INTRODUCTION

Lateral costal branches (LCB) of the internal thoracic artery (ITA) have been reported in approximately 10% of the population. However, they are rarely observed in anatomical dissection courses or clinical examinations such as angiography or other radiological examinations. A standard anatomical textbook describes LCB as frequently absent or very small [1]. Since the internal thoracic artery is frequently used for coronary artery bypass surgery, from a surgical perspective, knowledge of this anomaly is important. Herein, we report large, bilateral LCB in a human cadaver.

CASE REPORT

Bilateral LCB of the ITA was found in a male cadaver who was 66 years old at death. The chest wall was divided into three parts, cut at the bilateral anterior axillary lines and the center of the spine (Figure 1~4). The left ITA branched from the subclavian artery as a common trunk with the thyrocervical trunk. The left LCB flew into the collateral branch of the fifth intercostal artery after reaching the upper end of the sixth rib and after exiting the left ITA at the upper part of the first rib. The left ITA was disconnected near the second rib because it had been used for coronary artery bypass surgery. The right ITA arose from the anterior surface of the right subclavian artery just after the right ITA diverged from the brachiocephalic artery. The right LCB reached the upper end of the fifth rib and flew into the collateral branch of the fourth intercostal artery. The right ITA descended along the back of the costal cartilages as usual. The mechanism of the development of the LCB is thought to be due to a lateral longitudinal anastomosis connecting the inter-node arteries arising from the dorsal aorta during the embryonic phase. More anatomical and embryological studies are necessary to further elucidate this variant arterial branch.

Summary: We report a case of bilateral lateral costal branches (LCB) of the internal thoracic artery (ITA). On the left side, the ITA branched from the subclavian artery as a common trunk with the thyrocervical trunk. The left LCB flew into the collateral branch of the fifth intercostal artery after reaching the upper end of the sixth rib and after exiting the left ITA at the upper part of the first rib. The left ITA was disconnected near the second rib because it had been used for coronary artery bypass surgery. The right ITA arose from the anterior surface of the right subclavian artery just after the right ITA diverged from the brachiocephalic artery. The right LCB reached the upper end of the fifth rib and flew into the collateral branch of the fourth intercostal artery. The right ITA descended along the back of the costal cartilages as usual. The mechanism of the development of the LCB is thought to be due to a lateral longitudinal anastomosis connecting the inter-node arteries arising from the dorsal aorta during the embryonic phase. More anatomical and embryological studies are necessary to further elucidate this variant arterial branch.

Key words internal thoracic artery, lateral costal branch, intersegmental artery, longitudinal anastomosis, exertion angina
mm. After giving rise to the LCB, the ITA descended dorsal to the costal cartilages and disconnected near the second rib into a large mass of scar tissue. The left superior epigastric artery, which was the terminal branch of the ipsilateral ITA, was too atrophied to be observed (Figure 1). A scar made by the coronary artery bypass procedure was observed on the heart and three vascular grafts were found at the anterior wall of the ascending aorta connecting with the right coronary artery, anterior interventricular (anterior descending) and circumflex branches of the left coronary artery, respectively (Figure 5). The LCB descended medially within the thorax along the anterior axillary line, and reached the upper border of the sixth rib to anastomose with the collateral branch of the fifth intercostal artery. In the horizontal plane, the distance from the anterior part of the spine to the middle of the sternum, distance from the middle of the spine to the LCB, distance from the LCB to the left ITA, and distance from the left ITA to the middle of the sternum was 30.8 cm, 17.2 cm, 11.0 cm and 2.6 cm, respectively (Figure 2,4).

The right ITA branched from the lower surface of the right subclavian artery immediately after it branched from the brachiocephalic artery, then descended and gave rise to the LCB at the upper border of the first rib just as it did on the left side. The diameter of the ITA immediately after the branching of the LCB was 2.8 mm, and that of the LCB itself was 1.5 mm. The right ITA then descended dorsal to the costal cartilages to become the superior epigastric artery at the level of the seventh costal cartilage, and then traveled along the dorsal surface of the rectus abdominis muscle. The LCB descended along the anterior axillary line, reached the upper border of the fifth rib, and anastomosed with the collateral branch of the fourth intercostal artery. In the horizontal plane, the distance from the anterior part of the spine to the middle of the sternum, distance from the middle of the spine to the LCB, distance from the LCB to the right ITA, and distance from the right ITA to the middle of the sternum was 27.8 cm, 15.4 cm, 9.8 cm, and 2.6 cm, respectively (Figure 3,4).

**DISCUSSION**

The ITA originates from the first portion of the subclavian artery approximately 2 cm superior to the clavicle, opposite the origin of the thyrocervical trunk, and near the anterior margin of the anterior scalene muscle. It descends dorsal to the first to sixth costal cartilages approximately 1.25 cm lateral to the sternum and terminates as the musculophrenic and epigastric arteries at the sixth intercostal space. The ITA also gives rise to the pericardiocophrenic artery, mediastinal artery, thymic artery, bronchial artery, sternal artery, anterior intercostal branches, perforating branches, and LCB. The LCB is frequently absent or very small and occasionally originates from the ITA near the first rib. Approximately 25% of the population has a LCB, which descends lateral to the costal cartilages and forms an anastomosis with the superior portion of the anterior intercostal branches [1]. Adachi (1928) investigated 172 sides from 86 specimens, and found an LCB on 19 sides in 16 specimens (11.0%); 3 specimens bilaterally, 4 cases on the right side, and 9 cases on the left side. Another investigation of 86 specimens found LCB in 7 cases (8.1%) on the right side with 3 cases reaching the second intercostal space, 3 cases reaching the fourth intercostal space, and 1 case of unknown origin, and in 12 cases (14.0%) on the left side, with 4 cases reaching the second intercostal space, 5 cases reaching the second intercostal space, 2 cases reaching the fourth intercostal space, and 2 cases of unknown termination [2]. Henriquez-Pino (1997) reported finding LCB in 15% (15/100) of fresh cadavers with 5% bilaterally and 10% unilaterally [3]. According to Barberini (2004), the incidence of LCB ranged from 15 to 30.1% [4].

