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SNI: Neuroanatomy and Neurophysiology

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Review Article

Lingual artery: Angiographic anatomy and variations review for neurosurgeons

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Received: 20 March 2025
Accepted: 28 March 2025
Published: 25 April 2025

DOI
10.25259/SNI_282_2025

Quick Response Code:

ABSTRACT

Background: The lingual artery (LA) is an important branch of the external carotid artery with a distinct course and vascular supply. However, the knowledge of the LA's angiographic anatomy and variation may represent an obscure area for practicing neurosurgeons. Inconsistencies in the origin, shape, three-dimensional orientation, exact course, and branches are key features of the LA, necessitating a better understanding of its detailed angio-anatomical characteristics.

Methods: Summarized key concepts were included based on a review of the literature, including PubMed medical database, focusing on LA anatomy, angiography, and variations.

Results: A focused, high-yield review was provided in this paper, depicting multiple anatomical and angiographic characteristics of the LA based on 20 final identified articles.

Conclusion: Appreciating the LA's anatomy is essential for angiographic interpretation and enhances the precision of related neurovascular procedures.

Keywords: Anatomical variation, Lingual artery, Neuroanatomy

INTRODUCTION

The lingual artery (LA) is the second anterior branch of the external carotid artery (ECA) and serves as the main arterial supply of the tongue.[16,26] Typically, the LA emerges anteromedially from the ECA above the origin of the superior thyroid artery (STA) and below that of the facial artery (FA).[16,19] As it courses anteriorly through the tongue, the LA contributes both muscular and glandular collaterals.[18] Several branches can originate from the LA, including the suprahyoid, dorsal lingual, sublingual, and deep LAs, each playing a role in supplying the muscles and mucous membrane of the tongue, as well as the palatine tonsil and sublingual gland.[5,16] In addition, anastomoses with neighboring arteries, such as the FA and the STA, may augment blood supply from the LA, underscoring its functional interconnectivity.[18] Given this anatomical complexity, familiarity with the LA's anatomy and variation is crucial, particularly in neurovascular procedures where accurate vascular mapping can impact surgical planning

and outcomes. Here, we highlight key characteristics of the LA's angiographic anatomy and variations relevant to neurosurgical procedures involving this vessel.

MATERIALS AND METHODS

A literature review was conducted to identify studies on the LA's anatomy and variations. PubMed medical database was searched using the following keywords: "Lingual artery vascular anatomy" and "Lingual artery anatomical variation." The inclusion criteria were articles in English and those employing appropriate methodologies of the targeted data, while the exclusion criteria were non-English publications and studies with unreliable or questionable results. The literature review aimed to emphasize the key anatomical characteristics of the LA rather than providing a comprehensive compilation of all related information.

RESULTS

Applying the inclusion and exclusion criteria in our review of available articles and original studies on the LA, we identified 20 articles discussing the anatomy of the LA.[2,5,7,8,12,13,15,16,18-29] The origin, course, branching pattern, collateral circulation, and variations of the LA were analyzed from both angiographic and neurosurgical perspectives.

DISCUSSION

Embryology of the LA

The production of the adult configuration of the LA involves multiple changes related to the aortic arches. Between the first two aortic arches, the ventral pharyngeal artery lies in the median part of the embryo. The disconnection of the ventral portion of the second branchial arch from the dorsal aorta near the origin of the internal carotid artery forms it. Eventually, the ventral pharyngeal artery and the internal carotid artery fuse proximally to form the common carotid artery, while the distal segment of the ventral pharyngeal artery becomes the ECA. The LAs, which branch from the ECA, arise from the ventral pharyngeal artery and begin their development in most of the embryos at the 12–14 mm stage (Padget stage 4; Carnegie stage 17).[3,17]

