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Variations in the Origin of the Superior Laryngeal Artery and their Clinical Significance: A Case Report with a Proposal for a New Classification

Variaciones en el Origen de la Arteria Laríngea Superior y su Significado Clínico: Reporte de un Caso con una Nueva Propuesta de Clasificación

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SUMMARY: The superior laryngeal artery is the primary vessel providing the blood supply to the larynx. Commonly, it is derived from the superior thyroid artery. Different variations in the origin have been described in the current literature; knowledge of such variations is crucial for various surgical interventions of the larynx and surgical procedures in the lateral region of the neck regarding the carotid triangle. It should be noted that radiological studies, such as selective angiography of the thyroid gland, can also be misleading in cases of variations. Herein, we describe a case of bilateral superior laryngeal artery originating directly from the external carotid artery of the neck. The arteries at first have a transverse course and then pierce through the thyrohyoid membrane alongside internal laryngeal nerves. Moreover, we also review the known variations in the origin of the superior laryngeal artery and propose a new classification of all known variations.

KEY WORDS Anatomical variants; Classification; Clinical significance; Superior laryngeal artery.

INTRODUCTION

The superior laryngeal artery (SLA) is one of the main vessels supplying the larynx with arterial blood. Generally, the origin of the SLA is described as a derivative from the superior thyroid artery (STA), which is a branch of the external carotid artery (Standring, 2016). Commonly, the SLA is reported to pass downwards toward the larynx, accompanied by the internal ramus of the superior laryngeal nerve. The SLA penetrates the thyroid membrane and enters the larynx, where it divides into several branches, which provide the blood supply for the mucosa, glands, and laryngeal muscles. The blood supply area of the SLA is described from the top of the epiglottis to the inferior part of the thyroarytenoid muscle (Standring, 2016). Even though the most common origin of the SLA is from the STA, as described in many studies (Adachi, 1928; Andrea, 1975; Bergman *et al*., 2021; Devadas *et al*., 2016; Livini, 1903; Macalister, 1868; Nayak *et al*., 2011; Quain, 1844; Rusu *et al*., 2007; Schwalbe & Pfitzner, 1891; Terracol & Guerrier, 1951; Vázquez *et al*., 2009), the percentage of cases where the SLA originates from the STA ranges between 68 % (Rusu *et al*., 2007) and 94 % (Andrea, 1975). However, there are quite a few different variations in the origin of the SLA, which, despite their rare occurrence, have definite clinical significance in a wide range of surgical interventions of the larynx, such as laryngeal reconstruction, partial laryngectomy, and laryngeal transplantation (Anthony *et al*., 1996; Cernea *et al*., 1992; Hurtado-Lopez *et al*., 2005). Moreover, surgeons generally use the STA as a landmark during surgical interventions of the carotid triangle (Cernea *et al*., 1992). Cases of aberrant SLA originating directly from the external carotid artery (ECA) or even from the common carotid artery (CCA) could cause confusion and incorrect identification of ECA branches, which might have detrimental consequences (Cernea *et al*., 1992; Anthony *et al*., 1996; Hurtado-Lopez *et al*., 2005).

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As shown, the variations in the origin of the SLA are of utmost clinical significance. Therefore, this article aims to provide the most complete and relevant current information about the known variations of the SLA and to propose a new classification, as well as to feature one relatively rare bilateral case of SLA originating from the ECA.

