

## —Report on Experiments and Clinical Cases—

## Three Cases of Retroesophageal Right Subclavian Artery

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**Abstract**

We have experienced three cases of retroesophageal right subclavian artery. Two cases were cadavers, and one case was a live human.

In the two cadavers of a 68-year-old and a 76-year-old, respectively Japanese and European males, the right subclavian artery originated from the aorta after the aorta branched the right carotid artery, the left carotid artery and the left subclavian artery. The right carotid artery immersed solely from the aorta. Where the right subclavian artery originated from the aorta, the artery took a dorsal direction. It passed between the esophagus and the vertebral column. The esophagus was compressed from the dorsal side by the right subclavian artery. The structural anomaly of the right subclavian artery accompanied the cephalad recurrence of the branch from the right vagal nerve toward the larynx.

In the live human case, we obtained CT views. The patient was a 41-year-old Japanese, who complained of dysphagia lusoria. We found that the right subclavian artery was anomalous and originated from the aorta as the last cardinal branch in the thorax.

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**Key words:** subclavian artery, human, aortic arch, variation

**Introduction**

Congenital failure in the development of the primordial aortic arch results in various vascular anomalies<sup>1</sup>. In about 80% of individuals, 3 branches arise from the aortic arch; the brachiocephalic trunk, the left subclavian artery, and the left common carotid artery. Adachi first described this branching pattern as type A<sup>2</sup>. Another 11% of reported cases exhibit Adachi's type B pattern, which consists of a

common trunk for the left common carotid artery and the brachiocephalic artery. This branching pattern results in only 2 trunks originating from the aortic arch. The third most common pattern, type C, is characterized by the vertebral artery originating proximally to the left subclavian artery as a 4<sup>th</sup> branch of the aortic arch. In type G, Adachi described the pattern, in which the right subclavian artery was found as the last branch of the aortic arch (**Fig. 1**). He found the frequency of the type G at 0.2% out of 516 Japanese cadavers.

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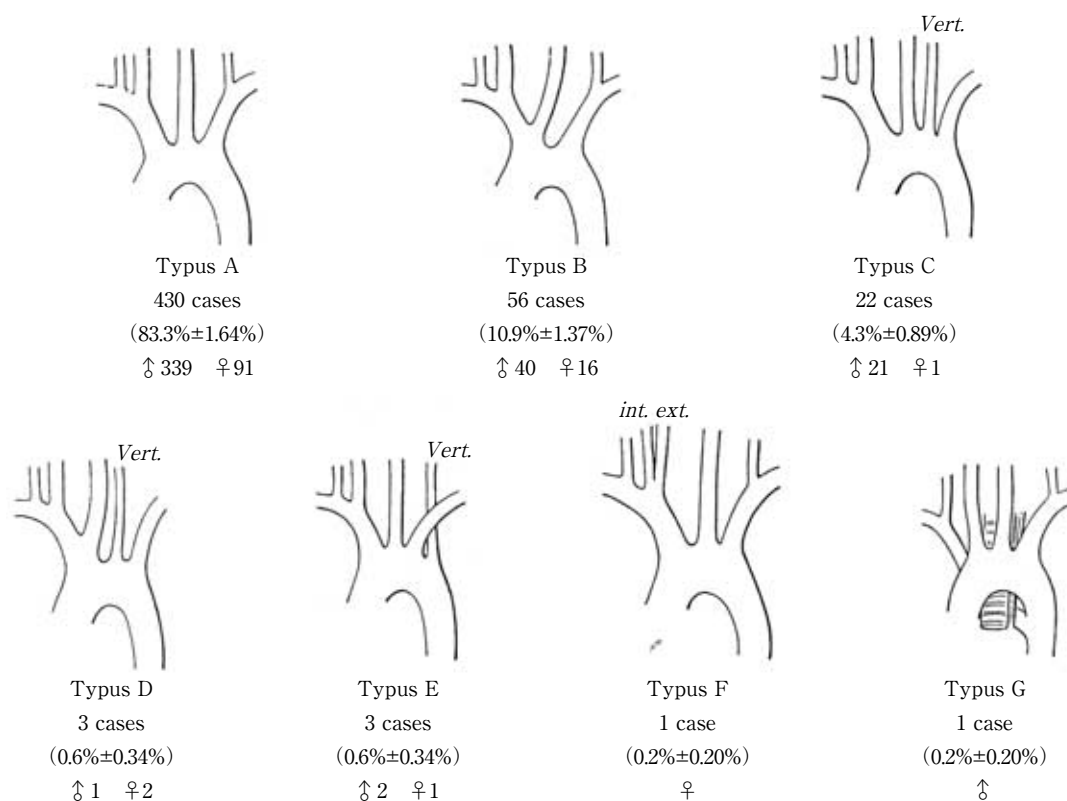