Origin of the LA

The typical origin of the LA is from the anterior ECA at the level of the greater horn of the hyoid bone.[5,16,22,25,29] Atypical origin of the LA, on the other hand, may arise from the common carotid artery or the carotid bifurcation, or it may share a common origin with the FA, the STA, or both.[22,23] Although the LA commonly arises as the second branch of the ECA, a proximal origin from the common carotid artery or its bifurcation has been reported. Such variation may alter the typical branching pattern of the ECA and may be associated with an atypical origin of other adjacent arteries as well.[7]

Aside from these proximal variations, the LA may also arise from a shared trunk with other branches of the ECA. Among these, the first and most common configuration is the linguofacial trunk (LFT), wherein the LA and FA share a common trunk arising from the ECA. A systematic review by Triantafyllou *et al*. found the pooled prevalence of LFTs to be 16.41% across the studied cases.[28] LFTs are more often unilateral than they are bilateral.[8,28] The morphologic characteristics of LFTs, including side of origin relative to the ECA, height of origin, course, shape, and length, can vary between cases and are challenging to predict.[8]

The second configuration is the common trunk with the STA, forming the thyrolingual trunk (TLT). This variant is far less common than the LFT, with one systematic review finding a pooled prevalence of 0.61%.[27] The third configuration is the thyrolinguofacial trunk (TLFT), where the LA, FA, and STA all share a common origin, which is rarer still, with a pooled prevalence of 0.09%.[28] Collectively, the LA's variant origins are a relatively common occurrence and should be taken into consideration when planning head-and-neck operations such as carotid endarterectomy, tumor resection, and trauma management.[24]

Course of the LA

The LA originates from the ECA and runs anterosuperiorly toward the greater horn of the hyoid bone.[16] It loops back downwards before traveling anteriorly toward the hyoglossus muscle, forming a double curvature.[16] Notably, this proximal curvature occurs near the horizontal course of the hypoglossal nerve toward the mylohyoid muscle.[13,16] After passing deep to the hyoglossus muscle, the LA gives off its sublingual branch inferiorly and becomes the deep LA, terminating at the anterior tip of the tongue.[2]

Variations in the course of the LA

The atypical anatomical course of the LA may or may not be related to its unusual origin, resulting in five distinct course variations.

In the first variation, the LA enters medially to the hyoglossus muscle at its posterior margin, just above the hyoid bone's larger horn, and then reemerges at the muscle's anterior border before continuing its path deep to the inferior longitudinal muscle and lateral to the genioglossus, reaching the tip of the tongue.[26] This course is considered the normal variant, representing 93% of cases in large cadaveric studies.[26] In this variant, the dorsal lingual branch typically arises from the LA beneath the hyoglossus, supplying the base of the tongue [Figure 1].[26]

