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# Cadaveric and angiographic studies of superior thyroid artery: anatomical variations in origin and distance to carotid bifurcation.

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**Abstract**

This study aims to analyze the incidence of variations in the origin of the superior thyroid artery (STA) in Thai people and the vertical distances from the origin sites of the STA to the level of carotid bifurcation (CB). A total of 220 carotids were retrospectively investigated. The 110 carotid arteries and branches were examined in 55 embalmed cadavers. The 110 carotid angiographs based on 2D digital subtraction and 3D rotational angiography examinations from 55 patients were analyzed. The data from both investigations showed the origin of the STA from the external carotid artery (ECA) in 26.8%, including branches of the thyrolingual trunks in 1.4%, whereas its origin at the CB level and the common carotid artery (CCA) was found as high as 73.2% of the samples. Regarding the sides, the STA origins from the ECA and the CB level were dominant on the right while that from the CCA predominated on the left. The average vertical distance from external carotid origin site of the STA to the CB level was 4.6±2.9 millimeters. The average vertical distance from common carotid origin site of the STA to the CB level was 6.1±5.5 millimeters. It is noted that the origin sites of the STA arose within a range of 10 millimeters above the CB to 10 millimeters below the CB level in 95.5% of the carotids investigated. The present study revealed a relatively high incidence of the STA arising from the CCA and CB level in Thai. The surgical approaches of the neck at/below the CB level should be performed with great care of these STA origins in order to avoid accidental injuries.

**Keywords:** Superior thyroid artery, Carotid bifurcation, Common carotid artery, External carotid artery, Angiographic

## 1. Introduction

Each neck surgery involving the superior thyroid artery (STA) encounters various risks and complications from bleeding to coma and mortality. The information on the origin of STA is significant to perform the accurate diagnostic and therapeutic procedures of neck organs, and to decrease the risk of subsequent surgical treatment and complications of neck lesions [1 & 2].

According to the representative textbooks of anatomy, the common carotid artery (CCA) has no branches until its division, the internal carotid artery (ICA) and the external carotid artery (ECA), and STA is usually the first branch of ECA [3–5]. However, there have been a considerable number of studies showing that STA could originate from CCA and the carotid bifurcation (CB) [1-2, 6–10]. Regarding the ethnic variance, higher frequency of STA origin from ECA was predominant in Caucasoids than in East Asians [11].

Though studies on the origin of STA have been performed in different countries, mostly European countries and Japan, but those in Southeast Asians, especially Thai, are rare [6–8].

Among the landmarks of the neck, CB is an anatomically and surgically important landmark implicating in a variety of pathological processes [12].

Therefore, the present study was undertaken to analyze the incidence of variations in the origin of STA in Thai people and the distances from the origin sites to the level of CB.

## 2. Materials and Methods

### *2.1 Classification*

The STA origin sites were classified into three levels: CB, ECA and CCA levels. The CB level was defined by the horizontal line crossing CB as well as the STA origin at either its cranial or caudal boundary, as previously mentioned in Esen's publication [10]. The origin sites above and below the CB level were defined as the origins from ECA and CCA, respectively.

### *2.2 Cadaveric dissection*

One hundred and ten carotid arteries and their branches were dissected in 55 adult embalmed cadavers (32 males and 23 females), aged between 29-92 years, from the Department of Anatomy, Faculty of Medicine, Khon Kaen University, Thailand. Subjects with the conditions of neck mass and blood flow occlusion of the neck region were excluded. The subjects aged under 20 years old were also excluded because of the shorter statures leading to the shorter vertical distances from the STA origin to the CB level than the adults. The patterns of STA origin were identified bilaterally. The vertical distances from the STA origins to the CB level were measured with digital vernier calipers (Mitutoyo; Tokyo, Japan).

### *2.3 Angiographic examination*

Carotid arteries were retrospectively analyzed based on 2D digital subtraction and 3D rotational angiography examinations performed with CT scanner (Shimadzu; Tokyo, Japan). The subjects were the adult patients who needed the diagnostic evaluation of the neck lesions from the Srinagarind Hospital, Khon Kaen, Thailand. Patients with the conditions of occluding blood flow of the neck region, neck mass, or aged under 20 years old were disregarded. A total of 110 angiographs from 55 patients (40 males and 15 females), aged between 20-79 years were included in the study. The patterns of STA origin were identified bilaterally and the vertical distances from the STA origin to the CB level were measured.

