

Embryological consideration of the inferolateral trunk

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Abstract

Inferolateral trunk (ILT), also called inferior or lateral cavernous branch, of the internal carotid artery is an important artery during neuro-intervention and neurosurgery. However, its embryological background is not well elucidated. Review of the developmental biology of this small artery indicated that the alleged nomenclatures of the remnant of the primitive maxillary artery of Sabin (1917) and primitive dorsal ophthalmic artery of Lasjaunias (1977) are misnomers because the primordium of the ILT does not nourish the maxilla or retina essentially, but it supplies the premandibular region where the premandibular (prechordal) mesoderm and its surrounding premandibular trigeminal neural crests are distributed. Thus, this embryological artery might be called the primitive premandibular artery more appropriately, and its remnant, i.e., the ILT, might be recognized as the remnant of the primitive premandibular artery.

Keywords

Maxillary artery, premandibular artery, embryology, inferolateral trunk (ILT), ophthalmic artery

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Introduction

Inferolateral trunk (ILT) of the internal carotid artery (ICA) is an important vessel, which nourishes the structures around the cavernous sinus, and is pivotal during neuro-intervention and neurosurgery. Although its anatomy is extensively studied,^{1–4} its embryological background is still not well understood. There are conflicting interpretations on the primordium of the ILT. In the embryological literature, it is regarded as the remnant of *the primitive maxillary artery*,^{5–8} which was first described in the pig embryo by Sabin F. in 1917⁹ and quoted in human embryo by Padget D. in 1948.⁵ In the neuroradiological literature, it was described as *the primitive dorsal ophthalmic artery*, which was first described by Lasjaunias P. et al. in 1977.²

In anatomy, the artery is basically named after the region where the artery nourishes. When the name of the artery is ascribed to the completely different artery or when the artery is named after the different region where it does not nourish, these nomenclatures are misnomers. The present author reviewed the developmental biology of the ILT^{10,11} and concluded that the alleged above-mentioned nomenclatures are misnomers. The author proposes to use the nomenclature of *the primitive premandibular artery* in view of the vascular anatomy and developmental biology.

Vascular anatomy of the ILT

The ILT, also called the lateral or inferior artery of the cavernous sinus, arises from the lateral aspect of the

cavernous portion of the ICA. It has usually three branches: anterior, superior, and posterior ones.^{1–4} Figure 1.

Anterior branch further divides into lateral and medial branches. The anterolateral one anastomoses with the artery of the foramen rotundum which runs through the foramen rotundum. The anteromedial branch supplies the 3rd, 4th, and 6th nerves and anastomoses with the recurrent meningeal branch of the intraorbital ophthalmic artery (also called the deep recurrent ophthalmic artery) through the medial portion of the superior orbital fissure. The author proposes to call the primordium of the anteromedial branch of the ILT *the primitive premandibular artery* in this communication (discussed below).

Superior branch supplies the roof of the cavernous sinus and the 3rd and 4th nerves, and anastomoses with the marginal tentorial artery and infrequently with the sphenoidal branch of the anterior branch of the middle meningeal artery. This superior branch may also anastomose with the branch of the meningohypophyseal trunk.

Posterior branch divides further into lateral and medial branches. The posterolateral one supplies the middle and lateral third of Gasserian ganglion and anastomoses with the cavernous branch of the middle meningeal artery which runs through the foramen spinosum. The

