Microsurgical exposure of the petrous portion of the carotid artery

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Occlusion of the cervical portion of the internal carotid artery (ICA) has been treated by vein graft bypass from the common carotid to the supraclinoid segment. However, this procedure has the disadvantages of requiring temporary occlusion of collateral flow, the short length of ICA available for anastomosis, and the retraction required for exposure of the supraclinoid area. In an attempt to find a more suitable bypass site for grafting, the petrous portion of 50 carotid arteries was studied in cadavers. It was found that there was a 1-cm length of the horizontal segment of the petrous carotid that could be exposed in the floor of the middle fossa lateral to the trigeminal nerve. This segment was covered by dura only or a thin layer of cartilage in approximately half of the specimens. In the remainder, there was often a thin shell of bone covering the artery, which could be drilled away. The petrous portion of the carotid artery had branches in only 38% of specimens, a Vidian branch in 30%, and a periosteal branch in 8%. The carotico-tympanic artery, previously reported to be the most common branch, was not found in a single case. These branches allow the retrograde flow needed to maintain the patency of this segment following proximal occlusions. The relationship of the carotid artery to structures that might be injured in exposing the petrous portion of the artery was reviewed; these structures include the cochlea, middle ear, Eustachian tube, tensor tympani muscle, geniculate ganglion, and facial, greater petrosal, and trigeminal nerves.

Key Words: microsurgical anatomy · carotid artery · carotid occlusion · cranial nerves · temporal bone
Materials and Methods

The intrapetrous course of 50 carotid arteries was studied in cadavers (Fig. 1). Tissue blocks from adult cadavers containing the carotid arteries and adjacent structures were examined under \( \times 3 \) to 40 magnification. The relationship of the petrous segment of the carotid artery to adjacent structures including the facial canal, internal acoustic meatus, cochlea, geniculate ganglion, facial, greater and lesser petrosal, and trigeminal nerves, middle ear, Eustachian tube, middle meningeal artery, and tensor tympani muscle was studied. These anatomical relationships are important because all of these structures could be injured if not protected during surgical exposure of the petrous segment of the carotid artery.

Results

Internal Carotid Artery and Carotid Canal

The ICA enters the cranial cavity by passing through the periosteal-lined carotid canal located in the petrous portion of the temporal bone. The external orifice of the carotid canal is directly anterior to the jugular foramen and its internal orifice is located at the petrous apex (Fig. 2). The artery was easily separated from the connective tissue adhesions within the canal, except at the entrance of the vertical canal, where a dense band anchored the artery.

There are two segments to the petrous portion of the artery and its bony canal: a vertical or ascending segment and a horizontal segment which join at the genu or geniculum (Fig. 2 upper right). There was no significant difference in the external diameter of the vertical and horizontal segment of the carotid artery; the average diameter of the petrous segment at the genu was 5.2 mm (range 4 to 8 mm).

The vertical segment of the artery passed directly upward after entering the petrous bone, before turning anteromedially at the genu to form the horizontal segment. In important relationship to the vertical segment were the jugular fossa posteriorly, the Eustachian tube anteriorly, and the tympanic bone anterolaterally (Figs. 3 and 4). The length of the vertical segment of the canal, measured along its anterior wall, ranged from 6.0 to 15.0 mm, the average being 10.5 mm.

The horizontal segment begins at the genu and passes forward and medially, anterior to the cochlea, within the petrous bone to emerge near the apex. It is separated from the cochlea by a thin plate of bone (Figs. 3 B, C, and 4 B). The medial part of the roof of the horizontal portion of the canal was formed by dura or a thin plate of bone that separated the carotid artery from the Gasserian ganglion. The length of the horizontal segment ranged from 15.0 to 25.1 mm, the average being 20.1 mm.