Fig. 1 Variation frequency of the aortic arch with frequency in the 516 Japanese cadavers. The retroesophageal right subclavian artery is classified in type G according to the Adachi's classification.

In this report, we present three cases of type G; the retroesophageal right subclavian artery and review the relevant anatomical and clinical literatures.

### Observation

We were able to examine three cases of retroesophageal right subclavian artery. Two of the three were found at academic institutions during the human body course. The other case was a male live human with dysphagia lusoria, found through a CT examination at a hospital.

#### Cadaver 1

The first retroesophageal right subclavian artery was found in the cadaver of a 68-year-old male. During the human body course for the students, we could find that there was no truncus brachiocephalicus in the cadaver (Fig. 2). We examined the branching of the artery at the aortic arch and its associated thoracic viscera carefully.

The anomaly of the retroesophageal right subclavian artery was recognized (Fig. 3). The first, second, third and fourth branches, taking origin independently from the aortic arch from right to left, were the right common carotid artery, the left common carotid artery, the left subclavian artery and the retroesophageal right subclavian artery. The right subclavian artery branched about 2.2 cm distal to the left subclavian artery and about 5 mm dorsal to it. It coursed upwards behind the esophagus from just where it originated. It reached the level of the first thoracic vertebra, and then pursued an ordinary course. Its branches and the areas of distribution were ordinary and similar to those of the left subclavian artery.

The vertebral arteries each arose from the corresponding subclavian artery and entered the transverse foramen of the sixth cervical vertebra. The other stems of the aortic arch followed normal arrangements.

The right vagus nerve descended into the thorax anterior to the anomalous vessel. Its inferior

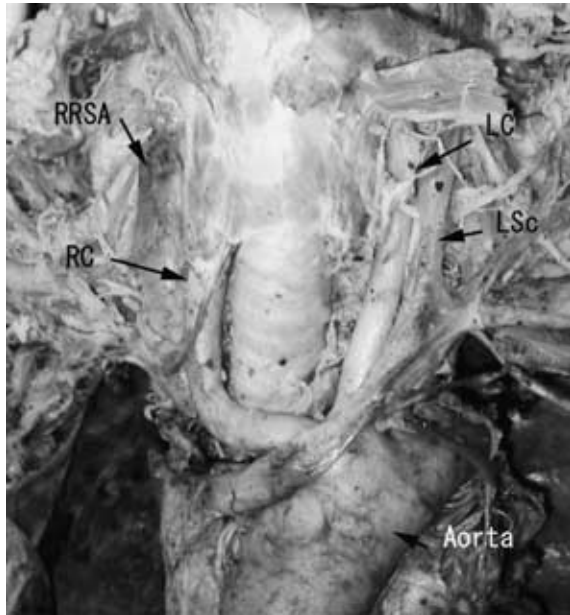


Fig. 2 The internal view of the chest of the first case. There was no truncus brachiocephalicus in this cadaver. The right common carotid artery and the right subclavian artery originated separately. The right common carotid artery, the left common carotid artery and the left subclavian artery originated very closely. But it can not be said that they had a common stem.  
Abbreviation: RRSA, retroesophageal right subclavian artery. RC, right common carotid artery. LC, left common carotid artery. LSc, left subclavian artery.

laryngeal branch passed directly into the neck to reach larynx without looping around the right subclavian artery (**Fig. 4**).