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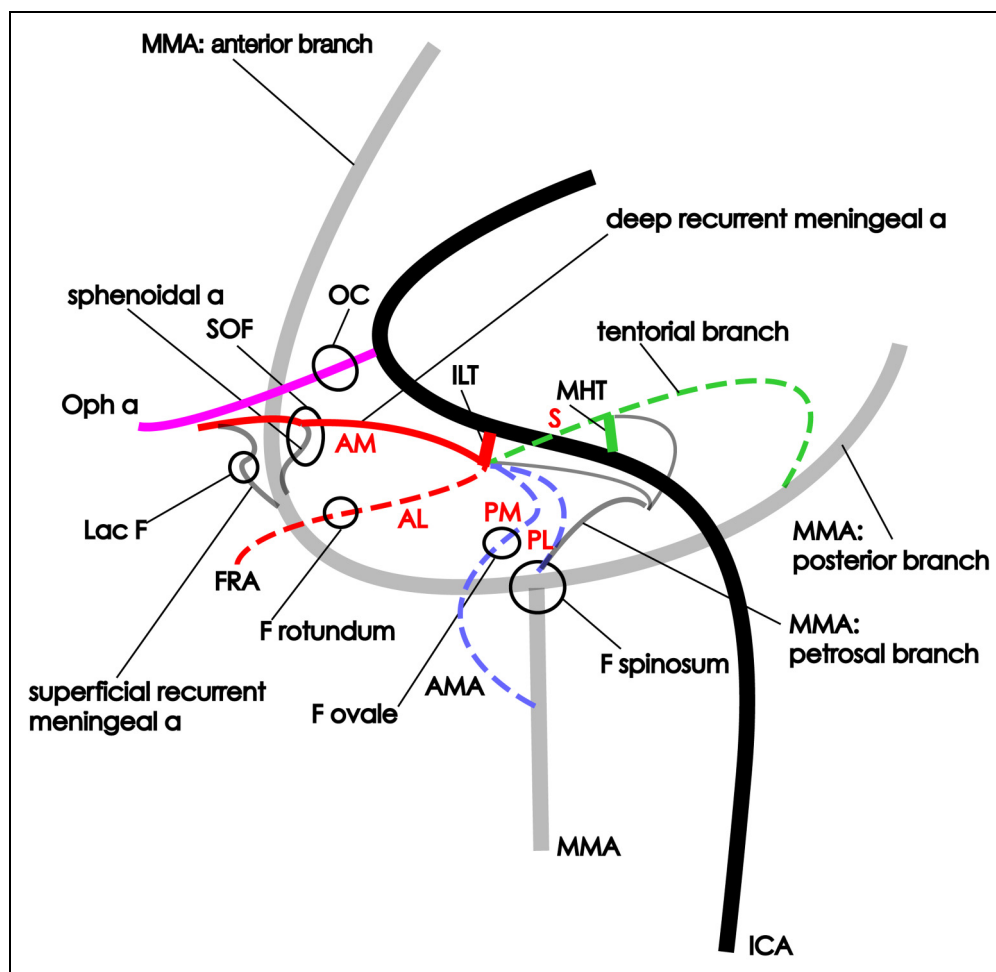


Figure 1. Inferolateral trunk and its branches and anastomoses. AL: anterolateral; AM: anteromedial; AMA: accessory meningeal artery; FRA: foramen rotundum artery; ICA: internal carotid artery; ILT: inferolateral trunk; Lac F: lacrimal foramen; MHT: meningo-hypophyseal trunk; MMA: middle meningeal artery; OC: optic canal; Oph a: ophthalmic artery; PL: posterolateral; PM: posteromedial; S: superior; SOF: superior orbital fissure.

posteromedial branch supplies the 6th nerve and the medial third of Gasserian ganglion and anastomoses with the accessory meningeal artery which runs through the foramen ovale.

Is the ILT the remnant of the dorsal ophthalmic artery?

The structure of the eye is phylogenetically well conserved across the vertebrates.¹² This implies that the vascular structure of the eye is also well conserved across the vertebrates, especially among mammals.¹³ The eye is essentially supplied by the ocular artery and orbital artery. The ocular artery, which supplies the retina, always passes through the optic canal in all vertebrates while the remaining orbital arteries, which nourish the extraocular muscles and lacrimal glands, cross the superior orbital fissure in early embryogenesis. When there are anatomical variations like the middle meningeal artery supplying the ocular artery, there must be the ocular artery initially that crossed the optic canal but has regressed soon due to various reasons and collaterals from the middle meningeal

artery have been reconstituted. Otherwise, normal development of the retina (eye) is less likely.