Failure to recognize an anomalous course of the petrous carotid has led to inadvertent biopsy of the artery within the tympanic cavity.\(^24\) The radiological criteria for recognition of an anomalous course of the carotid artery are failure to visualize the vertical segment beneath and anterior to the cochlea on lateral and coronal tomograms, and dehiscence in the floor of the middle ear and erosion along the promontory caused by grooving from the abnormally placed artery.\(^26\) This condition has been treated by creating a new protected canal utilizing a fascial graft and bone.\(^22\) Lapayowker, \textit{et al.},\(^13\) described a vestibular line lateral to which the carotid artery did not project on anteroposterior (AP) view tomograms except when
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FIG. 2. Posterior-superior views after bone removal to expose the petrous portion of the carotid artery. A: View through right posterior fossa showing area defined by broken line in inset, lower left. The bone posterior to the carotid canal has been removed to show the carotid artery (C.A.) and its relationship to the porus acusticus, jugular foramen (Jug. For.), greater petrosal nerve (Gr.P.N.), middle meningeal artery (M.M.A.), and cranial nerves V through XI. B: Same view as in A. The horizontal (C.A.hor.) and the vertical (C.A. ver.) segments joined at the genu. The porus acusticus and jugular foramen are posterolateral, the greater and lesser nerves are anterior, and the cochlea is lateral to the artery. C: Superior view of right middle and posterior fossa showing the tensor tympani muscle (Ten. Tym. M.) and greater (Gr.P.N.) and lesser petrosal (L.P.N.) nerves anterior to the horizontal segment, cochlea, and geniculate ganglion lateral to the carotid genu and the facial nerve and porus acusticus posterior to the vertical segment. VII Ga = seventh cranial nerve ganglion; VIIIsv = superior vestibular division of the eighth cranial nerve; Jug. Bb = jugular bulb.

the artery lay within the middle ear. The carotid artery, on 100 normal angiograms, was located an average of 5.38 mm medial to this line, which extends vertically through the midportion of the vestibule on AP views.

Intrapetrous Carotid Artery Branches

Petrous branches of the ICA are important in occlusion of the proximal ICA because they provide a channel for the retrograde flow needed to maintain the patency of the distal part of the artery. The two branches reported to arise from the petrous portion of the carotid artery are: 1) the carotico-tympanic artery, a small branch that enters the tympanic cavity through a foramen in the wall of the vertical portion of the carotid canal, and 2) the Vidian or pterygoid artery which usually arises from the internal maxillary artery, but which may arise from the horizontal segment of the carotid, and enters the pterygoid canal with the pterygoid nerve.

Only 38% of our specimens had branches within the carotid canal, and all arose from the horizontal segment. Although a review of the literature suggests that the carotico-tympanic branch is more frequent than the Vidian, we found the reverse to be true. In 50 specimens examined under magnification, we
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were unable to find a single branch that could be called the carotico-tympanic artery. Twenty-one arterial branches arose from the 50 arteries studied and none fitted the previous anatomic descriptions of the carotico-tympanic artery. The most frequent branch was the Vidian artery, which was found in 15 (30%) of the specimens (Figs. 4 C, D and 5 A). The only other branch seen in this study was a periosteal artery present in four cases (8%) (Fig. 5 B). The Vidian and periosteal arteries arose from the horizontal segment an average of 10.2 and 12.4 mm distal to the genu, respectively. These branches arose predominantly from the inferior (55%) or anteroinferior (35%) surface. The remaining branches arose from the anterior or posterior surface. None arose superiorly. The Vidian arteries coursed medially an average of 7.0 mm along the anterior wall of the canal before exiting through the cartilage of the foramen lacerum and proceeding toward the pterygoid canal. The diameter of the Vidian branches averaged 0.5 mm. The periosteal branches divided shortly after entering the periosteum of the canal. Other branches that penetrated the periosteum (included in periosteal group) terminated in the foramen lacerum and did not proceed to the Vidian canal. Lazorthes15 is the only previous investigator to identify periosteal branches from the petrous carotid. The Vidian and

