Original Article

Anatomy Section

A Case for Bleeding: Structures at the Risk of Injury during Invasive Procedures of the Cricothyroid Membrane

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ABSTRACT

Background: Transcutaneous puncture of the cricothyroid membrane is a component of several important invasive clinical procedures, including surgical cricothyroidotomy. One of its most feared complications is endolaryngeal haemorrhage that has been fatal at times.

Aim: Our aim was to determine the structures at the risk of injury during procedures which involved puncture of the cricothyroid membrane.

Materials and Methods: Anterior neck dissection was done on sixty three cadavers in a tertiary care, university teaching hospital. Results: Several structures were noted to be anterior to the membrane, such as the paired and the median anterior jugular veins, the transverse cricothyroid artery, the median descending artery, the sternohyoid muscle, the pyramidal lobe of the thyroid gland, the thyroidea ima artery and the jugular venous arch. The transverse cricothyroid artery was seen anterior to the upper 1/4th of the membrane in 98% of the cadavers. In most of the cadavers, the right and left transverse cricothyroid arteries joined to form a median descending artery. Both the transverse cricothyroid artery and the median descending artery gave multiple branches that perforated the cricothyroid membrane.

Conclusion: All invasive procedures require a firm grounding in anatomy. Regarding surgical cricothyroidotomy, the authors recommend an initial vertical incision of the skin and the investing layer of the deep cervical fascia, followed by a horizontal incision of the cricothyroid membrane, just above the arch of the cricoids, to avoid the transverse cricothyroid artery. For needle procedures, the authors suggest an anterior midline approach, immediately above the arch of the cricoid.

Key Words: Anatomy, Cricothyroidotomy

KEY MESSAGE

- Acute endolaryngeal haemorrhage is a dreaded complication, following cricothyroidotomy. There is a crucial role for a sound understanding of its underlying anatomy to ensure a safe performance. This study shows the structures which are at a risk of injury during a cricothyroidotomy.

INTRODUCTION

Puncture of the cricothyroid membrane or the median cricothyroid ligament (situated between the cricoid and the thyroid cartilage) is a component of several invasive clinical procedures such as surgical cricothyroidotomy for emergency airway access into the subglottic larynx, minitracheotomy for the clearance of excess tracheobronchial secretions, botox injections into the vocal cord for patients with adductor spasmodic dysphonia, scintigraphic measurement of the tracheal mucus velocity in patients with muco-ciliary dyskinaesia and retrograde intubation of the larynx. One of its most dreaded complications is acute endolaryngeal haemorrhage, which has been reported to be fatal by several clinicians [1-5]. The aim of the present study was to determine the vascular and other soft tissue structures which lie anterior to the cricothyroid membrane and could be at a risk of injury during the puncture of the membrane. An awareness of such anatomical considerations would result in safer surgical procedures.

MATERIALS AND METHODS

Anatomic dissection was done on sixty three cadavers at Madras Medical College and Research Institute in Chennai, India, which is a tertiary care, university teaching hospital. The skin of the infra-hyoid region of the neck was incised and reflected; the superficial fascia was examined for vascular structures and platysma. The investing layer of the deep cervical fascia was reflected and the infra hyoid group of the strap muscles were retracted. The pre-tracheal fascia was incised, and the vascular and the soft-tissue structures in front of the cricothyroid membrane were identified. All the vascular and soft tissue structures which were anterior to the cricothyroid membrane were noted. Their frequency and their percentage of occurrence were determined.

RESULTS

Various blood vessels and soft tissue structures were encountered anterior to the cricothyroid membrane; their frequency and percentage of occurrence is shown in [Table/Fig-1].

The anterior jugular vein was seen to course vertically downwards in the superficial fascia, in the region which was anterior to the cricothyroid membrane in 21 cases (33%). It was present as one of the following types: a) as a single median jugular vein in 6 cases (10%) [Table/Fig-2a]; b) as an unpaired unilateral vein in 4 cases (6%); c) as paired anterior jugular veins in 12 cases (19%) [Table/Fig-2b and d] as triple jugular veins (a median jugular vein in addition to the paired jugular veins in 13 cases (21%). Surprisingly, the anterior jugular venous system was completely absent in 28 cases (44%).

Structures at risk	Frequency of occurrence (n= 63)	Percentage %
Anterior jugular vein	21	33
Sternohyoid muscle	45	71
Transverse cricothyroid artery	62	98
Thyroidea ima artery	1	1.6
Levator glandulae thyroidea	13	21
Pyramidal lobe of thyroid	10	16
Jugular venous arch	1	1.6

[Table/Fig-1]: Frequency of occurrence of structures anterior to the cricothyroid membrane (n = 63

The jugular venous arch connects the two anterior jugular veins and it is normally situated in the suprasternal space of Burns. In the present study, the jugular venous arch was seen as a rare occurrence opposite the cricothyroid space in one case (1.6%).

