corvisart reported RAA in a case of tetralogy of Fallot, and then RAA has been shown to accompany various types of congenital heart disease (1). Edwards *et al.* classified three types of aortic anomalies based on a theoretical concept of the development of the aortic arch, and RAA is considered group III in their classification (10) (Table I). Stewart *et al.* classified RAA into three types: type I, mirror-image branching; type II, aberrant left subclavian artery, and type III, isolation of the left subclavian artery (11) (Table I). CT has been widely accepted as a non-invasive method for identifying anomalies of the aortic arch and great vessels, and 3D-CT imaging is more useful for preoperative simulation. Most patients with RAA have other abnormalities in the cardiovascular and nervous systems in the mediastinum; therefore, the

Figure 1. Three-dimensional computed tomography showing the right aortic arch (RAA) with mirror-image branching and aortic diverticulum (AD) known as Kommerell's diverticulum. RSA: Right subclavian artery; RCA: right common carotid artery; LCA: left common carotid artery; LSA: left subclavian artery; O: oesophagus; T: tumour, A: anteroposterior view; L: left lateral view.

Figure 2. Thoracoscopic view showing the left ductus arteriosus (LDA) connected to the aortic diverticulum (AD) and pulmonary artery, and the left recurrent laryngeal nerve (LRLN) branching from the vagus nerve (VN) passes behind the LDA and ascends posteriorly.

preoperative evaluation must include cardiac ultrasonography to detect any associated latent heart malformation. The symptoms that RAA may cause depend on the degree of compression on the trachea or oesophagus.

EC accompanied with RAA is extremely rare. In such cases, surgery should be designed for the individual patient in consideration of the anatomic features of RAA. Yano *et al.* first reported the resected case of EC with RAA in 1998 (12), and subsequently, approximately 33 resected cases of EC with RAA have been reported (2-4, 13). In most cases, left thoracotomy was performed in order to gain a sufficient operation view, but some authors proposed the left door open method (14), addition of median sternotomy (15), or addition of right thoracotomy for radical lymphadenectomy along the RRLN.

Recently, as well as for other digestive cancers, thoracoscopic surgery against EC has been increasing, and three studies about EC accompanied with RAA have been reported. In the first article, the authors performed thoracoscopic surgery with a 5-cm mini-thoracotomy and the patient in the right lateral decubitus position (2). They reported the usefulness of marking the LRLN with coloured tape during the cervical portion of the surgery before thoracoscopic surgery. This indicated the importance of identifying the LRLN in an unfamiliar operative position. In the second one, the authors first performed thoracoscopic surgery with the patient in the prone position (3). In the third article, the authors also performed thoracoscopic surgery using the prone position, with sufficient lymphadenectomy along both recurrent laryngeal nerves from the cervical incision (4).

Thoracoscopic surgery for EC was first reported by Cuschieri *et al.* in 1992 (5). Since then, many reports on the advantages and non-inferiority of this approach compared to open surgery for EC have been published (5, 6). Cuschieri *et al.* also first reported performing thoracoscopic surgery in six patients placed in the prone position in 1994 (16). Then, Palanivelu *et al.* (17) and Fabian *et al.* (18) reported the advantages of thoracoscopic oesophagectomy with the patient in the prone position: increased operative exposure, improved surgeon ergonomics, better oxygenation of the patient, and shortened operative time compared with surgery performed with the patient in the left lateral decubitus position. Thus, use of this approach has spread worldwide.

Our patient showed only pharyngeal discomfort and did not complain of dysphagia even though EC was developing. Chest CT revealed the presence of RAA with mirror-image branching, which was classified as group IIIA1 according to Edwards' classification and type I according to Stewart's classification. Our case also demonstrated AD of the right descending aorta, known as Kommerell's diverticulum. In our Institute, thoracoscopic oesophagectomy using prone positioning was first applied for EC in 2006, and since then,

it has been performed safely in about 50 patients with EC at stages up to T3 with regional lymph node metastasis and without severe pleural adhesion. First, neoadjuvant chemotherapy was performed because of the advanced stage of EC based on a previous report (9), and we were able to obtain good tumour reduction. During this term, no tumour progression and no obvious distant metastases were identified. Next, we performed thoracoscopic oesophagectomy according to the criteria of our own institute. Identifying the LDA and LRLN took more time than expected; however, preoperatively, we obtained a 3D-CT image of the anatomy and understood the location of the lymph nodes that needed to be dissected. The LDA connected the AD and pulmonary artery but was not visualised on the preoperative contrast-enhanced CT scan; therefore, the LDA was considered to be closed without a blood stream and could be cut with a vessel sealing device. We processed the LDA uneventfully, but some articles referred to bleeding related to cutting the LDA (15). Therefore, surgeons must observe the stump of the LDA on the aorta side carefully and consider the need of covering the stump if it compresses other organs. Since the chest CT scan showed no evidence of lymph node metastasis around the RRLN, curative lymphadenectomy in this region was not performed. It was difficult to identify the RRLN *via* left thoracotomy alone, even if under thoracoscopy. After operation of the upper thoracic region, the other part of the procedure could be performed smoothly, and the patient's postoperative course was almost uneventful. Since the pathological findings showed no metastatic lymph nodes, we planned to continue adjuvant chemotherapy during the follow-up because of the advanced stage.

EC with RAA is rare, but in such cases, sufficient preoperative preparation and sharing an adequate strategy for the surgical approach with the surgical team are definitely necessary. Although the thoracoscopic approach for EC with RAA is a useful surgical procedure, more considerations are needed for certain issues, such as lymphadenectomy along the RRLN and processing the stump of the LDA. Left thoracotomy is an irregular and unfamiliar method in oesophageal surgery; therefore, it is important to perform the surgical procedure with reference to past reports and determine the proper treatment for each patient.

Conflicts of Interest

The Authors declare no conflicts of interest regarding this study.

Authors' Contributions

The conception of the study: HO, YY, MG; the acquisition of data: SK, AT, DM, OM, RT, HE, YM; interpretation of data: MG; Drafting the manuscript: MG; revising the manuscript critically for important intellectual content: HO, YY, SK, AT, DM, OM, RT, HE, YM. All authors approved the final version of the manuscript, and

agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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