Case Report

The Occurrence of 4 Variations: Retroesophageal Right Subclavian Artery, Aortic Origin of Left Vertebral Artery, Right Non-Recurrent Laryngeal Nerve and Right-Sided Thoracic Duct in Thai Cadaver: A Case Report

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Background: *An understanding of the variability of branches of aortic arch and associated anomaly impact in radiological examination and surgery for diagnosis.*
Objective: *To present the retro esophageal right subclavian artery and theaortic origin of left vertebral artery associated with right-sided thoracic duct and right non-recurrent laryngeal nerve.*
Material and Method: *The case study was carefully dissected to investigate the great vessels of the aortic arch and other related variation structures.*
Results: *We found four anatomical variations in a 75-year-old Northeast Thai male cadaver. The four variations are composed of anomalies of the aortic origin of left vertebral artery, retro esophageal right subclavian artery, the right-sided thoracic duct and the right non-recurrent laryngeal nerve.*
Conclusion: *The finding of four variations in this case benefits for awareness during surgery in order to decrease the risk of iatrogenic injury.*

Keywords: *Aortic origin of left vertebral artery, Retroesophageal right subclavian artery, Right-sided thoracic duct, Right non- recurrent laryngeal nerve*

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The major branches of aortic arch are the great ways for blood supply to head and upper limbs, and they are of particular interest in clinical angiography[10]. The aortic arch in the majority of the population has three branches that consist of right brachiocephalic trunk as the first branch, left common carotid artery, and left subclavian artery, respectively. The right subclavian artery originates from the brachiocephalic trunk. It arises deep to the right sternoclavicular joint, ascends over the clavicle and terminates medial to the first rib and becomes axillary artery[1,6]. The left and right vertebral arteries originate from first part of subclavian arteries each side. As for the thoracic duct, it originates from the cisterna chili and passes through the aortic hiatus, entering the posterior mediastinum. Then it ascends to drain into the venous system, the site of the left jugular and subclavian veins, and sometimes into the left brachiocephalic vein. The right recurrent laryngeal nerve coils around the right subclavian artery, then passes the inferior thyroid artery and innervates the lower larynx[6].

During dissection of cardiovascular system at gross anatomy laboratory, we found an abnormal branching pattern of the aortic arch in a 75-year-old male cadaver. His aortic arch presents five branches composes of right common carotid artery, left common carotid artery, left vertebral artery, left subclavian artery, and right subclavian artery as the fifth branch which originates from the distal part of aortic arch in the retroesophageal position (the retroesophageal right subclavian artery, RRSA). We also found right-sided thoracic ductand non-recurrent right inferior laryngeal nerve in this case.

There were reports that showed RRSA associated with other anomaly such as the aortic origin

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of left vertebral artery, truncusbicaroticus with common trunk of left subclavian and vertebral artery[16,24], anomalous origin of bilateral vertebral arteries[11], right-sided thoracic duct[9], non-recurrent laryngeal nerve[13,19,22,27], both a non-recurrent laryngeal nerve and a right-sided thoracic duct[6,14], and associated with both aortic origin of left vertebral artery and right-sided thoracic duct[5]. However this is the first case report presents the occurrence of four variations which consist of RRSA, aortic origin of left vertebral artery, right non-recurrent laryngeal nerve and right-sided thoracic duct since 1983. Furthermore, this study discusses about how they impact for diagnosis and patient injury prevention in radiological examination and surgery[9,10].

Material and Method

A cadaver was carefully dissected in chest and mediastinum region in order to identify the great vessels of the aortic arch and investigate variations associated structures. Diameter, circumference and length of the great vessels of the aortic arch artery were measured by the vernier caliper.

Results

A 75-year-old Northeast Thai male cadaver that cause of death was pulmonary emphysema was dissected in chest and mediastinum region. He was observed that the heart showed normal size and anatomical position. In addition, the aorta arose normally from the left ventricle. The abnormal branching pattern of the aortic arch was observed as follow:

1) The first branch of the aortic arch is right commoncarotid artery (RCA), which originates from the upper surface of the aortic arch. Diameter and circumference of RCA at the origin is 8.15 mm and 25.62 mm respectively. The length of this artery from the origin to its bifurcation is 120.67 mm.