CASE REPORT

The 73-year-old male cadaver had undergone a standard dissection administered in the dissection hall of the Department of Anatomy, Histology, and Embryology to the Medical University of Sofia for educational purposes of medical students, approved by the Medico-Legal Office and Local Ethics Committee. During the standard dissection of the cadaver's neck, bilateral variation in the origin of the SLA was found. After the aberrant arteries were thoroughly cleaned of the surrounding tissue, it was established that bilaterally, the SLA originated from the ECA. On the right side, the origin point of the SLA was approximately 1.4 cm superior to the carotid bifurcation. Furthermore, it was determined that the right SLA has an initial transverse then ascending course, passing superior to the right STA. On the left side, the SLA has a point of origin approximately 0.6 cm superior to the carotid bifurcation. Moreover, the left SLA has a transverse course, passing superior to the left STA. Measurement of the variant arteries was taken with a standard ruler. The length of the right SLA, from the point of its origin to the point of its entrance into the larynx, was measured to be 2.4 cm, and the length of the left SLA was measured to be 2.2 cm. It should be noted that the left STA was cut during the dissection procedure. Furthermore, it was observed that the internal ramus of the superior laryngeal nerve bilaterally passes superiorly alongside the aberrant artery. Both structures penetrate the thyrohyoid membrane and enter the larynx. Medical records of the cadaver show no history of surgical interventions, of any kind, in the region of the neck, nor were any scars observed prior to the dissection. The described variations are shown on Figure 1.

DISCUSSION

The SLA is not only an essential artery from an anatomical point of view because it is the main artery providing the blood supply to the larynx (Standring, 2016), but it is also a vital artery from a clinical point of view because of its high clinical significance. Therefore, detailed knowledge of the variations in the origin of the SLA is paramount for all medical professionals working in the anterior and lateral regions of the neck. First, a brief comparison of the results submitted by different studies (Quain, 1844; Macalister, 1868; Schwalbe & Pfitzner, 1891; Livini, 1903; Adachi, 1928; Terracol & Guerrier, 1951; Andrea, 1975; Rusu *et al*., 2007; Vázquez *et al*., 2009; Nayak *et al*., 2011; Devadas *et al*., 2016; Bergman *et al*., 2021) was performed throughout the years.

The most common origin of the SLA is from the STA, which is present in 68 % (Adachi, 1928) to 94 % (Rusu *et al*.). Second, SLA is being described to originate from the ECA, with an incidence rate of 4 % (Adachi, 1928) to 32 % (Rusu *et al*., 2007). A rare variation of the SLA originating from the lingual artery (LA) has been described in 1.7 % (Devadas *et al*., 2016) to 5.4 % of cases. Another uncommon variation of SLA originating from a linguo-facial trunk was described with a probability rate of 2.7 %. SLA originating from the CCA has been described with an incidence rate of 1 % (Quain, 1844;

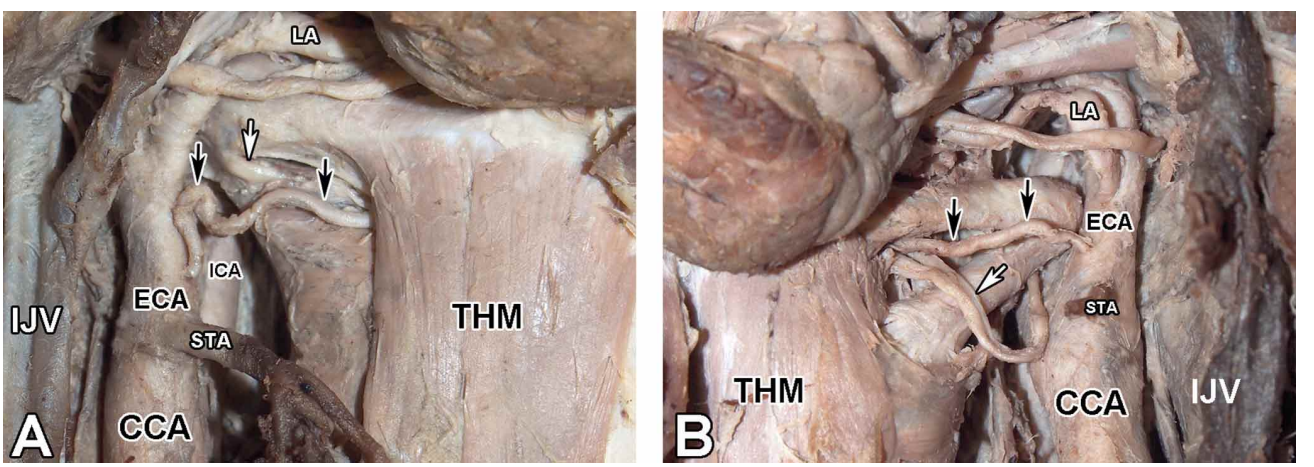

Fig. 1. Picture of the superior laryngeal artery (SLA) originating from the external carotid artery (ECA). A-right side, B-left side. CCA - common carotid artery; ICA – internal carotid artery; IJV – internal jugular vein; white arrows – internal laryngeal nerve (ILN); black arrows – SLA; STA – superior thyroid artery.

