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Anatomical Variations in the Origin of the Lingual Artery in the Kenyan Population

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Abstract

Study design: Descriptive cross-sectional study.

Objective: To determine the variations in origin of the LA and its relationship to surgical landmarks.

Background: The Lingual artery (LA) is a branch of the External Carotid Artery (ECA) that constitutes the principal supply to structures within the oral cavity and floor of the mouth. Knowledge of its variant anatomy is therefore vital during radiological and surgical procedures performed in the head and neck region since they may predispose it and other branches of the ECA to iatrogenic injury. There is, however, a dearth of regional data on the same.

Materials and Methods: A total of 70 LA dissections were performed bilaterally on 35 human cadavers. The borders of the carotid triangle were identified after which the external carotid artery and its branches were exposed. The pattern of origin and the diameter of the LA was noted and distances from its origin to the CB, GCHB and the HN were measured. Similar measurements were carried out for any variant trunks. Data was collected and analyzed using SPSS (IBM version 27). A paired t-test was used to compare side differences. Representative photos of the vessel and its variations were taken.

Results: The LA was found to be present in all cadavers dissected and was bilaterally symmetrical in 43% of cases. Four (4) types of branching patterns were encountered in the present study, the most commonly observed being the solitary LA followed by the LFT, TLT and finally the TLFT. The average diameter was least in the solitary pattern and greatest in the TLT. In relation to the CB, the solitary LA originated at a distance of 1.51 ± 0.89 cm while the LFT, TLT and TLFT originated at a distance of 1.80 ± 0.73 cm, 1.02 ± 0.64 cm and 1.25 ± 0.01 cm respectively from the CB. The mean distance from the origin of the LA to the GCHB was least in the TLT and greatest in the TLFT. With reference to the hypoglossal nerve, the LA was at an average, 0.82 ± 0.15 cm from the HN for the solitary pattern, 1.34 ± 0.86 cm for the LFT, 1.34 ± 0.90 cm for the TLT and 1.38 ± 0.93 cm for the TLFT.

Conclusion: The LA in the Kenyan population exhibited a high frequency of variation in comparison to other populations regarding its pattern of origin and relationship to landmarks such as the CB, GCHB and HN. These findings may provide further insight into the understanding of the vascular anatomy to the radiologist and the surgeon to avert complications and improve overall treatment outcome.

Keywords

lingual artery, external carotid artery, variations, origin, diameter, surgical landmarks

Introduction

The lingual artery (LA) is one of the 3 anteromedial branches of the external carotid artery (ECA).[1] It arises opposite the tip of the greater cornu of the hyoid bone (GCHB), between the superior thyroid artery (STA) and the facial artery (FA). The artery passes between the hyoglossus and the middle pharyngeal constrictor, at which point it turns sharply upward to reach the floor of the mouth accompanied by the lingual veins and the glossopharyngeal

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nerve.[2] At this point it enters the inferior surface of the tongue and courses as far forward as its tip thus forming the chief source of blood to the structures located both in the floor of the mouth and the tongue.[3,4] However, this anatomy is subject to considerable variation and if not understood well, may pose difficulty in identifying the vessel during surgical, diagnostic or interventional procedures in the head and neck.

Population specific variations have been described regarding the patterns of origin of the LA. The linguofacial trunk (LFT) is reported to be most prevalent of the variants followed by the thyrolingual trunk (TLT) and the thyrolinguofacial trunk (TLFT) which is rarely observed.[5-9] These variants alter the relationship of the LA to landmarks such as the carotid bifurcation (CB), GCHB and the hypoglossal nerve (HN) which are used to locate the artery during surgery. This may predispose it to iatrogenic injuries resulting in rapid swelling of the submandibular area thus compromising the airway.[10,11] Additionally, procedures such as hemiglossectomy, total glossectomy and surgical resection of hemangiomas require ligation of the LA in order to avoid excessive hemorrhage.[3,12] However, these aberrations in the pattern of origin may result in inadvertent ligation of a common trunk thus resulting in severe complications.

Some of the anatomical variants of the LA place it in close proximity to the oral cavity hence making it more vulnerable to injury during intraoral surgeries.[13] They also present a significant challenge to radiologists in interpretation of angiograms during procedures such as embolization or intra-arterial injection of anti-cancer drugs into the LA.[14,15] Current literature is mainly focused on the variations of the ECA and comprehensive studies pertaining to the LA are scarce. Further, there is a dearth in regional data on the variations of the origin of the LA. Therefore, this study aims to determine the same.

