The Endoscopic Sublabial Anterior Transmaxillary Approach: Middle Meningeal Artery as a Landmark to the Upper Parapharyngeal Internal Carotid Artery

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Abstract

Background: The Endoscopic Sublabial Anterior Transmaxillary Approach (ESATMA) is a novel application of an established surgical route to access the infratemporal fossa(ITF) and parapharyngeal space (PPS). This study aims to identify the middle meningeal artery (MMA) as a critical anatomical landmark for localization of the upper parapharyngeal internal carotid artery (upper-ppICA) as part of the ESATMA.

Methods: Cadaver dissection of 7 heads (14 sides) was performed via the ESATMA. The step-by-step procedure of the the ESATMA to access the ITF and PPS was outlined. Additionally, measurements were taken from CTA scans of 20 pituitary adenoma patients (40 sides) to evaluate the relationship between the MMA and upper-ppICA.

Results: In all 7 cadavers (14 sides), the upper-ppICA was found posteromedial to the MMA. The upper-ppICA was also located posterior to or posteromedial of the origin point of the MMA from the IMA (MMA-OP), with distances from the upper-ppICA measured at 12.05 (6-18)mm (ruler) and 13.2 (7.9-18.3) mm (neuronavigation confirmation) on the same axial level. The upper-ppICA was located posterior or posteromedial to the cranial entry point of the MMA (MMA-EP) or foramen spinosum (FS), with distances measured at 12 (9-15) mm (ruler) and 11.7(9.1-14.9) mm (neuronavigation confirmation) on the same axial level. The results obtained from the CTA measurements were consistent with those from the measurements on cadavers. Additionally, the length of the extracranial segment of the MMA (from MMA-OP to MMA-EP) was approximately 12.9 mm (cadaveric dissection) and 13.6 mm (neuronavigation confirmation), while the maximum length of exposure of the upper-ppICA achievable through the ESATMA was 26.3 mm (cadaveric dissection) and 26.9 mm (neuronavigation confirmation). These cadaveric dissections demonstrate an effective method for localizing the upper-ppICA. This involves locating the internal maxillary artery (IMA) between the temporalis and lateral pterygoid muscles (LPMs), tracing it back to the MMA-oP, and identifying the MMA-EP. Within 1cm posterior to this point, landmarks such as the attachment point of the cartilaginous eustachian tube (ET) and the LVPM (LVPM) to the skull base are sequentially identified. Finally, dissection of the stylopharyngeal fascia （SPF） and carotid sheath (CaSH) reveals the upper-ppICA.

Conclusion: The MMA serves as a novel anatomical landmark for localizing the upper-ppICA within the ESATMA to access the ITF and PPS, providing crucial guidance for surgeons managing tumors or lesions in these regions.

Keywords: Middle meningeal artery, Upper-ppICA, Endoscopic Endonasal Approach, Endoscopic Sublabial Anterior Transmaxillary Approach, Surgical landmark

Introduction

Traditional skull base surgical approaches for addressing lesions within the infratemporal fossa (ITF) and the parapharyngeal space (PPS) typically entail an intricate open lateral procedure [1]. These techniques are fraught with substantial surgical trauma, anatomical complexities, and the propensity for postoperative complications, hence posing formidable challenges even for seasoned skull base surgeons [2]. The rapid evolution of endoscopic techniques and their broadened applications in skull base surgery has led to the development of alternative approaches in order to manage lesions in these anatomical regions [3]. Augmenting the Endoscopic Endonasal Approach (EEA) with the Endoscopic Sublabial Anterior Transmaxillary Approach (ESATMA) provides a wide operative field with reduced surgical distances, thus enhancing surgical dexterity, and maneuverability [4]. However, preserving the integrity of the upper-ppICA within the PPS still remains a daunting challenge during such interventions.

Statistically, the incidence of ICA injury during endoscopic procedures ranges from 0.2% to 1.4%, making it one of the most serious complications that could be encountered [5]. When skull base tumors are in contact, intricately intertwined with, pressuring, or encasing the internal carotid artery, safeguarding the latter becomes significantly more difficult [6]. Intraoperative compromise of the internal carotid artery can precipitate severe ischemic complications or even death [6]. The identification of relevant anatomical landmarks that ensure the protection of the ICA and neighboring critical neurovascular structures is paramount when attempting infratemporal and parapharyngeal skull base surgery.

To address the scarcity of literature on this topic, this anatomical study investigates the utility of the MMA as a landmark for identifying the upper-ppICA during the endoscopic skull base surgery. A meticulous series of cadaveric dissections and radiographic assessments were used to delineate the relationship of the MMA to the upper-ppICA. Additionally, we comprehensively described the step-by-step access to the pterygopalatine fossa (PPF), ITF and the PPS, through the combined EEA and ESATMA.

Methods and Materials

This study was approved by the Institutional Review Board of our Department and CORID. Seven cadaveric heads were used for anatomical dissection via the combined EEA and ESATMA. Color-coded liquid silicone was injected into the arterial and venous circulation of each head (red and blue, respectively) to facilitate visualization during dissection. Dissections were performed using instrumentation commonly employed in endoscopic endonasal surgery (Storz Endoscopy, Tuttlingen, Germany) and high-speed drills equipped with diamond burrs and cutting edges (Stryker, Portage, Michigan).