Table I. Summary of known variations in the origin of STAs and their probability rate shown as percentages. SLA - superior laryngeal artery; ECA - external carotid artery; LA - lingual artery; CCA - common carotid artery, APA - ascending pharyngeal artery; FA - facial artery.

Origin of SLA / Authors	Quain, 1844	Schwalbe & Pfitzner, 1891	Livini, 1903	Adachi, 1928	Terracol & Guerrier,1951	Andrea, 1975	Rusu *et al.*, 2007	Vazques *et al.*, 2009	Nyak *et al.*, 2011	Devadas *et al.*, 2016
from STA	91 %	70 %	72 %	92%	69 %	94 %	68 %	78 %	79.6 %	91,5 %
from ECA	8 %	24 %	12 %	4%	26 %	5 %	32 %	9 %	12.1 %	5 %
from LA	-	-	-	-	-	-	-	-	5.4 %	1.7 %
from a linguo-facial trunk	-	-	-	-	-	-	-	-	2.7 %	-
from CCA	1 %	1 %	-	-	5 %	-	-	5 %	-	-
from the carotid bifurcation	-	-	-	-	-	-	-	4 %	-	-
from APA	-	-	-	-	-	-	-	-	-	1.7 %
from FA *	-	-	-	-	-	-	-	-	-	-
from a common trunk with the lingual artery	-	-	1.5 %	-	-		-	-	-	-
from a common trunk with the hyoidean branch**	-	-	-	-	-	-	-	-	-	-
Doubled SLA	-	-	-	-	-	-	-	-	One such case	-
Absent	-	-	-	-	-	-	-	4 %	-	-

Described by Bergman, 2021; ** Described by Macalister, A., 1868

Schwalbe & Pfitzner, 1891) to 5 % (Terracol & Guerrier, 1951; Vázquez *et al*., 2009). The SLA can also originate from carotid bifurcation, and this deviation has a probability of 4 % (Vázquez *et al*., 2009). A more unusual variation of the origin of the SLA is from the ascending pharyngeal artery (APA) (Lasjaunias & Moret, 1976; Devadas *et al*., 2016), with an incidence rate of 1.7 % (Devadas *et al*., 2016). Cases of SLA originating from the facial artery (FA) have also been described (Bergman *et al*., 2021); however, the exact percentage of this uncommon variation has not been specified. Another variation is the SLA originating in a common trunk with the LA, with an incidence rate of 1.5 %, which has been described by Livini (1903). Seldom the SLA can be found originating from a common trunk with the hyoidean branch from the ECA – only one such case has been described by Macalister (1868). A singular case of doubled SLA was reported. Finally, SLA was described as absent in 4 % of cases (Vázquez *et al*., 2009).

All of the described variations in the origin of the SLA and their probability rates are summarized in Table I.

To be utmost thorough with the data representation of our review of the literature, we made a comparison between all the previously conducted studies on this matter that we could find in the literature. All of the cited studies have been conducted on formalin-fixated cadavers. In Table II, we summarize the total sample size of heminecks used throughout the studies and the male to female ratio (where the data were provided). Furthermore, we made a comparison of the most common variations in the origin of the SLA and gave the left to right ratio of the described variations (where the data were provided). It should be noted that variations described by singular authors are excluded from the comparison table for obvious reasons. In addition, we performed a meta-analysis of the data. Incidence rates of the variations were calculated by dividing the number of variant cases by the number of total cases.