The course and termination of the thoracic duct were normal.

### Cadaver 2

The second case of the retroesophageal right subclavian artery was found in the cadaver of a 68 year-old male. During the human body course, a mass was noted in the retroesophageal space. Further dissection revealed that the mass was a type G aortic arch; the retroesophageal right subclavian artery<sup>23</sup>. All four cardinal arteries (right carotid, left carotid, left subclavian and right subclavian arteries) originated sequentially (**Fig. 5**). The origins of the first three arteries were aligned in order. Although these arteries originated from the

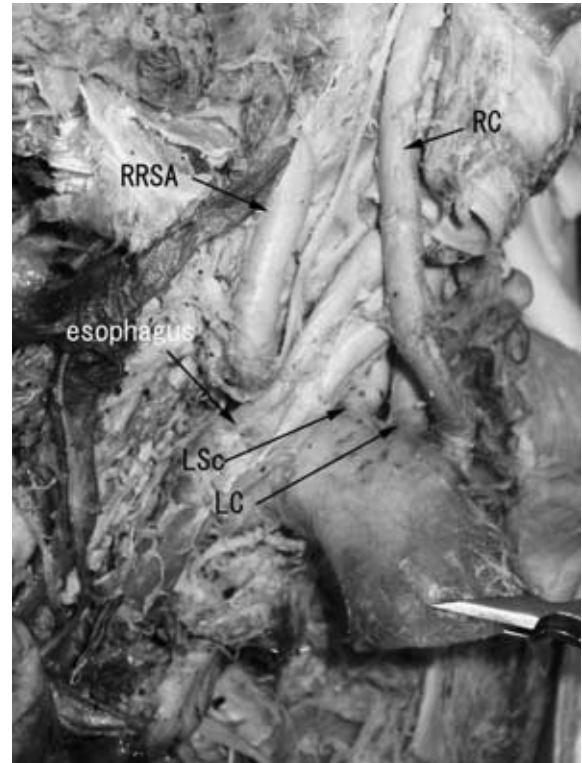


Fig. 3 The aortic arch with the four branches. The aorta is pulled forward and to the right to show the origin of the branches. The right subclavian artery arose cephalad behind the esophagus, and pursued an ordinary course to the right upper arm region later.

superior surface of the aorta, the retroesophageal right subclavian artery originated at the rear-upper surface of the aorta. It originated distally at 2.2 cm from the origin of the left subclavian artery. The retroesophageal right subclavian artery was bigger than the left subclavian artery in diameter.

In this case, the right common carotid artery ran more anteriorly and medially comparable to standard. The artery ran up anterior to the thyroid gland toward the brain (**Fig. 6**). The other two arteries; the left common carotid and the left subclavian artery, did not show any particularity. The shape of the aortic arch was normal.

The right recurrent laryngeal nerve did not recur around this anomalous vessel as in case 1. The left recurrent laryngeal did recur normally around the ligamentum arteriosus. Both left and right vertebral arteries originated from the subclavian arteries in a normal fashion and both entered the transverse foramina of C6. The thoracic duct drained into the

