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Oblique Thyroarytenoid Muscle in Humans: An Independent Muscle or an Accessory Belly?

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Objectives/Hypothesis: This study aimed to determine the prevalence and morphological variations of the oblique thyroarytenoid (TA) muscle in humans.

Study Design: Cadaveric anatomic dissections.

Methods: One hundred hemilarynges from 50 formalin-embalmed cadavers were dissected to investigate the morphology of muscle fibers of the TA muscle.

Results: Thirty-six (36%) hemilarynges were found to have a distinct oblique belly superficial to the TA muscle. In 28 cases, the belly had a relatively constant origin and an insertion that extended straight onto the TA muscle from the anterosuperior area of the internal surface of the thyroid lamina to the base of the muscular process of the arytenoid cartilage. Eight cases were located in a similar area but with some differences in the origin or insertion features.

Conclusions: We proposed that the oblique TA muscle has a high prevalence and probably acts to close and relax the vocal cords. It remains to be determined whether the oblique TA muscle is an independent muscle or an accessory belly of the main TA muscle.

Key Words: Anatomy, intrinsic laryngeal muscles, morphologic variations, oblique thyroarytenoid muscle.

Level of Evidence: NA.

INTRODUCTION

The human larynx functions in respiration, phonation, and protecting the lower airway.1,2 The thyroarytenoid (TA) muscle is one of the intrinsic laryngeal muscles that is known to play an important role in controlling the equality and intensity of phonation.3–5 The TA muscle draws the arytenoid cartilage toward the thyroid cartilage, thereby rotating the arytenoid cartilage medially and relaxing the vocal ligaments.6,7 The typical morphology of the TA muscle is commonly considered to comprise unidirectional muscle fibers from the lower half of the anterior part of the thyroid cartilage to the arytenoid cartilage. Occasionally an anomalous muscle belly lying on the lateral surface of the main mass of the TA muscle extends obliquely from the connective tissues under the angle of the thyroid cartilage to the muscular process of the arytenoid cartilage. This is designated in Gray’s Anatomy as the superior thyroarytenoid muscle,8 but the prevalence of this muscle and its topography relative to the other intrinsic laryngeal muscles remain unclear.

The present study focused on cases with anomalous muscle bellies superficial to the TA muscle that originate from the anterosuperior part of the internal surface of the thyroid cartilage and insert in the vicinity of the arytenoid cartilage. The prevalence of these cases and their morphological variations were investigated.

MATERIALS AND METHODS

Fifty larynges from formalin-embalmed cadavers were collected after applying exclusion criteria of esophageal and thyroidal malignancies, and 100 hemilarynges were investigated in this study. The donors comprised 29 males and 21 females who were aged 70.8 ± 15.7 years (mean ± standard deviation) at death. Before they died, the donors signed documents agreeing to their participation in the body donation program of the medical school and the use of their body for clinical studies.

The thyroid cartilage was removed using a rongeur. The underlying perichondrium and the connective tissues were then dissected carefully to expose the muscle fibers of the TA muscle. The fasciae of adjacent laryngeal muscles were also removed so that the origin and insertion point of the muscle fibers of the TA muscle could be determined accurately. Many of the cases exhibited interwoven and a few dispersed muscle fibers originating from muscle fibers of the TA muscle proper, which were not included as anomalous muscle bellies superficial to the TA muscle. Sex- and side-related differences in each variable were analyzed statistically using the independent-samples t test. The threshold for statistical significance was set at P < .05.

RESULTS

The TA muscle is usually attached anteriorly to the lower half of the angle of the thyroid cartilage.9 Its fibers pass backward laterally and upward to the
anterolateral surface of the arytenoid cartilage (Fig. 1A). An anomalous muscle belly superficial to the TA muscle was found in an 83-year-old female cadaver during parasagittal dissection of the thyroid cartilage (Fig. 1B). This muscle belly extended obliquely from the anterosuperior area of the internal surface of the thyroid lamina to the muscular process of the arytenoid cartilage.

An oblique anomalous muscle belly was also found in the opposite hemilarynx in the same specimen. Two separated muscle bellies originated from the same area on the contralateral side and were interwoven on the middle of the TA muscle. In contrast to the contralateral side, the two oblique muscle bellies inserted respectively to the region of the lateral cricoarytenoid (LCA) muscle and the muscular process of the arytenoid cartilage.

