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**A rare arterial branch distributing to the thymus, ectopic intrathymic parathyroid
and thyroid glands which passed ventral to the right common carotid artery: a
case report**

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Abbreviated title: A rare branch to the thymus and intrathymic parathyroid, thyroid
gland.

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Abstract

The intrathymic parathyroid has been reported that this variation might be related with the hyperthyroidism. In the present study, the arterial pattern supplying the intrathymic parathyroid was examined in detail in the human cadaver (67 year-old, female, right side). The ectopic parathyroid was only detected on the right side, but not on the left side. This ectopic intrathymic parathyroid was supplied by the supernumerary arterial branch that originated from the inferior thyroid artery and passed ventral to the common carotid artery. This supernumerary branch further divided into two thin branches; 1) the one distributing the intrathymic parathyroid and the right lobe of the thyroid gland and 2) the other descending toward the thoracic cavity to supply the mediastinum organs. Other arteries supplying the thyroid gland and thymus of both sides were normal. In the surgical resection of the ectopic intrathymic parathyroid, physicians should pay attention to arteries ventral to the common carotid artery. This supernumerary branch distributing to the intrathymic parathyroid may be caused by incomplete division into the primodium for the inferior parathyroid and the primodium for the thymus on the developmental process.

Keywords: Thymus, Parathyroid, Thyroid gland, Variation

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Introduction

Ectopic intrathymic parathyroid, which the inferior parathyroid gland is embedded in the thymus, is associated with the hyperparathyroidism [9, 14]. Prevalence of this variation has been reported as 13 % [14]. In general, parathyroid glands are situated on the posterior surface of the lateral lobes of the thyroid gland and are divided into superior and inferior [3]. The parathyroid gland is supplied by the nutrient artery originating from the inferior or superior thyroid artery [5]. However, arterial pattern of this rare variation, *i.e.* ectopic intrathymic parathyroid, has not been well documented.

Anatomical variations of the arterial suppliers of the thyroid gland, parathyroid and thymus have been reported in conjunction with these developmental processes [1, 2, 4, 7, 10, 16-19]. Both the inferior parathyroid and thymus derive from the 3rd pharyngeal pouch, and thyroid gland derive from the pharyngeal epithelia between the tuberculum impar and the copula [20]. The ectopic parathyroid result from aberrant migration during early stage of development [11]. The formation of arterial patterns distributing to the ectopic intrathymic parathyroid might be associated with the migration of parathyroid and thymus during development.

Clinically, anatomical variation of the arterial branch distributing to the thymus, thyroid and parathyroid glands is important for the surgical resection of these organs. Recently, detailed anatomy of these arterial branches using the angiography has been reported in the radiogenic cancer of thyroid gland [8]. Here we have shown a rare arterial branch distributing to the thymus, ectopic intrathymic parathyroid and thyroid glands which passed ventral to the right common carotid artery.

Case report

During an educational dissection of the neck at Kobe University of the Medicine, ectopic intrathymic parathyroid were observed, whose cause of death was sepsis. In this cadaver (67 year-old, female), in addition to the thymic branch from the internal thoracic artery and the superior and inferior thyroid arteries, the supernumerary arterial branch, which supplied the right lobe of the thymus, right lobe of the thyroid gland and ectopic intrathymic parathyroid on the right side, was recognized (Fig. 1a-d). Any variations of the position of the parathyroid glands and the arterial pattern distributing to the thymus, thyroid and parathyroid glands were not found on the left side. This right supernumerary arterial branch originated from the right inferior thyroid artery. Right thyrocervical trunk originated from the superior aspect of the subclavian artery. The thyrocervical trunk gave off five arterial branches; 1) the suprascapular artery, 2) transverse cervical artery, 3) branch to the levator scapulae muscle and the groove for the spinal nerve of 4th cervical vertebra, 4) branch to the scalenus anterior, longus capitis and the groove for spinal nerve of 5th or 6th cervical vertebra, and 5) the inferior thyroid artery. The inferior thyroid artery bifurcated craniocaudally at the dorsal surface of the common carotid artery and the ventral surface of the vertebral artery (Fig. 1a). The course and distribution of this cranial branch correspond to the normal inferior thyroid artery described below, and caudal branch corresponds to the supernumerary branch. This rare supernumerary branch passed caudally along with the lateral surface of the common carotid artery and divided into two branches; medial branch and the inferior branch running to the thoracic cavity. Here we designate medial and inferior branches as branch 1 and 2, respectively. The branch 1 passed mediosuperiorly in anterior surface of the common carotid artery and ran dorsal surface of the thymus. This

