Two Triangles as the Landmarks for the Upper Parapharyngeal Internal Carotid Artery: Surgical Anatomy and Relevance for Endoscopic Sublabial Anterior Transmaxillary Approach to Infratemporal Fossa and Parapharyngeal Space

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Abstract

BACKGROUND AND OBJECTIVES: The upper parapharyngeal internal carotid artery (upper-ppICA) is perhaps the most challenging segment of the artery to surgically localize and control. Understanding this anatomy is crucial for endoscopic access to the infratemporal fossa (ITF) and parapharyngeal spaces (PPS). This study evaluates two triangles (six key points) including an **ACCESS triangle** and **DANGER triangle** as the landmarks for the upper-ppICA localization during the endoscopic sublabial anterior transmaxillary approach (ESATMA).

METHODS: Five cadaveric specimens (10 sides) were dissected. The ITF and PPS were accessed through the ESATMA. The anatomical relationship of ITF and PPS with upper-ppICA was dissected. The 2 triangles were defined, described, and measured.

RESULTS: In order to identify the upper-ppICA, six specific points were designated within the ESATMA: A (lingual nerve cranial entry point), B (lingual nerve junction point with the base of the maxillary sinus), C (eustachian tube cartilage junction point with the base of the maxillary sinus), D (cranial entry point of the middle meningeal artery (MMA)), E (origin of the MMA from the internal maxillary artery (IMA)), and F (junction point of the posterior inferior margin of levator veli palatini and maxillary sinus base). The distances from the upper-ppICA to points A, B, C, D, E, and F were measured as 22.2 mm, 19.5 mm, 31.7 mm, 12.1 mm, 12.1 mm, and 10.5 mm respectively by ruler, and as 21.75 mm, 19.41 mm, 32.53 mm, 11.74 mm, 13.03 mm, and 10.57 mm respectively by neuronavigation.

. Furthermore, 2 triangles were defined: points ABC constituted the **ACCESS triangle**, and DEF constituted the **DANGER triangle**. These triangles reliably localized the upper-ppICA as a key step in anatomical exploration of the pterygopalatine fossa, ITF and PPS via the ESATMA.

CONCLUSION: The 2 triangles (6 key points) serve as novel anatomical landmarks for the upper-ppICA during the ESATMA in accessing the ITF and PPS. These landmarks can be utilized independently or in conjunction, offering valuable guidance for surgeons in the precise and secure treatment of tumors or lesions within these regions.

Keywords: parapharyngeal internal carotid artery, endoscopic surgery, infratemporal fossa, parapharyngeal space

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Introduction

The PPS and ITF represent critical and intricate regions of the lateral skull base. While the two spaces are delineated by distinct boundaries, there are overlapping regions where lesions frequently encroach [1]. The PPS and ITF contain complex neurovascular structures, with the internal carotid artery (ICA) as the most critical structure. During the endoscopic surgery of the ITF, the upper-ppICA is at risk of injury with potential for catastrophic bleeding and/or stroke.

Various surgical approaches, such as transoral, transnasal, transmaxillary, transpterygoid or combined approaches have been used to access these regions [2-5]. The advance of endoscopic surgical techniques and instruments brings the sublabial anterior transmaxillary approach back to the light as a single approach or in combination with the endonasal approach [6]. This method offers a large exposure area and sufficient access to the ITF and the upper-PPS, making it particularly advantageous for achieving a direct angle of attack for lesions located in the areas. This approach also provides access to the floor of the middle cranial fossa for pathology extending to this region[7]. ICA injury is a potentially fatal complication of endoscopic skull base surgery, especially ppICA during the ITF approach because of intricate anatomy, deep positioning, land proximity to surrounding structure. The ppICA is surrounded by muscles, nerves and soft tissue and does not possess a distinct bony anatomical landmark in contrast other segments of the skull base ICA [8]. Hence, the recognition of efficacious surgical anatomical landmarks is crucial in safeguarding the ppICA during surgical procedures.

This study describes the relevant surgical anatomy of the upper-ppICA during the ESATMA. Additionally, triangular landmarks are defined for localization of the upper-ppICA and their distances from the upper-ppICA.

Methods and Materials

Approval for this study was obtained from the institutional review board of the University of Pittsburgh Medical Center. Ten sides of ITF and upper PPS of 5 color-injected, lightly embalmed cadaveric head specimens were endoscopically dissected using a 0° rod lens endoscope (4-mm diameter, 18-cm length, Karl Storz, Tuttingen, Germany) with high-definition camera and high-speed drill (Stryker, Portage, Michigan). A ruler was used to measure the distances between two points, and image - guided neuronavigation (Stryker, Portage, Michigan) was employed as a tool to facilitate precise measurements for verification. .