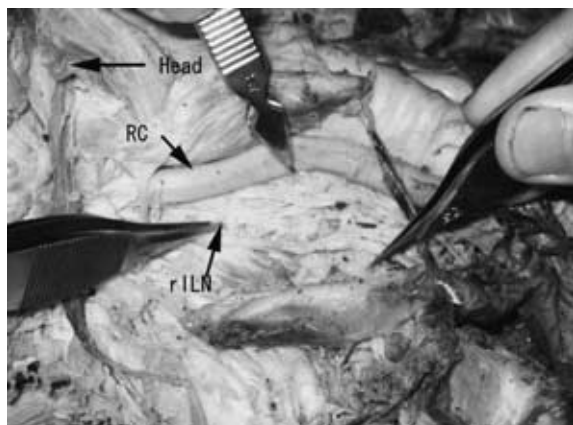


Fig. 4 The superior branching of the inferior laryngeal nerve. The right vagus nerve gave rise the branch of the inferior laryngeal nerve at the level of thyroid cartilage, whose nerve did not turn around the right subclavian artery.  
Abbreviation: rILN, right inferior laryngeal nerve.

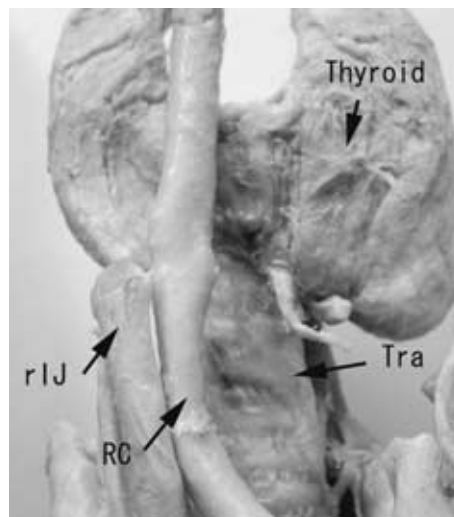


Fig. 6 The relation between the right carotid artery and the thyroid. The right carotid artery had the layout more anteriorly and medially.  
Abbreviation: rIJ, right internal jugular vein.  
Tra, trachea.

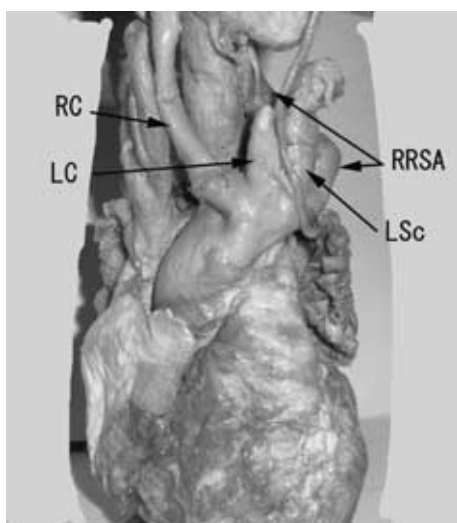


Fig. 5 Branching of the four cardinal arteries of the second case. The specimen was removed aorta with the heart and the arteries. The four cardinal arteries (right carotid, left carotid, left subclavian and right subclavian arteries) originated sequentially. The retroesophageal right subclavian artery originated as the fourth branch and went cephalad and to the right side behind the esophagus.

junction of the left internal jugular and left subclavian veins. Gross cardiac dimension was within normal limits.

#### The Case of the Live Human

A patient with retroesophageal right subclavian artery was found in a routine health check. The patient was found because he claimed dysphagia for a long time after he was born (**Fig. 7**). The patient was a 41 year-old male. He was willing to be examined because he wanted to know the reason of the dysphagia. The dysphagia was only one symptom he had. **Fig. 8** is the CT image of the major arteries in the thorax in this case. We can see aberrant artery formation between the esophagus and the vertebral column.

The recurrent branch of the vagus nerve and the thoracic duct were not identified in the CT examination. The layout of the thyrocervical artery was also not seen in the routine CT examination. After he understood the cause of the dysphagia, the patient did not receive any medical treatment, although he was recommended surgical interventions. The size of the heart and the shape of the aorta were not abnormal. All abdominal viscera were normally positioned without any malformation or disease.