2) The second branch is left commoncarotid artery (LCA), which originates from the convexity of the aortic arch. It's slightly bigger and longer than RCA. Diameter and circumference of LCA at the origin is 8.96 mm and 28.15 mm respectively. The length of this artery from the origin to its bifurcation is 133.51 mm.

3) The third branch is left vertebral artery (LVA), which originates from the aortic arch between LCA and left subclavian artery (LSA). It's slightly bigger and longer than right vertebral artery (RVA). Diameter and circumference of LVA at the origin is 5.23 mm (RVA 4.20 mm) and 16.44 mm (RVA 13.20 mm), respectively. The length of this artery from the origin to the point that vertebral artery enter into transverse foramen of C5 is 84.97 mm. Alternatively, the right vertebral artery in this case originates from RRSA in the normal position (proximal to scalene muscle) then enter to transverse foramen of C6. The length of RVA is 14 mm which shorter than LVA. Both LVA and RVA don't have any branches in the neck.

4) The forth branch is LSA. Diameter and circumference of LSA at the origin is 10.12 mm and 31.79 mm, respectively. The length of this artery from the origin to the lateral border of first rib (at the end) is 57.97 mm. Other branching pattern of this artery is as a normal except it doesn't have a vertebral artery as the first branch.

5) The fifth branch is RRSA which originates from the posterior aspect of the most distal part of the aortic arch. It's a biggest branch of the aortic arch. Diameter and circumference of RRSA at the origin is 17.05 mm and 53.58 mm, respectively. It passes from the left to the right into the midline between the esophagus and the third vertebral body (posterior to the esophagus and anterior to the vertebral body). Then it runs into the normal position of right subclavian artery and gives off the normal branching pattern. The length of this artery from the origin to the end (at lateral border of first rib) is 91.67 mm (Fig. 1 and Table 1).

The diameter and circumference of the aorta was also measured at the point after it gives off each branch. The diameter and circumference of the aorta is 29.35, 92.26 mm (after gives off coronary artery), 26.48, 83.25 mm (after gives off RCA), 28.70, 90.21 mm (after gives off LCA), 29.19, 91.75 mm (after gives off LVA), 28.79, 90.47 mm (after gives off LSA), and 27.66, 86.94 mm (after gives off RRSA), respectively (Table 2).

Furthermore, we found the thoracic duct join with the right lymphatic duct then terminate into the junction of the right internal jugular vein and the right subclavian vein. In this case, we found branch of right vagus nerve directly supply to right larynx instead of the right recurrent laryngeal nerve. Therefore, this case showed right non-recurrent laryngeal nerve.

Discussion

Several studies reported anomalies associated with of aberrant right subclavian artery (ARSA) including a non-recurrent right inferior laryngeal nerve[5,6,9,13,14,19,27], a common origin of the common carotid arteries[16,24], a replaced right or left vertebral artery[16,24] coarctation of the aorta[18], a right-sided thoracic duct[5,9,14], and a right-sided aortic arch[18].

Fig. 1 Branches of the aortic arch: 1) right common carotid artery, 2) left common carotid artery, 3) left vertebral artery, 4) left subclavian artery and 5) right subclavian artery. (A) Anterior view of branches of the aortic arch shows aortic origin of left vertebral artery and anomalous of right subclavian artery, (B) Posterior view shows anomalous of right subclavian artery that originates from the distal part of aortic arch in the retroesophageal position called retroesophageal right subclavian artery (RRSA), (C) Anterior view (D) Posterior view: 1 = the right common carotid artery (RCA), 2 = left common carotid artery (LCA), 3 = left vertebral artery (LVA) branch, 4 = left subclavian artery (LSA), 5 = retroesophageal right subclavian artery (RRSA) and 6 = Right vertebral artery (RVA).

