MORPHOLOGICAL AND MORPHOMETRIC OF THE THYROID FORAMEN OF THE LARYNX AND ITS CLINICAL-SURGICAL IMPLICATIONS

MORFOLOGIA E MORFOMETRIA DO FORAME TIREOIDIANO DA LARINGE E SUAS IMPLICAÇÕES CLÍNICO-CIRÚRGICAS

Ismael Felipe Gonçalves Galvão[1], Silvio José de Vasconcelos[2]; Felipe Diego Santos Fonseca[3], Fernando Augusto Pacífico[4]

[1]Medical student at the Faculdade de Medicina de Olinda; [2]Professor of Otorhinolaryngology at the Federal University of Pernambuco; [3]General Practitioner at the emergency care unit of São Lourenço da Mata and Cabo de Santo Agostinho, Pernambuco; [4]Professor at the Faculdade de Medicina de Olinda

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ABSTRACT

Introduction: The thyroid foramen is an opening in the posterior portion of the cartilage. Knowledge about the vascular and nervous structures and possible anatomical variations (e.g., the thyroid foramen) of the neck region is important for the success of surgeries. From this perspective, the present study aimed to investigate the incidence, morphometry, and morphology of the thyroid foramen of the thyroid cartilage in cadaveric human larynges, and discuss its clinical-surgical implications. **Methods:** A total of 100 human larynges were selected from the collection of cadaveric parts of the Department of Anatomy at the Federal University of Pernambuco, which allowed the visualization of the cartilaginous skeleton of the larynx, especially the thyroid cartilage. **Results:** Of the 100 selected larynges, 2 presented the thyroid foramen, indicating an incidence of 2%. Conclusion: The thyroid foramen had an incidence of 2%, a circular format, and measured 7.00 mm in the laryngeal cartilage with unilateral presentation and 0.45 mm (left) and 0.50 mm (right) in the bilateral presentation. The present study provided important morphological and morphometric data on this anatomical variation, which should be addressed during surgeries in the neck region.

Keywords: Morphology, morphometry, thyroid foramen.

RESUMO

Introdução: O forame tireoidiano é uma variação anatômica caracterizada por uma abertura na porção póstero-superior da lâmina da cartilagem tireoide da laringe. Ter conhecimento anatômico sobre as estruturas vasculares e nervosas da região do pescoço e saber da existência de variações anatômicas, tais como o forame tireoidiano, são de vital importância para o sucesso cirúrgico. Nessa perspectiva, o presente estudo teve como objetivo investigar a incidência, a morfometria e a morfologia do forame tireoidiano da cartilagem tireoide em laringes humanas cadavéricas e discutir as relações cirúrgicas e clínicas decorrentes dessa variação anatômica. **Método:** Foram selecionadas 100 laringes humanas do acervo de peças cadavéricas do Departamento de Anatomia da Universidade Federal de Pernambuco que permitissem a visualização do esqueleto cartilaginoso da laringe, em especial, da cartilagem tireoide da laringe. Resultados: Das 100 laringes, 2 apresentaram o forame tireoidiano, configurando uma incidência de 2%. **Conclusão:** O estudo embasou a importância do conhecimento anatômico sobre o forame tireoidiano. Observou-se uma incidência de 2% desse forame. Ele era circular, medindo 7 mm na cartilagem laríngea com apresentação unilateral e 0,45 mm e 0,5 mm no lado esquerdo e direito, respectivamente, na apresentação bilateral. Ademais, este estudo apontou importantes dados morfológicos e morfométricos dessa variação anatômica, que não deve ser negligenciada no momento de procedimentos na região do pescoço.

Palavras chaves: Forame tireoidiano, Morfometria, Morfologia.

RESUMO

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Palavras chaves: Forame tireoidiano, Morfometria, Morfologia.

INTRODUCTION

The thyroid foramen is an anatomical variation characterized by an opening in the posterior-superior portion of the thyroid cartilage lamina. This foramen is commonly circular and may contain nerves, vessels, neurovascular bundles, and connective tissue. Among these structures, the most important are the internal branch of the superior laryngeal nerve (SLN) and the superior laryngeal arteries and veins[1,2].