The paired sternohyoid muscles lay close to each other on either side of the midline. The medial borders of the muscles touched each other in the midline in 31 cases (49%).

The transverse cricothyroid artery was seen in 62 cases (98%). In all the cases, it was seen to run anterior to the upper 1/4th of the cricothyroid membrane, close to lower border of the thyroid cartilage [Table/Fig-3a and b]. In 94% of the cases, it arose as a branch from the main pedicle of the superior thyroid artery, but in 6% of the cases, it arose as a branch from the superior laryngeal artery.

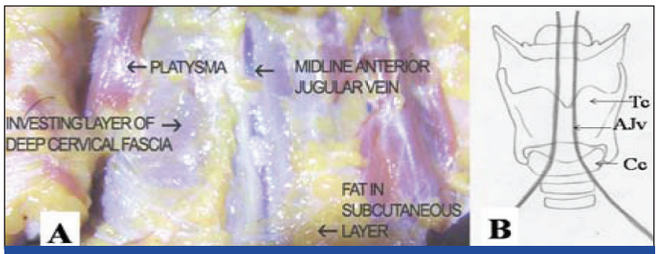
In 92% of the cases, the right and the left transverse cricothyroid arteries joined in the midline to form a median descending artery, which ran downwards to a variable extent, and ended by supplying the isthmus of the thyroid gland, the pyramidal lobe of the thyroid gland, the levator glandulae thyroidea and the strap muscles. The median descending artery anastomosed with the anterior descending branches of the superior thyroid artery, along the upper border of the isthmus of the thyroid in 13 cases (21%). Only in one case (1.6%), the median artery ascended beneath the lower border of the thyroid cartilage.

The transverse cricothyroid arteries and the median descending artery gave branches that perforated the cricothyroid membrane in 46 cases (73%). Multiple small perforations were seen in few cases, and single large perforations were seen in most of the cases [Table/Fig-4b]. These perforating vessels were thought to anastomose with the endolaryngeal arteries.

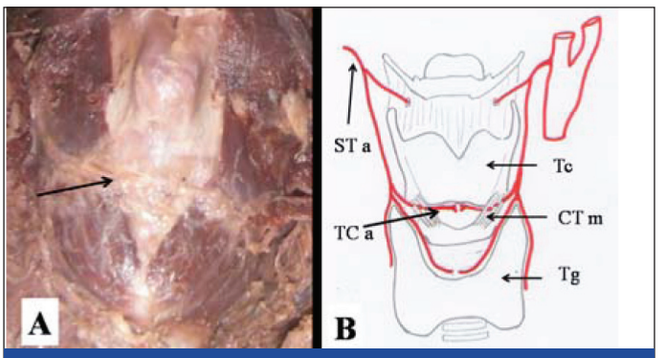
In one case (1.6%), the thyroidea ima artery which arose from the arch of the aorta, crossed the cricothyroid membrane to reach up to the level of the hyoid bone.

The levator glandulae thyroideae was seen in 13 cases (21%), to lie anterior to the cricothyroid membrane.

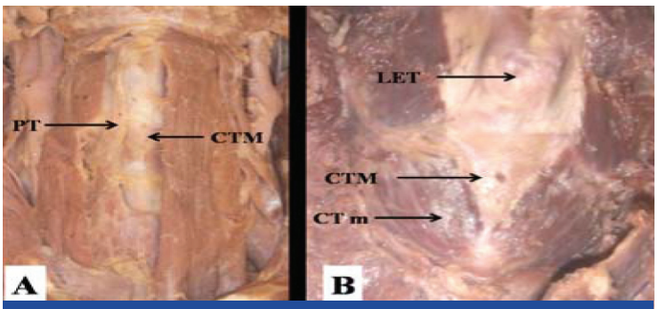
The pyramidal lobe of the thyroid gland was seen in 10 cases (16%), to lie anterior to the cricothyroid membrane [Table/Fig 4a].



[Table/Fig-2]: (A) Single midline jugular vein coursing across the cricothyroid space. (B) Paired anterior jugular veins (Tc-Thyroid cartilage, Cc-Cricoid cartilage, AJv-Anterior Jugular vein).



[Table/Fig-3]: (A) The transverse cricothyroid artery seen anterior to the cricothyroid membrane (B) Sketch showing the transverse cricothyroid artery as a branch from the superior thyroid artery, running close to the lower border of the thyroid cartilage (TCa-Transverse cricothyroid artery, STa-Superior Thyroid artery, Tc- Thyroid cartilage, Tg-Thyroid gland, CTm-Cricothyroid muscle).