Fig. 3. Superolateral views of the right middle fossa with temporal lobe removed. A: The carotid artery (C.A.), facial nerve, and geniculate ganglion have been exposed lateral to the trigeminal nerve by bone removal. The intracavernous segment and its meningo-hypophyseal branch (M.H.A.) are medial to cranial nerves III through VI. The greater petrosal nerve (Gr.P.N.) and middle meningeal artery (M.M.A.) are anterior to the horizontal carotid segment. The posterior cerebral (P.C.A.) and superior cerebellar arteries (S.C.A.) course around the cerebral peduncle. B: The posterior trigeminal root has been divided and the trigeminal ganglion reflected forward to expose the horizontal carotid segment. The bone has been removed over the lateral part of the horizontal segment. Cranial nerves III through VI course lateral to the cavernous segment of the carotid artery. The petrosal artery (Pet. A.) arises from the middle meningeal artery (M.M.A.), proceeds toward the geniculate ganglion, and sends a branch ventral to the fifth nerve into the cavernous sinus. O.N. = optic nerve. C: The carotid artery (C.A.), cochlea, facial nerve, and geniculate ganglion have been exposed lateral to the trigeminal ganglion by bone removal. The tegmen tympani has been removed to show the middle ear and the insertion of the tendon of the tensor tympani muscle (Tnd. Ten. Tym.) on the malleus. The lesser petrosal nerve (L.P.N.) courses anterior to the greater petrosal nerve (Gr.P.N.).
FIG. 4. A: Surgical exposure of the petrous segment of the right carotid artery (C.A.) through a right temporal craniotomy. Inset, upper left shows incision for craniotomy. The temporal lobe (T. Lobe) is retracted to show supraclinoid carotid and basilar (B.A.) arteries and their branches. Dura removal exposes the lateral part of the trigeminal ganglion, greater petrosal nerve (Gr.P.N.), and horizontal segment of the carotid artery. P.C.A. = posterior cerebral artery; P.Co.A. = posterior communicating artery; Pe.A. = perforating artery. B: The bone over the horizontal segment of the carotid artery has been removed. The greater petrosal nerve (Gr.P.N.) serves as the landmark for the anterior margin of the carotid canal. The periarterial venous plexus can be seen through the periosteum.
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Fig. 4 (continued). C: Periosteum opened to expose the carotid artery, deep petrosal branch (D.P.N.) of the sympathetic trunk (Sym.), and the periarterial venous plexus (Ven. Plex.). A small Vidian artery (Vid. A.) courses anteromedially before exiting from the canal. D: The tegmen tympani opened to show the insertion of the tensor tympani muscle (Ten. Tym. M.) to the malleus. Removal of a section of the tensor tympani muscle exposes the Eustachian tube (Eus. Tub.) anterior to the carotid genu at its entrance into the middle ear. The relationship of the geniculate ganglion, Eustachian tube, and middle ear to the carotid genu are shown. VIIIc = cochlear division of the eight cranial nerve.
periosteal branches explain why the petrous portion of the carotid remains patent and fills retrograde in some cervical carotid occlusions.

A knowledge of the embryology of the petrous carotid provides the basis for understanding its branches and anomalies. The Vidian artery usually arises from a remnant of the mandibular (first) aortic arch and later becomes a branch of the internal maxillary artery, but it arose from the carotid artery in 30% of our specimens. Although most anatomists describe the artery as arising from the internal maxillary artery, Gray's Anatomy describes it as a small inconstant branch of the petrous carotid artery and Teal, et al., angiographically demonstrated its origin from the petrous portion of the carotid in patients with tumor and fibrous dysplasia. The carotico-tympanic branch of the petrous carotid, although not encountered in this series, is said to be a remnant of the embryonic hyoid artery.

A rarely occurring branch of the vertical segment is a persistent stapedial artery which originates as a secondary branch of the embryonic carotid. The stapedial artery takes its name from the fact that it passes through the primordium of the stapes. At one stage of development it is the parent vessel for the middle meningeal and part of the external carotid artery. Later, as the stapedial involutes, the middle meningeal and external carotid branches lose their connection with the petrous carotid and are fed by the internal maxillary artery.

The stapedial artery rarely persists into adult life, but has on occasion been encountered during middle ear exploration. Persistence of the stapedial artery may cause a congenital hearing loss, and Hogg, et al., have suggested that occlusion of a persistent stapedial artery might result in brain-stem infarction, because persistence of such an artery is frequently associated with other vascular anomalies; however, the authors could not find a report of such an untoward event following occlusion. Recently, McLennan, et al., have reported two variants of the stapedial artery in which the middle meningeal artery arises from the ICA, and the foramen spinosum is absent. In one variant, the stapedial-middle meningeal type, the stapedial artery persists and runs forward to supply the middle meningeal artery. The artery, if persistent, passes from the region of the genu of the petrous carotid, through the crus of the stapes, and then on to the
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meninges. In the other variant, the ophthalmic-middle meningeal type, the middle meningeal artery arises from the lacrimal branch of the ophthalmic artery. Anastomosis between the ophthalmic and middle meningeal arteries has been seen in tumors and carotid occlusions.