The SLN is a branch of the vagus nerve (X cranial nerve) that emerges from the jugular foramen at the base of the skull and descends near the horn of the hyoid bone, dividing into the internal (or superior) and the external (or inferior) branches; the former enters the larynx after piercing the thyroid membrane and is related to the sensory innervation of the supraglottic portion. This topography can anastomose with the branches of the recurrent laryngeal nerve to form Galen's anastomosis. The external or inferior branch runs over the inferior constrictor muscle of the pharynx or pierces it with a craniocaudal and oblique trajectory until it innervates the cricothyroid muscle. This branch has a motor function and maintains the tension of the vocal folds. Anastomoses with the recurrent laryngeal nerve also exert a motor function in the thyroarytenoid and interarytenoid muscles[3].

The superior laryngeal artery is the main vessel distributed in the larynx, originating from the superior thyroid artery in most cases. This artery follows the internal branch of the SLN to irrigate the larynx. Knowing the morphology of this vessel, as well as its anatomical relationships and variations in its course, is important in surgeries, such as laryngectomy and partial laryngeal reconstructions[4,5].

The anatomical knowledge of the vascular and nervous structures in the neck region and its anatomical variations, including the thyroid foramen, is important for the success of surgeries. In addition, physicians and specialists (e.g., otolaryngologists, neurosurgeons, and head and neck surgeons) need to be aware of the existence and importance of this foramen[1,2].

Thus, the present study aimed to investigate the incidence, morphometry, and morphology of the thyroid foramen on the thyroid cartilage in human cadaveric larynges and discuss its surgical-clinical implications.

METHOD

This study was conducted at the Department of Anatomy of the Federal University of Pernambuco. A total of 100 human larynges were selected from the collection of cadaveric parts.

Dissected human larynges were analyzed to allow the visualization of their cartilaginous skeleton, particularly the thyroid cartilage. In some

cadaveric parts, the blocks of viscera from the cervical region (larynx-pharynx-trachea-esophagus) needed to be dissected: the sternohyoid, omohyoid, sternothyroid, and thyroid muscles were separated and removed from the larynx. After this procedure, the specimens were ready to be included in the study.

The blocks of viscera of the cervical region were not included; they were only superficially dissected without the possibility of further dissection. Therefore, the laryngeal skeleton or dissected larynges in axial, coronal, and sagittal planes (hemilarynx) were not visualized. Dissections in the sagittal plane were maintained if they occurred in the posterior region. The cadaveric parts were fixed in 10% formalin.

The study was divided into three stages: (1) screening and selection of human laryngeal specimens; (2) investigation of the presence of the thyroid foramen in the selected larynges; and (3) morphological description of the thyroid foramen. After the screening, 100 larynges were included in the study.

RESULTS

Of the 100 selected larynges, 2 presented the thyroid foramen (Figures 1 and 2), corresponding to an incidence of 2%. Regarding its location and laterality, one larynx presented the thyroid foramen in the posterior-superior portion of the thyroid cartilage lamina unilaterally (right side), and the other presented the thyroid foramen on the same portion but on both sides symmetrically. The thyroid foramen interrupted the oblique line in both cases and was located near the superior tubercle of the thyroid cartilage of the larynx.

The thyroid foramen was circular in both larynges, and measured 7.00 mm in the unilateral presentation and 0.45 mm (left) and 0.50 mm (right) in the bilateral presentation. The content passing through or occupying the thyroid foramen could not be determined because the larynges were already dissected.

