Acousticofacial–Glossopharyngeal Triangle: An Anatomic Model for Rapid Surgical Orientation

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ABSTRACT

The cerebellopontine angle (CPA) poses a surgical challenge due to the complexity and variation of its associated structures. This study examined the relationship between the glossopharyngeal nerve (CN IX) and the acousticofacial complex (AFC). Retrosigmoid suboccipital dissections were performed on 10 cadaveric specimens. A triangle formed by the AFC, CN IX, and the skull base was consistently observed. The cisternal portions of the AFC and CN IX formed two sides of the triangle. The base was formed by a line traversing the respective dural portals of these nerves at the skull base. Triangular proportions were utilized to predict distances from five points along the course of CN IX to a corresponding point along the course of the AFC. Predicted distances were not statistically different when compared with cadaveric measurements in all 10 specimens ($p > 0.05$). A table of predicted distances between CN IX and the AFC at all five points along CN IX was developed, revealing a quantitative model to predict the native location of the AFC in the lateral pontine cistern. The triangle and predicted location of the AFC can serve as points of reference for the identification and preservation of these structures in CPA surgery.

KEYWORDS: Acousticofacial complex, glossopharyngeal nerve, cerebellopontine angle, triangle, posterior cranial fossa, skull base, microsurgical anatomy

The cerebellopontine angle (CPA) contains the facial (CN VII), vestibulocochlear (CN VIII), glossopharyngeal (CN IX), and vagus nerves (CN X), which course through the lateral aspect of the pontine cistern. The lateral pontine cistern is bordered by the upper medulla, lower pons, cerebellar hemisphere (particularly the flocculus), and skull base—between the internal auditory meatus and jugular foramen. The direct relationship between the cerebellum, brain stem, and these cranial nerves poses an anatomic challenge during surgical approaches to the CPA. Pathological or iatrogenic processes may lead to significant complications or neurological deficits as a result of damage to these structures.

A precise understanding of the anatomic relationships of these structures is essential in the prevention of unintended surgical outcomes.

Microsurgical anatomy of the CPA has been described for the acousticofacial complex (AFC) and the glossopharyngeal, vagus, and spinal accessory (CN XI) nerves.^{1–10} The AFC, consisting of CN VII and CN VIII, arises from the brain stem at the pontomedullary sulcus, and courses through the lateral aspect of the pontine cistern to enter the internal auditory canal (IAC) along with the labyrinthine artery and vein. The glossopharyngeal nerve (CN IX) originates from the postolivary sulcus of the medulla, courses through the lateral

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pontine cistern, and pierces the dura at the jugular foramen (JF).^{3,5-10} The specific rotation and microanatomic orientation of the vestibular and cochlear nerves from the brain stem to the labyrinth as well as consistent anatomic landmarks have been described.¹¹⁻¹³ However, the spatial relationship between AFC and CN IX has not been reported.

The purpose of this investigation was to evaluate and describe the specific relationship of the AFC to CN IX within the posterior cranial fossa. Measured distances from five points along the course of CN IX to a corresponding point along the course of the AFC were utilized to develop a predictive model for the localization of the AFC within the lateral pontine cistern. Detailed knowledge of this relationship can contribute to efficient orientation and identification of the AFC and CN IX in the CPA.

MATERIALS AND METHODS

The AFC and glossopharyngeal nerve (CN IX) were studied in 10 adult cadaveric specimens. Two specimens were examined bilaterally, and six were examined unilaterally. The CPA was approached using a combined lateral, transmastoid and posterior, extended retrosigmoid/suboccipital dissection (Fig. 1A). A portion of the cerebellar hemispheres and the dura surrounding the IAC and JF was removed to expose these nerves in the lateral pontine cistern. A translabyrinthine dissection was preformed to expose the course of cranial nerves VII and VIII within the IAC. The dissections and measurements of the specimens were performed under magnification using a L&W Optics 120 (Angelus Medical & Optical, Gardena, CA) stereoscopic dissection microscope.

The length of the intracisternal portion of CN IX along with the distance between the AFC (CN VII–VIII) and CN IX at their dural exits in the skull base was measured in each specimen. Reference points at

2.0, 3.5, 5.0, 7.5, and 9.0 mm were marked along the course of CN IX from the JF (Fig. 1B). A triangular relationship was observed between the AFC, CN IX, and the skull base (Fig. 2A). Triangular proportions were utilized to develop an equation predictive of the distance between CN IX and the AFC for all five points in each specimen. Measurements between CN IX and the AFC were made at all five points and compared with the predicted values (Fig. 1B). In two specimens, CN VII and VIII were distinctly separate and did not form an AFC. In this case, measurements were obtained between CN IX and the vestibulocochlear nerve (CN VIII). Measurements were made utilizing Castro-Viejo and vernier digital calipers. Averages for predicted and measured values were calculated for each specimen, and statistical analysis was performed utilizing a one-sample *t* test constructed in SPSS. The anatomic and predicted location of the AFC was plotted based upon the average of measured and predicted distances for each specimen (Fig. 2B).

RESULTS

The average cisternal length of CN IX was 17.34 ± 2.17 mm, and the average distance between CN IX and the AFC at the skull base was 4.56 ± 0.97 mm. Data analysis revealed an inverse correlation between the cisternal length of CN IX and the distance between CN IX and the AFC (VII–VIII) at the skull base. As the cisternal length of CN IX decreases, the distance between CN IX and the AFC at the skull base increases. Based upon these findings, a table of predicted reference distances at certain points along the glossopharyngeal nerve (CN IX) was developed (Table 1).

The predicted distances between the AFC and CN IX were not statistically different when compared with cadaveric measurements in all 10 specimens [$t(9) = 0.434$, $p > 0.05$]. These findings confirm a con-

Figure 1 (A) Cerebellopontine angle viewed from a posterior retrosigmoid approach in a cadaveric specimen to simulate intraoperative visualization of the acusticofacial complex (AFC), glossopharyngeal nerve (IX), vagus nerve (X), anterior inferior cerebellar artery (AICA), accessory nerve (XI), internal auditory canal (IAC), jugular foramen (JF), trigeminal nerve (V), cerebellum (CB), and jugular dural fold (JDF). (B) Reference points along the glossopharyngeal nerve (IX) at successive increments from the jugular foramen (JF) were used to measure the distance from IX to the AFC. Measured distances were compared with predicted distances derived from triangular proportions.

Figure 2 (A) A drawing of the AGT viewed through an extended posterior retrosigmoid suboccipital approach with transection of the cerebellum exposing the MCP and removal of associated vasculature. Side 1: glossopharyngeal nerve (IX). Side 2: AFC. Side 3: the distance between the nerves as they enter their respective dural portals in the skull base. (B) The dotted line illustrates the anatomic location of the AFC based on measured cadaveric distances from the glossopharyngeal nerve (IX) to the AFC. The dashed line illustrates the predicted location of the AFC based on predicted distances from IX to the AFC derived from triangular proportions. AFC, acousticofacial complex; CB, cerebellum; JDF, jugular dural fold; MCP, middle cerebellar peduncle; AGT, acousticofacial–glossopharyngeal triangle.

sistent triangular relationship between the following structures: the AFC, glossopharyngeal nerve (CN IX), and a line drawn between them at their dural portals in the skull base (Fig. 2A).

DISCUSSION

Geometric descriptions of cranial anatomy are not an uncommon method to recognize and utilize anatomic relationships for effective surgical dissection.

Microsurgical anatomy of the cavernous sinus has been described using triangles outlining natural corridors through which pathological lesions can be reached.^{14,15} The acousticofacial–glossopharyngeal triangle (AGT) may be used in conjunction with other anatomic landmarks to allow for more accurate localization of the middle and lower neurovascular complexes in the posterior cranial fossa. Rapid identification and preservation of important anatomic landmarks is essential to performing procedures safely within the CPA. This is true in

Table 1 Table of Predicted Reference Distances from the Glossopharyngeal Nerve (IX) to the Acousticofacial Complex (AFC)

Distance Between IX and AFC at Skull Base (mm)*	IX Reference Point (mm) [†]					Cisternal Length of IX (mm) [‡]
	2.0	3.5	5.0	7.5	9.0	
3.12	2.86	2.67	2.48	2.16	1.96	21.0
3.34	3.06	2.85	2.64	2.29	2.08	20.5
3.56	3.25	3.02	2.80	2.41	2.18	20.0
3.78	3.45	3.20	2.95	2.53	2.29	19.5
4.00	3.64	3.37	3.10	2.65	2.38	19.0
4.22	3.83	3.54	3.25	2.77	2.48	18.5
4.44	4.02	3.71	3.40	2.87	2.56	18.0
4.66	4.21	3.87	3.54	2.98	2.64	17.5
4.88	4.40	4.04	3.68	3.07	2.71	17.0
5.10	4.58	4.20	3.81	3.17	2.78	16.5
5.32	4.77	4.35	3.94	3.25	2.84	16.0
5.54	4.95	4.51	4.06	3.33	2.88	15.5
5.76	5.13	4.66	4.18	3.40	2.92	15.0
5.98	5.31	4.80	4.30	3.46	2.95	14.5
Predicted Distance to AFC (mm)						

[‡]Predicted distances can be calculated using one of the reference points along the cisternal portion of the glossopharyngeal nerve

*coupled with either the distance between the nerves at the skull base

[†]and/or the cisternal length of IX.

cases where pathology occupies a large portion of the CPA or in cases where the basic anatomic relationships remain consistent. Examples include vestibular nerve section, cases of vascular compression, approaches for trigeminal neuralgia, and select approaches to cerebrovascular aneurysm.

In addition to its anatomic significance, the AGT may provide a foundation to further describe and examine the large amount of anatomic variation within the posterior cranial fossa and may serve as an effective teaching tool for the study of posterior cranial fossa anatomy.

The table of predicted distances adds to the current knowledge base of CPA microsurgical anatomy (see Table 1). The predictive estimates of the location of the AFC prior to pathological involvement may be useful in anatomic or pathological studies and/or surgical approaches to the CPA. In the case of acoustic neuromas involving the CPA, the tumor frequently displaces the cochlear and facial nerve anteriorly or anterosuperiorly, resulting in nerve displacement away from CN IX.³ Predicting the location of the AFC prior to tumor displacement may be helpful in assessing the amount of displacement of the cochlear and facial nerve fibers as a result of pathology. Measurement of this displacement may result in a better understanding of the relationship of CPA pathology to normal anatomic structures.

CONCLUSION

The AGT is validated by a comparison study of predicted and measured values between the AFC and CN IX in the CPA. The table of predicted reference values is derived from triangular proportions and reflects the inverse relationship between the cisternal length of CN IX and the distance between the AFC and CN IX at the skull base. This table accurately predicts the location of the AFC as measured at five points along the glossopharyngeal nerve (CN IX). Used in conjunction with other consistent anatomic landmarks, this model can serve as a point of reference for the identification and preservation of these structures in surgical approaches involving the CPA.

The above findings demonstrate an innovative method for examining the microanatomic relationship between these structures from their brain stem origins to their respective dural portals and may translate into more efficient evaluation and treatment of processes involving this aspect of the posterior cranial fossa.

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