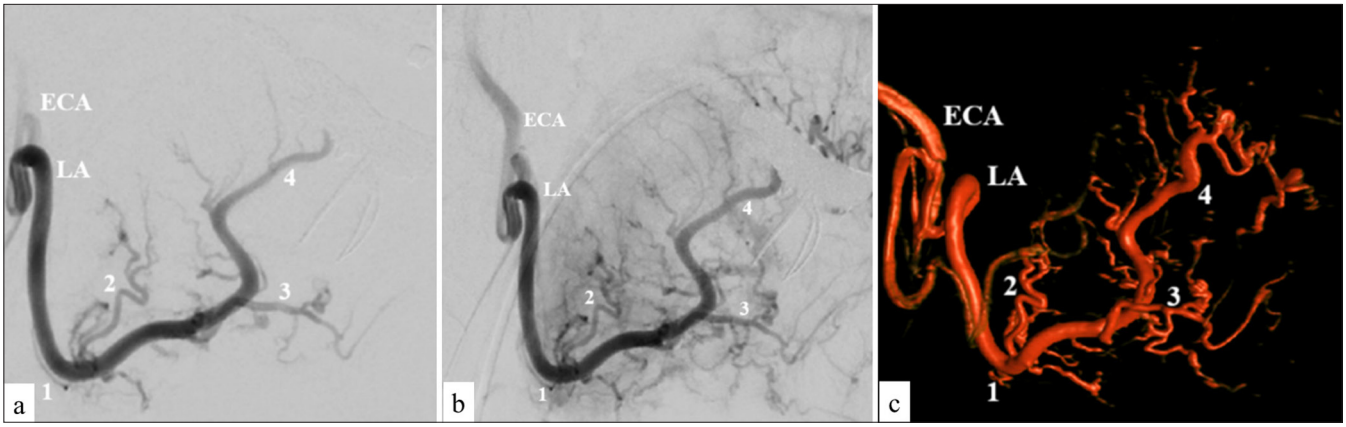

Figure 1: Digital subtraction angiography of the lingual artery showing its branches. (a) Arterial phase. (b) Capillary phase. (c) Three-dimensional computed tomography angiography. ECA: External carotid artery, LA: Lingual artery, 1: Supra-hyoid branch, 2: Dorsal lingual branch, 3: Sub-lingual branch, 4: Deep lingual branch.

In the second course variation, the LA originates from the FA near the submental branch, taking a lateral course relative to the hyoglossus before continuing as the deep LA (representing 1.8% of cases).[26] In Seki *et al.*'s description of this variant, a second artery (residual LA) emerges from the ipsilateral ECA and follows a medial path similar to the classic course but terminates as the dorsal LA without reemerging at the anterior border.[26] The dorsal lingual branch in this variation arises from the LA near the hyoglossus' anterior border.

For the third course variation, the LA initially runs laterally and superficially along the posterior aspect of the hyoglossus, then turns medially into the muscle and reemerges at its anterior border (representing 1.8% of cases).[12,26] This superficially coursing variant in relation to the hyoglossus may facilitate extraoral ligation of the LA in appropriate circumstances.[12] In this variant, the dorsal lingual branch arises from the LA but can also arise from the FA proximal to the origin of the submental artery.[26]

As for the fourth course variation, the LA arises from the submental artery and penetrates the mylohyoid muscle en route to forming the deep LA (representing 1.8%), with the sublingual branch arising after this muscular passage.[26]

In the fifth course variation, which represents 0.9% of cases, there are two distinct LAs, one following the classic medial course and giving rise to another artery that takes the mylohyoid-penetrating route.[26] The dorsal lingual branch in this variation originates from the latter after piercing the muscle.

Branches of the LA

The LA has four consistent branches, including the suprahyoid, dorsal lingual, sublingual, and deep lingual, along with a few atypical branches [Table 1 and Figure 2a]. The typical branches include:

Suprahyoid branch

The suprahyoid artery is the first branch of the LA. It emerges from the LA as the LA descends from its loop and travels along the upper margin of the hyoid bone to nourish the muscles surrounding the hyoid bone.[5,16] It forms anastomoses with the ipsilateral STA and contralateral suprahyoid artery [Figure 2b].[16]

Dorsal lingual branch

The dorsal LA arises second. Its origin is positioned deep to the hyoglossus muscle, coursing upward and medially toward the posterior and dorsal area of the tongue.[22] It supplies the base of the tongue and mucous membrane while also nourishing the palatoglossal arch, soft palate, tonsil, and epiglottis [Figure 2c].[5,16]

Sub LA

The sub LA usually originates at the anterior border of the hyoglossus muscle and courses between the mylohyoid and genioglossus muscles to the sublingual glands.[16] Not uncommonly, it arises from the FA.[16,21] The sub LA supplies the sublingual and submandibular glands, the floor-of-mouth mucosa and muscles, the gingiva, and the mandible. It divides into two terminal branches: the mandibular and submental branches. The mandibular branch supplies the medial mandible, floor-of-mouth mucosa, and gingiva, forming anastomoses with the dental and deep LAs.[16] The submental branch projects anteroinferiorly to supply the suprahyoid muscles and connects with the submental artery [Figure 2d].[16]

Table 1: Anatomical overview of the lingual artery branches.