Materials and Methods

A total of 70 LA dissections were performed on 35 donated human cadavers ranging between 20 and 35 years of age. Ethical approval was sought and provided by the Department of Human Anatomy, University of Nairobi as per the Kenyan constitution. Cadavers having undergone any surgical procedures or traumatic injuries to the neck were excluded from the study. The modified Y incision made during autopsy was extended superiorly to the mastoid process. The resulting skin flap was reflected along the inferior border of the mandible thus exposing the structures beneath. The borders of the carotid triangle were identified which include the posterior belly of digastric muscle superiorly, the sternocleidomastoid laterally and the inferior belly of omohyoid inferiorly. The ECA, its branches and the HN were identified and carefully exposed (Figure 1A-D).

All observations and measurements were made bilaterally using a Vernier callipers. Distances from the point of origin of the LA to the CB, HN and GCHB were measured. In addition, the diameter of the LA was recorded. Similar measurements were made if a variant trunk was encountered. The average of each measurement was calculated and analyzed using SPSS (IBM version 27). A Paired t-test was used to compare the right and left sides for any statically significant difference between the results. P-value of 0.05 was considered significant. Representative photos of the vessel and its variations were taken.

Results

Pattern of Origin of the Lingual Artery

A total of 70 LA's were dissected of which 43% were bilaterally symmetrical while 57% were asymmetrical in the pattern of origin. In all cases, the vessel and its variants were found to originate from the anteromedial surface of the ECA. A total of 4 patterns were identified which included a solitary LA, the LFT, the TLT and the TLFT (Figures 2-5). Of these, the most common pattern was noted to be the typical solitary LA which was more consistent on the right side of the neck in comparison to the left. The LFT was found to be the most frequently observed variant trunk followed by the TLT and TLFT (Table 1).

Diameter of Lingual Artery and Its Variant Trunks

The average diameter of all 3 variant trunks was found to be greater than that of the solitary LA (Table 2). The TLT had the largest diameter followed by the LFT and the TLFT. The latter 2 were found to differ significantly bilaterally (P-value <0.05).

Relationship to the Carotid Body

The solitary LA was located at an average distance of 1.51 ± 0.89 cm from the CB. There was a tendency of the LFT to originate at a more superior level while the TLT originated more inferiorly thus placing it closer to the CB (Table 3). These results did not show any significant differences between the 2 sides with exception of the TLFT whose distance from the CB on the left was significantly greater than the right.

Relationship to Clinically Relevant Landmarks

The average distances from the origin of the LA and its variant trunks to clinically relevant landmarks has been summarized (Table 4). The results reveal that the mean distance from the origin of the solitary LA to the GCHB was greater than that of the LFT and TLT. However, among the variants, the point of origin of the TLFT was furthest from the GCHB. Statistical significance was only noted in the TLT and TLFT distances to the GCHB (P-value <0.05). With reference to the HN, the LA was at an average