gave off the twig passed anterior to the trachea and branch distributing the dorsal surface of the thymus including the ectopic intrathymic parathyroid (Fig. 2d, asterisk). And then it distributed to the dorsal surface of the sternothyroid muscle and the anterior surface of the right thyroid gland. The branch 2 descended anterior to the subclavian artery and distributed to the anterior surface of the base of the aortic arch and the inferior tracheobronchial lymph nodes (Fig. 1b). The inferior thyroid artery passed medially across the dorsal surface of the common carotid artery and gave off two twigs superiorly supplying the longus coli muscle and the periosteum of 6th cervical vertebra, and the branches to the dorsal surface of the right lobe of the thyroid gland (Fig. 1c). The inferior thyroid artery ascended and gave off the inferior laryngeal artery and branches distributing to the superior parathyroid gland and the right lobe of the thyroid gland. These courses and distributions correspond to the normal inferior thyroid artery.

The superior part of the right thymus which was supplied by the branch 1 was examined histologically (Fig. 1f-h). This part of the thymus was removed from the cadaver, and embedded in paraffin for hematoxylin-eosin stain. In normal case, there is no cell in adult human thymus due to fatty change. However, this part of the thymus of the present case included the chief and eosinophilic cells of the parathyroid gland (Fig. 1h). The right inferior parathyroid lacked within the thyroid gland.

Discussion

Both the inferior parathyroid and thymus developmentally derive from the 3rd pharyngeal pouch (Fig. 2b) [20]. These primordia separate from the 3rd pharyngeal pouch and then descent along the ventral surface of the common carotid artery, brachiocephalic trunk and aortic arch (Fig. 2c-f) [20]. Subsequently, the primordia

separate into the inferior parathyroid and the thymus, the former migrates near the thyroid gland and the latter descends further to the final destination [20]. In the present case, the primordia for the thymus and the inferior parathyroid did not separate during the developmental stage (Fig. 2e), which may result in ectopic intrathymic parathyroid. In this case, the right inferior parathyroid was not detected and the ectopic intrathymic parathyroid and the thymus were supplied by same arterial branch (*i.e.*, branch 1), suggesting that this ectopic intrathymic parathyroid may correspond to the right inferior parathyroid gland.

Previously, the anatomical variations of the arteries to the thyroid gland and the thymus have been reviewed from the developmental points of view by Yamasaki (1989a, b) [16, 17]. He examined the patterns of the arteries distributing to the thyroid gland and the thymus and suggested that these patterns of the variations are formed by partial disappearance or persistence of the arterial network accompanying with descent of the thyroid gland and thymus during embryonic period. Cahill (1998) reported a rare case in which the arterial branch supplying the thymus originated from the anterior aspect of the right common carotid artery [4]. Cahill (1998) suggested that in his case the rudimental arterial branch persisted when the thymus descend just anterior to the brachiocephalic trunk, common carotid and internal carotid arteries during the embryonic period. In the present case, the arterial branch 1 originated from the inferior thyroid artery, passed anterior to the common carotid artery and distributed the ectopic intrathymic parathyroid (Fig. 1a, b, d). The thyrocervical trunk, which gives off the inferior thyroid artery, derives from the pre-costal anastomosis of the intersegmental arteries during the embryonic period (Fig. 2a) [6]. As mentioned above, the common primordia of the inferior parathyroid and thymus descent ventral to the common carotid

artery, brachiocephalic trunk and aortic arch (Fig. 2c-f) [20]. In addition, the inferior parathyroid and the thymus did not separate in this case, indicating that the arterial branch 1 supplying the ectopic intrathymic parathyroid may reflect the migration course of primordia of the inferior parathyroid and the thymus during the developmental period. It suggests that this branch might be formed in early developmental period of these organs.

