Editorial

# Three-dimensional model to simulate esophagectomy in patients with a mediastinal vascular anomaly: to see is to believe

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The thoracic esophagus is located nearby the major mediastinal vessels, and thus surgeons should be familiar with the surgical anatomy. However, some patients undergoing esophagectomy have a concomitant vascular anomaly, which makes the operation challenging because many surgeons have seldom encountered the particular situation. Hamada *et al.* reported a case of esophageal cancer concomitant with a double aortic arch (DAA), successfully treated by esophagectomy with preoperative simulation using a 3D model (1).

Vascular rings are congenital aortic arch anomalies that lead to compression of the trachea and the esophagus. Vascular rings mainly consist of five categories: DAA, right aortic arch (RAA) with the left ligamentum arteriosum, pulmonary artery sling, innominate artery compression, and aberrant right subclavian artery (ARSA) (2). A two-dimensional echocardiography screening showed that the incidence of vascular rings was 0.59% in 186,213 school-aged children in Taiwan. In the study, the incidences of ARSA, RAA with left ligamentum, DAA, and pulmonary artery sling were 0.53%, 0.05%, 0.004%, and 0.006%, respectively (3).

Esophagectomy for patients with DAA or RAA is challenging. Dissection of the proximal esophagus and the upper mediastinal lymph node is complex because the DAAs or the right-sided aortic arch with left ligamentum arteriosum create a ring surrounding the esophagus and the regional lymph nodes to be dissected. We have previously reported that the cervicothoracoscopic approach consisting of transcervical upper mediastinal lymphadenectomy followed by left-sided thoracoscopic esophagectomy was helpful for esophagectomy in an esophageal cancer patient with RAA (4).

Esophagectomy for patients with the pulmonary artery sling is also problematic because an intraoperative compression of the pulmonary artery may cause circulatory collapse. We also reported that the cervicothoracoscopic approach with a right-sided thoracoscopic surgery is practical to ensure the left recurrent laryngeal nerve lymph node dissection, preventing pulmonary artery compression (5). Preoperative planning of the surgical approach is essential to achieve a favorable result in patients with such situations.

It is well known that ARSA accompanies a right non-recurrent inferior laryngeal nerve. Surgeons must take care of this anomaly when dissecting the right recurrent laryngeal nerve lymph nodes in patients with ARSA. Besides, we identified different anomalous thoracic duct types in four ARSA cases (6). Careful inspection of the thoracic duct is also required in patients with ARSA undergoing esophagectomy. Understanding the concomitant anomalous structures is also critical for successful operation.

Patient-specific 3D models of anatomical structures can be generated from various medical imaging, such as computed tomography and magnetic resonance imaging (7).

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When performing surgery in cases of very unusual anatomy, a well-prepared surgical plan based on a simulation using the 3D models is a key to treatment success. Hamada *et al.* first reported an esophageal cancer case with DAA that underwent esophagectomy after a preoperative simulation using the 3D model (1). The 3D model enables surgeons to select an appropriate surgical approach for patients with unusual anatomy. Most importantly, they can try differential approaches repeatedly and choose the best after trial and error, which has never been allowed in the real world. Further, this technology will be an educational tool for inexperienced surgeons unless patients have anomalous anatomy. The 3D printing technology will contribute to improving surgical quality while ensuring safety.

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