The primitive dorsal ophthalmic artery does not arise from the cavernous portion of the ICA. According to the Padgett, it arises from the intradural ICA near the origin of the posterior communicating artery.⁵ This artery migrates proximally to the point where adult ophthalmic artery arises from the ICA. The primitive ventral ophthalmic artery arises from the intradural ICA near the origin of the anterior choroidal artery and regresses at its origin.⁵ Both primitive dorsal and ventral ophthalmic arteries are intradural ocular vessels, and they eventually constitute the primitive ophthalmic artery, more accurately the primitive *ocular* artery, to nourish the retina. As described above, ocular artery always runs through the optic canal together with the optic nerve and supplies the retina and choroidal membrane by the central retinal artery and posterior ciliary arteries.⁵ Consequently, *the primitive dorsal ophthalmic artery of Lasjaunias* is apparently a misnomer because this vessel (remnant: the anteromedial branch of the ILT) does not cross the optic canal nor nourish the retina^{10,11} (Figure 2).

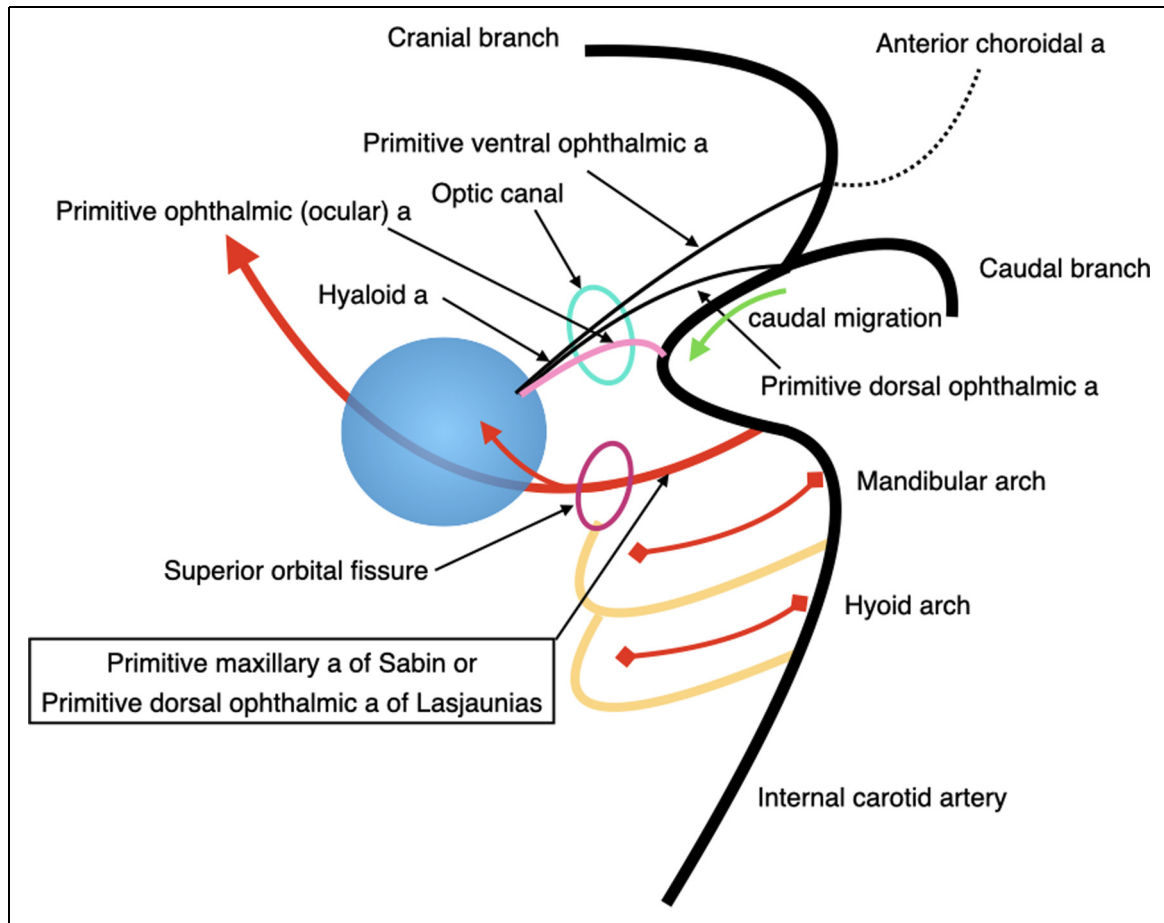


Figure 2. Embryology of the ophthalmic artery. The primitive ocular branch of the primitive ophthalmic artery is formed from the primitive dorsal and ventral ophthalmic arteries, both of which are intradural embryonic vessels of the internal carotid artery. Primitive ocular artery runs through the optic canal, which is well conserved across the vertebrates. **The primitive dorsal ophthalmic artery of Lasjaunias** enters the orbit through the superior orbital fissure, but it does not contribute to the retina.

Is the ILT the remnant of the primitive maxillary artery?

In the early pharyngula stage when only the first pharyngeal arch (mandibular arch) is formed, **the primitive maxillary artery of Sabin** is also formed.⁵⁻⁸ This large artery at this stage courses ventral to the optic vesicle toward the ventral region of the forebrain and extends to the vascular plexus surrounding the forebrain.