The Impact of Internal Carotid Artery Geometry on Medial Wall Resection of the Cavernous Sinus: A Cadaveric Study

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Introduction

Endoscopic endonasal approaches are frequently employed to access lesions in the cavernous sinus (CS). This approache often involve opening the anterior wall of the cavernous sinus, and removing the medial wall of the cavernous sinus (MWCS), which can be achieved through two primary techniques: lateral-to-medial and medial-to-lateral. Using sharp instruments to incise the anterior wall of the CS dura carries a risk of internal carotid artery (ICA) injury, particularly if the vessel has tortuous trajectory or abuts the dura due to its anatomical course or tumor presence. Adjunctive tools such as doppler ultrasound are recommended to map the course of the cavernous ICA before incising the anterior wall, but a safe entry zone may not always be identifiable due to the ICA's trajectory. The aim of this paper is to present the relation between the geometry of the ICA configuration and the pituitary gland, as the surgical implication during the resection of the MWCS.

Materials and Methods

Twenty-seven fresh cadaveric specimens underwent meticulous bilateral dissections using an endoscopic endonasal approach. A detailed anatomical analysis focused on the ICA geometry in the parasellar and paraclival regions was performed. The relationship between ICA geometry, the pituitary gland, surrounding neurovascular structures, and implications for surgical planning was further classified and analyzed.

Results

This study analyzed the ICA geometry in 27 cadaveric specimens (54 side) within the parasellar and paraclival regions using the Cebula classification. Distribution was: 12 type I (pronounced curvature), 8 type II (mild curvature), 24 type III (linear course), and 10 type IV. Complex ICA geometries indicated varied surgical risks. Type I ICAs, closer to the pituitary gland, presented higher risks and potential doppler mapping false positives. The trajectory of the inferior hypophysial artery was horizontal in 26 cases and superior in 28 cases. Type III geometry was more favorable for pituitary hemi-transposition and medial wall resection due to its linear course. Types I and II, with complex curvatures and reduced distances to critical structures, required additional precautions. These findings highlight the importance of ICA geometry in surgical planning to reduce the risk of ICA injury.

Discussion

Preoperative identification of the internal carotid artery (ICA) configuration is essential for safe access to the parasellar region during transsphenoidal surgery, reducing recurrence and complications. Type I ICA geometry, with sharp angles and proximity to the pituitary gland, poses higher risks for vascular injury and limits visualization of the anterior cavernous space. Geometric analysis aids in predicting surgical challenges and planning safe approaches, including MWCS resection. The Cebula classification of ICA trajectories helps anticipate vascular variations and guide intraoperative strategies, enabling precise drilling and tumor removal while minimizing the risk of ICA injury and improving surgical outcomes.

Conclusions

Understanding the structural variability of the parasellar and paraclival ICA anatomy around the pituitary gland provides valuable insights for planning safer and more precise dissections during the endoscopic transcavernous approach. When the ICA is closely associated with the pituitary gland, the risk of arterial injury may increases. Therefore, recognizing these anatomical nuances is crucial for minimizing surgical risks and improving patient outcomes.