The cadaveric and angiographic data of the STA origins and the vertical distances from the origin sites to CB were analyzed.

Approval for this study was obtained from the Khon Kaen University Ethics Committee in Human Research. All records and information of the cadavers and patients in the present study were anonymized.

## 3. Results

### *3.1 Cadaveric analysis*

The origin of STA from ECA (Figures 1a and 1b) was found in 22.7%. This included direct branches in 20.9% and branches of the thyrolingual trunk in 1.8% (Table 1). The origin of STA at CB level (Figures 2a and 2b) and CCA (Figures 3a and 3b) was found in 77.3%. There were 30% and 47.3% of this pattern arising in the vicinity of CB and CCA, respectively (Table 1).

The average vertical distance from ECA origin site of the STA to the CB level was 6.0±2.0 mm. The average vertical distance from CCA origin site of the STA to CB level was 7.0±4.2 mm. The longest distance was 30 mm below CB.

### *3.2 Angiographic analysis*

The STA arising from ECA (Figures 1c and 1d) was found in 30.9%. This included direct branches in 30% and branches of the thyrolingual trunk in 0.9% (Table 1). The STA origin at CB level (Figures 2c and 2d) and CCA (Figures 3c and 3d) was found in 69.1%. There were 26.4% and 42.7% of this pattern arising in areas of the CB and CCA, respectively (Table 1).

The average vertical distance from ECA origin site of the STA to the CB level was 3.5±3.0 mm. The average vertical distance from CCA origin site to the CB level was 5.1±6.5 mm. The longest distance was 42 mm below CB.

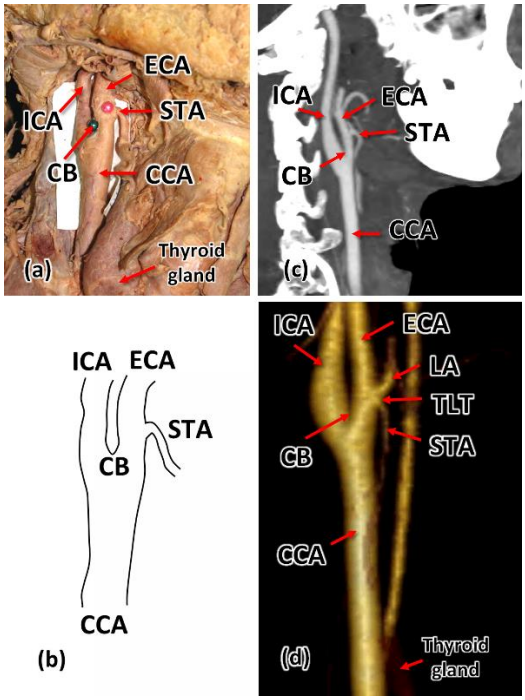


**Figure 1** Pattern of the origin of the superior thyroid artery arising from the external carotid artery illustrated by (a) cadaveric photograph; (b) schematic drawing; (c) 2D angiograph; and (d) 3D angiograph
(CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; CB, carotid bifurcation; STA, superior thyroid artery; LA, lingual artery; TLT, thyrolingual trunk)