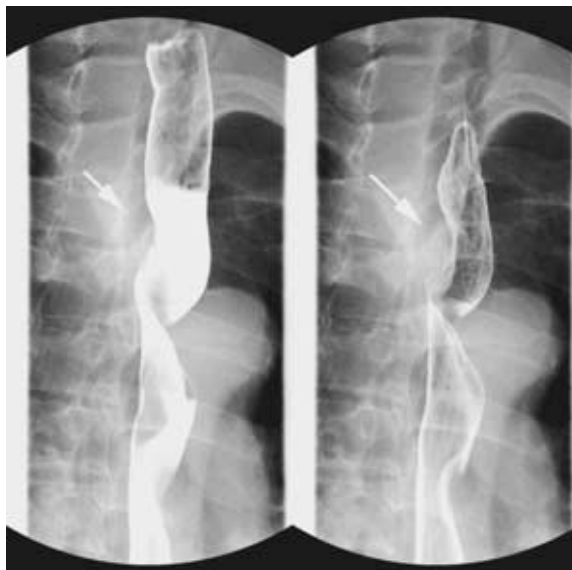


Fig. 7 The X-ray view of the esophagus in the patient with dysphagia. The path of the esophagus is twisted by the pressure from the rear side; dysphagia lusoria (**arrow**). The retroesophageal right subclavian artery is thought to pass behind the esophagus from the right to the left side.



Fig. 8 The CT view of the chest of the patient. The retroesophageal right subclavian artery is located behind the esophagus. Accordingly, the esophagus is pushed forward.

### Discussion

The origin of the retroesophageal right subclavian artery as the last branch of the aortic arch is a common congenital aortic arch anomaly, with a reported prevalence of 0.4~2%<sup>3</sup>. The earliest reported description of this anomaly is published by Hanuld in 1735<sup>4,5</sup>.

The classification of the retroesophageal right subclavian artery is currently made according to the Adachi report about the branching pattern of the aorta<sup>2</sup>. There are various morphologic types in the retroesophageal subclavian artery<sup>6,7</sup>. According to Adachi-Williams' classification, the anomalous branching pattern of the subclavian artery may take any of the following four basic morphologic forms (**Fig. 9**). All our cases belonged to Type G in this classification.

#### 1) Type G

The right subclavian artery arises from the distal pattern of the aortic arch as its last branch. The other stems (the right and left common carotids, and the left subclavian artery) follow the ordinary

arrangements. Our present case belongs to this category.

#### 2) Type CG

The right subclavian artery is anomalous (as type G). And the left vertebral artery arises directly from the aortic arch.

#### 3) Type H

The right subclavian artery is anomalous (as type G). And the right and left common carotid arteries have a common stem called the bicarotid trunk.

However, there are still very rare morphologic types reported by Holzapfel, Poynter, Edwards, and Nizankowski<sup>8-11</sup>.

#### 4) Type N

This is the mirror image of type G. In this type, a right aortic arch is present and the origin of the left retroesophageal subclavian artery succeeds those of the two carotid and right subclavian artery. The incidence of this type is much rarer than that of the retroesophageal right subclavian artery<sup>12</sup>.

### Developmental Considerations

The right subclavian artery usually develops during the sixth to eighth week of gestation from 1) the right fourth aortic arch artery (forms the proximal part), and 2) the right dorsal and right

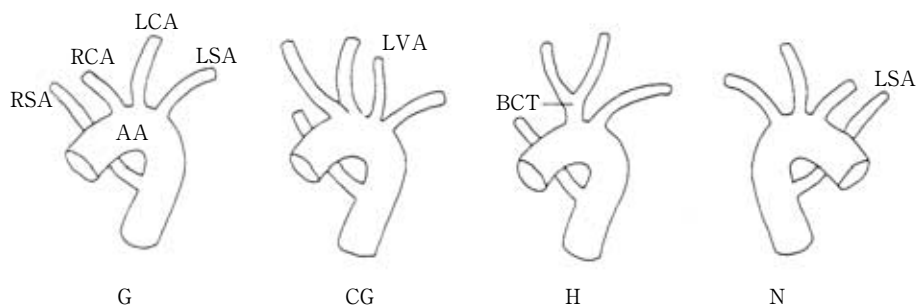


Fig. 9 The main morphologic types of the retroesophageal subclavian artery (cited from reference 3 after the approval).