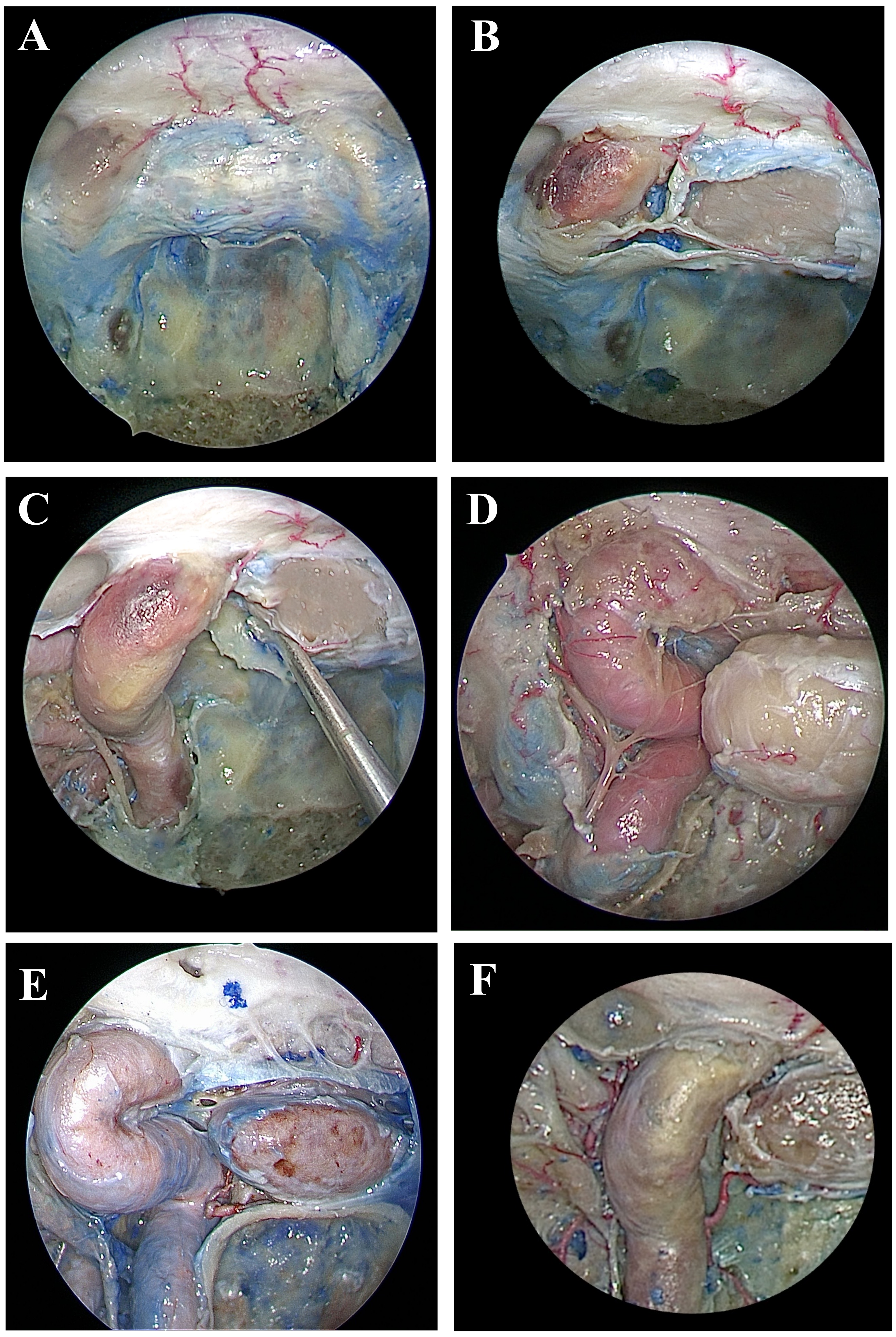

Figure 1. A: This image shows the anterior wall of the cavernous sinus (AWCS). **B:** This image shows the AWCS being incised with a sharp instrument and the separation of the AWCS and the MWCS. The internal carotid artery (ICA) is visible with a pronounced curvature, closely abutting the dura. **C:** Type III ICA geometry with a linear course, demonstrating a favorable configuration for medial wall resection with minimal risk of arterial injury. **D:** Type I ICA with pronounced curvature, closely abutting the pituitary gland, highlighting a challenging configuration where the risk of injury is higher. **E:** Type II ICA geometry, showing mild curvature with a clear distance between the pituitary gland and the posterior bend of the ICA. The horizontal trajectory of the inferior hypophysial artery is also visible. **F:** Type I ICA (with a relatively straight segment), emphasizing the ascending trajectory of the inferior hypophysial artery, which can present additional considerations during dissection.

ICA type (N = 27)	Shape of the ICA			
	Trapezoid	Square	Hourglass	Total
Type I	12	0	0	12 (22.2%)
Type II	2	6	0	8 (14.8%)
Type III	0	4	20	24 (44.4%)
Type IV	Type I: 2 Type II: 1 Type III: 1	Type I: 1 Type II: 2 Type III: 1	Type I: 0 Type II: 1 Type III: 1	10 (18.6%)
Total	9	7	11	54

Table 1.

References: