Anatomy of the cavernous sinus

A microsurgical study

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Fifty cavernous sinuses from cadavers were studied in detail using magnification, with special attention to the relationships important in surgical approaches on the intracavernous structures, and to understanding arterial contributions to arteriovenous fistulas involving the cavernous sinus. Significant findings were: 1) The three main branches of the intracavernous portion of the carotid artery were the meningohypophyseal artery, present in 100% of the specimens, the artery of the inferior cavernous sinus (84%), and McConnell’s capsular arteries (28%). In addition, the ophthalmic and dorsal meningeal arteries arose from the carotid artery within the cavernous sinus in 8% and 6%, respectively. The three main branches of the meningohypophyseal trunk were the tentorial artery, present in 100%, the dorsal meningeal (90%), and the inferior hypophyseal (80%). 2) The carotid artery was separated from the trigeminal nerve just proximal to the sinus by only dura in 84% of the specimens, and the artery was exposed in the floor of the middle fossa lateral to the trigeminal nerve in 38%. 3) The intracavernous portion of the carotid artery indented the lateral side of the pituitary gland in 28% of dissections but could be as far as 7 mm from it. 4) A triangular area, described by Parkinson, through which the intracavernous portion of the carotid artery could be exposed surgically was found in all specimens. 5) The sixth cranial nerve may split into as many as five rootlets as it passes lateral to the intracavernous portion of the carotid artery. 6) The three major venous spaces within the sinus were posterosuperior, anteroinferior, and medial to the intracavernous portion of the carotid artery.

KEY WORDS • microsurgical anatomy • microsurgery • cavernous sinus • carotid artery • cranial nerves • carotid-cavernous fistula

The cavernous sinus is located nearly in the center of the head, and has connections with the cerebrum, cerebellum, brain stem, face, eye, orbit, nasopharynx, mastoid, and middle ear. These connections and the relationships of the cavernous sinus to the carotid artery, extraocular nerves, and pituitary gland make the sinus of special interest to neurologists, neurosurgeons, ophthalmologists, otolaryngologists, and endocrinologists. The sinus is connected to the orbit by the superior and inferior ophthalmic veins, to the cerebral hemispheres through the middle and inferior cerebral veins, to the retina by the central retinal vein, to the dura by tributaries of the
middle meningeal veins, to the transverse sinus via the superior petrosal sinus, to the jugular bulb by way of the inferior petrosal sinus, to the pterygoid venous plexus by the emissary veins passing through the cranial base, and to the facial veins through the ophthalmic veins.

The name "cavernous sinus" was first applied by Winslow, who noted that it contained numerous filaments which gave the interior of the sinus a cavernous or plexiform appearance. Because of the increasing frequency of use of magnification in dealing with problems involving the cavernous sinus, we studied this area under magnification.

Methods

The cavernous sinuses are located on each side of the sphenoid sinus, sella, and pituitary gland. They extend from the superior orbital fissure in front to the apex of the petrous portion of the temporal bone behind, and surround the horizontal portion of the carotid artery and a segment of the abducens nerve. The oculomotor and trochlear nerves, and the ophthalmic and maxillary divisions of the trigeminal nerve are in the lateral wall. Twenty-five tissue blocks containing 50 cavernous sinuses were removed from the cranial base of adult cadavers and examined under 3 to 40 × magnification. Each block contained the sella and both cavernous sinuses. Care was taken to preserve the normal anatomical relationships of the structures mentioned above.

Arterial Relationships

The initial portion of the intracavernous carotid ascended from the foramen lacerum toward the posterior clinoid process. Then it turned abruptly forward to its horizontal portion, approximately 2 cm in length, and terminated by passing upward on the medial aspect of the anterior clinoid process, where it perforated the roof of the cavernous sinus. 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. However, in 84% of instances the carotid artery was exposed under some portion of the trigeminal nerve with only dura, and no bone, separating the nerve from the artery (Fig. 1). In the 14% of specimens in which bone separated the nerve and artery the bone was often paper-thin. In 63%, the absence of bone over the carotid extended to the lateral edge of the trigeminal nerve and in 38% the bone covering the carotid was defective lateral to the edge of the third division. The maximum length of artery exposed lateral to the nerve was 7 mm (Figs. 2 and 3). Where the carotid artery was exposed lateral to the trigeminal nerve the average length of the artery exposed was 4.1 mm. Kerr suggested that pulsation of the carotid artery against the trigeminal nerve may cause trigeminal neuralgia. The cell bodies of the trigeminal sensory nerves supplying the more common trigger points in trigeminal neuralgia are on the medial side of the Gasserian ganglion adjacent to the carotid artery.