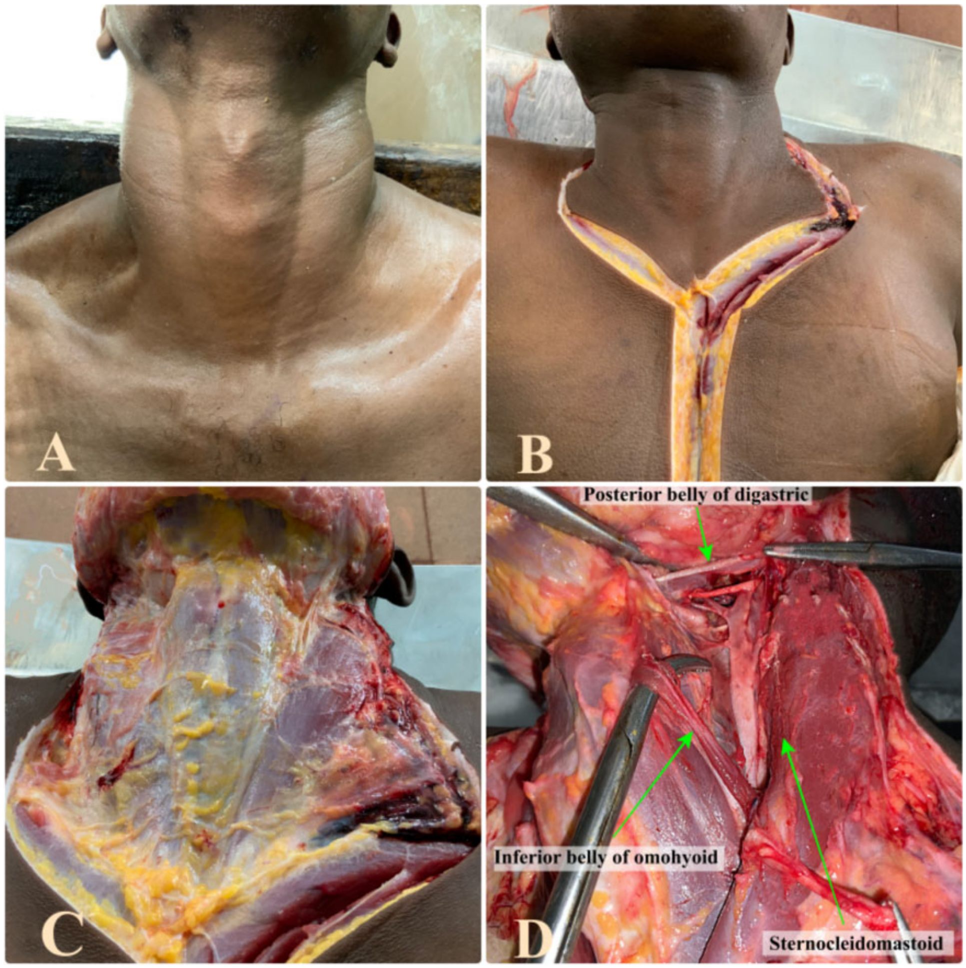

Figure 1. Showing the positioning of the neck (1A) and the modified Y incision (1B). The reflection of the flap was done superiorly (1C) in order to expose the carotid triangle and the vessels within (1D).

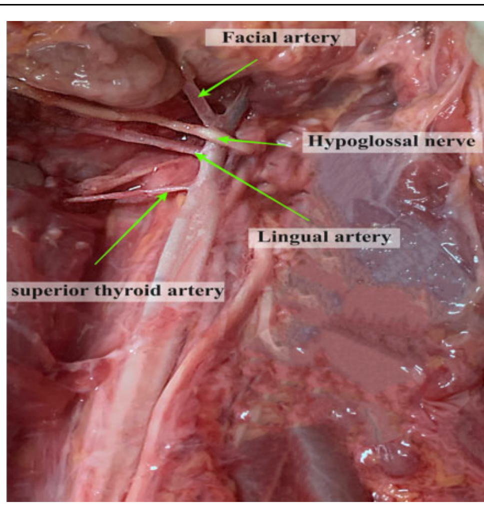

Figure 2. A solitary LA originating from the ECA between the STA and FA.

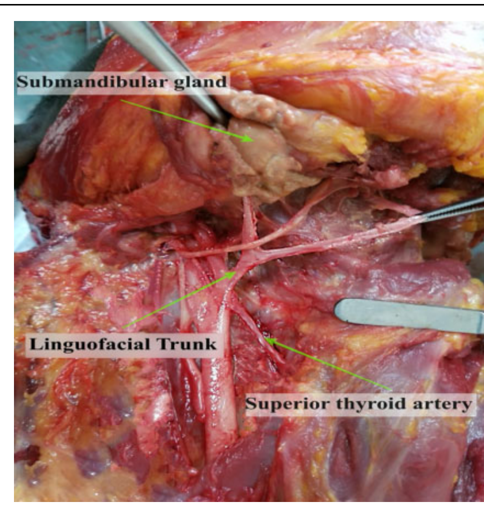

Figure 3. The variant LFT originating from the ECA.

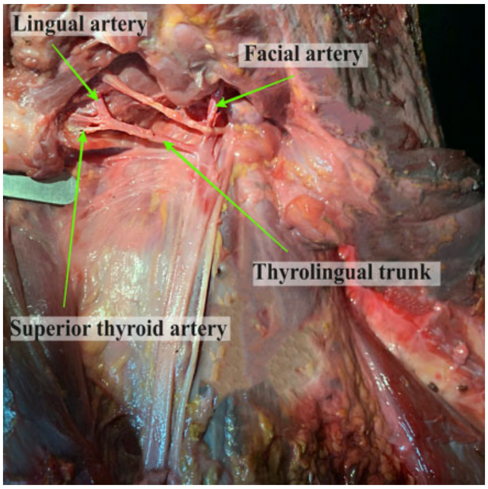

Figure 4. The variant TLT originating from the ECA.