^{7,8} It should be noted that **the primitive maxillary artery of Sabin** does not nourish the maxilla despite the nomenclature of this vessel. Also, this artery does not nourish the retina essentially unless the proximal ocular artery regresses in the very early stage. The cranial division of the primitive ICA passes dorsal to the optic vesicle and ends at the vascular plexus in the forebrain.⁸ The maxilla and mandibula are embryologically formed from the mandibular arch (the first pharyngeal arch) which must be fed by the primitive mandibular artery. The primitive mandibular artery is mingled into the stapedial artery. The inferior branch of the stapedial artery is the maxillo-mandibular artery which nourishes both maxilla and mandibula. Thus, **the primitive maxillary artery of Sabin** is a misnomer because this vessel does not nourish the maxilla. Figure 3.

What should we call it?

The artery is basically named by the regional name where the artery nourishes. Thus, the appropriate name for **the primitive maxillary artery of Sabin** should be named after the regional name that this artery supplies. Knowledge of developmental biology helps to find the appropriate nomenclature of this vessel.

In the head and neck regions during the embryogenesis, there are two types of mesenchyme: of neural crest origin and of mesodermal origin. They are called ectomesenchyme and mesodermal mesenchyme, respectively. In pharyngula stage, the cephalic neural crest includes three distinct population of the neural crest cells: trigeminal (mandibular), hyoid (preotic), and common branchial (postotic).¹⁴ They adhere to the rhombomere 2 (r2), r4, and r6 and more caudal part of the hindbrain, respectively. These cephalic neural crests are separated each other by the absence of the cells from r3 and r5.¹⁴ The second pharyngeal arch (hyoid arch) is populated by only hyoid neural crest cells. The trigeminal crest cells, however, populate not only the mandibular arch but extend rostrally beyond this arch to the premandibular region. Thus, the trigeminal neural crest can be divided into premandibular