An additional 49 larynges were dissected to investigate the prevalence of these oblique muscle bellies superficial to the TA muscle. Thirty-six percent of the 100 investigated hemilarynges were found to have a distinct oblique belly on the TA muscle, with eight of these larynges having unilateral oblique bellies. The morphology and distribution of the oblique bellies superficial to the TA muscle varied significantly among the specimens (Fig. 2). The origin and insertion point of the muscle were relatively constant in 28 cases, whereas it extended straight onto the TA muscle from the anterosuperior area of the internal surface of the thyroid lamina to the muscular process of the arytenoid cartilage in 18 cases (Fig. 2A). Other cases exhibited a different origin shape (branched or triangular) but similar insertion features (Fig. 2B,C). There were eight cases with oblique bellies that inserted to the superficial fascia of the LCA muscle or inserted to the medial side of the LCA muscle, rather than constituting muscular processes of the arytenoid cartilage (Fig. 3). There was no sex- or side-related difference in the prevalence of the oblique belly.

**DISCUSSION**

Different parts of the TA muscle are functionally specialized in humans. The medial portion of the TA muscle that is close to the vocal ligaments (which is the medial vocalis compartment) has been thought to be involved in the vibrations of the vocal cords that occur when the tissue is driven into oscillation for the abrupt onset of phonation. The lateral muscularis compartment contains a high proportion of fast-contracting muscle fibers that may be specialized for the rapid vocal cord adduction necessary to protect the airway, responding to the stimulation of the laryngeal mucosa.

Anomalous muscle bellies superficial to the lateral muscularis compartment of the TA muscle were present in 36% of the cases in this study. They generally extended obliquely from the anterosuperior area of the internal surface of the thyroid lamina to the muscular process of the arytenoid cartilage. This muscle was previously described as being a superior TA muscle based on it originating from the superior part of the thyroid lamina. However, it is much more reasonable to designate it as an oblique TA muscle based on consideration of the entire morphology of the oblique muscle belly superficial to the TA muscle and the direction of the muscle fibers from the anterosuperior thyroid lamina to the posteroinferior arytenoid cartilage.

Among the intrinsic laryngeal muscles, it is generally understood that the contraction of TA muscle alone completely closes the anterior glottis, whereas complete glottal closure, including the posterior gap, requires...
activation of the LCA muscle.\textsuperscript{5} The oblique TA muscle joined other intrinsic laryngeal muscles in 8% of the present cases, inserting to the fascia covering the lateral surface of the LCA muscle or the medial side of the LCA muscle (Fig. 3). These descriptions support a hypothesis that cooperative activity of the oblique TA muscle with
contraction of the LCA muscle influences the adduction force of the arytenoid cartilage and glottis synkinesis. An additional method for controlling LCA muscle contraction and adduction of the arytenoid cartilage could result in multiple functions for the vibrations of the vocal cords.

Variations in the prevalence and morphology of the intrinsic laryngeal muscles both within and between normal subjects could influence the glottis vibration pattern and the posture of the vocal cords. It is suspected that the oblique TA muscle exerts ancillary forces that rotate the muscular process of the arytenoid cartilage obliquely (Fig. 4B). By adding a collateral force to the action of the TA muscle proper, the path of the vocal process of the arytenoid cartilage could also be influenced by movements of the muscular process. Multidirectional movements of the vocal process might generate an abrupt periodic phonation onset, which is especially important in singing. Furthermore, this additional muscle on the TA muscle could help a vocalist to change the pitch of sound generated by the vocal cords. Physiological studies are needed to interpret the function of these significant interindividual variations in relation to this additional muscle.

Knowledge of the prevalence and dimorphism of the oblique TA muscle is also expected to improve the understanding of idiopathic dysfunction of the TA muscle and when choosing appropriate treatments. Glottal closure in the elderly can be mostly incomplete due to atrophic changes of the TA muscle with aging, especially in men. Atrophy of the vocal cords in the elderly results from the scarcity of elastic fibers and hyaluronic acid, and combined with atrophy of the vocal cord muscles could affect phonation. A cross-innervation pattern to the TA muscle via the external branch of the superior laryngeal nerve and the classical recurrent laryngeal nerve further increases the challenge of understanding and treating dysfunction of the TA muscle. Knowledge about the innervation pattern of the oblique TA muscle is also needed to address dysfunction of the TA muscle. Future studies should investigate how the physiological operation of the oblique TA muscle affects the action of the main TA muscle, the posture of the vocal cords, and movements of the arytenoid cartilage.

**CONCLUSION**

Thirty-six percent of the TA muscles in this study had an oblique TA muscle superficial to the anterosuperior perichondrium of the internal surface of the thyroid lamina to the muscular process of the arytenoid cartilage, and showed diverse and asymmetrical muscle fiber patterns. Knowledge of the high prevalence and the morphological variations of the oblique TA muscle could contribute to furthering the understanding of the biomechanics of human laryngeal muscles. However, controversy remains regarding whether the oblique TA muscle is an independent muscle or an accessory belly of the main TA muscle.

**BIBLIOGRAPHY**