The distal end of the branch 1 supplied the thyroid gland (Fig. 1a, b, d). However the thyroid gland could not migrate across the ventral surface of the common carotid artery in developmental process [20], and therefore, this distal part of the branch 1 could not be explained by the developmental process mentioned above. In the later developmental stage of the human embryo, *i.e.*, Carnegie Stage 18 (Fig. 2d), the anlage of the inferior parathyroid begins to separate from the future thymus [20]. In this period, the primordium of the thyroid gland is located adjacent to the anlage of the inferior parathyroid and thymus. These primordia were supplied by the arterial network originating from the common carotid artery, brachiocephalic trunk or the aortic arch (Fig. 2b-f) [20]. Therefore, the distal end of the branch 1 may derive from this arterial network in the later developmental period.

Clinically, the ectopic parathyroid gland has the relevance to the hyperparathyroidism [11]. The ectopic parathyroid is largely found in the thymus as the present case. If the ectopic parathyroid within the thymus is needed to harvest, physicians should pay attention to this arterial branch due to the course (just anterior to the common carotid artery) and distribution to the thyroid gland.

Conflict of interest

None.

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Figure legends

Fig. 1. The arterial branches supplying the thymus, superior and inferior parathyroid and thyroid gland in the present case. **a:** Photograph showing the antero-lateral view of the right cervical region. The right sternothyroid muscle (St) is reversed upward. The subclavian artery (ScA) gives off the thyrocervical trunk (TT). The thyrocervical trunk gives off the inferior thyroid artery (open arrowheads). The inferior thyroid artery runs dorsally to the common carotid artery (CCA) and gives off supernumerary branch (white arrowheads). This supernumerary branch divides into two. The rare arterial branch 1 (see text; white arrowheads 1) passes ventrally to the common carotid artery (CCA), distributes to the upper part of the right thymus (asterisk), the right sternothyroid muscle (St) and lower portion of the right thyroid gland. The branch 2 (see text; white arrowheads 2) descends to the thoracic cavity. **b:** Photograph showing right antero-lateral view of the superior mediastinum region. The azygos vein (AV) is cut off and the superior vena cava (SCV) is reversed inward. The branch 2 (see text; white arrowheads 2) distributes to the inferior tracheobronchial node (ITN) and the aortic arch as a vasa vasorum (VV in **d**). **c:** Right lateral view of the laryngeal region. The common carotid artery (CCA) is put to forward. Normal course and distribution of the inferior thyroid artery (white open arrowheads) are shown. **d:** Schematic drawing of the artery in the cervical and superior mediastinum region in addition to the right recurrent laryngeal nerve. The supernumerary branches are painted pink. **e:** Photograph of antero-lateral view of the left cervical region. The left sternothyroid muscle (St) and sternohyoid muscle (Sh) are put to upward. Normal arterial pattern is shown. **f-h:** The coronal section of the right thymus obtained from the upper end of it in the dotted quadrangle in **e** (asterisk) and stained with H-E. This part of the thymus has two type