The more common branches of the carotid artery within the cavernous sinuses were the meningohypophyseal trunk, the largest intracavernous branch, present in 100% of our specimens, the artery of the inferior cavernous sinus, present in 84%, and McConnell's capsular arteries, present in 28% (Fig. 4). Less frequent branches of the intracavernous carotid were the ophthalmic artery (8%) and the dorsal meningeal artery (6%) (Fig. 5).

The meningohypophyseal trunk, the most proximal intracavernous branch, arose at the level of the dorsum sellae just before the apex of the first curve of the carotid where it turns forward after leaving the foramen lacerum. It was approximately the same size as the ophthalmic artery. Its divisions were near the roof of the cavernous sinus. The third and fourth nerves entered the dural roof of the cavernous sinus just above or slightly behind the trifurcation of the meningohypophyseal trunk. The meningohypophyseal trunk typically gave rise to three branches: 1) the tentorial artery, also called the artery of Bernasconi-Cassinari, which coursed laterally to the tentorium; 2) the inferior hypophyseal, which traveled medially to supply the posterior pituitary capsule; and 3) the dorsal meningeal artery which perforated the dura of the posterior cavernous sinus wall to supply the clival area and sixth nerve. Parkinson found the meningohypophyseal trunk and the above three branches to be present in 100% of his dissections of the cavernous sinus. A less frequent branch of the meningohypophyseal trunk was the artery of the inferior cavernous sinus which arose from it in 6% of our specimens.
Microsurgical anatomy of the cavernous sinus

The tentorial artery, the most constant branch of the meningohypophyseal trunk, present in 100% of instances, passed posterolaterally to the roof of the cavernous sinus and along the free edge of the tentorium, gave branches to the third and fourth nerves, and anastomosed with the meningeal branches of the ophthalmic artery and its mate of the opposite side. Bernasconi and Cassinari first reported the angiographic visualization of a tentorial artery supplying tentorial meningiomas. Schnürer and Stattin noted that the vessel had a wavy appearance and ranged from 5 to 35 mm in length in angiograms of normal subjects. If longer than 40 mm, a pathological lesion was considered probable. It has also been seen angiographically in metastatic tumors, trigeminal neuromas, and subtentorial arteriovenous malformations.

The dorsal meningeal artery arose from the meningohypophyseal trunk in 90% of specimens. It passed posteriorly through the cavernous sinus to the dura over the dorsum, sent a branch to the sixth cranial nerve, and anastomosed with its mate of the opposite side. In 6%, the dorsal meningeal artery arose directly from the carotid, below the meningohypophyseal trunk, and passed to the dorsum (Fig. 5).

The inferior hypophyseal artery, the least frequent of the three common branches of the meningohypophyseal trunk, was present in only 80% of dissections. It passed medially to the posterior pituitary capsule and lobe and anastomosed with its mate of the opposite side after supplying the dura of the sellar floor. It has been demonstrated angiographically, supplying pituitary adenomas and tumors of the sphenoid sinus.

The artery of the inferior cavernous sinus arose from the lateral side of the midportion of the horizontal segment of the intracavernous carotid approximately 5 to 8 mm distal to the origin of the meningohypophyseal trunk (Figs. 6 and 7). It arose directly from the carotid artery in 84% and from the meningohypophyseal artery in another 6%. It passed over the sixth nerve and downward medial to the ophthalmic division of the fifth nerve to supply the dura of the inferior lateral wall of the cavernous sinus and the area of the foramina ovale and spinosum. It may anastomose with the middle meningeal artery at the foramen spinosum. Some branches passed to the Gasserian ganglion. Schnürer and Stattin noted a branch of artery of the inferior cavernous sinus, the marginal tentorial artery, running along the tentorial edge. The artery of the inferior cavernous sinus has been seen angiographically in patients with sphenoid sinus carcinoma and with parasellar meningiomas.

We were able to identify carotid branches corresponding to McConnell's capsular arteries in only 28% of the specimens. They arose from the medial side of the carotid approximately 0.5 cm beyond the nearest proximal branch, the artery of the inferior cavernous sinus. McConnell described the inferior and anterior capsular arteries as follows: the inferior capsular arteries ran medially in the dura covering the sellar floor and the anterior lobe of the pituitary and anastomosed with the branches of the inferior hypophyseal artery; the anterior capsular artery originated just before the carotid pierced the dural roof of the cavernous sinus, and ran medially in the dura of the anterior sellar wall, anastomosing with its opposite mate. McConnell found these capsular arteries in half of his specimens. These arteries have been visualized angiographically in patients with sphenoid sinus carcinoma, craniopharyngioma, and parasellar meningioma.