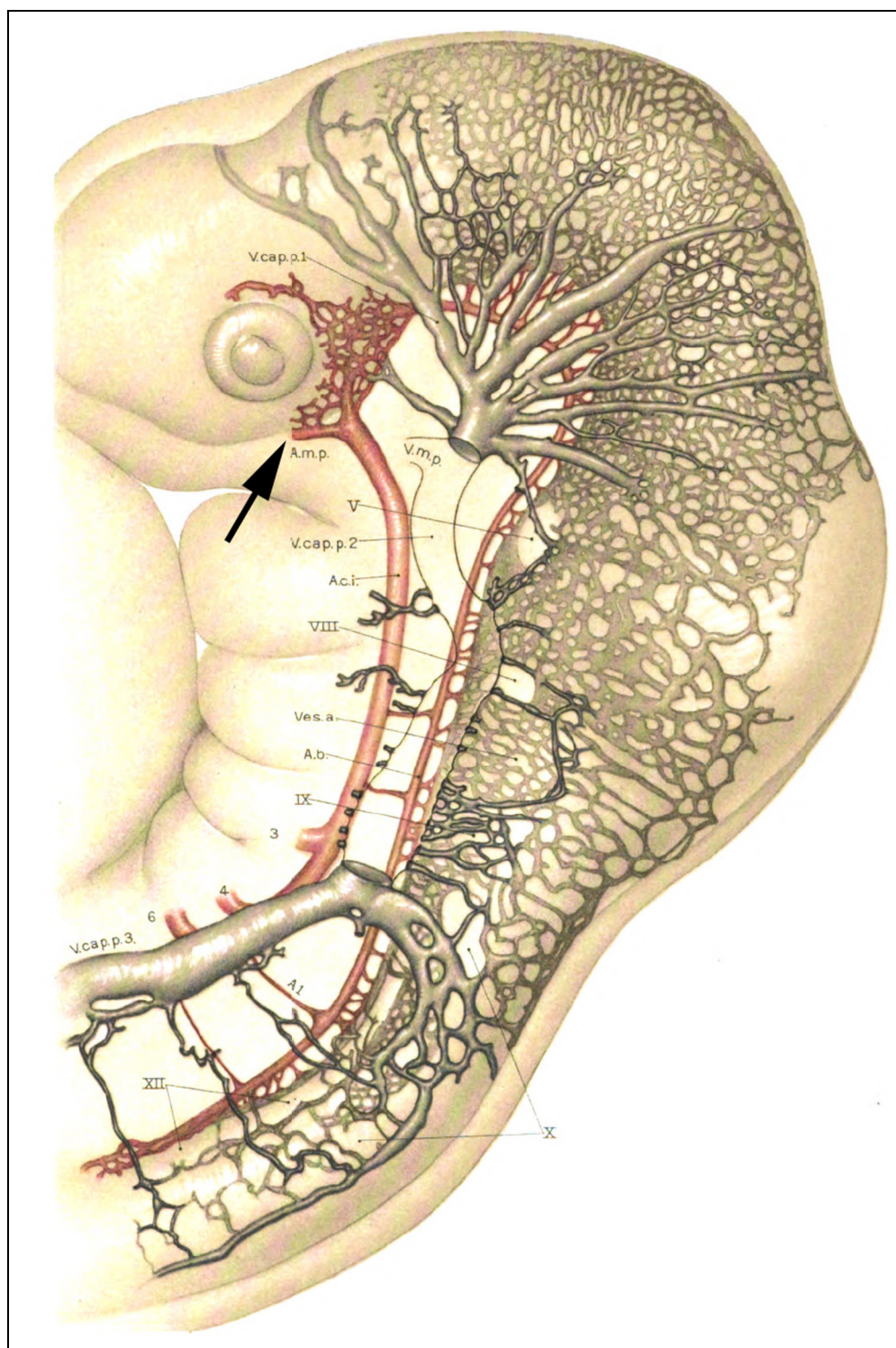


Figure 3. Primitive maxillary artery first described by Sabin in 1917. From Table 7 in the paper by Sabin F.⁹ The arrow is added to the original figure. **Primitive maxillary artery of Sabin** courses ventral to the optic vesicle. Maxillary prominence is not apparent at this stage. **amp** (primitive maxillary artery, arrow) does not nourish the mandibular arch. It nourishes mainly the ventral forebrain and optic stalk. Origin of this artery from the internal carotid artery is the future inferolateral trunk. Most visceral arches and cerebral arteries are not drawn in this figure. Ab: basilar artery, Aci: internal carotid artery, Amp: primitive maxillary artery, A1: artery to the medulla in the first interspace, Vcap.p.1, 2, 3: primary head vein. 1st, 2nd, 3rd segment, Ves a: otic (auditory) vesicle, Vmp: primitive maxillary vein, V: trigeminal nerve, VIII: 8th nerve, IX: glossopharyngeal nerve, X: vagal nerve, XII: hypoglossal nerve, 3, 4, 6: 3rd, 4th, and 6th aortic arches.