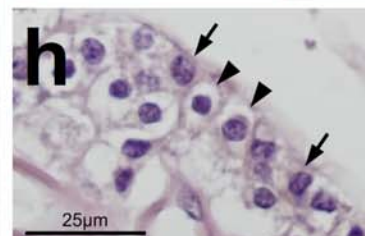
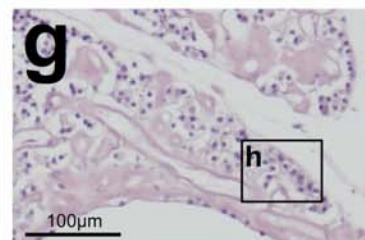
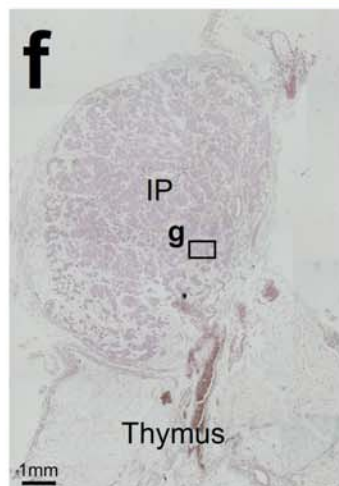
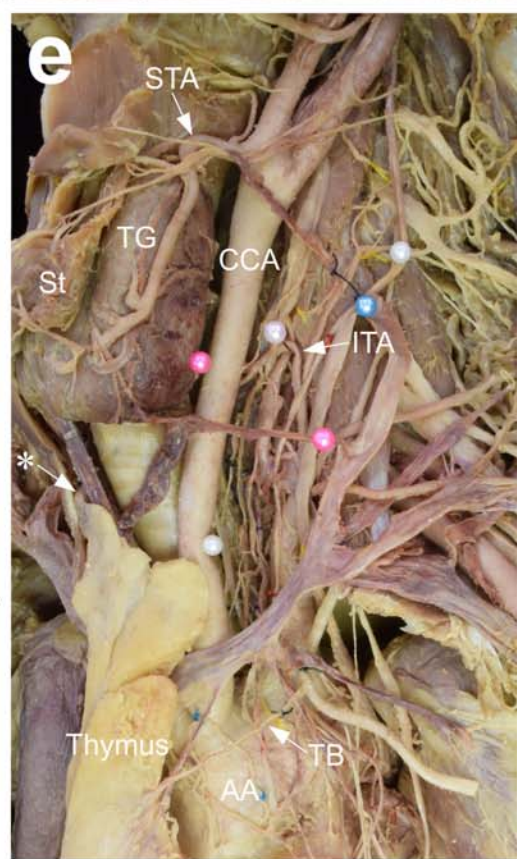
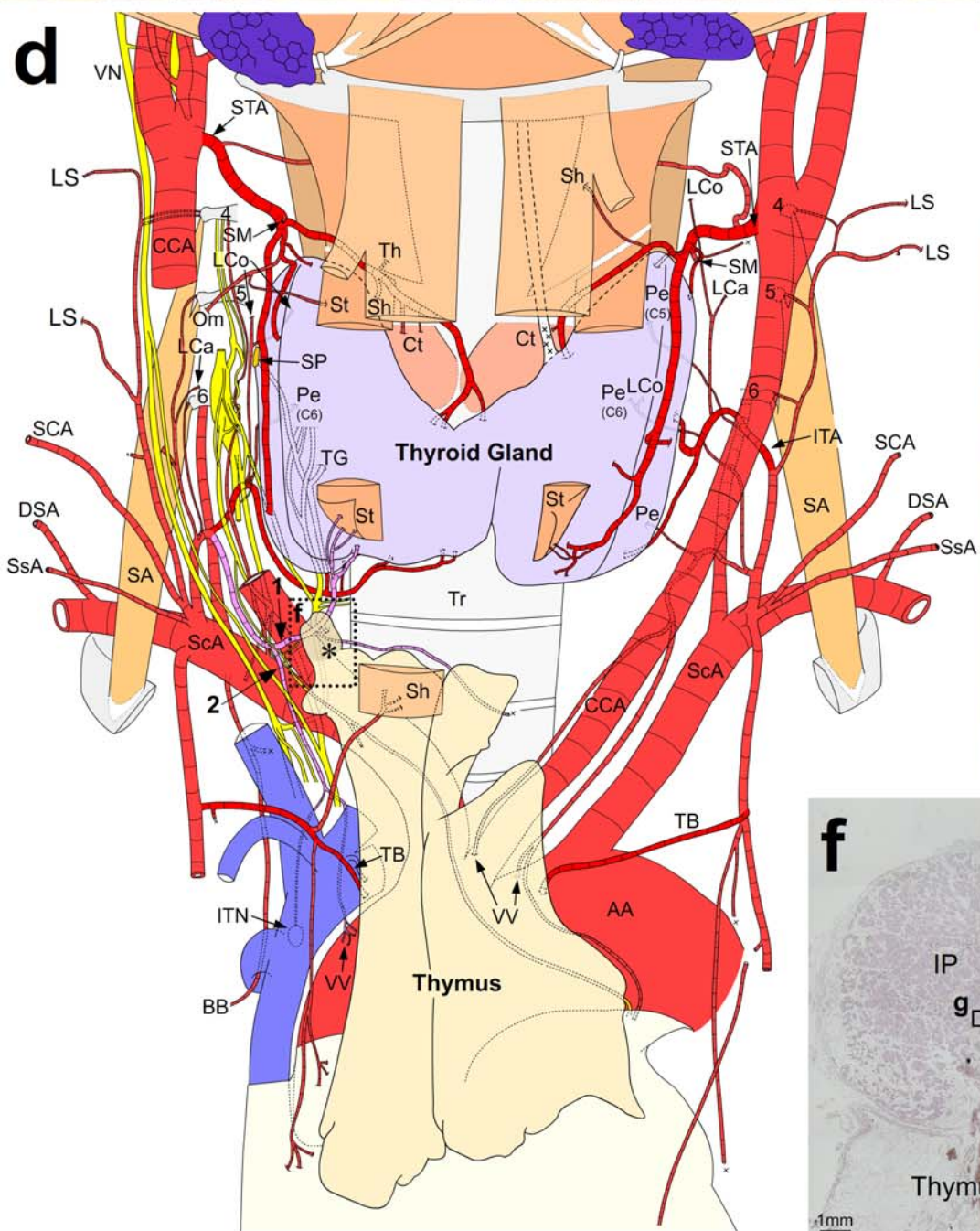
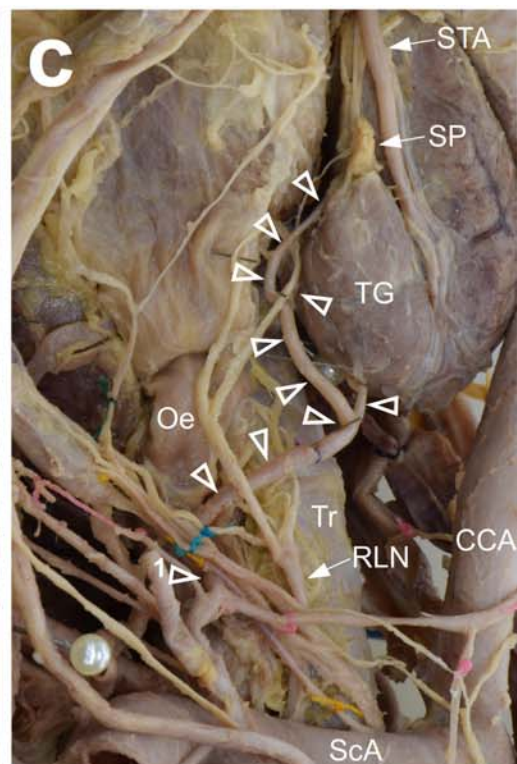