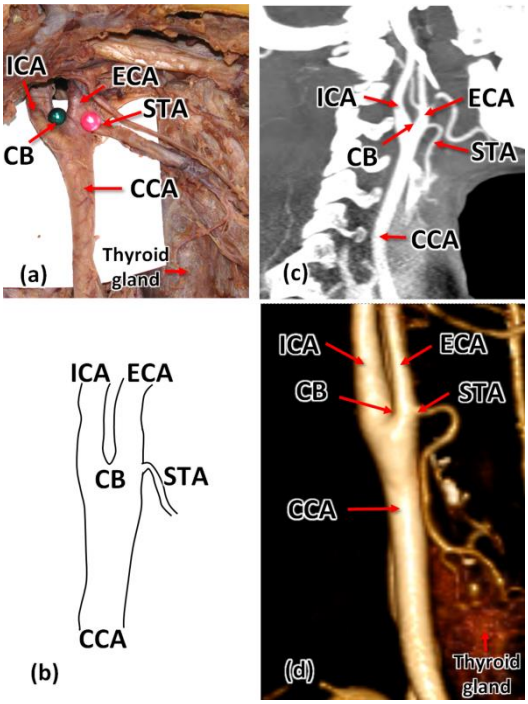


**Figure 2** Pattern of the origin of the superior thyroid artery arising from the carotid bifurcation level illustrated by (a) cadaveric photograph; (b) schematic drawing; (c) 2D angiograph; and (d) 3D angiograph
(CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; CB, carotid bifurcation; STA, superior thyroid artery)

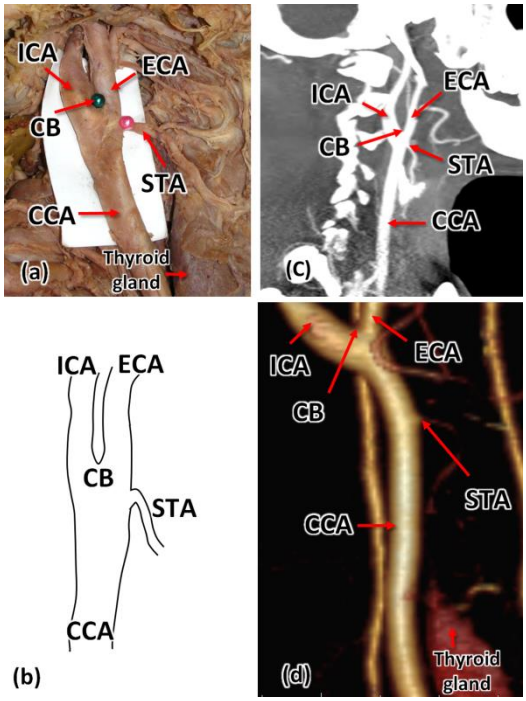


**Figure 3** Pattern of the origin of the superior thyroid artery arising from the common carotid artery illustrated by (a) cadaveric photograph; (b) schematic drawing; (c) 2D angiograph; and (d) 3D angiograph
(CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; CB, carotid bifurcation; STA, superior thyroid artery)

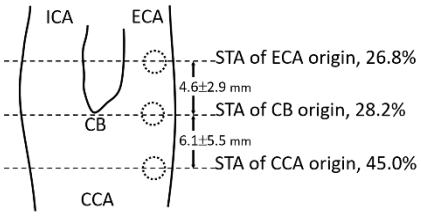


**Figure 4** Frequency of variable origin of superior thyroid artery and average vertical distances from the origins to the level of carotid bifurcation
(CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; CB, carotid bifurcation; STA, superior thyroid artery)

**Table 1** Incidence of origins of superior thyroid artery in cadaveric and angiographic investigations

| Origin of superior thyroid artery | Cadavers | Angiographs | Total |
|---|---|---|---|
| | n **(%)** | n **(%)** | N **(%)** |
| External carotid artery | 25 **(**22.7**)** | 34 **(**30.9**)** | 59 **(**26.8**)** |
| Direct branch | 23 **(**20.9**)** | 33 **(**30.0**)** | 56 **(**25.4**)** |
| Thyrolingual trunk | 2 **(**1.8**)** | 1 **(**0.9**)** | 3 **(**1.4**)** |
| Carotid bifurcation and Common carotid artery | 85 **(**77.3**)** | 76 **(**69.1**)** | 161 **(**73.2**)** |
| Carotid bifurcation | 33 **(**30.0**)** | 29 **(**26.4**)** | 62 **(**28.2**)** |
| Common carotid artery | 52 **(**47.3**)** | 47 **(**42.7**)** | 99 **(**45.0**)** |
| **Total** | 110 | 110 | 220 |

The present study revealed a relatively high incidence of the STA arising from CCA and the CB level in both cadaveric and angiographic investigations with a slightly higher percentage in the former**.** Of the total 220 carotids, the origin of STA at the CB level and CCA comprised 73.2%. This pattern arose in the vicinity of CB and CCA in 28.2% and 45.0%, respectively (Table 1). The origin sites from ECA of the total carotids was found in 26.8% (Figure 4). This pattern included direct branches of the ECA (25.4%) and thyrolingual trunks (1.4%) (Table 1). There was not any case presenting with thyrolinguofacial trunk arising from either ECA or CCA.