**Middle Meningeal and Petrosal Arteries**

The middle meningeal artery passes through the cranial base anterior to the carotid canal (Figs. 3, 4 B-D and 5 A). It was composed of a single trunk which passed through the foramen spinosum in all except one case in which the artery split into two equal arteries below the cranial base and entered two separate but adjacent foramina. No other anomalies of the middle meningeal artery were encountered in this series. If the artery arises from the stapedial branch of the petrous portion of the carotid artery, the foramen spinosum is absent on skull x-ray film.

The petrosal artery arose from the middle meningeal artery and ran with the greater petrosal nerve to supply the geniculate ganglion and facial nerves (Fig. 3 B). It arose proximal to the foramen spinosum in 58%, and distal to it in 42%. It supplied predominantly the facial genu and geniculate ganglion, although it ramified distally with branches of the stylomastoid artery and proximally with branches of the anterior-inferior cerebellar artery. These collateral sources usually prevent facial nerve dysfunction if the petrosal artery is occluded. The largest branch of the petrosal artery accompanied the greater petrosal nerve in 92%, the lesser petrosal nerve in 8%, and it sent branches to the trigeminal ganglion in 46% (Fig. 3 B). Occasionally a branch passed below the trigeminal ganglion into the cavernous sinus.

**Periarterial Venous Plexus**

A venous plexus, a lateral extension of the cavernous sinus, extended around the artery within the periosteal covering of the distal part of the carotid canal in 76% (Fig. 4 B, C). It was poorly developed or absent in 24%. It extended an average of 7.6 mm (range 1 to 22 mm) into the canal. It passed beneath but not lateral to the trigeminal nerve in 76% and along the horizontal segment lateral to the nerve in 20%, reaching the genu in two cases and the vertical segment in one. The plexus was located between the floor of the middle fossa and the artery in only 4%, and in the remainder was predominantly on the anterior or inferior side of the artery. A fistula between this plexus and the carotid artery could produce a clinical picture mimicking a carotid-cavernous fistula.

**Periarterial Neural Plexus**

The carotid nerve, a branch of the cervical sympathetic ganglia, branches into two parts near the genu; a larger anterior-superior and a smaller posterior-inferior trunk. The posterior branch sends rootlets that accompany the cerebral arteries and the trochlear and trigeminal nerve (Fig. 4 C, D). The anterior branch gave origin to the deep petrosal nerve, which joins the greater petrosal nerve to form the Vidian nerve, and sent some filaments to the abducens and trigeminal nerves. Several small filaments entered foramina in the posterior wall of the vertical portion of the canal. These rootlets, and not the carotico-typanic artery or its branches as previously reported, pass through the foramina in the vertical portion of the canal.

**Foramen Lacerum**

The foramen lacerum is located between the petrous apex and the posterolateral part of the body of the sphenoid sinus. Fibrocartilage fills its lower half. It is approximately 1 cm long and no structures pass completely through it. The relationship of the carotid artery to the foramen lacerum is poorly understood because the carotid artery passes through only the upper half of the foramen. It courses above, not through, the inferior half of the foramen. The terminal part of the horizontal segment of the carotid canal opens into its midportion and the artery ascends through its upper half to enter the cranial cavity.

**Foramina Ovale and Spinosum**

The foramen ovale through which the mandibular root passes is anteromedial to the foramen spinosum and both foramina are anterior to the carotid canal. The foramen ovale and the foramen spinosum were separated by an average of 3.2 mm (range 1.0 to 6.0 mm) and the foramen spinosum and
foramen ovale lay an average of 4.7 mm (range 2.5 to 8.0 mm) and 4.4 mm (range 2.0 to 9.0 mm) anterolateral to the carotid canal, respectively.