and mandibular domains. The premandibular-mandibular boundary is defined between premandibular and mandibular neural crest cells (Figure 4).

Face is embryologically composed of 9 prominences, i.e., 1 frontonasal, 2 medial nasal, 2 lateral nasal, 2 maxillary, and 2 mandibular prominences.¹⁵ The maxillary

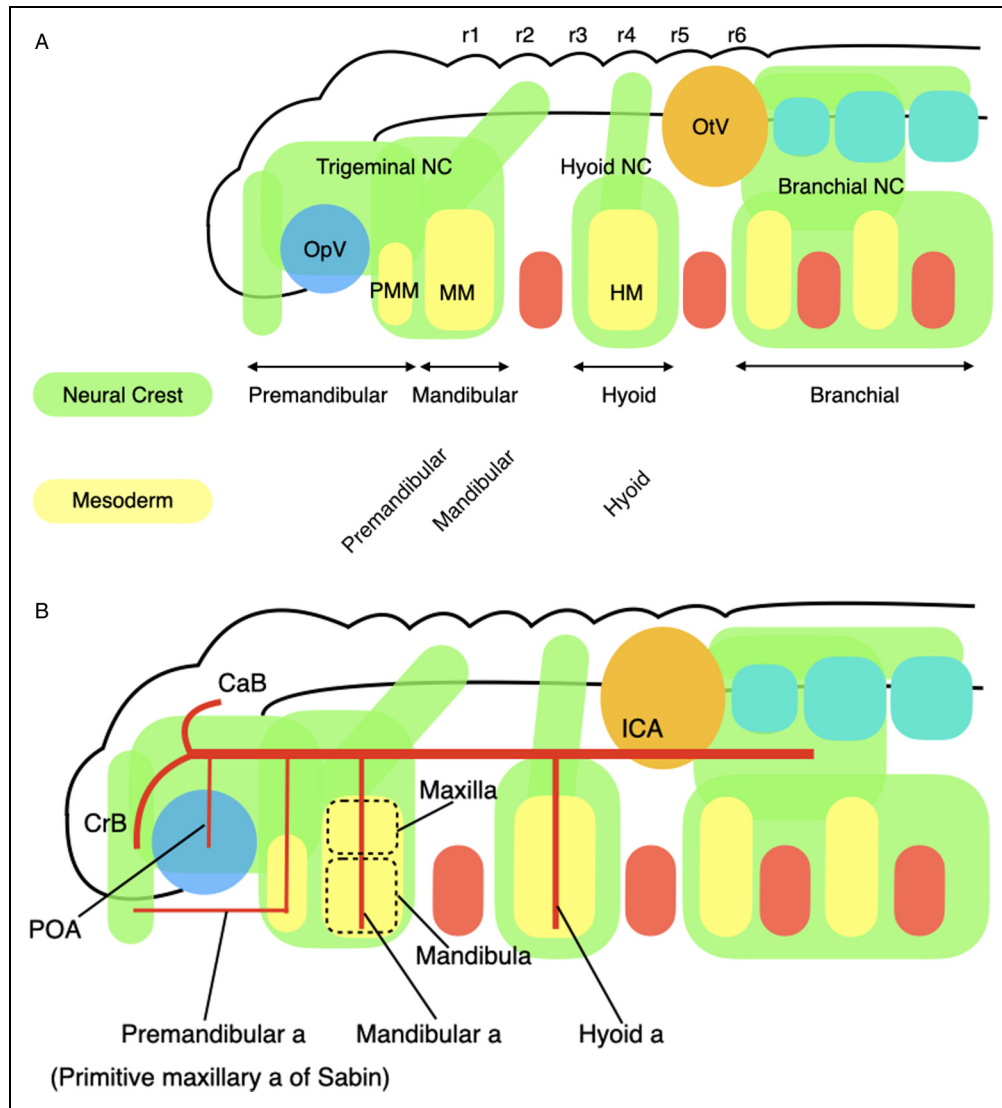


Figure 4. Distribution of the cephalic neural crests and mesoderm, and primitive vessels. A. Distributions of the prechordal and paraxial mesoderm, and cephalic neural crests, which include trigeminal, hyoid, and branchial neural crests. Trigeminal crest is further divided into the premandibular and mandibular neural crests. Premandibular region includes premandibular neural crest of trigeminal crest origin and mesoderm of prechordal mesoderm origin. Mandibular crest and mandibular mesoderm produce both maxilla and mandibula. Modified from the original Figure 1 in the paper by Kuratani S.¹⁴ B. Primitive arteries arising from the primitive internal carotid artery are mapped on the Figure 4A with the distribution of the neural crests and prechordal/paraxial mesoderm. **The primitive premandibular artery** is erroneously called **the primitive maxillary artery of Sabin** or **the primitive dorsal ophthalmic artery of Lasjaunias**. Premandibular artery does not nourish the maxilla, which is formed from the mandibular arch. CaB: caudal branch, CrB: cranial branch, HM: hyoid mesoderm, ICA: internal carotid artery, MN: mandibular mesoderm, NC: neural crest, OpV: optic vesicle, OtV: otic vesicle, PMN: premandibular mesoderm, POA: primitive ophthalmic artery, r1-6: rhombomere 1-6.