Lingual branches	Origin	Course	Anastomosis	Supply
Suprahyoid artery	Descending section of the LA	Runs along the upper margin of the hyoid bone	Superior thyroid and contralateral counterparts	Hyoid muscles
Dorsal lingual artery	Medial to the hyoglossus muscle	Runs into the posterior aspect of the tongue	Contralateral counterparts	The base of the tongue, tonsil, epiglottis
Sublingual artery	At the anterior border of the hyoglossus muscle	Between the mylohyoid and genioglossus muscles	Dental and deep lingual arteries.	Sublingual glands, floor of mouth, and mandible
Deep lingual artery	The terminal branch of the LA	Between inferior longitudinal and genioglossus muscles	Sublingual and contralateral counterparts	Body of the tongue

LA: Lingual artery

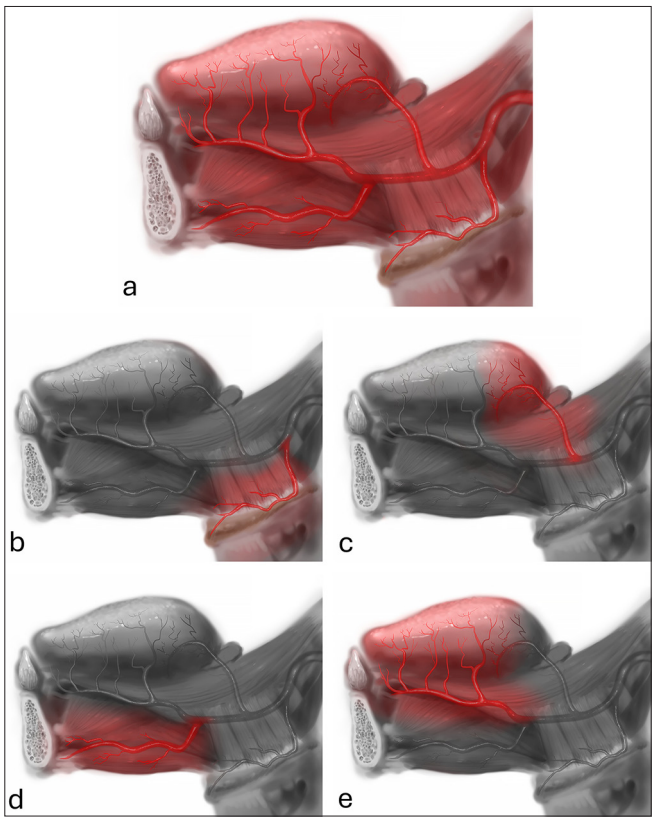

Figure 2: Artistic depiction of the lingual artery branches and their supplying areas. (a) Lingual artery proper. (b) The suprahyoid artery. (c) The dorsal lingual artery. (d) The sublingual artery. (e) The deep lingual artery. Illustration prepared by John Na and courtesy of Samer Hoz.

Deep LA

After emerging from the hyoglossus, the LA continues as the deep LA.[22] It courses ventrally, near the frenulum, until it reaches the tip.[22] Along its path, it supplies the tongue's body, emitting small branches that interconnect to form an arterial network within the submucosa [Figure 2e].[16]

Rare branches of the LA

Buffoli *et al.* reported a rare instance where the LA gave rise to extra branches that serve functions typically associated with the superior thyroid, inferior thyroid, or internal thoracic arteries.[5] This unusual accessory branch can split into medial and inferior divisions to supply the infrahyoid muscles.[5] In addition, the LA may also emit a pharyngeal branch that helps supply the middle constrictor muscles and tonsils.[16]

Collateral circulation of the LA

The LA has an extensive collateral circulation and a dense network of anastomoses, contributing to the tongue's rich blood supply and its tendency to bleed profusely from injuries. It also provides some redundancy: if one artery is compromised, others can partially compensate.[20,22]

The ventropharyngeal region's midline location ensures a robust, bilateral blood supply that supports collateral circulation.[18] In cases of proximal LA obstruction, blood flow is maintained through sublingual routes.[18] The STA may also provide additional collateral support in the linguofacial area when both the LAs and FAs are compromised.[18] Collateral flow can also be supplemented by reversed flow in vessels such as the superior masseteric and proximal occipital arteries.[18]

Clinical applications

The three-dimensional configuration of the LA's origin and course makes it a challenging anatomical structure to identify during an angiographic procedure or while interpreting angiographic imaging of the head and neck. The posterior loop of the origin, with its interchanging course with the FA artery, makes differentiating these arteries difficult in some instances near their origin from the ECA unless one can follow their distal course.

