Anatomical evaluation of the inferolateral trunk by multiplanar reformatted images of rotational angiography: normal anatomy and pathologic features

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Authors: R. Shimada¹, H. Kiyosue², S. Tanoue², J. Kashiwagi³, Y. Hori⁴, T. Dotsu⁴, M. Okahara⁵, H. Mori², ¹Yufu city/JP, ²YUFU/JP, ³Yufu, Oita/JP, ⁴Oita/JP, ⁵Beppu/JP
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Aims and objectives

Nomal anatomy of the inferolateral trunk(Fig.1)

The inferolateral trunk (ILT) of the internal carotid artery (ICA) arises from the C4 segment of the ICA. The ILT gives rise to three branches: superior/tentorial branch, anterior branch and posterior branch. The superior branch supplies the cavernous roof and the # and # cranial nerves as they enter the cavernous sinus area. This branch gives rise to the marginal tentorial artery. The anterior and posterior branch divides into the medial branch and lateral branch, respectively. The anteromedial branch extends towards the inner part of the superior orbital fissure supplies the # cranial nerves as they enter the orbit and terminates as the recurrent meningeal artery. The anterolateral branch extends towards the foramen rotundum which supplies the dura of the adjacent temporal fossa and the nerve. It can anastomose with the artery of the foramen rotundum. The posteromedial branch of the ILT extends toward the foramen ovale, where it often anastomoses with the accessory meningeal artery; it contributes to the supply of the # cranial nerve, the medial third of the gasserian ganglion, and the motor root of the # cranial nerve. The posterolateral branch of the ILT extends toward the foramen spinosum, where it anastomoses with the middle meningeal artery; it contributes to the supply of the middle and lateral third of the gasserian ganglion (1).

Although It is reported that the ILT has been identified in 80 to 84% of all anatomical specimens, the ILT is visualized in only 11% of ICA angiograms in previous literature (1,2). In pathologic condition such as parasellar hypervascular tumors, arteriovenous shunt and ICA occlusion, the branches of ILT may enlarge as a feeding artery or a collateral channel (2,3). Recent developments in 3D angiography technology allow us to evaluate the angioarchitecture more precisely (4,5). However, there is no report to assess the ILT by 3D angiography to our knowledge. Our aim is to evaluate visibility and branching types of inferolateral trunk (ILT) by multiplanar reformatted images of rotational angiography in normal hemodynamic status. We also evaluate the ILT in pathologic condition.

Images for this section:
Fig. 1: Schematic drawing of the inferolateral trunk (ILT). The ILT arises from lateral surface of the C4 segment of the internal carotid artery. The ILT gives rise to three branches: tentorial branch, anterior branch, and posterior branch. The anterior branch divides into the anteromedial branch and anterolateral branch. The posterior branch divides into posteromedial branch and posterolateral branch. ; AB, anterior branch; ALB, anterolateral branch; AMB, anteromedial branch; ICA, internal carotid artery; ILT, inferolateral trunk; OpA, ophthalmic artery; PB, posterior branch; PLB, posterolateral branch; PLB, posterolateral branch; TB, tentorial branch
Methods and materials

We retrospectively reviewed cerebral angiography in 177 sides/146 patients with normal hemodynamic status who underwent cerebral rotational angiography between May 2010 and July 2013 in our hospital. The branches of the ILT were classified into the following 4 types depending on anatomical classification by Lasjaunias, anteromedial branch, anterolateral branch, posterior branch and tentorial branch (1). Selective digital subtraction angiography of the ICA or common carotid artery (CCA) was performed in all patients by using biplane angiography equipment (Infinix VB; Toshiba Medical, Tokyo, Japan). The rotational angiography was subsequently performed. 3D images with maximum intensity projection and volume rendering reconstruction and multiplaner reformatted images composed of sections with 0.3- to 1-mm thickness and a 0.2-0.5 mm interval were obtained from the data of rotational angiography by using a workstation (Ziostation; Ziosoft, Tokyo, Japan). Each patient gave written informed consent before the examination. We evaluated visibility and types of ILT and its branches. In 27 patients with dural arteriovenous fistula (dAVF), meningioma, and ICA stenosis/occlusion, we also analyzed about the contribution of ILT branches.