These anomalies have been affectedof abnormal development during embryo period[1,2,4,6,7,9,11,13-15,25,26,28]. RRSA is the most common of aberrant right subclavian artery (ARSA), which is rare congenital anomaly with reported incidence of 0.4 to 2.0%[2,4,6,7,9,11,13,15,25,26,28]. According to Adachi-Williams, the classification of the RRSA currently has 4 types of anomalous branching patterns as type G, type CG, Type H and Type N (Fig. 2)[29]. This case is classified as CG type (RRSA and the aortic origin of left vertebral artery), and the incidence of this type has been reported 28.6% in the RRSA population[5,24].

This is the first RRSA case associated with anomaly of the aortic origin of left vertebral artery, the

Table 1. Diameter, circumference and length of right common carotid artery (RCA), left common carotid artery (LCA), left vertebral artery (LVA), left subclavian artery (LSA), retroesophageal right subclavian artery (RRSA) and Right vertebral artery (RVA) (data shown in mm)

Artery	Diameter at the origin	Circumference at origin	Diameter at the end	Circumference at the end	Length
1) RCA	8.15	25.62	11.14	35.86	120.67
2) LCA	8.96	28.15	11.76	36.97	133.51
3) LVA	5.23	16.44	5.15	16.18	84.97
4) LSA	10.12	31.79	8.27	25.98	57.97
5) RRSA	17.05	53.58	9.58	30.10	91.67
6) RVA	4.20	13.20	4.22	13.26	14.00

Table 2. The diameter and circumference of the aorta at the point after it gives off each branchright common carotid artery (RCA), left common carotid artery (LCA), left vertebral artery (LVA), left subclavian artery (LSA), retroesophageal right subclavian artery (RRSA) (data shown in mm)

Aortic branch	Coronary artery	RCA	LCA	LVA	LSA	RRSA
Diameter of aorta after give off branch	29.35	26.48	28.70	29.19	28.79	27.66
Circumference of aorta after give off branch	92.26	83.25	90.21	91.75	90.47	86.94

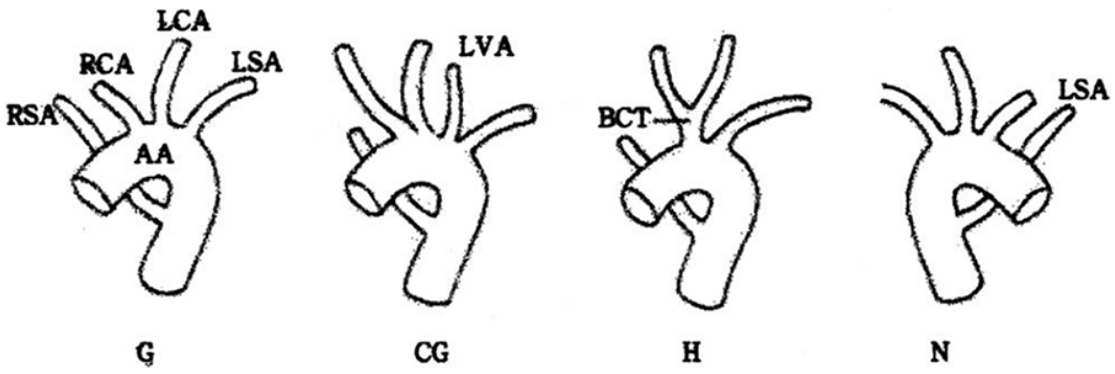

Fig. 2 The main morphologic types of the RRSA according to Adachi-Williams[29].

right-sided thoracic duct, and the right non-recurrent laryngeal nerve.

An anomalous origin of the right subclavian artery and the left vertebral artery arise from altered development of primitive aortic arches into vessels of the embryo during the early gestation period[5,6,9], then thoracic duct and laryngeal nerve are affected from this altered development.