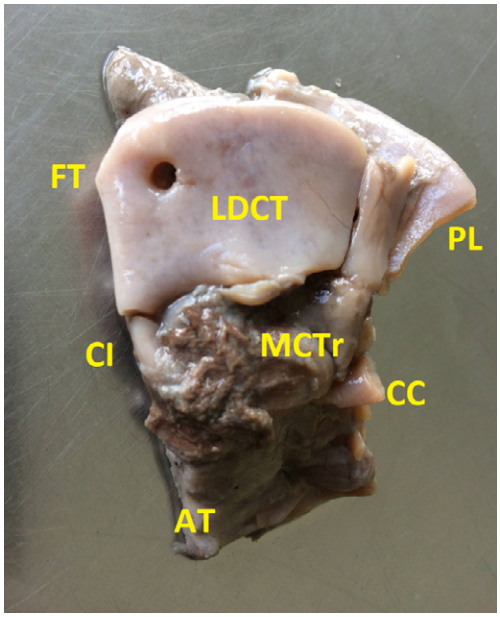

Figure 1. Unilateral thyroid foramen. LP: laryngeal prominence. RLTC: right lamina of the thyroid cartilage. TF: thyroid foramen. CTM: cricotracheal membrane, CC: cricoid cartilage. TR: tracheal rings. IH: inferior horn.

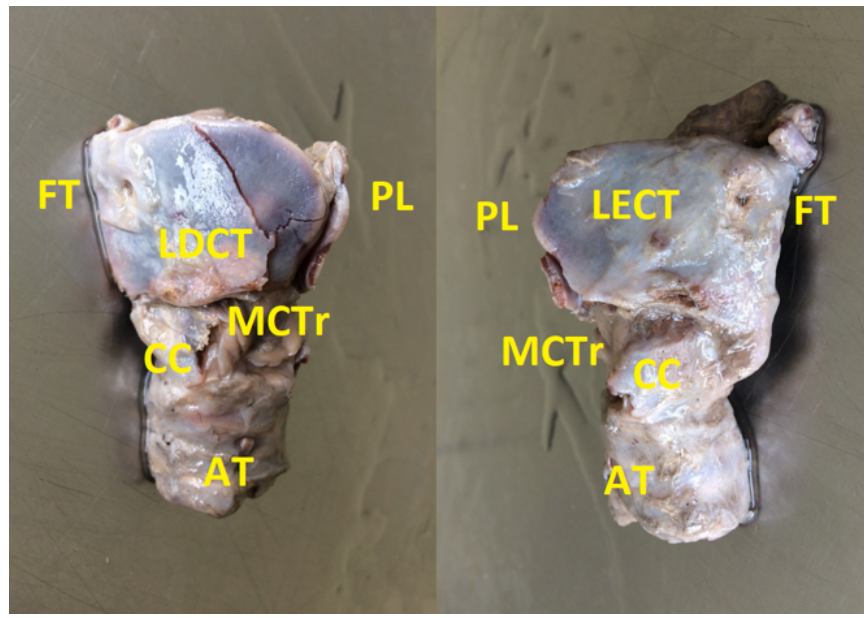

Figure 2. Bilateral thyroid foramen. A: Right lateral view. B: Left lateral view. LP: laryngeal prominence. RLTC: right lamina of the thyroid cartilage. LLTC: left lamina of the thyroid cartilage. CTM: cricotracheal membrane. CC: cricoid cartilage. TR: tracheal rings. TF: thyroid foramen.

DISCUSSION

The thyroid foramen, characterized by an opening in the postero-superior region of the thyroid cartilage lamina, was first described by Segond in 1847. Its incidence is controversial since it varies according to ethnic study. Yalçın et al. (2018) reported clinical and anatomical relevance of the thyroid foramen; the authors found an occurrence of 2% to 57% in adults. They also observed a relative prevalence of the unilateral presentation of the thyroid foramen compared with the bilateral presentation[2], which was not observed in the present study.

The development of the thyroid cartilage lamina begins around the first trimester of gestation and is characterized by the presence of quadrilateral plates and a foramen; the latter closes during the later stages of fetal development in most cases. The literature proposed two theories to explain the embryological origin of this anatomical variation: the first suggests that a disruption in the union of cartilaginous tissue between the fourth and sixth pharyngeal arches may leave this foramen open. The second proposes that the presence of neurovascular content interferes with the proper chondrification of the thyroid lamina, causing the variation[1,2,6].