prominences develop late to the mandibular prominences. The notch between lateral nasal prominence (premandibular crest origin) and maxillary prominence (mandibular crest origin) is a future nasolacrimal duct.¹⁴ Within the mandibular arch, neural crest cells condense to form a dorsal primordium (maxillary condensation) and a ventral primordium (mandibular condensation). Then, the mandibular arch gives rise to both maxillary and mandibular prominences.¹⁵ When **the primitive maxillary artery of Sabin** dwindles, the first pharyngeal arch is interrupted, and its distal part is transformed into **the primitive mandibular artery** and gives rise to many branches to the maxillary prominences.⁸ When the second pharyngeal arch is

interrupted, the dorsal portion is transformed into the hyoid artery which extends as the vascular networks situated within the hyoid arch.⁸ Thus, the maxilla is developmentally nourished by **the primitive mandibular artery** or its derivative (maxillary branch of the primitive mandibular artery).

The primitive mandibular artery dwindles progressively after the 4 mm Crown rump length (CRL) stage, and it becomes Vidian artery. The hyoid artery becomes the stapedia artery later, which overtakes the territory of the remaining mandibular artery. Stapedia artery is composed of the plexal remnant of the mandibular and hyoid arches, and possibly the premandibular artery as well.

Stapedial artery has the upper and lower divisions at 18 mm CRL stage. The upper division is further divided into the anterior branch (supraorbital artery) and posterior branch (middle meningeal artery). The lower branch (maxillo-mandibular artery) nourishes the mandibular arch, which is divided into the maxillary artery and mandibular artery, running together with V2 and V3 of the 5th nerves, respectively. Supraorbital artery runs together with V1 of the 5th nerve and gives rise to the orbital branches (supraorbital, frontal, ethmoidal, and lacrimal arteries), and forms the secondary anastomosis with the definitive stem of the intraorbital ophthalmic artery. At 24 mm CRL stage, the supraorbital artery loses the connection with the ophthalmic artery near the orbital margin.⁵