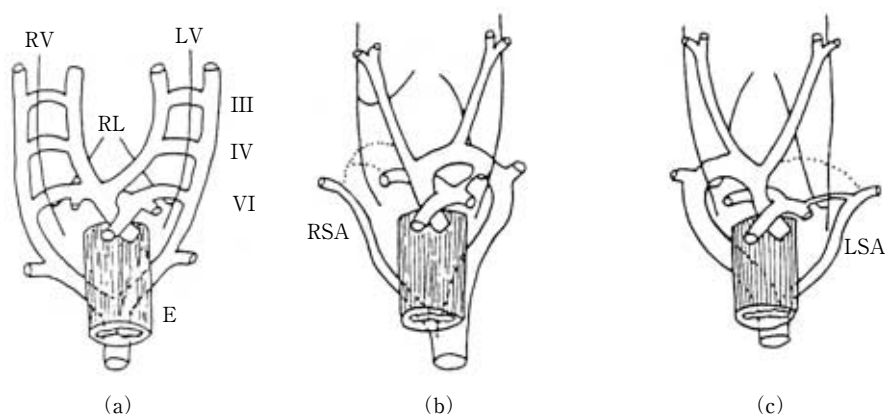


Fig. 10 Diagram illustrating the development of the retroesophageal subclavian arteries and the relation of the recurrent laryngeal branches of the vagus nerve (cited from reference 3 after the approval).

seventh intersegmental artery (form the distal part) (**Fig. 10a**<sup>13,14</sup>).

Under abnormal conditions, the right fourth aortic arch artery and/or the right dorsal aorta involute cranial to the seventh intersegmental artery; i.e. the connection between the aortic sac and the origin of the right subclavian artery disappears (**Fig. 10b**). Consequently, the right subclavian artery develops from 1) the right seventh intersegmental artery and 2) the distal segment of the right dorsal aorta. As development proceeds and the arch of the aorta forms, differential growth shifts the origin of the right subclavian artery cranially, so that it comes to lie close to the origin of the left subclavian artery. As a result of its dorsal origin, the artery necessarily passes behind the esophagus.

On the other hand, the left anomalous retroesophageal subclavian artery develops when the left fourth aortic arch artery disappears, and

concomitantly the right fourth aortic arch artery and right dorsal aorta form the arch of the aorta<sup>15</sup> (**Fig. 10c**).

#### Common Associated Anomalies of the Retroesophageal Right Subclavian Artery

The following anomalies are reported to occur frequently along with the retroesophageal subclavian artery. In our cases, we could find an abnormal layout of the recurrent laryngeal branch of vagus nerve in the two cadaver cases, and that, in the second case, the right common carotid artery took a gradual course across the front of the trachea.

##### 1. Recurrent laryngeal branch of the vagus nerve.

This branch normally turns around the lowest persisting aortic arch on either side, hence, normally, on the left side around the junction of the ductus arteriosus (sixth aortic arch) to the aorta, and on the

right side (where the fifth and sixth arches do not persist) around the right subclavian artery. However, in case of the retroesophageal right subclavian artery, there is no vessel arising in such a manner as to draw the nerve downward in a looping course. The nerve of the right side, typically, lies in the neck, leaving the vagus at the level of the larynx and passes to its area of supply either directly (**Fig. 10b**), as in the present case, or looping around the inferior thyroid artery<sup>15</sup>.

In the case of the left anomalous subclavian artery, both recurrent nerves arise in the thorax (**Fig. 10c**), as such a condition is associated with persistent ductus arteriosus<sup>12</sup>.