**Trigeminal Nerve and Middle Fossa**

The portion of the middle fossa formed by the petrous apex has a slight depression for the trigeminal ganglion. The bone lateral to the trigeminal impression forms the roof over the medial part of the horizontal segment. In surgical approaches to the trigeminal and cavernous area through the middle cranial fossa, one tends to assume that the carotid artery is distant from the trigeminal nerve and floor of the middle fossa. However, the inferolateral edge of the trigeminal ganglion is separated from the terminal portion of the horizontal segment of the carotid artery by dura only or dura and a thin layer of bone and the superomedial edge rests against the ascending limb of the intracavernous segment of the artery (Figs. 1, 3, and 4). The portion of the ganglion, giving rise to the mandibular and maxillary divisions, lies directly above or over the anterior margin of the carotid canal in 98%. In 2%, the ganglion was anterior to the canal. Kerr suggested that pulsation of the carotid artery against the trigeminal nerve may cause trigeminal neuralgia.11

In a previous study by Harris and Rhoton,5 the carotid artery was exposed under some portion of the trigeminal nerve with only dura, and no bone, separating the nerve from the artery in 84% of instances, and in 38% the roof of the carotid canal was defective lateral to the edge of the third division. In this study, the carotid artery was exposed lateral to the trigeminal ganglion in 68%. In those carotid arteries exposed lateral to the trigeminal nerve, the average length of artery exposed was 5.2 mm, and the maximum was 14.0 mm. The average length of carotid artery exposed directly under the trigeminal was 8.2 mm, and if this is added to the length of artery exposed lateral to the nerve, the average total length exposed was 12.2 mm. A segment of carotid artery longer than 5 mm was exposed lateral to the ganglion in two-thirds and greater than 10 mm in one-third of cases. In the cases in which the carotid lateral to the nerve was covered by bone, this covering was usually thin and could be easily removed.

The average length of carotid artery that could be exposed lateral to the trigeminal nerve by bone removal was 10.2 mm (maximum 14.0 mm). In one specimen, the mastoid cells blocked exposure of the artery because pneumatization of the petrous apex was associated with a displacement of the horizontal segment 8 to 10 mm below the level of the trigeminal nerve and floor of the middle fossa. In the majority of specimens, a sufficient length of carotid artery could be exposed between the trigeminal and facial nerve for either end-to-end or end-to-side anastomosis (Fig. 4).

**Facial and Greater Petrosal Nerves**

The facial and greater petrosal nerves are considered together because they are intimately related through their connection at the geniculate ganglion, and because the greater petrosal nerve provides a reliable landmark for orientation of the initial dissection in the middle fossa approach to the carotid artery, facial nerve, and internal acoustic meatus (Figs. 2, 3, and 4 B-D). The approach to the internal acoustic meatus through the middle cranial fossa is done by removing bone successively over the greater petrosal nerve, the geniculate ganglion, the facial nerve, and the meatus.

The greater petrosal nerve originates at the geniculate ganglion, exits through the bone at the hiatus fallopi, and runs under the dura in an anteromedial direction toward the trigeminal ganglion. The proximal part of the greater petrosal nerve was usually covered by bone; however, in 30% the nerve had no bone covering after its origin from the geniculate ganglion. The average length of greater petrosal nerve covered by bone before exiting at the hiatus, was 3.7 mm, the range being 0.5 to 8.0 mm.

The greater petrosal nerve ran above but parallel to the horizontal segment; it was directly above the anterior margin of the horizontal segment in 66% of cases, anterior to the canal margin in 20%, and posterior to the canal margin and directly above the anterior half of the canal in 14%. The lesser petrosal nerve also arises from the geniculate ganglion, and enters a canal of bone separate from and anterior to the bone canal for the greater petrosal nerve (Figs. 2 B, C, 3 C). The geniculate ganglion was located either posterolateral (58%), directly posterior (26%), or directly lateral (16%) to the genu of the carotid. The average distance between the
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genu and the ganglion was 6.5 mm (range 3.0 to 13.0 mm).

The geniculate ganglion was usually separated from the floor of the middle fossa by a layer of bone; however, in 16% of specimens the geniculate ganglion had no bone covering and was exposed in the floor of the middle fossa. In the 84% with a bone covering, the average thickness of bone over the ganglion was 1.2 mm, a value in agreement with Rhoton, et al. These results show that there is danger of injuring the facial nerve at the time of elevating the dura from the roof of the temporal bone during surgery for trigeminal neuralgia. There are several reasons why the absence of bone over the geniculate ganglion is not readily noted during middle fossa surgical approaches. When exposed by the absence of bone, the genu and ganglion do not protrude from the bone defect, but remain flush with or slightly depressed from the surrounding bone surface. When such a bone defect is viewed from the side, as in the usual extradural subtemporal approach for trigeminal neuralgia, the irregularities of the floor of the middle fossa could hide it or make it barely perceptible. Because bleeding may result from elevation of the dura and avulsion of the petrosal branch of the middle meningeal artery from its entrance into the facial hiatus, it is easy to understand why electrocoagulation might be used in close proximity to the exposed facial nerve, although this should be avoided.