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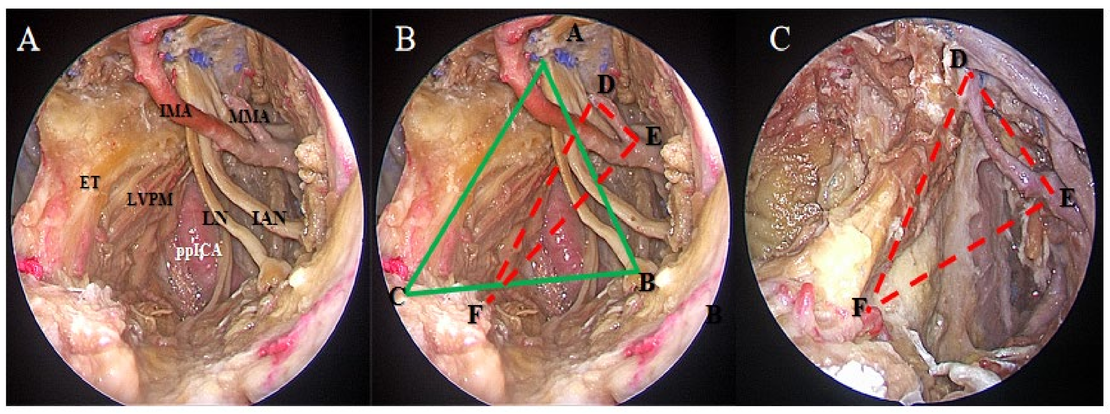

Figure 1. The 6 key points and the two triangles of the ITF and PPS through the endoscopic sublabial anterior transmaxillary approach. The surgical anatomy and important structures of ITF and PPS were depicted via the anterior transmaxillary corridor on the left sides. The 6 key points (A, B, C, D, E, and F points), the **ACCESS triangle** (green triangle) and the **DANGER triangle** (red, dash-line triangle) were depicted in B; After removal of the ET, further exposure of LVPM and the DANGER triangle was depicted in C. The ACCESS triangle (green triangle) was defined by the lines between A (cranial entry point of the LN), B (the junction between the LN and the base of maxillary sinus), and C (the junction between the cartilaginous ET and the base of maxillary sinus). This triangle was the first reached triangle to determine the upper-ppICA. The DANGER triangle (red, dash-line triangle) was defined by the lines between D (cranial entry point of the MMA), E (the MMA origin from the IMA), and F (the junction between posteroinferior margin of the LVPM and the base of maxillary sinus). This triangle was proximity to the upper-ppICA, further dissection should be carefully performed to avoid the upper-ppICA injury. ET, eustachian tube; IAN, inferior alveolar nerve; IMA, internal maxillary artery; ITF, infratemporal fossa; LN, lingual nerve; LVPM, levator veli palatini muscle; MMA, middle meningeal artery; ppICA, parapharyngeal internal carotid artery; PPS, parapharyngeal space.

Results

In the ESATMA, we defined 6 points, as shown in Figure 1, which were A (cranial entry point of lingual nerve), B (lingual nerve junction point with basal plane of maxillary sinus), C (eustachian duct cartilage junction point with basal plane of maxillary sinus), D (cranial entry point of the MMA), E (origin point of the MMA from the IMA), and F (junction point of the posterior inferior margin of levator veli palatini and basal plane of maxillary sinus). The mean distances from A, B, C, D, E, and F to the upper-ppICA were 22.2mm, 19.5mm, 31.7mm, 12.1mm, 12.1mm and 10.5mm by ruler and 21.75mm, 19.41mm, 29.35mm, 13.36mm, 13.03mm, and 10.75mm by neuronavigation software, respectively.

Additionally, based on the spatial arrangement of the 6 points relative to the upper-ppICA, two triangles were defined. The lines from A, B, and C points constituted the **ACCESS triangle**, while the lines from D, E, and F points comprised the **DANGER triangle**. Specifically, the lengths of AB, AC, BC, DE, DF, and EF were determined. The lengths of AB, AC, BC, DE, DF, and EF are 28.4mm, 29.0mm, 27.5mm, 12.4mm, 24.3mm, and 21.9mm, respectively (Figure 1).

Discussion

This study defines 6 key points, shown in Figure 1, which are a combination of vascular, neural, and muscular structures surrounding and superficial to the upper-ppICA. Based on the measured values, we propose the **ACCESS triangle**, and **DANGER triangle** for localizing the upper-ppICA during the ESATMA. The upper-ppICA can always be found within the **ACCESS** and **DANGER triangles**. The ACCESS triangle is the first triangle reached to identify the upper-ppICA during ITF and the PPS surgery. When the **DANGER triangle** is reached, the upper-ppICA is very close within this triangle. The upper-ppICA can be reliably identified in all specimens by using this method. Our anatomical and measurement results show that two triangles (combination of 6 points) can be used as effective landmarks of the upper-ppICA.

There are several limitations of this study. First, this study is anatomical study without additional clinical cases. Second, the number of dissected cadavers is small that may limit the anatomical variation of these regions.

Conclusions

The proposed two triangles (6 points) can serve as the new anatomical landmarks for the upper-ppICA determination during the endoscopic anterior transmaxillary approach to the ITF and PPS. These landmarks can be utilized independently or in conjunction as valuable guidance for surgeons in the precise and safe treatments of lesions within these regions.

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