The primitive artery, arising from the cavernous portion of the ICA, coursing ventral to the optic vesicle and nourishing the ventral forebrain in early pharyngula stage, might be called **the primitive premandibular artery**. This artery is erroneously named as **the primitive dorsal ophthalmic artery of Lasjaunias** or **the primitive maxillary artery of Sabin** because this vessel does not nourish the retina or maxilla. This artery is prominent up to 5–6 mm CRL stage and then regresses. Although the fate of this artery is not well investigated, it is highly possible that it is mingled into the distal branches of the primitive mandibular and hyoid arteries, and finally stapedial artery. The remnant of this artery is the anteromedial branch of the ILT which runs through the oculomotor foramen together with the 3rd nerve within the annulus of Zinn at the medial portion of the superior orbital fissure to the intraorbital ophthalmic artery.¹⁶

Conclusions

Embryological background of the ILT is not well elucidated. However, review of the developmental biology of the vessel indicated that it is not the remnant of **the primitive maxillary artery of Sabin** or **the primitive dorsal ophthalmic artery of Lasjaunias** because it does not supply the maxilla or retina. The primordium of the ILT is the artery that nourishes the premandibular region where premandibular mesoderm as well as premandibular neural crest are distributed. It is embryologically appropriate to call the ILT the remnant of **the primitive premandibular artery** and to discard to use its misnomers.

Declaration of conflicting interests

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References

1. Harris FS and Rhoton AL. Anatomy of the cavernous sinus: a microsurgical study. *J Neurosurg* 1976; 45: 169–180.
2. Lasjaunias P, Moret J and Mink J. The anatomy of the inferolateral trunk (ILT) of the internal carotid artery. *Neuroradiology* 1977; 13: 215–220.
3. Capo H, Kumersmith MJ, Berenstein A, et al. The clinical importance of the inferolateral trunk of the internal carotid artery. *Neurosurgery* 1991; 28: 733–738.
4. Lasjaunias P, Berenstein A and ter Brugge KG. Surgical neuroangiography. In *Clinical vascular anatomy and variations*. 2nd ed. Berlin: Springer Verlag, 2001, 1. 387–455.
5. Padgett D. The development of the cranial arteries in the human embryo. *Contrib Embryol* 1948; 2: 205–261.
6. De La Torre E and Netsky MG. Study of persistent primitive maxillary artery in human fetus: some homologies of cranial arteries in man and dog. *Am J Anat* 1960; 106: 185–195.
7. Moffat DB. The development of the anterior cerebral artery and its vessels in the rat. *Am J Anat* 1961; 108: 17–29.
8. Hiruma T, Nakajima Y and Nakamura H. Development of pharyngeal arch arteries in early mouse embryo. *J Anat* 2002; 201: 15–29.
9. Sabin FR. Origin and development of the primitive vessels of the chick and of the pig. *Contrib Embryol Carnegie Inst* 1917; 6: 61–124.
10. Komiyama M. Embryology of the ophthalmic artery: a revived concept. *Interv Neuroradiol* 2009; 15: 363–368.
11. Komiyama M. Embryology of the ophthalmic artery. *Interv Neuroradiol* 2019; 25: 562–563.
12. Liem KF, Bemis WE, Walker WF, et al. The sense organ. In: *Functional anatomy of the vertebrates. An evolutionary perspective*. 3rd ed. Belmont, CA: Thomson Learning, 2001, 396–436.
13. Bugge J. The cephalic arterial system in insectivores, primates, rodents and lagomorphs, with special reference to the systemic classification. *Acta Anat* 1974; 87: 1–159.
14. Kuratani S. Cephalic neural crest cells and the evolution of craniofacial structures in vertebrates: morphological and embryological significance of the premandibular-mandibular boundary. *Zoology* 2005; 108: 13–25.
15. Sadler TW: *Langman's medical embryology*. 13th ed. Philadelphia: Wolters Kluwer, 2015, 278–305.
16. Lasjaunias P, Merland JJ, Theron J, et al. Vascularization méningée de la fosse cérébrale moyenne. *J Neuroradiol* 1977; 4: 361–384.