The junction of the facial canal and acoustic meatus lies an average of 2.3 mm (range 2.0 to 2.8 mm) below the surface of the middle fossa, and can be exposed by locating the geniculate ganglion and following the facial nerve medially toward the meatus. The initial portion of the facial canal lay an average of 6.6 mm (range 4.0 to 10.0 mm) from the genu of the carotid canal (Figs. 3, and 4 B–D). It is unlikely that the facial nerve would be damaged in exposing the carotid artery because of this wide separation and because the cochlea and its dense bony capsule is located between the carotid genu and the facial canal (Figs. 2 C, and 3 B, C). The average distance between the facial nerve and the cochlea was 0.8 mm.

Cochlea

The cochlea is encased in very dense bone anterior to the internal auditory canal, below the floor of the middle fossa and posterior to the carotid genu (Figs. 2 C, 3 B, C, 4 B, and 5 A). The superior aspect of the basal turn may be entered and injured in exposing the petrous portion of the carotid artery. Although the cochlea may lie as deep as 4.5 mm from the floor of the middle fossa, it could be as near the floor as 3.0 mm, the average depth being 3.8 mm. In most cases, the cochlea lay posterior or posterosuperior to the genu of the carotid artery, the average separation being 2.1 mm (range 0.6 to 10.0 mm).

Eustachian Tube, Tensor Tympani, and Middle Ear Cavity

The Eustachian tube and tensor tympani muscle are located anterior and parallel to the horizontal portion of the carotid canal below the floor of the middle fossa (Figs. 4 D, and 5 A). The tensor tympani muscle may be superior (72%), anterior (20%), or posterior (8%) to the Eustachian tube. A thin lamina of bone separated the floor of the semicanal of the tensor tympani from the roof of the semicanal of the Eustachian tube in 67% of specimens, but in 33% there was only mucosa and fibrous tissue separating them.

The tensor tympani muscle was separated from the carotid canal by a septum of bone in every case; septal thickness varied from 0.1 mm to 5.0 mm (average 1.3 mm). Although the superior surface of the tensor tympani muscle is usually covered by bone, a small part of it may be exposed in the floor of the middle cranial fossa through a bone dehiscence between the carotid canal and the foramen spinosum. The Eustachian tube was separated from the carotid artery by a thin layer of bone in 94%, and by mucosa only in 6%. In 56% the bone was very thin, measuring 0.1 mm to 0.3 mm in thickness, the average thickness being 0.8 mm.

The genu of the carotid artery was directly posterior to the entrance of the Eustachian tube into the middle ear (Figs. 4 D, and 5 A). The middle ear cavity lay posterolateral to the genu and vertical portion of the carotid canal in 63% of specimens, lateral in 20%, and posterior in 17%. The average thickness of bone separating the carotid canal and middle ear was 3.2 mm, and it was less than 1.0 mm in 22%. The internal carotid artery projected posteriorly into the middle ear cavity, and was separated from it by only mucosa in one case (2%). The close relationship between the
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carotid artery and the middle ear may permit middle ear infection to extend into the carotid canal.