Statistical analysis was conducted using SPSS version 23.0. Independent-sample or paired-sample t-tests were applied with a significance level set at $\alpha = 0.05$. A p-value less than 0.05 was considered statistically significant.

Results

In the lateral aspect of the lateral pterygoid plate (LPP), the IMA consistently lies on the medial aspect of the temporalis muscle (TM), between the superior and inferior heads of the lateral pterygoid muscles (LPMs). Following the IMA invariably leads to the MMA-OP and to the full length of the MMA . The upper-ppICA can always be found posterior or posterior-medially to the MMA using this method . Utilizing this approach, the upper-ppICA could reliably be identified in all 7 specimens (14 sides).

The upper-ppICA was situated posterior or posteromedial to the MMA-OP. On the same axial axis, the distance between the MMA-OP and the upper-ppICA was measured at 12.05(6-18)mm by direct measurement via ruler (13.2mm by neuronavigation). The upper-ppICA was located posterior or posteromedial to the MMA-EP (FS), the distances between the MMA-OP and the upper-ppICA is 12 (9-15) mm by direct ruler measurement (11.7 mm by neuronavigation). The extracranial segment length of the MMA (from origin to foramen spinosum) was approximately 12.9(9-21) mm by direct measurement (13.6 mm by navigation) .

CTA data further measured results showed that the upper-ppICA was situated posterior or posteromedial to the MMA-OP. On the same axis, the distance from the the upper-ppICA was 9.7(5.0-14.2) mm (right side) and 10.8(5.8-19.6)mm (left side), and The upper-ppICA was located posterior or posteromedial to the MMA-EP (FS), with distances of 9.3(7.0-12.9)mm (right side) and 9.4(6.4-14.7)mm (left side) .

The distances to reach the upper-ppICA using the ESATMA and the endonasal transpterygoid approach were 72.1mm by direct ruler measurement (70.2 mm by navigation) and 111.2 mm by direct measurement (109.7mm by navigation), respectively. The ESATMA significantly reduced the distance to reach the upper-ppICA. Additionally, the maximum length of exposure of the upper-ppICA using the ESATMA was 26.3(19-37) mm by direct measurement (26.9mm by navigation).

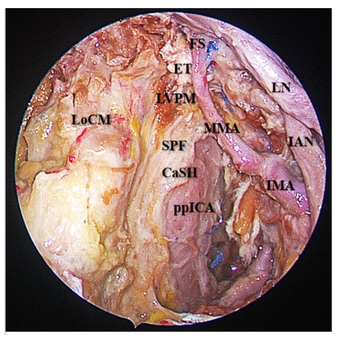

Fig 1.The MMA as an anterolateral landmark of the upper-ppICA within the endoscopic-assisted Sublabial Anterior Transmaxillary Approach（Left side）.

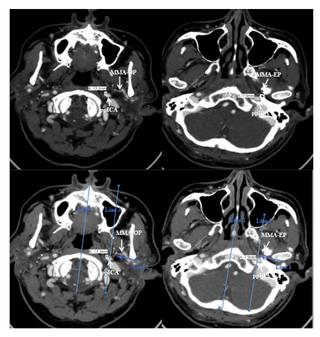

Fig.2. The MMA serves as the anterolateral landmark for the upper-ppICA in computed tomography angiography (CTA) images.（Left side）

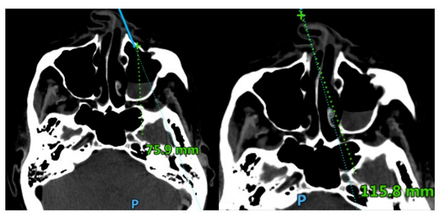

Fig.3. The distances to reach the upper-ppICA using the ESATMA and the endonasal transpterygoid approach.

Discussion

In this study, based on the corridor of the ESATMA combined with EEA, we identified the MMA as a consistent and reliable vascular surgical landmark for the upper-ppICA. Our findings revealed that the extracranial segment of the MMA, extending from its origin at the IMA to the FS, measures approximately 13 mm in length. More importantly, in all 14 sides examined, the upper-ppICA was consistently located posterior or posteromedial to the MMA-OP or MMA-EP (foramen spinosum). Therefore, the MMA represents a highly reliable anatomical landmark for the upper-ppICA during the combined ESATMA and EEA, being the first identified vascular surgical landmark for the upper-ppICA under direct endoscopic visualization. However, the MMA may not hold comparable significance to the upper-ppICA during EEA alone, since the medial to lateral trajectory of the approach obviates the vessel's prompt visualization.

In this study, we also compared the mean operative distances achieved with the ESATMA and EEA, which were 7 mm and 11 cm, respectively. Additionally, we assessed the maximum length of exposure of the upper-ppICA within the ESATMA. Our findings demonstrate that the ESATMA assisted by the EEA corridor, significantly reduces the operative distance compared to EEA alone, while simultaneously extending the length of upper-ppICA exposure.

Conclusions

Understanding the ventralendoscopic anatomy of the upper-ppICA is crucial for preventing its inadvertent injury. The MMA, located anterior or anterolateral to the upper-ppICA, serves as the closest and most consistently identifiable vascular structure in vicinity. By applying this technique, the upper-ppICA can be readily located by tracing posteriorly or posteromedially to the MMA. Significant experience with conventional endoscopic procedures is necessary before employing this technique in real clinical scenarios.

Contact

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