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Neuroanatomical Study

Cadaveric study of the endoscopic endonasal transtubercular approach to the anterior communicating artery complex

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A B S T R A C T

The endoscopic transnasal approach to the anterior communicating artery (ACoA) complex is not widely performed. This cadaveric study investigated the surgical relevance of the anterior endoscopic approach to the treatment of ACoA aneurysms. Bi-nasal endoscopic transtubercular surgery was carried out on fresh adult cadavers. Primary outcomes measures incorporated dimensions of the endonasal corridor (operative field depth, lateral limits, size of the transplanum craniotomy and dural opening); vascular exposure (proximal and distal anterior cerebral arteries [ACA], ACoA, clinoidal internal carotid artery [ICA] segment); and operative manoeuvrability defined by clip placements (ipsilateral and contralateral). Eight cadaver heads were used (mean age 84 ± 7 years, range 76–94 years, 75% female). Mean operative depth was 97 ± 4 mm. The lateral corridors were limited proximally by the alar rim openings (31 ± 2 mm), and distally by the optic nerves (22 ± 6 mm). The endonasal craniotomy dimensions were 21 ± 5 mm anteroposteriorly, and 22 ± 4 mm laterally. Vascular exposure was achieved in 100% of subjects for the ACoA segment and the ACA segments proximal to the ACoA (A1). The ACA segments distal to the ACoA (A2) were accessible only in 40% of subjects. Endonasal clip placement across the ACoA segment, clinoidal ICA, A1 and A2 were 100%, 90%, 90%, and 30%, respectively. The ventral endoscopic endonasal approach to the ACoA complex provides excellent vascular visualisation without brain retraction or gyrus rectus resection. However, the limitation in access to the A2 for temporary clip placement may prove to be a significant limitation of this approach.

1. Introduction

Of all cerebral aneurysms, the anterior communicating artery (ACoA) aneurysm is the most frequent and represents an increased risk of rupture as compared to aneurysms in other locations [1–8]. Transcranial clip ligation (via the pterional transsylvian, supraorbital or interhemispheric corridors) presents significant technical challenges because of the deep and midline location of these lesions. Infrequently, surgical morbidity arises from the frontal lobe retraction or partial gyrectomy that are necessary to facilitate aneurysm exposure [4,9–11]. The application of endovascular techniques in recent years has provided a less invasive alternative to the management of ACoA aneurysms, but has led to an inferior durability of aneurysm repair and an increased risk for retreatment [12–16]. Cranial base approaches with clip obliteration maintain treatment robustness but come at the expense of a greater amount of bone removal and extracranial tissue morbidity.

The concept of an anterior transnasal approach to the ACoA complex is not new. Previously, the microscopic transsphenoidal approach for treatment of aneurysms around the circle of Willis has been described [17]. However, early efforts to gain direct ventral surgical access have been hindered by poor operative exposure, an inability to achieve watertight dural closure and an increased risk of postoperative cerebrospinal fluid leaks and meningitis [18–20].

The emergence of endoscopic endonasal surgery as a ventral corridor to the cranial base has brought new surgical relevance to the ACoA complex that may provide a more direct access route and minimal brain retraction. In this anatomical study, the applicability of an endoscopic transnasal access to the ACoA complex vasculature was investigated. Three outcome measures were considered for (1) the depth and lateral limitations of the endonasal corridor; (2) the degree of vascular exposure; and (3) the degree

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of surgical freedom and clip placement permissible within the constraints of the endonasal corridor.

2. Methods

This study was approved by the local Institutional Review Board and was conducted in accordance with Ethics Committee guidelines for the use of human anatomical specimens. Adult fresh frozen cadaver heads were used. The cadaver heads were placed in the supine position slightly extended and turned 10 to 15 degrees toward the right in the horizontal plane. Zero degree endoscopes (Karl Storz and Co., Tuttlingen, Germany) that were 4 mm in diameter and 18 cm in length were used. The endoscope was connected to a light source via a fibre-optic cable and to a camera fitted with three charge-coupled device (CCD) sensors. The video camera was connected to a 21 inch monitor supporting the high resolution of the three CCD technologies.

2.1. Surgical dissection

Expanded endoscopic endonasal surgery through the planum sphenoidale and tuberculum sella was performed. The middle turbinate was lateralised or the lower half of the middle turbinate removed to facilitate visualisation of the entire sphenoid anterior wall. The sphenoid sinus was opened widely, exposing the parasellar segment of the internal carotid artery (ICA), sella and planum sphenoidale. The full width of the sphenoid from the lateral optico-carotid recess (OCR) to the contralateral OCR was exposed. A 20 mm posterior nasal septectomy was performed to allow for a binasal expanded endonasal technique.

The anterior sella bone, tuberculum sella, and planum sphenoidale were removed. The bone opening of the planum was extended in the postero-anterior direction for approximately 20 mm and laterally to the optic canals. From this point, the assistant held the endoscope to allow the surgeon use of both hands. The dura mater was opened and resected maximally along the margins of the transplanum opening. The arachnoid bands forming the chiasmatic cisterns above the optic chiasm were opened using sharp dissection, upon which the anterior communicating complex vasculature was systematically identified.

2.2. Defining the endonasal dimensions

The endonasal corridor was defined in mm by (1) the depth of the operative field, which was measured from the anterior choanae to the ACoA segment, and (2) the lateral limits, as defined proximally by the margins of the alar rims and more distally by the divergent margins of the optic nerves. Because the distance between the optic nerves was variable, measurement was taken at an arbitrary line that passes through the centre of the craniotomy. The extent of the transplanum and transtubercular craniotomy and dural opening (mm) were measured and recorded. Three attempts were made before a decision was agreed upon, following which the average measurement was recorded.

2.3. Exposure of the ACoA complex

The degree of vascular exposure in the ACoA region above the optic chiasm was recorded as dichotomous outcomes of accessible or not. These included four sites of the left and the right proximal (A1) and distal (A2) anterior cerebral arteries (ACA). The ACoA segment itself was assessed separately and categorically divided into four surfaces (anterior, posterior, superior and inferior). These surfaces represented the hypothetical aneurysm dome projections, in which access and manoeuvrability of clip placement was later evaluated.

2.4. Feasibility assessment of instrument access and clip placement

Instrument access and surgical manoeuvrability were measured by assessing the ability of surgical instruments to access and manipulate the proximal and distal ACA and the ACoA segment (recorded dichotomously as successful or unsuccessful from three attempts). To assess for the ability of temporary clip placements, a 10 mm window over the parasellar prominence of the ICA was drilled to expose the clinoidal ICA on each side. The Vidian canal was used as the inferior limit of this exposure, which anatomically represents the anterior genu of the petrous ICA [21]. Temporary clip placement was assessed at multiple sites, including the clinoidal ICA (Fig. 1), and proximal and distal ACA (Fig. 2, 3). Finally, the ACoA segment was evaluated for the ability of the clip to "open and close" over the anterior, posterior, superior and inferior surfaces. This represented the ability of clip placement for the different types of aneurysm dome projections at this region.

2.5. Statistical analysis

Descriptive data were presented as percentage and mean ± standard deviation. A paired *t*-test (two-tailed) was used for comparisons of paired parametric data. Student's *t*-test (two-tailed) was used for comparisons of unrelated groups of parametric data. The Statistical Package for the Social Sciences software (SPSS, Chicago, IL, USA) was used for statistical calculations. A p value of less than 0.05 was considered statistically significant. The modified Wald method was used to calculate the 95% confidence intervals (CI) for a proportion (GraphPad Software, La Jolla, CA, USA).

3. Results

Endoscopic endonasal transtubercular exposure of the ACoA complex was performed on eight adult cadaver heads (mean age 84 ± 7 years, range 76–94 years, 75% female). One specimen had an ACoA aneurysm (Fig. 4). Transnasal and dura exposure was possible in all specimens.

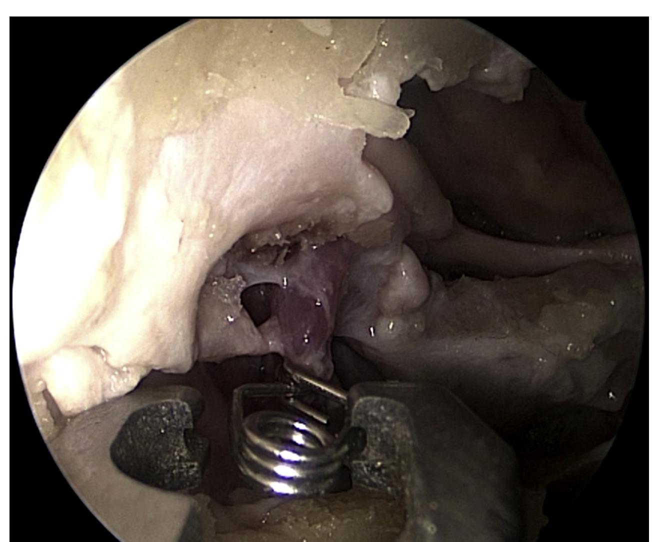

Fig. 1. Intraoperative photograph of endoscopic endonasal clip application of the right clinoidal internal carotid segment for proximal vascular control.

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