[Table/Fig-4]: (A) Pyramidal lobe of thyroid extending across the cricothyroid interval. (B) Foramina in the membrane (PT-Pyramidal lobe of thyroid, CTM-Cricothyroid membrane, LET-Laryngeal eminence of thyroid cartilage, CTm-Cricothyroid muscle).

The tributaries of the superior thyroid vein crossed the cricothyroid membrane only in two cases (3.1 %).

DISCUSSION

There is a crucial role for a sound understanding of the underlying anatomy of any clinical procedure [6]. Several vascular and soft tissue structures lie anterior to the cricothyroid membrane and are at a risk of injury during these invasive clinical procedures. These structures can often complicate the performance of a cricothyroidotomy.

(1) The anterior jugular vein: Single or paired anterior jugular veins were found to course across the region of the membrane in 21 cases (33%). Brofeldt et al. (1982) reported bleeding from the anterior jugular veins in one patient during a cricothyroidotomy [7]. Dover et al. (1996) found the paired anterior jugular veins to cross the membrane in a vertical direction in a majority of his specimens and suggested a midline approach to avoid this structure [8].

(2) The transverse cricothyroid artery: The transverse cricothyroid artery was seen close to the lower border of the thyroid cartilage in 98% of the cadavers. Dover et al. (1996), in their landmark article, reported that the cricothyroid artery coursed across the upper one-third of the membrane in 13 out of 15 specimens (93%) [8]. Bennett et al (1996) reported that an artery ran transversely across the cricothyroid membrane in only 8 out of 15 subjects (62%) [9]. In the present study, the transverse cricothyroid artery was found to arise as a branch from the main pedicle of the thyroid artery in 94% of the cadavers, and in only 6% of the cadavers, it arose as a branch from the superior laryngeal artery. Dover et al. (1996) found the cricothyroid artery to arise from the superior thyroid artery in 93% of the cases [8]. However, Lippert et al [10] and Bergmann

et al [11] reported that the cricothyroid artery usually arose from the superior laryngeal branch of the superior thyroid artery.

(3) The median descending artery: The transverse cricothyroid artery and the median descending artery gave smaller branches that perforated the upper part of the cricothyroid membrane in 46 cases (73%). These perforators anastomosed with the endolaryngeal vessels and were implicated in the extra-laryngeal spread of laryngeal cancers. Ortug et al. (2005) studied the vascular anatomy of the cricothyroid space in 50 Turkish cadavers and found the vessels to pass through the foramens in the membrane in 20 cases (40%) [12].

(4) The superior and the inferior thyroid veins: Only in two cases (3%), the tributaries of the superior thyroid vein crossed anterior to the membrane. However, Krausen [13] and Dover et al. [8] found numerous tributaries of the superior and inferior thyroid veins to cross the cricothyroid membrane. This may be a racial variation.

(5) The paired sternohyoid muscles: The paired sternohyoid muscles were close to the midline, anterior to the cricothyroid membrane in 45 cases (71%). The muscles being vascular structures, are capable of haemorrhage. The sternohyoid is at a risk of being incised, especially during surgical cricothyroidotomy, when a horizontal stab incision is made above the cricoid cartilage.

(6) The pyramidal lobe of the thyroid gland: The pyramidal lobe was anterior to the cricothyroid membrane in 16% of the cadavers. Boon et al. (2004) stated that the pyramidal lobe may extend as high as the hyoid bone in 40% of the people and that it may be at a risk of injury during a cricothyroidotomy [14].

The frequency of occurrence of the structures such as the median descending cricothyroid artery, the thyroidea ima artery, the jugular venous arch and the levator glandulae thyroidea have not been discussed for want of comparative data in the literature. All the vascular and soft tissue structures which were encountered anterior to the cricothyroid membrane must be known to the clinicians, who should anticipate them when they do invasive procedures. The occurrence of uncommon structures is more dangerous.

CONCLUSION

Postgraduate students and residents are called to perform a variety of invasive procedures during their training. All the clinical procedures, however simple they may seem, require a firm grounding in anatomy. Invasive procedures that fail to achieve their objectives, or that result in complications, are often linked to a lack of understanding or misunderstanding of the anatomy [15]. Various structures which are mentioned above can complicate the performance of a cricothyroidotomy. Regarding surgical cricothyroidotomy, the authors suggest a vertical incision of the skin and investing the deep cervical fascia (to avoid the vertically oriented venous structures), followed by a horizontal incision of the cricothyroid membrane (close to the lower border of the membrane, just above the arch of the cricoid) to avoid the transverse cricothyroid artery. For needle cricothyroidotomy, the authors suggest an anterior midline approach which is immediately superior to the arch of the cricoid. The authors believe that the findings of this study would be useful in planning for any invasive procedure of the cricothyroid membrane.

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