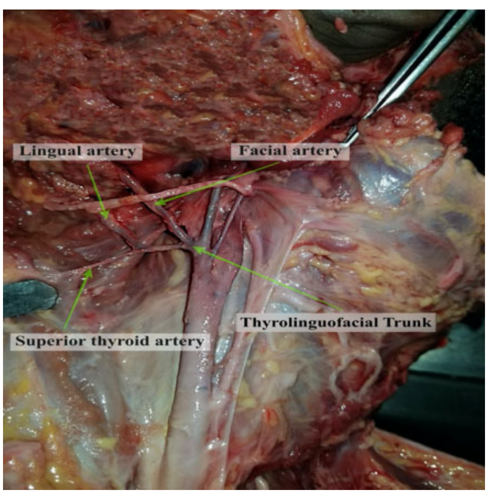

Figure 5. The variant TLFT originating from the ECA.

distance of 0.82 $\pm$ 0.15 cm from the HN for the solitary pattern, 0.33 $\pm$ 0.88 cm for the LFT, 1.34 $\pm$ 0.91 cm for the TLT and 1.38 $\pm$ 0.93 cm for the TLFT. Among these measurements, statistical significance was solely observed for the solitary LA (P-value <0.05).

Discussion

Findings from our study show that in all cases, the LA originated from the anteromedial surface of the ECA, similar to reports from text book literature.[16] Our findings however, differed from those by Herrera-Núñez et al (2020), where majority of the LA originated from the medial surface of the ECA (53%) while anteromedial origin was only noted in 30.9% of their population.[17]

The vessel was also noted to originate as a solitary branch in majority of the cases while in the least of cases, it originated as the TLFT. Our findings were contrasted that

Table 1. Percentage Values Showing the Prevalence of the LA and Its Variant Trunks on the Right and Left Side of the Neck.

Pattern of origin	Right side (%)	Left side (%)
Solitary Lingual artery (LA)	71.43	62.86
Linguofacial trunk (LFT)	22.86	25.71
Thyrolingual trunk (TLT)	2.86	8.57
Thyrolinguofacial trunk (TLFT)	2.86	2.86

from other populations (Tables 5 and 6) with some populations having higher values of the variations as compared to others.[13,18-21]

Several hypotheses have been suggested for the presence of the variant patterns of origin. For example, on the LFT existence, a review by Sirbu et al (2019) suggests that its occurrence could be determined by the remnants of the second aortic arch in the fetal period.[16] The existence of this variation may be critical in certain surgical procedures where uncontrolled bleeding may occur or during biopsies, tumor invasion or trauma in the oral and maxillofacial region. Similarly, during surgical procedures in the cervical region, one of the most common complication is the rupture of the ECA or one of its branches, which may occur due to the existence of these common vascular trunks. Under these conditions, angiography remains the 'gold standard' for the preoperative visualization of the vascularization of this region.[2]

As for the TLT variation, this type of variation may expose the LA to surgical risk during thyroid gland surgery. From the surgical and radiological point of view, knowing the variations in the origin of the LA in the cervical region is necessary in order to avoid errors in invasive procedures in this region, such as, for example, extraoral ligation of the LA. TLFT variants on the other hand, even though rare, might be susceptible to iatrogenic injury in procedures such as thyroidectomy or reconstruction of aneursyms.[25]

Owing to the possibility of the existence of any of these variants, we therefore recommend imaging procedures for detection prior to all surgical interventions in the cervical region.

Findings of our study revealed that the mean diameter of the vessels, regardless of patterns, were higher than that reported in standard text books Additionally, the TLT pattern had the largest diameter followed by the LFT and the TLFT. These findings differed to those of Fazan et al, 2009 where there were no statistically significant differences observed between the diameters of the different patterns[5] (Table 7).

Arterial diameter is a good indicator of blood flow and is therefore relevant when ensuring good reperfusion of local structures during reconstructive surgery.[27] Therefore, large caliber vessels offer better healing options as compared to areas with small caliber vessels and as such the large vessel

Table 2. Average Diameter of the LA and the Variant Trunks.