In normal development, the proximal portion of the right subclavian artery would be formed from the right fourth aortic arch, the distal portion from the right dorsal aorta, and the right seventh intersegmental artery[1]. RRSA occurs when the right aortic arch has remained intact and the normal root of the subclavian artery has obliterated. There is the absence of right fourth aortic arch so that the proximal portion of the right subclavian artery derives from the right seventh intersegmental artery instead. In addition, the distal portion of artery forms from the continuing dorsal aortic root caudal to it[5,6,9].

According to this period of time, the first part of left vertebral artery develops from proximal part of dorsal branch of left seventh cervical intersegmental artery proximal to post-costal anastomosis. The second

part is derived from longitudinal communications of the post-costal anastomoses[1]. Due to caudal shifting of aorta (RRSA might make more aorta caudal shift), the proximal parts of these segmental arteries are exposed to longitudinal tension and bending with the resulting retarded blood flow. Hence, it has resulted in abnormal connections between the longitudinal channels and the aortic arch. Then the left sixth dorsal intersegmental artery persisted as first part of the vertebral artery, therefore, the left vertebral artery is arising from arch of aorta[10,12].

In this case, the variation of the right recurrent laryngeal nerve and the right terminating thoracic duct would begin after RRSA development was done. The degeneration of the fourth aortic arch leads to the absence of the proximal portion of the right subclavian artery and then leads to the non-recurrent laryngeal nerve because it lacked of an artery to hook[6]. Finally, right-larynx area is directly supplied from vagus nerve instead of the recurrent laryngeal nerve.

The occurrence of the thoracic duct derives after finished-RRSA development. RRSA crosses the superior mediastinum from left to right side behind the esophagus and in front of the third thoracic vertebra. Besides, RRSA becomes a physical barrier because it obstructs the normal course of the thoracic duct towards to the left side of the mediastinum in order to join the left subclavian vein. This phenomenon leads to the deviation of thoracic duct towards the right side, and then it joins the right subclavian vein[6,8,9].

RRSA is usually asymptomatic[2,6,14,22,25,26,28] as in this case; however, there was the report of tracheo-esophageal symptoms such as dysphagia lusoria in 10% of population so that it is called the lusoria artery[14]. A common symptom of RRSA is a dilation of the artery of the aortic arch that leads usually to aneurysm at the proximal part of ARSA known as Kommerell's diverticulum. This incidence occurs in 60% of ARSA patients and treatments may be vital depending on the size of the dilation. Due to the compression of ARSA between the esophagus and the vertebrae, the upper limb ischemia is reported to be 30-45% of the patients[2,6,14,20,22,25,26,28]. A symptomatic patient controversially requires surgical intervention to correct this anomaly[6,21].

In this case, LVA arises from aortic arch between the origins of LCA and LSA. Then it courses to enter the foramen transversarium of the fifth cervical vertebra. Diameter of LVA (5.23) is bigger than RVA (4.20) without cerebral disorders. The incidence of aortic origin of vertebral artery is very low 3.1-8.3% in normal population[10,12,16,23]. However, this variation plays an important role in vascular surgeons, neurosurgeons and thorax surgeons because vertebral artery injury is a known complication of the extended lateral decompression during anterior cervical spine surgery, which can result in exsanguinations and permanent neurologic deficits[10,12].

The abnormal course of the thoracic duct joins the right lymphatic duct then terminates into the junction of the right internal jugular vein and the right subclavian vein. It may result in inadvertent injury, especially during oesophagectomy. Subsequently, it causes schylothorax with the iatrogenic occurrence of 3%. Chylothorax, a scarce condition from the thoracic duct injury, causes chyle leakage to the pleural space and leads to respiratory distress, malnutrition and immunosuppression that can be fatal to the patient[6,8,9,14]. The right-sided thoracic duct is harder to investigate than RRSA so that RRSA patients should be aware of this variation which decreases thoracic duct injury during the course of neck surgery.