Clinical significance of the variations in the origin of the SLA

Variants of the SLA, as mentioned above, are not uncommon. Therefore, knowledge of these variations can be crucial in surgical settings and stress the need for extensive yet practical classification. There are a series of complications due to unrecognized variations in SLA during procedures such as laryngeal reconstruction, partial laryngectomy, and laryngeal transplantation (Cernea *et al*., 1992;Anthony *et al*., 1996; Hurtado-Lopez *et al*., 2005). As Anthony *et al*. (1996) noted, the reattaching of a single superior thyroid artery can revascularize the entire larynx. In cases of variants of the SLA, its preservation is crucial for retaining the functions of the aryepiglottic fold and epiglottis and the laryngopharynx in the arytenoid region. The typically meandering intralaryngeal branches of the SLA supply the following: the aryepiglottic fold – superior posterior branch, anterior laryngeal wall- anterior branch, medial wall- medial branch, posterior medial branch – arytenoid region, anteroinferior

Table II. Summary of the number of heminecks used in the different studies (total sample); the male to female ratio; the incidence rate of different variations in the origin of the SLA with their left to right ratio. In brackets are shown the percentages (%). SLA - superior laryngeal artery; STA – superior thyroid artery; ECA - external carotid artery; LA - lingual artery; CCA - common carotid artery.

Authors	Total sample (heminecks)	Male	Female	SLA originating from STA			SLA originating From ECA			SLA originating from CCA			SLA originating from LA		
				right	left	total	right	left	total	right	left	total	right	left	total
Quain, 1844	292	-	-	-	-	266(91)	-	-	24(8)	-	-	2(1)	-	-	-
Schwalbe and Pfitzner, 1891	132	-	-	-	-	92(70)	-	-	32(24)	-	-	1(1)	-	-	-
Livini, 1903	200	-	-	-	-	175(72)	-	-	25(12)	-	-	-	-	-	-
Adachi, 1928	215	-	-	-	-	198(92)	-	-	9(4)	-	-	-	-	-	-
Terracol & Guerrier, 1951	42	-	-	-	-	29(69)	-	-	11(26)	-	-	2(5)	-	-	-
Andrea, 1975	247	-	-	-	-	232(94)	-	-	13(5)	-	-	-	-	-	-
Rusu *et al.*, 2007	100	74(74)	26(26)	-	-	68(68)	-	-	32(32)	-	-	-	-	-	-
Vazques *et al.*, 2009	142	63(44)	79(56)	-	-	111(78)	-	-	13(9)	-	-	7(5)	-	-	-
Nyak *et al.*, 2011	74	58(78)	16(22)	31(42)	28(38)	59(80)	4 (5)	5(7)	9(12)	-	-	-	1(1)	3(4)	4(5)
Devadas *et al.*, 2016	60	50(83)	10(17)	-	-	55(92)	-	3(5)	3(5)	-	-	-	-	1 (1.7)	1 (1.7)
Meta-analysis	1504	-	-	-	-	1285(85)	-	-	171(11)	-	-	12 (0.8)	-	-	5 (0.3)

and posteroinferior branches supply the corresponding areas (Iimura *et al*., 2004). There are specific considerations that should be taken in the partial reconstruction/partial laryngectomy process to regain mobility and preserve phonation and swallowing, which would be rendered obsolete if the branching pattern is overlooked and the artery is damaged early in the procedure (Oki, 1958). Proper artery identification is helpful in superselective intra-arterial administration of chemotherapy for laryngeal and pharyngeal cancer. Although the administration is usually through the STA, it should be directly catheterized if the SLA arises from the ECA (Terayama *et al*., 2006). It is important to note that the clinical significance does not only apply to procedures on the larynx per se and various operative techniques in which the arterial vessels are used as landmarks, such as ligation of the ECA. As ligation is usually performed inferior to the origin of the STA, SLA branching directly from the ECA as a first artery could cause difficulties in obtaining the best results (Hollinshead, 1968). It should be noted that the STA is used as a landmark for the superior laryngeal nerve and the ECA itself. Therefore, variations of the ECA with SLA branching as a separate artery before STA can be a cause for the misidentification of STA (Cernea *et al*., 1992; Hurtado-Lopez *et al*., 2005). Procedures targeting thyroid tissues, such as selective embolization of the thyroid arteries (SETA), must be performed with caution to avoid affecting the SLA, as the dominant arterial supply of the larynx (Tazbir *et al*., 2005). Aberrant SLA can cause vascular damage and subsequent bleeding in a plethora of surgical procedures, including superior laryngeal nerve blocks, radical neck dissection, and bloodless surgery. It is important to mention that although the surgical implications are more often discussed, radiological studies can also be misleading in cases of variant SLA. Studies focused on the branching pattern of the STA classify the latter into 3 to 6 patterns (Gupta *et al*., 2014; Hu *et al*., 2006; Ozgur *et al*., 2009). Variants that are usually discussed are the origin of the SLA from the ECA. However, it should be noted that in angiographic studies in cases of variations of the SLA, not only the pattern of the STA can be difficult to define but also interventional procedures can be complicated.