Results

The ILT was demonstrated in 102 of 177 sides (57%). All 4 branches of the ILT were demonstrated in 3 sides (Fig.2), 3 branches were demonstrated in 15 sides, 2 branches were demonstrated in 26 sides, and 1 branch was demonstrated in 58 sides. Anteromedial branch was most frequently demonstrated (n=51). Anterolateral branch, posterior branch, and tentorial branch were demonstrated in 44 sides, 40 sides, and 29 sides, respectively. The demonstrations of each branch of the ILT in normal hemodynamic status are summarized in Table1. The anastomosis between anteromedial branch of the ILT and recurrent meningeal artery of the ophthalmic artery was observed in 1 side (Fig.3). In pathologic condition, the ILT was recognized as feeding arteries in 6 cases of 8 dAVFs (Fig.4.5) and in 2 cases of 6 meningiomas. In 2 of 13 cases of ICA stenosis/occlusion (Fig.6), the ILT became a collateral pathway from ECA to ICA (Table2).

Images for this section:
Fig. 2: Branches of the ILT. Sagittal reformatted images (a-c) and MIP image (d) of rotational angiography of the right internal carotid artery show all 4 branches of ILT (orange arrow), including tentorial branch (white arrow), anteromedial branch (yellow arrow), anterolateral branch (white arrowhead), and posterolateral branch (yellow arrowhead).
**Fig. 3:** Anastomosis between ILT and ophthalmic artery via recurrent meningeal artery (anteromedial branch).  

a. Right internal carotid angiography shows an anteromedial branch (yellow arrow) of ILT arising from C4 segment. It runs anteriorly into the orbit and anastomoses with the ophthalmic artery.  

b,c. Axial reformatted images of rotational angiography of the right internal carotid artery show the anteromedial branch (yellow arrowhead) of the ILT which arises at the cavernous portion of internal carotid artery, runs anteriorly through superior orbital fissure, and anastomoses with the ophthalmic artery (white arrowhead) in the orbit. Note the central retinal artery originating from the ophthalmic artery.
**Fig. 4:** Right superior petrosal sinus dAVF supplied from the ILT (tentorial branch). Lateral view of the right internal carotid angiography (a) and axial reformatted images of rotational angiography of the right internal carotid artery (b,c) show enlarged tentorial branch (yellow arrowhead) which runs posterolaterally and fed the AVF draining into the petrosal vein (white arrowhead).
Fig. 5: Left cavernous sinus dAVF supplied by the recurrent meningeal artery of the ophthalmic artery and the tentorial branch of the ILT. a. Left internal carotid angiography show cavernous sinus dAVF supplied by branches of the ICA (white arrowhead). b-e. Axial reformatted images of rotational angiography of the left internal carotid artery show enlarged recurrent meningeal artery (yellow arrowhead) which originates from ophthalmic artery (white arrow), runs posteriorly anastomosing with tentorial branch of the ILT, and feeds the dAVF.
**Fig. 6:** Collateral pathway via the ILT in occlusion of left internal carotid artery. Frontal (a) and lateral (b) views of left common carotid angiography show accessory meningeal artery (arrow) which originates from middle meningeal artery, runs superiorly, and anastomoses with the ILT. Other collateral pathway to the ICA via the ophthalmic artery from orbital branches of the external carotid artery (superficial temporal artery, infraorbital artery and the middle meningeal artery) are also noted. Arrowhead shows partial opacification of the internal carotid artery via meningohypophyseal trunk - middle meningeal artery anastomosis. Coronal reformatted images of rotational angiography of the left common carotid artery (c-f) show accessory meningeal artery which runs through foramen ovale and anastomoses with posterior branch of the ILT. ICA: internal carotid artery SOA: supraorbital artery MMA: middle meningeal artery STA: superficial temporal artery IMA: internal maxillary artery APA: ascending pharyngeal artery AMA: accessory meningeal artery PAA: posterior auricular artery PSB: petrosquamous branch AMA-MHT: anastomosis between the accessory meningeal artery and meningohypophyseal trunk ILT: inferolateral trunk FO: foramen ovale FS: foramen spinosum
Conclusion