The layout of the right recurrent laryngeal nerve is recently focused on because esophageal cancer in the chest frequently makes skip metastasis to the lymphnodes around the recurrent nerve<sup>16</sup>. Anomalous layout of the right recurrent nerve will affect surgical intervention in the case of esophageal cancer.

## 2. The thoracic duct

In cases of right anomalous vessel, the thoracic duct usually opens into the veins of the right side<sup>15,17</sup>, most probably due to pressure of the anomalous vessel on the left side of the front of the vertebral column, which interferes with the development of the upper end of the originally paired ducts. However, in our two cadaver cases the thoracic ducts drained into the vein at the left venous angle.

## 3. Tracheoesophageal fistula

This fistula results from interference with the normal development of the esophagus and trachea by pressure of the anomalous vessel<sup>15</sup>. We did not see any fistula.

## 4. Other vascular anomalies

The anomalous subclavian artery more often occurs in individuals with other anomalies affecting the aortic arch, e.g. Fallot's tetralogy, patent ductus arteriosus, aortic coarctation, aneurismal formation, and pulmonary stenosis<sup>18,19</sup>. These accompanying diseases should be corrected if necessary. In the case of right anomalous vessel, the right common carotid artery tends to take a more gradual course across the front of the trachea to attain its position behind the thyroid gland. This may cause tracheal

compression, and is vulnerable to injury during tracheostomy<sup>3</sup>. In our second case the course of the right common carotid artery took a gradual course. Although we did not examine further, the arteries originating from the subclavian artery on the right side may have also been anomalous. The vertebral and thyrocervical arteries should be examined whether or not their layouts are normal, because the region is relevant to the clinical regimen e.g. stellate ganglion block.

## 5. The right sympathetic cardiac nerves

Horiguchi et al. reported absence of the right middle cervical cardiac nerve in a case of right aberrant artery. They attributed this anomaly to the agenesis of the primordium of this nerve concurrent with disappearance of the right fourth aortic arch artery<sup>20</sup>.

## Clinical Correlations

The clinical syndrome of the retroesophageal right subclavian artery was found to be associated with dysphagia, as termed "dysphagia lusoria" by Bayford in 1787. The meaning is dysphagia caused by the deformed alimentary pathway. The majority of patients are generally asymptomatic. The symptom occurs when the retroesophageal right subclavian artery produces a vascular ring known as Kommerell's diverticulum in adults. In elderly patients, an retroesophageal right subclavian artery occasionally becomes tortuous resulting in esophageal or tracheal compression, for which surgery is indicated if the symptoms are severe<sup>21-24</sup>.

The inferior right recurrent laryngeal nerve is also a clinically relevant aside of dysphagia lusoria. The abnormal layout of the nerve is asymptomatic. This can be an important obstacle and be seriously damaged during cervicotomy, thyroid and parathyroid surgery. Recently, the right recurrent laryngeal nerve has been found to be important in the skip metastasis of esophageal cancer<sup>16</sup>. The cancer of the esophagus in the middle portion in the thorax makes frequent metastases to the lymphnodes along the right recurrent nerve. Obviously, the anomalous layout of the right recurrent laryngeal nerve affects the procedure of the dissection of the lymphnodes in the radical

esophagectomy.

Also, the gradual course of the right common carotid artery may affect the procedure of the needle insertion around the thyroid cartilage. The change of the carotid artery is possibly accompanied by the change of the position of the surrounding organs. This may cause accidental organ damage and unexpected spread of the anesthetic solution in the neck region (e.g. in the stellate ganglion block).

Finally, the retroesophageal right subclavian artery is important to the angiographer who uses the right axillary, brachial or radial approach to the ascending thoracic aorta. The presence of the anomaly is suspected in cases in which catheterization of the ascending aorta proves difficult<sup>25</sup>.

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