Classification of SLA's variations. Our literature review showed a plethora of different studies and sources providing in-depth information about different variations in the origin of the SLA. However, although none of the above mentioned studies provides thorough information for all of the known variations in the origin of the SLA, the main point of this article is to provide the utmost comprehensive information regarding all known variations in the origin of the SLA to date and to propose a new classification that is anatomically thorough and clinically relevant. With that being said, during our literature review, we stumbled upon one classification proposed by Vasquez *et al*., which divides the variations in the origin of the SLA into four different categories: "Type I: the SLA arising from the STA; Type II: the SLA arising from the ECA; Type III: the SLA arising from CCA; Type IV: the SLA arising from the carotid bifurcation" (Vázquez *et al*., 2009). In their study, they also reported 5 cases of the SLA being absent (4 %), but they did not specify which, if any other artery overtook the function of the SLA to provide adequate blood supply to the larynx, nor did they include this type in their classification. Even though both of the reviewed above classifications do indeed cover the most common deviations in the origin of the SLA, they both fail to cover the vast majority of the rarer variations. Moreover, there is a significant discrepancy between Types II to IV proposed

by the two authors (Vázquez *et al*., 2009). Therefore, we suggest a new, thorough classification including all the known variations in the origin of the SLA. To create a simple and easy-to-understand yet thorough anatomical classification, we divided all of the reviewed above variations in the origin of the SLA into five categories: I to III are regarding the deviations in the origin point of the SLA. Category III addresses variations of the SLA arising from a common trunk with other arteries. Furthermore, as category IV, we marked the duplicated SLA, and finally as category V – the absence of the SLA.

Anatomical classification

Type I. Variations in the SLA arising from branches of the ECA:
1. The SLA arising from the STA.
2. The SLA arising from the LA.
3. The SLA arising from the APA.
4. The SLA arising from the FA.

Type II. Variations of the SLA arising from the carotid tree:
1. The SLA arising from the ECA.
2. The SLA arising from the CCA.
3. The SLA arising from the carotid bifurcation.

Type III. Variations of the SLA arising from a common trunk:
1. The SLA arising from a common trunk with the LA.
2. The SLA arises from a common trunk with the Hyoidean branch originating from the ECA.
3. The SLA arising from a linguo-facial trunk.

Type IV. Doubled SLA

Type V. Absent SLA.

All of the described variations are shown in Figure 2.

CONCLUSION

Comprehensive knowledge of the variations in the origin of the SLA is paramount for every medical profession regarding the lateral region of the neck due to the high clinical significance of the SLA for a plethora of surgical, radiological, and invasive procedures. Therefore, this article aims to provide meticulous information regarding the variable origin of the SLA. Furthermore, the systematized classification that we propose strives to clarify the variant origin of the SLA.

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"The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. The results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude."