Discussion

In 1971, Lougheed, et al., reported their experience with common carotid to supraclinoid ICA bypass using a saphenous vein graft. The procedure, done for occlusion of the cervical portion of the ICA, required temporary occlusion of the collateral through the posterior communicating artery and ophthalmic arteries, and provided only a 5-mm segment of carotid artery for the intracranial anastomosis. There was a marked improvement of blood flow to that hemisphere following the anastomosis. Others have also reported using saphenous vein bypass grafts for lesions proximal to the middle cerebral artery, because they could provide sufficient flow to supply both hemispheres and the posterior fossa contents, and the flow is anterograde and more physiological than the retrograde flow with superficial temporal to middle cerebral artery (STA-MCA) anastomosis. Even though the venous bypass graft to the supraclinoid carotid has these theoretical advantages over the STA-MCA anastomosis, the associated morbidity, the disadvantage of requiring occlusion of collateral flow, and the short arterial segment available for anastomosis have prevented it from gaining acceptance. Bypass to the petrous portion of the internal carotid may provide a suitable alternative to the supraclinoid segment. The petrous carotid can easily be exposed, and provides a 1-cm length of artery lateral to the trigeminal nerve for anastomosis. This portion of the carotid may remain patent in selected cases of ICA occlusions. This arterial segment does not give origin to any arterial branches that would jeopardize the neurological status of the patient if occluded. We suggest that this segment of the carotid artery may supplant the supraclinoid segment as the site for bypass grafting in selected cases of cervical carotid occlusions.

Surgical approaches to the floor of the middle fossa have been performed by neurosurgeons in the treatment of trigeminal neuralgia and by otologists in the treatment of eighth nerve hyperfunction and small acoustic neuromas. There is a risk of facial nerve injury following middle fossa retrogasserian rhizotomy, possibly because of interference with the blood supply to the facial nerve, traction upon the greater petrosal nerve that injures the facial nerve at the point of its origin from the facial nerve, or direct trauma to the geniculate ganglion where it is exposed in the floor of the middle cranial fossa. House has not reported any cases of facial nerve dysfunction following explorations of the internal auditory canal via the middle fossa. It seems reasonable to assume that the carotid could be approached with an equally low morbidity. Identification of the petrosal nerve and facial hiatus is the initial step for unroofing the facial or carotid canal. An awareness of the anatomical relationships reviewed above helps reduce the risk of injury to important structures during middle fossa exposures.

It has been assumed that there is antegrade thrombosis at least to the level of origin of the ophthalmic artery following occlusion of the ICA in the neck. However, there is evidence to suggest that antegrade thrombosis does not extend into the petrous canal. Angiographic patency of the cavernous and petrous carotid arteries has been demonstrated in ICA occlusions. It is postulated that the petrous and cavernous branches allow the retrograde flow needed to maintain the patency of these segments. Davie and Richardson were able to extract a thrombus from the distal internal carotid in a totally occluded carotid using a Fogarty catheter, and implied that the antegrade thrombosis had not extended past the petrous carotid. Shucart and Garrido reported four cases of complete carotid occlusions in which the thrombosis did not extend into the petrous carotid and flow could be restored. They concluded that the distal segment of the ICA remained patent because of the small arterial branches arising from the cavernous and petrous segments.

Petros carotid aneurysms may be of congenital (60%), traumatic (22%), postinfectious (9%), or atherosclerotic (9%) origin. One-half arose near the genu and projected posterior and lateral. The horizontal site was more frequently seen than the vertical segment, the latter accounting for only one reported case. The diagnosis of petrous carotid aneurysm has occasionally been made only after a biopsy was taken for a supposed tumor. Approximately one-third of
the cases presented with epistaxis or aural hemorrhage. The hemorrhage may be spontaneous or be induced by trauma such as myringotomy or picking the ear with an object such as a bobby pin. Epistaxis was more common than aural hemorrhage. The bleeding was controlled in most cases by packing the artery or carotid ligation, but was associated with a 9% mortality. In one case presenting with severe recurrent epistaxis, the diagnosis could not be made with angiography and the patient exsanguinated after the external carotid was ligated. Other presenting symptoms included hearing loss and tinnitus (44%), diplopia due to extraocular nerve involvement (16%), and trigeminal dysfunction (12%). The diagnosis was established preoperatively in most cases. The group with an accurate preoperative diagnosis did well following treatment as compared to the poor results when surgery was done in the absence of knowledge that the middle ear mass was an aneurysm.

Approximately one-half of the reported cases were treated with either common or internal carotid ligation or trapping, and 30% had no definitive treatment. An attempt was made to reinforce the aneurysm and preserve the patency of the artery in only two cases. Others appeared to have been located where they could have been treated by clipping the neck or reinforcement if it had been attempted.

References

This work was supported by NIH Grant NS 10978-03 and the American Heart Association Broward County Chapter, Inc.

This paper was presented at the Second National Joint Stroke Conference, February 25-26, 1977, in Miami, Florida.

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