	LA	LFT	TLT	TLFT
Right side	0.36 ± 0.12	0.56 ± 0.13	0.70 ± 0.01	0.60 ± 0.01
Left side	0.36 ± 0.12	0.68 ± 0.12	0.67 ± 0.15	0.50 ± 0.01
Combined	0.36 ± 0.12	0.62 ± 0.13	0.69 ± 0.08	0.55 ± 0.01
p-Value	>0.05	<0.05	>0.05	<0.05

Table 3. Table Showing the Average Distance of the LA and Variant Trunks From the CB.

	Solitary LA	LFT	TLT	TLFT
Right side	1.50 ± 0.85	1.75 ± 0.86	0.90 ± 0.01	0.70 ± 0.01
Left side	1.51 ± 0.94	1.85 ± 0.60	1.13 ± 1.27	1.80 ± 0.01
Combined	1.51 ± 0.89	1.80 ± 0.73	1.02 ± 0.64	1.25 ± 0.01
p-Value	>0.05	>0.05	>0.05	<0.05

Table 4. Distance From the LA and the Variant Trunks to Clinically Relevant Landmarks.

	Solitary LA		LFT		TLT		TLFT	
Parameter (cm)	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
LA origin to GCHB	1.83 ± 0.59	2.06 ± 0.55	1.59 ± 0.52	1.67 ± 0.61	0.90 ± 0.01	1.50 ± 0.30	2.30 ± 0.01	2.40 ± 0.01
P-value	>0.05		>0.05		<0.05		<0.05	
LA origin to HN	0.90 ± 0.14	0.74 ± 0.16	1.36 ± 0.94	1.32 ± 0.81	1.41 ± 0.97	1.37 ± 0.82	1.37 ± 0.92	1.38 ± 0.94
P-value	<0.05		>0.05		>0.05		>0.05	

Table 5. Table Showing a Comparison of Pattern of Origin of the LA, LFT and TFT With Other Populations.

		Variation on pattern of origin (%)		
Author	**Population**	**Solitary LA**	**LFT**	**TFT**
Ogeng'o et al, 2015[13]	Kenyan	41	44.7	—
Anuradha and Chitra, 2017[18]	Indian	90	10	—
Mata et al, 2012[19]	Brazilian	77.8	19.4	2.5
Ozgur et al, 2008[20]	Turkish	90	7.5	2.5
Yonenaga et al, 2010[21]	Japanese	41.1	28.6	—
Present study	**Kenyan**	**67.15**	**24.29**	**5.71**

diameters in our case might be advantageous. Further, the differences observed among the vessel diameter might be due to racial differences which might influence the embryology of the vessels due to population heterogeneity in the genes governing their development.

Our data showed that majority of the solitary LA originated at a point slightly higher to those reported by Fazan et al,[5] however, for the TLT trunks, our findings were similar to those reported from several case studies where values ranged from 1.45 cm to 3 cm (Table 8).[8,9,28,29]

The knowledge these vascular variations might be very useful during intra-arterial chemotherapy for the treatment of tongue cancers, musculomucosal island flap for partial tongue reconstruction and superselective intra-arterial chemotherapy for head and neck carcinomas.[22,30] These variations should be taken into consideration, as they may increase the risk of hemorrhagic accidents during surgery.[31] Additionally, during procedures such as the ligation of ECA as a means of controlling hemorrhage, either traumatic or operative, surgical dictate for ligating the ECA is to demonstrate a branch and for ligating above the demonstrated branch which is usually the STA. However, in cases where there is an anomalous TLT trunk which originates at the bifurcation of common carotid artery, iatrogenic injury might occur following ligation of the LA as well.[28] Therefore in our setting, since most vessels originated a distance from the CB, patients might not be at a high risk of the aforementioned iatrogenic injury.

Table 6. Table Showing a Comparison of Pattern of Origin of the TLFT With Other Populations.

Author	Population	Prevalence of thyrolinguofacial trunk (%)
Gupta and Agarwal, 2014[6]	Indian	3.3
Zümre et al, 2005[22]	Indian	2.5
Patel et al, 2013[23]	Indian	1
Anitha et al, 2011[24]	Indian	2
Present study	**Kenyan**	**2.86**

Table 7. Table Showing a Comparison of Arterial Diameter With Those Observed in Other Populations.

		Variation on pattern of origin (values in mm)			
Author	**Population**	**Solitary**	**LFT**	**TLT**	**TLFT**
Drake et al, 2005[26]	—	3.0	—	—	—
Fazan et al, 2009[5]	Brazilian	2.3	2.3	—	—
Herrera-Núñez et al, 2020[17]	Mexican	—	3.1	2.97	—
Iwai et al, 2012[8]	Japanese	—	—	—	3.5
Present study	**Kenyan**	**3.6**	**5.6**	**7.0**	**6.0**

Table 8. Table showing the distance of the LA from the CB.