The intercostal artery originates from the dorsal branch of the dorsal aorta, which issues 30 pairs of intersegmental arteries. The dorsal branch arborizes into dorsal rami distributed to the dorsal spinal cord, muscles and skin, and ventral rami distributed to the anterior surface of the body wall. The dorsal rami form mainly two longitudinal anastomoses, the post-costal anastomosis and the post-transverse anastomosis. The ventral rami are well-developed in the thoracolumbar region, seen as the intercostal arteries in the thoracic region and the lumbar arteries in the lumbar region. Just as the dorsal rami, the ventral rami form longitudinal anastomoses between the superior and inferior intersegmental arteries to form an artery running in the longitudinal direction. A pre-costal anastomosis forms with the costocervical trunk on the dorsal side and a ventral anastomosis forms the ITA, and superior and inferior epigastric arteries which supply the rectus abdominis muscle [5]. Although there is no description of other longitudinal anastomoses of the ventral rami in textbooks, Igarashi et al. suggested the existence of a lateral longitudinal anastomosis along with the lateral branch of the intercostal branch in the middle axillary line, the LCB in the thorax and the deep iliac circumflex artery in the abdomen [6]. A reported case of LCB which ran along the entire length of the thorax to reach the diaphragm supports this lateral longitudinal anastomosis theory [7].
Fig. 1. Medial surface of the anterior thorax. The chest wall was cut at the bilateral anterior axillary lines and removed from the body with bilateral upper part of the rectus abdominis muscles. The right internal thoracic artery descended posterior to the costal cartilages as expected. Whereas, the left internal thoracic artery discontinued around the second costal cartilage with scar. Note the bilateral internal thoracic arteries (arrows). LITA; left internal thoracic artery, RITA; right internal thoracic artery

Fig. 2. Findings of the left lateral costal branch (LCb)
The picture on the left side shows the origin of the left LCb and LITA. The picture on the right side shows the medial view of the left thorax.
On the left picture, the left internal thoracic artery (LITA) and thyrocervical trunk formed a common trunk that branched off from the left subclavian artery (LSC), which gave rise to the suprascapular artery (SSA) near the medial part of the anterior scalene muscle and to the left LCb at the upper edge of the first rib (1st Rib).
On the right picture, the thorax was cut at the center of the spinal column and the left anterior axillary line. The left LCb descend near the anterior axillary line of the internal surface and flew into the fourth left subclavian artery.

Fig. 3. Finding of the right lateral costal branch
The picture on the left side shows the origin of the right lateral costal branch (LCb) and right internal thoracic artery (RITA). The picture on the right side shows the medial view of the right thorax.
On the left picture, the RITA branched from the lower surface of the right subclavian artery, which descended and gave rise to the right LCb at the upper border of the first rib (1st Rib) just as it did on the left side.
On the right picture, the thorax was cut at the center of the spinal column and the right anterior axillary line. The right lateral costal branch (LCb) descend near the anterior axillary line of the internal surface and flew into the fourth right subclavian artery same as left side.

Fig. 4. Schematic findings of the bilateral lateral costal branches
The left picture shows the frontal view of the chest wall. And the right picture shows the horizontal section of the chest wall.

Fig. 5. Anterior aspect of the heart
LCxB; bypass of the ascending aorta and the circumflex of the left coronary artery, LADB; bypass of the ascending aorta, RCAB; bypass of the ascending aorta and right coronary artery
In the present case, it is unclear whether the bilateral LCBs are congenital or acquired. This was a cadaveric case, so we can’t deny the possibility of secondary enlargement of congenital small caliber arteries due to the surgery or other effects. However, we believe this is a congenital anomaly because we usually don’t observe similar findings in other cadavers who had a history of heart surgery or chest trauma. In this case, the left ITA was disconnected around the second rib. Based on the findings of the disconnection of the left ITA and coronary bypass findings of the heart, the left ITA is presumed to have been used as a free graft. The left ITA is usually used as an in-situ graft, and the treatment objective in this case is unknown. Although the postoperative course of this case is unclear, it has been reported that patients with LCB have developed exertional angina after bypass surgery of the coronary artery [8, 9]. In addition, the thoracic cavity drainage could damage the ITA because the LCB runs along the anterior axillary line. Therefore, it is necessary to recognize the existence of the ITA in order to avoid unnecessary bleeding during surgical procedures along its course.

CONCLUSION

We report bilateral, well developed LCB of the ITA. It is presumed that the LCB of the ITA is a remnant of the lateral longitudinal anastomosis of the intersegmental artery seen during the fetal period. The knowledge of this artery could reduce or prevent complications during surgery.

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