The practical right non-recurrent laryngeal nerve must be examined especially in thyroid or parathyroid surgery[6]. The incidence of neural damage during surgeries of the recurrent laryngeal nerve is 0.5-2%, whereas neural damage of right non-recurrent laryngeal nerve is around 12.9% being six times more vulnerable to damage[5,6]. In various neck surgeries such as lymph node resection, thyroidectomy, and esophagectomy, RRSA patients should be aware of the right non-recurrent laryngeal nerve and of decreasing iatrogenic injury[19,27].

Even though most variations of the aortic arch and great vessels are not a reason for patient complaints, the surgeon should be concerned about right side thoracic duct and right non-recurrent laryngeal nerve in order to decrease the risk of iatrogenic injury during surgery. The operative approach involved in the correction of dysphagia lusoria[18], during oesophagectomy and/or operation of a thyroid or parathyroid surgery[6,13,19].

Furthermore, an understanding of the molecular and embryological basis of this variation would benefit in finding a new strategy to prevent and provide early detection of this anomaly in the future.

What is already known on this topic?

In the past several reports, RRSA present with one or another anomaly such as the aortic origin of left vertebral artery, a right-sided thoracic duct, and both a non-recurrent laryngeal nerve and a right-sided

thoracic duct. However, it was not been presented with any of these anomalies.

What this study adds?

The present study reports the occurrence four variations of the RRSA, the aortic origin of left vertebral artery, non-recurrent right laryngeal nerve, and right-sided thoracic duct. This is the first report that shows the occurrence of four anatomical variations.

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Potential conflicts of interest

None.

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รายงานผู้ป่วย: การพบ 4 ความผันแปร: หลอดเลือดแดง subclavian ข้างขวาหลังหลอดอาหารและหลอดเลือดแดง vertebral ข้างซ้ายออกมาจาก arch of aorta ท่อน้ำเหลือง thoracic duct เทลงสู่ข้างขวาและเส้นประสาท laryngeal ข้างขวาไม่คล้องหลอดเลือดแดง subclavian ในศพคนไทย

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ภูมิหลัง: *ความผันแปรของแขนงของหลอดเลือดแดง aorta และความผิดปกติอื่น ๆ ที่เกิดร่วมด้วยเป็นข้อมูลที่สำคัญในการตรวจทางรังสีวินิจฉัยและการผ่าตัด*

วัตถุประสงค์: *เพื่อรายงานความผันแปรของต้นกำเนิดของหลอดเลือดแดง subclavian ข้างขวา หลอดเลือดแดง vertebral ข้างซ้าย ซึ่งสัมพันธ์กับท่อน้ำเหลือง thoracic duct เทลงสู่ข้างขวา และเส้นประสาท laryngeal ข้างขวาไม่คล้องหลอดเลือดแดง subclavian*

วัสดุและวิธีการ: *ชำแหละอาจารย์ใหญ่อย่างละเอียดเพื่อศึกษาความผิดปกติดังกล่าวและหาความผิดปกติอื่น ๆ ที่อาจเกิดร่วมด้วย*

ผลการศึกษา: *พบ 4 ความผันแปรของหลอดเลือดแดง subclavian ข้างขวาออกจากด้านหลังส่วนปลายของ arch of aorta แล้วทอดผ่านด้านหลังของหลอดอาหารออกไปสู่แขนขวา หลอดเลือดแดง vertebral artery ข้างซ้าย ออกมาจาก arch of aorta ร่วมกับพบท่อน้ำเหลือง thoracic duct เทลงสู่หลอดเลือดดำข้างขวาและเส้นประสาท laryngeal ข้างขวาไม่คล้องหลอดเลือดแดง subclavian ในร่างอาจารย์ใหญ่ชายไทยอีสานอายุ 75 ปี*

สรุป: *การนำความรู้เรื่องความสัมพันธ์ของผันแปรดังกล่าวมาใช้เพื่อเพิ่มความระมัดระวังในการวินิจฉัยและการผ่าตัด ลดความเสี่ยงต่อการบาดเจ็บของผู้ป่วยได้*