The thyroid foramen can be circular, oval, crescent-shaped, or, rarely, irregularly shaped. The dimensions vary according to the study, with diameters ranging from 0.50 to 9.00 mm in men and from 0.45 to 6.50 mm in women7. In the present study, the gender could not be analyzed because the larynges were already dissected, limiting its determination. The area occupied by the foramen is proportional to the caliber of the elements that pass through it and varies from 3.2 mm^2 (when nerves pass through the foramen) to 13.8 mm2 (when neurovascular arrangements pass through the foramen)[1].

The thyroid foramen may be filled with neural, vascular, neurovascular, or connective tissue, and these contents must be known to better understand the possible clinical-surgical implications[1].

In the vascular group, the possible structures are (1) isolated superior laryngeal artery; (2) superior laryngeal artery and vein; and (3) anastomosis between a branch of the superior laryngeal artery and cricothyroid vessels. In the neural group, the possibilities are (1) external branch of the SLN; (2) external branch along with an internal branch of the SLN, externally or internally to the larynx; and (3) double neural anastomosis between the external and internal branches of the SLN (proximal loop) and external branch of the SLN and inferior laryngeal nerve (distal loop). In the neurovascular group, the possible structures are (1) superior laryngeal artery and anastomosis between the internal and external branches of the superior laryngeal nerve; and (2) similar to type 1 but nonspecific vessels passing by the foramen. Last, the thyroid foramen may be only filled with connective tissue[1,6,8].

The superior laryngeal artery irrigates the larynx and anastomoses with the inferior laryngeal artery, being one of the crucial vessels in laryngeal irrigation. In most cases, the superior laryngeal artery arises from the superior thyroid artery. These vessels are usually identified by piercing the thyroid membrane; however, they can pass anomalously by the thyroid foramen. Rusu et al., in their morphological study of 50 adult human larynges, identified that the superior laryngeal artery originated from the superior thyroid artery in 68% of cases, while the remaining 32% arose directly from the external carotid artery[4,9].

Devadas et al. reported the importance of anatomical knowledge regarding variations related to the superior laryngeal artery in partial laryngectomy, laryngeal reconstruction surgeries, and transplants. This knowledge can also assist in radical dissections in the neck region, reducing postoperative complications[9].

The external branch of the SLN is responsible for the motor innervation of the cricothyroid muscle and is closely related to the superior thyroid artery. This branch is located at a varied distance from the superior pole of the thyroid gland: 60% pass more than 1 cm above the superior pole, 17% pass less than 1 cm above this pole, and 20% pass below the described plane; the latter presents the highest inherent risk of iatrogenic injury10. The recommended steps to maximize the identification and preservation of the SLN are the sectioning of the sternothyroid muscle, with careful dissection of the cricothyroid space and caudal retraction of the

superior pole of the gland to expose the superior thyroid vessels. Then, controlled retraction of the vascular pedicle to expose the SLN (external branch), which will be found on the surface of the cricothyroid muscle. If identification is not possible, the vessels of the superior pedicle should be individually ligated to prevent injury[11]. The literature described the iatrogenic injury to the SLN after thyroidectomy, with incidence ranging from 0% to 58%[12].

Dekhou et al. reported clinical repercussions of injury to the SLN, such as loss of the ability to elevate vocal frequency due to loss of motor innervation of the cricothyroid muscle and increased risk of aspiration due to loss of the laryngeal cough reflex. The risk of nerve damage in surgeries derives, among other reasons, from its proximity to arteries, such as the superior thyroid artery[13].

CONCLUSION

The anatomical knowledge about the thyroid foramen is important since the structures that may be contained within it should be preserved in different surgeries. The thyroid foramen was circular in both larynges, and measured 7.00 mm in the unilateral presentation and 0.45 mm (left) and 0.50 mm (right) in the bilateral presentation.. The data are similar to those of previous studies but differ depending on the location of the study. This study also provided important morphological and morphometric data on this anatomical variation, which should be addressed in surgeries involving the laryngeal cartilage and structures directly related to it.

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