Regarding the sides, the STA origins from ECA and the CB level were dominant on the right (76.4% and 60.0%, respectively), while that from CCA predominated on the left (71.0%). The average vertical distance from ECA origin site of the STA to the CB level was 4.6±2.9 mm, and that from CCA origin site of the STA to the CB level was 6.1±5.5 mm (Figure 4). The longest distance was 42 mm below CB. In 95.5% of the total carotids, STA originated within a range of 10 mm above and below the CB level.

**4. Discussion**

Incidence of the STA arising from either CCA or CB is not uncommon in Caucasoids and East Asians as reported from studies in French, German, Croatian, Japanese, New Zealander, Turkish, British, and Greek, including the current study in Thai as shown in Table 2. The high frequency (73.2%) of the STA originating from the CCA and CB in the present study agreed with results of several past reports [2,7, 13–18].

Nevertheless, the incidence was opposed to many standard textbooks describing that STA is usually the branch of ECA [3–5]. The studies in Japanese [1], German [19], Kenyan [8], and Indian [20 & 21], as presented in Table 2, consistent with the textbooks.

**Table 2** Literature review of STA origins in a chronological order

| Authors | Nationality | Type of study | Numbers of specimens | ECA (%) | At and Below CB (%) | | |
|---|---|---|---|---|---|---|---|
| | | | | | CB + CCA | CB | CCA |
| Poisel & Golth, 1974 | German | Cadaveric | 158 | 69.9[a] | 30.1 | 23.7 | 6.4 |
| Espalieu et al., 1986 | French | Cadaveric & Angiographic | 86 | 45.0 | 55.0[b] | - | - |
| Remmert et al., 1995 | German | Cadaveric | 30 | 47.0 | 53.0 | 30.0 | 23.0 |
| Lucev et al., 2000 | Croatian | Cadaveric | 40 | 30.0 | 70.0 | 22.5 | 47.5 |
| Hayashi et al., 2005 | Japanese | Cadaveric | 98 | 70.0 | 30.0[b] | | |
| Terayama et al., 2006 | Japanese | Angiographic | 95 | 46.3 | 53.7 | 44.2 | 9.5 |
| Lo et al., 2006 | New Zealander | Cadaveric | 65 | 46.2 | 53.8 | 52.3 | 1.5 |
| Klosek & Rungruang, 2008 | Thai | Cadaveric | 72 | 66.7 | 33.3[b] | - | - |
| Ozgur et al, 2009 | Turkish | Cadaveric | 40 | 25.0 | 75.0 | 40.0 | 35.0 |
| Vázquez et al., 2009 | British | Cadaveric | 207 | 24.0 | 76.0 | 49.0 | 27.0 |
| Natsis et al., 2011 | Greek | Cadaveric | 100 | 39.0 | 61.0 | 49.0 | 12.0 |
| Ongeti et al., 2012 | Kenyan | Cadaveric | 92 | 86.9 | 13.1 | 2.2 | 10.9 |
| Joshi et al., 2014 | Indian | Cadaveric | 66 | 66.7 | 33.3 | 31.8 | 1.5 |
| Rajapriya et al., 2017 | Indian | Cadaveric | 25 | 52.0 | 48.0 | 4.0 | 44.0 |
| This study, 2018 | Thai | Cadaveric & Angiographic | 220 | 26.8[a] | 73.2 | 28.2 | 45.0 |

[a] Including thyrolingual trunks
[b] Combined STA origins of CB and CCA
(CB, carotid bifurcation; CCA, common carotid artery; ECA, external carotid artery; STA, superior thyroid artery)

In the present study, the STA origin from ECA revealed a predominant location on the right side while that from CCA was outstanding on the left. This confirms with the studies in both Caucasoids and East Asians as reported by Toni et al. [11].