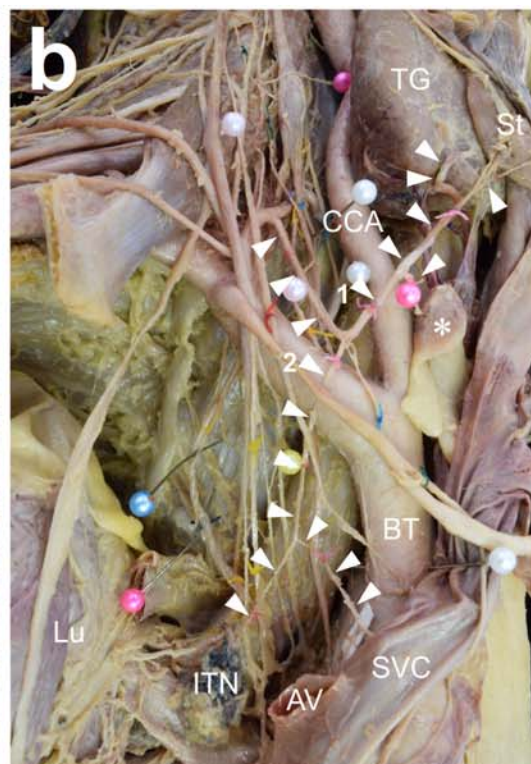
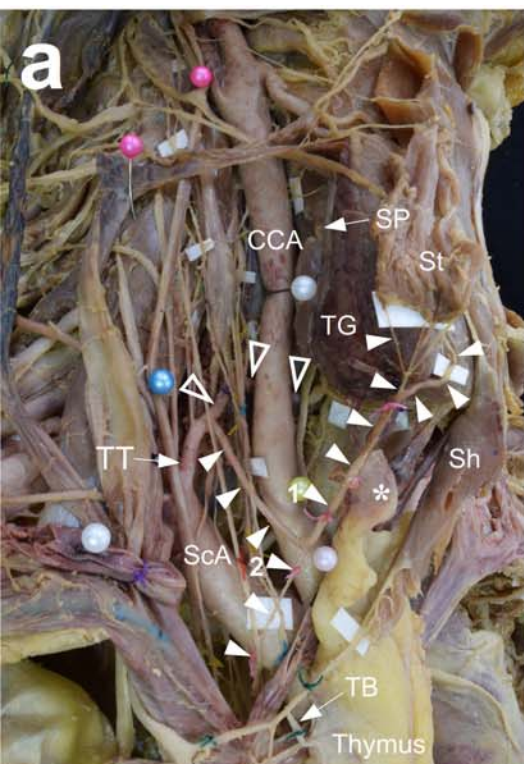
cells, the chief cells (black arrowheads in **h**) and eosinophilic cells (black arrows in **h**), which consists of the parathyroid.