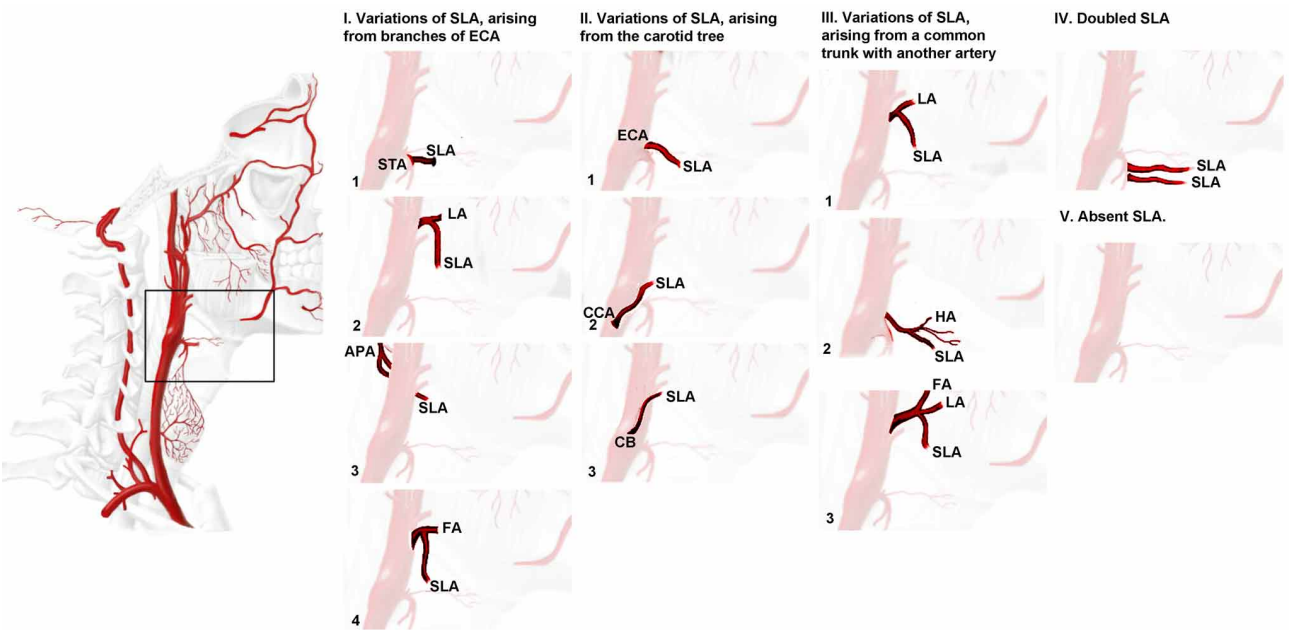

Fig. 2. The variations described in the classification are shown. SLA - superior laryngeal artery; STA – superior thyroid artery; ECA - external carotid artery; LA - lingual artery; CCA - common carotid artery, CB – carotid bifurcation, APA - ascending pharyngeal artery; FA - facial artery, HA – hyoid artery.

ETHICAL APPROVAL. The article was performed in accordance with the ethical standards, approved by the Medico-Legal Office and Local Ethics Committee, Medical University of Sofia.

LANDZHOV, B.; GAYDARSKI, L.; ANGUSHEV, I.; TIVCHEVA, Y.; OLEWNIK,L.; KRASTEV, N.; KIRKOV, V. & GEORGIEV, G. P. Variaciones en el origen de la arteria laríngea superior y su significado clínico: Reporte de un caso con una nueva propuesta de clasificación. *Int. J. Morphol., 40(3)*:595-600, 2022.

RESUMEN: La arteria laríngea superior es el vaso principal que proporciona el suministro de sangre a la laringe. Comúnmente, se deriva de la arteria tiroidea superior. Han sido descritas diferentes variaciones en su origen y el conocimiento de éstas resulta crucial para las intervenciones quirúrgicas realizadas en la laringe, como también en los procedimientos quirúrgicos que se llevan a cabo en la región lateral del cuello, respecto al triángulo carotídeo. Cabe señalar que los estudios radiológicos, como la angiografía selectiva de la glándula tiroides, también pueden ser engañosos en casos de variaciones anatómicas. Aquí, describimos un caso de arteria laríngea superior bilateral que se originaba directamente de la arteria carótida externa. Las arterias al inicio tenían un curso transversal y luego atravezaban la membrana tirohioidea junto con los nervios laríngeos internos. Revisamos también las variaciones conocidas en el origen de la arteria laríngea superior y proponemos una nueva clasificación de todas las variaciones conocidas.

PALABRAS CLAVE Variantes anatómicas; Clasificación; Significado clinic; Arteria laríngea superior.

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