The LA can serve as a potential source of blood supply for head-and-neck paragangliomas, particularly glomus tumors.[1,4,14] Its involvement can vary depending on the tumor's location, size, and the overall vascular architecture of the region. Juszkat *et al*. found that the LA can contribute to the blood supply in 45% of cases with carotid body tumors.[14] In addition, it can also be one of the feeding arteries to the tumor jugulare, especially when other primary feeders are compromised.[11] However, due to its small size and critical supply, the LA is not typically a target for the embolization of those tumors.[9,11]

In cases of extracranial-to-intracranial bypass procedures, the LA anatomy may affect the location of the anastomosis point at the ECA when using saphenous vein or radial artery grafts.[6]

Another application worth considering is the importance of variations in the LA's origin in carotid endarterectomies, particularly in more complex and extended procedures. Recognizing the STA is typically used as a landmark by surgeons in such procedures, understanding the anatomical variation, such as a proximally originating LA or a common trunk with the STA, is essential for accurate navigation and minimizing surgical complications.[10]

There are several clinical scenarios where the anatomical variations of the LA origin represent a cornerstone in surgical planning and interventional procedures. One example is the LFT common truck, where the endovascular intervention for malignant tumors related to the tongue for patients with this LFT variant necessitates precise catheter tip positioning within the common trunk for anticancer agents to be adequately delivered to the LAs or FAs.[15] However, the variable morphologic characteristics of the LFT may make such positioning of the catheter tip challenging[8]. Furthermore, a common LFT implies that an injury or ligature at that trunk would affect blood flow to unanticipated regions, potentially complicating hemorrhage control and flap surgeries.[25]

In addition, an anomalous origin can change the location of the artery relative to the hypoglossal nerve and the carotid bifurcation, which surgeons utilize to locate the LA during neck dissections or emergency ligation.[25]

Course variants can also have significant implications in surgical intervention. A LA that runs lateral to the hyoglossus or through the sublingual region is more exposed and, consequently, may be more susceptible to injury during transoral surgeries or floor-of-mouth procedures due to its unexpected lateral position. The occurrence (and recognition thereof) of such a lateral course may, conversely, facilitate extra oral ligation of the LA.[12]

In summary, the LA varies considerably in its origin and course. Variations of the origin include the formation of the LFT with the FA, while less common variations include the TLT or the rare TLFT. The LA generally courses medially to the hyoglossus muscle, but variations can include lateral or superficial pathways, sometimes even penetrating the mylohyoid. It branches into suprahyoid, dorsal lingual, sublingual, and deep LAs and has rich collateral circulation with contributions from the superior thyroid, occipital, and FAs. Understanding these variations is crucial in related neurovascular procedures.

CONCLUSION

Anatomical variations of the LA may involve its origin, course, or branching pattern and can lead to unfamiliar surgical landmarks. Appreciating LA anatomy is essential for optimal surgical planning, minimizing complications, and refining the interpretation of head-and-neck angiography.

Ethical approval: The Institutional Review Board approval is not required.
Declaration of patient consent: Patient's consent was not required as there are no patients in this study.
Financial support and sponsorship: Nil.
Conflicts of interest: There are no conflicts of Interest.
Use of artificial intelligence (AI)-assisted technology for manuscript preparation: The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Na J, Kakazu A, Muthana A, Shukur M, Hoz SS, Prestigiacomo CJ. Lingual artery: Angiographic anatomy and variations review for neurosurgeons. Surg Neurol Int. 2025;16:156. doi: 10.25259/SNI_282_2025