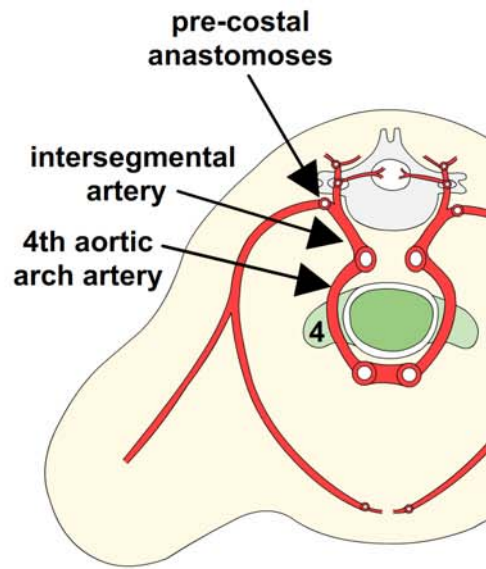
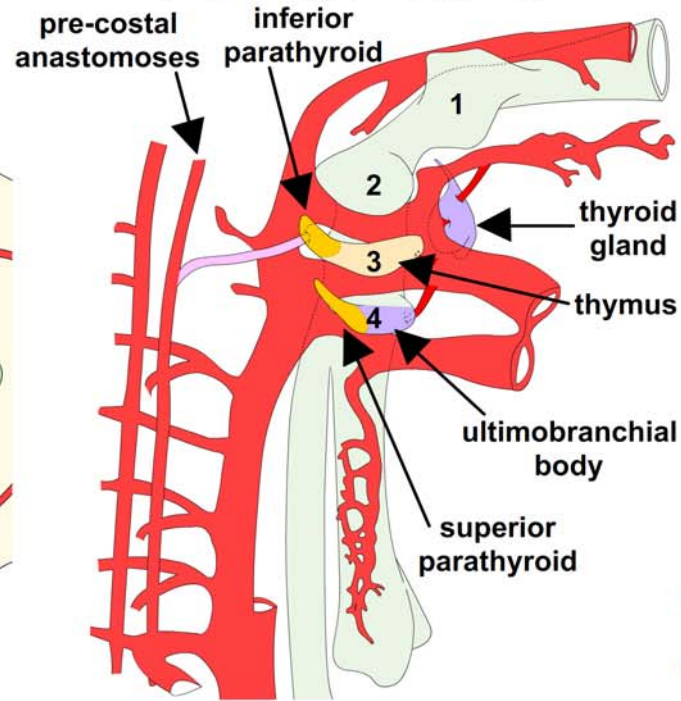
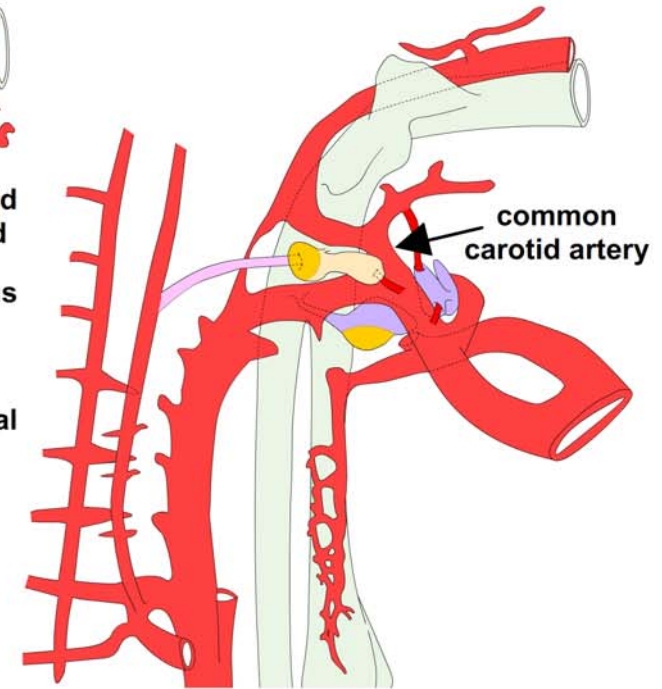
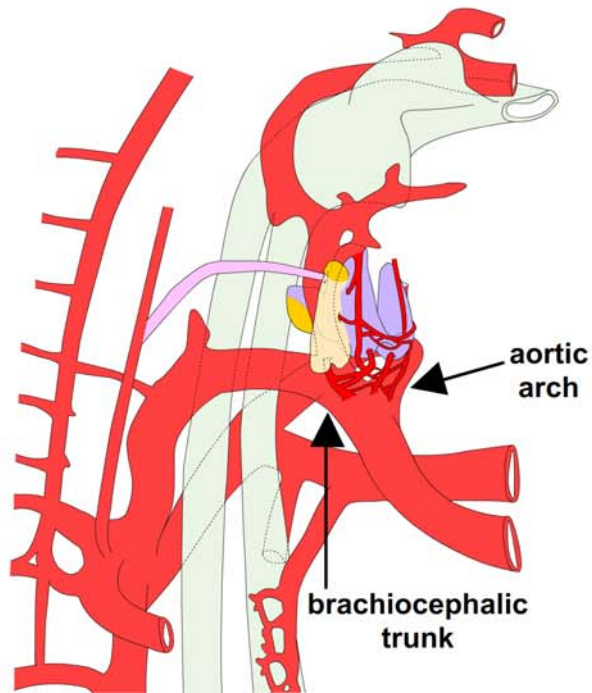
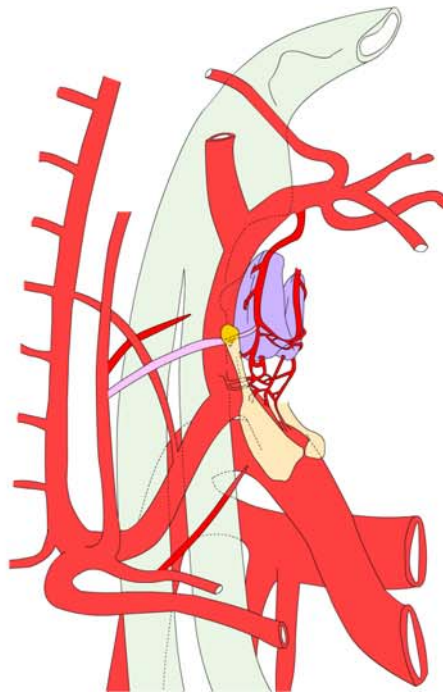
Abbreviations: **AA**, aortic arch; **AV**, azygos vein; **BB**, bronchial branch; **BT**, brachiocephalic trunk; **CCA**, common carotid artery; **Ct**, cricothyroid; **DSA**, dorsal scapular artery; **ITA**, inferior thyroid artery; **ITN**, inferior tracheobronchial node; **IP**, inferior parathyroid; **LCa**, longus capitis; **LCo**, longus colli; **LS**, levator scapulae; **Lu**, Lung; **Oe**, oesophagus; **Om**, omohyoid; **Pe**, periosteum; **RLN**, recurrent laryngeal nerve; **SA**, scalenus anterior; **ScA**, subclavian artery; **SCA**, superficial cervical artery; **Sh**, sternohyoid; **SM**, sternocleidomastoid; **SP**, superior parathyroid; **SsA**, suprascapular artery; **St**, sternothyroid; **STA**, superior thyroid artery; **SVC**, superior vena cava; **TT**, thyrocervical trunk; **TB**, thymic branch; **TG**, thyroid gland; **Th**, thyroidhyoid; **Tr**, trachea; **VN**, vagal nerve; **VV**, vasa vasorum