It is noted that the prevalence of STA origins can be found different within the same ethnic group as found in German and Japanese (Table 2). The previous cadaveric study in Thai people reported the dominancy of its origin from ECA [6]. In contrary, higher percentages of STA origins from CCA and CB in the present study got a consensus in both cadaveric study and angiographic examination.

In thyrolingual trunk, STA and the lingual artery originate from the same point as a common trunk that gives off separate branches after a short course. The STA origin from ECA as the thyrolingual trunk occurred in 1.4% of the present specimens. The trunk is infrequent and this corresponds to those from previous data occurring in just 0.6-3.5% with different origins [7, 18, 22-23], whereas some studies do not report the portion where the common trunk arose [1, 2, 24].

Embryological textbook explains that CCA and the proximal part of ICA usually develop from the third aortic arch while the ECA develops from remnants of the first aortic arch together with some contribution from the second aortic arch [25]. Therefore, the ICA is the continuity of the CCA whereas ECA should be considered as an anterior branch of the CCA. In addition, the term of CB may be controversial because it is not actually the

bifurcation of a vessel separating into two equal-sized branches. Natsis et al. [7] proposed that many classic anatomical studies and some modern ones may fallaciously consider CB as a part of ECA. As a result, the origination of STA may be erroneously classified, resulting in the various incidence of the STA origin.

The STA provides dominant blood supply to thyroid gland and superior part of larynx. Anatomic feature and relationship of the STA are the paramount issue in certain surgical neck procedures, such as laryngotomy, radical neck dissection, catheterization, reconstruction of aneurysm, and carotid endarterectomy. Each operation involving neck vessels and viscera predisposes it to unexpected risks and serious complications including air leaks, bleeding, chylous fistula, facial and cerebral edema, coma and mortality [2]. Unawareness of possible anatomic variations, including the STA origin sites at/below the CB, could lead to fatal mistakes. Despite rare cases, the extremely low STA origin may be presented as it was found at 42 mm below the CB in this study. Consequently, the length of 4 cm of the CCA extending downwards from the CB is potentially hazardous during operation in this certain area.

## 5. Conclusion

The present study revealed a relatively high incidence of the STA arising from the CCA and CB level in Thai**.** The surgical approaches of the neck at/below the CB level should be performed with great care of these STA origins in order to avoid accidental injuries**.**

## 6. Acknowledgement

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## 7. References

[1] Hayashi, N., Hori, E., Ohtani, Y., Ohtani, O., Kuwayama, N., Endo, S., 2005. Surgical anatomy of the cervical carotid artery for carotid endarterectomy. Neurologia Medico-Chirurgica 4, 25–29.

[2] Ozgur, Z., Govsa, F., Celik, S., Ozgur, T., 2009. Clinically relevant variations of the superior thyroid artery: an anatomic guide for surgical neck dissection. Surgical and Radiologic Anatomy 31, 151–159.

[3] Snell, R. S., 2012. Clinical anatomy by regions, 9th ed. Wolters Kluwer Health/Lippincott Williams& Wilkins, Baltimore.

[4] Moore, K. L., Dalley, A. F., Agur, A. M. R., 2014. Clinically oriented anatomy. 7th ed. Clinical Anatomy 27, 274. doi.org/10.1002/ca.22316

[5] Standring, S., 2016. Gray's anatomy: the anatomical basis of clinical practice. 41st ed. Elsevier, Philadelphia.

[6] Klosek, S. K., Rungruang, T., 2008. Topography of carotid bifurcation: considerations for neck examination. Surgical and Radiologic Anatomy 30, 383–387.

[7] Natsis, K., Raikos, A., Foundos, I., Noussios, G., Lazaridis, N., Njau, S. N., 2011. Superior thyroid artery origin in Caucasian Greeks: A new classification proposal and review of the literature. Clinical Anatomy 24, 699–705.

[8] Ongeti, K. W., & Ogeng'o, J. A., 2012. Variant origin of the superior thyroid artery in a Kenyan population. Clinical Anatomy 25, 198–202.