Embryology of the ILT

According to Lasjaunias, the ILT corresponds to the proximal remnant of the dorsal ophthalmic artery (DOA) of the human embryo, while the distal remnant corresponds to the recurrent meningeal artery. Two primitive ophthalmic arteries, the ventral ophthalmic artery (VOA) and the DOA, supply the orbit at the beginning of the 12mm stage. In his hypothesis, The VOA arises from the anterior cerebral artery and courses through the optic canal while DOA arises at the carotid siphon passes through the superior orbital fissure (SOF). Then, intraorbital anastomosis between the VOA and DOA is formed, and the proximal parts of the DOA regress, resulting in the formation of the adult ophthalmic artery. The remnant of the proximal DOA becomes the inferolateral trunk (1,6). Although this theory has been well accepted generally, Komiyama has been disapproved of this theory based on Padget's detailed diagrams. According to Padget, the DOA first appears at the opposite side of the bifurcation of the primitive ICA, in front of the posterior communicating artery, giving off the hyaloid artery and common temporal ciliary artery, which supply the dorsolateral aspect of the developing optic vesicle. Subsequently, the origin of the DOA moves proximally to the point of the adult ophthalmic artery. At the same time, the stapedial artery gives off two branches: supraorbital and maxillo-mandibular artery. The supraorbital artery enters the orbit through the SOF and anastomoses with the VOA-DOA complex, making a small arterial ring around the optic nerve, at the future second intraorbital portion of the adult OA. After regression of the ventral aspect of the arterial ring, the final adult configuration of the OA is established (6,7). As described above, DOA is not mentioned as the precursor of the ILT in Padget's report.

The anterior and the posterior branch of the ILT runs together with the corresponding nerves; anteromedial branch running toward superorbital fissure with (V1), anterolateral branch running toward foramen rotundum with (V2), posteromedial branch running toward foramen ovale with (V3), respectively. Thus, ILT accompanies the division of the trigeminal nerves and passes through the corresponding fissure or foramina. Embryologically, maxillary and mandibular nerves are related to the first aortic arch, but the ophthalmic nerve is different and not related to the first aortic arch. There is a possibility that the ophthalmic nerve is related to the premandibular arch. The inferolateral trunk could be related to the dorsal remnant of the premandibular arch.

In our study, the ILT branches were more frequently identified compared to the previous report using 2D angiography (57% vs 11%). The higher rate of identification of the ILT branches would be due to an analysis method by multidirectional and multiplanar assessment. However, In autopsy study, the ILT branches were found in 100% of specimens (8). This suggests that the ILT branches are not identified in nearly half of the cases of normal hemodynamic status.
In evaluation of pathologic cases, the branch of the ILT supplied the neoplasms, arteriovenous shunts more than half of the parasellar lesions. Of all branches of the ILT, the tentorial branch was associated with pathologic condition in 6 cases of these cases. It is speculated to be a reason that the tentorial branch supplies more widespread dura mater compared to other branches of the ILT. The branch of the ILT functions as a collateral passway between the ECA and ICA in 2 of 13 cases, however the frequency is less than that of arteriovenous shunt and neoplasms.

As described before, approximately half of the cases ILT cannot visible on angiography in normal hemodynamic status even autopsy study identified ILT in all subject. Therefore, during transarterial embolization of the ECA branches, one should note that the ILT can exist and can anastomoses with external carotid branches even though angiography does not demonstrate the ILT branch to prevent migration of embolic materials via the dangerous anastomosis.

**Personal information**

**References**