Fig. 2 The developmental model of the supernumerary rare arterial branch 1 (see text) referred from previous embryological reports and findings of the present case. **a**: Distribution of intersegmental artery at the lower cervical level in horizontal section (after Hamilton et al., 1972) [6]. Upper is dorsal, superior view. Pre-costal anastomoses give origin to the thyrocervical trunk. **b-f**: The developmental model of the branch 1 (pink) in the present case. Upper is cranial, right is anterior, lateral view. Positions of the anlage of the thyroid gland, thymus, inferior and superior parathyroid and ultimobranchial body are based on the report by Weller (1933), Hamilton et al. (1972) and Takanashi et al. (2015) [6, 15, 20].

At Carnegie Stage 15, anlage of the thyroid gland is separated from pharyngeal epithelia (**b**). In this stage, the primordia of the thymus and inferior parathyroid are

formed on the 3rd pharyngeal pouch. In addition, the ultimobranchial body and superior parathyroid are formed on the 4th pharyngeal pouch (**b**). The primordia of the parathyroid and thymus are separated from the 3rd pharyngeal pouch at Carnegie Stage 17 (**c**) and passes ventrally the common carotid artery and brachiocephalic trunk (**d**). At Carnegie Stage 19, the thyroid gland at the final position is adjacent to the descending thymus and inferior parathyroid (**e**). In this stage, the inferior parathyroid begin to be separated from the thymus (**e**). In addition, the arterial network plexus which consists of the braches from the common carotid artery, brachiocephalic trunk and aortic arch can be seen (**e**). This arterial network distributes to the thyroid gland, thymus and inferior parathyroid (**e**). After Carnegie Stage 19, in normal case the thymus and inferior parathyroid are divided and the thymus descends to the thoracic cavity, however in present case (**e, f**), the thymus and inferior parathyroid is not separated, and therefore, arterial branch to these organs might be persisted.



a**b** (Carnegie Stage 15)**c** (Carnegie Stage 17)**d** (Carnegie Stage 18)**e** (Carnegie Stage 19)**f** (Carnegie Stage 21; present case)