[9] Won, S.-Y., 2016. Anatomical considerations of the superior thyroid artery: its origins, variations, and position relative to the hyoid bone and thyroid cartilage. Anatomy & Cell Biology 49, 138–142.

[10] Esen, K., Ozgur, A., Balci, Y., Tok, S., Kara, E., 2018. Variations in the origins of the thyroid arteries on CT angiography. Japanese Journal of Radiology 36, 96–102.

[11] Toni, R., Della Casa, C., Castorina, S., Malaguti, A., Mosca, S., Roti, E., Valenti, G., 2004. A meta-analysis of superior thyroid artery variations in different human groups and their clinical implications. Annals of Anatomy 186, 255–262.

[12] Michalinos, A., Chatzimarkos, M., Arkadopoulos, N., Safioleas, M., Troupis, T., 2016. Anatomical considerations on surgical anatomy of the carotid bifurcation. Anatomy Research 2016, Article ID 6907472.

[13] Espalieu, P., Cottier, M., Relave, M., Youvarlakis, P., Cuilleret, J., 1986. Radio-anatomic study of the carotid axis with regard to the implantation of microsurgical vascular anastomoses. Surgical and Radiologic Anatomy 8, 257–263.

[14] Remmert, S., Majocco, A., Gehrking, E., 1995. Neurovascular infrahyoid myofascial flap. Anatomic-topographic study of innervation and vascular supply. HNO 43, 182–187.

[15] Lucev, N., Bobinac, D., Maric, I., Drescik, I., 2000. Variations of the great arteries in the carotid triangle. Otolaryngology--Head and Neck Surgery 122, 590–591.

[16] Terayama, N., Sanada, J., Matsui, O., Kobayashi, S., Kawashima, H., Yamashiro, M., Takanaka, T., Kumano, T., Yoshizaki, T., Furukawa, M., 2006. Feeding artery of laryngeal and hypopharyngeal cancers: role of the superior thyroid artery in superselective intraarterial chemotherapy. Cardiovascular and Interventional Radiology 29, 536–543.
[17] Lo, A., Oehley, M., Bartlett, A., Adams, D., Blyth, P., Al-Ali, S., 2006. Anatomical variations of the common carotid artery bifurcation. ANZ Journal of Surgery 76, 970–972.
[18] Vázquez, T., Cobiella, R., Maranillo, E., Valderrama, F. J., McHanwell, S., Parkin, I., Sañudo, J. R., 2009. Anatomical variations of the superior thyroid and superior laryngeal arteries. Head & Neck 31, 1078–1085.
[19] Poisel, S., Golth, D., 1974. Variability of large arteries in the carotid trigone. Wiener medizinische Wochenschrift 124, 229–232.
[20] Joshi, A., Gupta, S., Vaniya, V. H., 2014. Anatomical variation in the origin of superior thyroid artery and it's relation with external laryngeal nerve. National Journal of Medical Research 4, 138–41.
[21] Rajapriya, V., Ramya, T. P., Anjana, T. S. R., 2017. An anatomical study on the origin and length of the superior thyroid artery in adult human cadavers with its clinical significance. International Journal of Anatomy and Research 5, 3421–3425.
[22] Budhiraja, V., Rastogi, R., 2010. Variant origin of thyrolingual trunk from left common carotid arterythe. International Journal of Anatomical Variations 3, 44–45.
[23] Kapre, M., Mangalgiri, A. S., Mahore, D., 2013. Study of thyro-lingual trunk and its clinical relevance. Indian Journal of Otolaryngology and Head and Neck Surgery 65, 102–104.
[24] Shintani, S., Terakado, N., Alcalde, R. E., Tomizawa, K., Nakayama, S., Ueyama, Y., Ichikawa, H., Sugimoto, T., Matsumura, T., 1999. An anatomical study of the arteries for intraarterial chemotherapy of head and neck cancer. International Journal of Clinical Oncology 4, 327–330.
[25] Moore, K. L., Persaud, T. V. N., Torchia, M. G., 2016. The developing human: clinically oriented embryology, 10th ed. Elsevier, Philadelphia.