	Variation on pattern of origin (distance from the CB) (values in cm)			
Author	**Solitary**	**LFT**	**TLT**	**TLFT**
Fazan et al, 2009[5]	1.03	1.10	—	—
Kapre et al, 2013[28]	—	—	1.7	—
Babu, 2001[29]	—	—	2.0	—
Lemaire et al, 2001[9]	—	—	3.0	—
Iwai et al, 2012[8]	—	—	1.45	—
Present study	**1.51**	**1.80**	**1.02**	**1.25**

Table 9. Table Showing the Distance From the Origin of the LA to the GCHB.

		Relation to the GCHB on the pattern of origin (values in mm)			
Author	**Population**	**Solitary**	**LFT**	**TLT**	**TLFT**
Lemaire et al, 2005[33]	Belgian	0.5	—	—	5.4
Desai et al, 2012[34]	Indian	—	4.2	—	—
Iwai et al, 2012[8]	Japanese	—	—	6.7	—
Present study	**Kenyan**	**1.95**	**1.63**	**1.2**	**2.35**

Considering the complicated anatomy of the cervical and submandibular region, the use of only 1 surgical landmark is not recommended.[32] In this case, we looked at 2 landmarks, the GCHB and the HN. A summary of the findings from our study showed that the LA was at different distances from the different landmarks based on the pattern of the origin of the LA.

In the case of the solitary LA, the vessel was a greater distance to the GCHB as compared to values reported by Lemaire et al among the Belgian.[33] As for the LFT, TLT and TLFT, our mean values were lower than that reported in other populations (Table 9).

Despite the population differences observed, it is important to note that the study by Lemaire et al and Desai et al were a case study and as such despite the comparison, the low sample size in these studies might not yield the best comparison.[9,34] The differences observed might be due to genetic heterogeneity that may govern vascular development. Both radiological diagnosis and surgical approach depend on anatomical knowledge of the region and the variability in the vasculature involved. A coherent understanding of the variations of the ECA and its branches are vital for procedures performed in the head and neck region.[8] Similarly, during trans-oral robotic surgery (TORS), especially for tongue cancers, several measures are usually taken to avoid injury to the deep vessels, such as skeletonization of the styloglossus and stylopharyngeus muscles. However in cases where deep resection of the tongue base is paramount, the lingual artery may be iatrogenically damaged, therefore laying emphasis on understanding its anatomy. The vessel, in most cases, arises around the hyoid bone. From the hyoid bone, it courses lateral to the middle constrictor muscle where it is crossed by the hypoglossal nerve, and then it passes deep to the hyoglossus muscle where it runs on the superior surface of the hyoid bone. It is in this location that it is vulnerable to injury. In our case, the vessel was 1.66 cm and 1.90 cm (on average) on the right and left sides respectively from the greater horn of the hyoid bone (regardless of the type of trunk). In the case where the dorsal lingual artery is encountered (instead of the main trunk) laterally in the tongue base, tracing it laterally will lead to the lingual artery trunk. Surgeons during TORS may therefore keep these in mind and when encountering the lingual artery, should clip it with several endoscopic hemoclips to prevent life threatening bleeding in the post-operative setting. In the case of hemostasis, compressing the neck at the level of the superior thyroid cornu to slow bleeding may be performed, especially, if the artery is inadvertently transected before clips are applied.[35]

The distance of the LA to the HN in our setting (1.18 cm) was higher than that reported by Souza et al (2017) among Indians (0.58 cm).[32] The nerve constitutes an important anatomic structure that is related to the LA.[36] The relation between the 2 structures might therefore help the surgeon in locating the HN in reference to the LA and vice versa.

Conclusion

The LA shows a high frequency of variations comprising of 3 variant patterns of origin. Of these, the LFT was found to be most common followed by the TLT while the TLFT was most rare. These variations alter the relationship of the vessel to radiological and surgical landmarks such as the CB, GCHB and HN thus predisposing the vessels to inadvertent injury. A clear anatomical understanding of the angioarchitecture will help to improve procedure outcome and prevent fatal complications. In addition, knowledge of the variant anatomy allows precise interpretation of angiograms prior to surgical procedures in the head and neck region.

Limitations

In our study, the cadavers used were volunteered and as such, information concerning their BMI and height were not available.

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