In a previous study, Renn and Rhoto found that the ophthalmic artery arose within the cavernous sinus in 8% of the cases; in 2% it exited from the carotid artery in the cavernous sinus and entered the floor of the optic canal through a foramen in the bone; the other 6% entered the intracranial end of the optic canal. In this study, the location of the origin of the ophthalmic artery from the carotid artery was determined in relationship to the anterior clinoid. The anteroposterior site of origin was measured from the tip of the anterior clinoid and the transverse site was measured from the medial side of the anterior clinoid. The ophthalmic artery arose between 5 mm anterior and 7 mm posterior to the clinoid tip, and between 2 and 10 mm medial to the medial side of the anterior clinoid. The average ophthalmic artery arose 0.6 mm anterior to the tip of the anterior clinoid and 4.5 mm medial to the clinoid.

Another artery, larger than the meningohypophyseal trunk, which may pass through the cavernous sinus but was not present in any
Fig. 1. Superolateral view of the pituitary gland and right cavernous sinus and intracavernous structures including the carotid artery and the third, fourth, fifth, and sixth cranial nerves (CN III, IV, V, and VI). Upper: Lateral dural wall of cavernous sinus removed. Tortuous carotid artery bulges superiorly pushing interclinoid ligament and cavernous sinus roof upward, and indents the lateral margin of the pituitary gland. The inferior hypophyseal artery passes to the pituitary gland. CN III and IV enter the roof of the cavernous sinus by passing through the interclinoid ligament. CN VI on the left side enters the dura posterior to the dorsum and passes laterally around the left carotid artery. CN VI is above the superior margin of the trigeminal sensory (CN V5) and motor roots (CN Vm) and only the first division (CN V1) is exposed distal to the ganglion. Lower: Further dural removal exposes the trigeminal root and its second (CN V2) and third divisions (CN V3). The foramen lacerum is exposed lateral to the Gasserian ganglion. The trigeminal root is reflected laterally to show a second branch of the CN VI as it passes lateral to the carotid artery.

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Microsurgical anatomy of the cavernous sinus

of our cases is a persistent trigeminal artery. This artery arises from the carotid artery in the cavernous sinus proximal to the origin of the meningohypophyseal trunk, and joins the basilar artery between the superior cerebellar and anteroinferior cerebellar arteries.\textsuperscript{16} Wallace, \textit{et al.},\textsuperscript{20} stressed the importance of a knowledge of the cavernous arterial branches, because of the frequency with which these branches are visualized angiographically in carotid cavernous fistulas, stenotic lesions of the carotid, and intracranial tumors. The branches of the cavernous carotid anastomosed with those of the opposite side and provide an important collateral pathway in occlusion of the internal carotid artery below the cavernous sinus. These branches also enlarge and are of significance in the diagnosis and management of carotid-cavernous fistulas. The demonstration of these arteries does not necessarily indicate the presence of a lesion but their presence should precipitate careful review of the base of the skull and tentorium.

Parkinson\textsuperscript{13} noted that spontaneous carotid-cavernous fistulas that are presumed to be due to aneurysm rupture have a single source and occur at the junction of one of the branches with the intracavernous carotid. Traumatic fistulas due to tears of the carotid and or one or more of its intracavernous branches may have several sources, and are commonly located anteriorly in the sinus.\textsuperscript{13}

\textbf{Venous Relationships}

We found three main venous spaces within the sinus, and identified them for their relation to the carotid artery; they are the medial, the anteroinferior, and the posteroinferior compartments. The medial compartment lay between the pituitary gland and the carotid artery (Fig. 4). The medial space was as wide as 7 mm but was frequently obliterated by a tortuous carotid which indented the pituitary gland (Fig. 8). The anteroinferior space was in the concavity below the first curve of the intracavernous carotid (Figs. 1 and 7). The sixth nerve entered the anteroinferior space after passing around the intracavernous portion of the carotid (Fig. 7). The posteroinferior space was between the carotid and the posterior half of the roof of the sinus.

\begin{figure}
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\includegraphics[width=\textwidth]{fig1}
\caption{(continued). The trigeminal root is reflected forward exposing the carotid artery in the foramen lacerum. A sympathetic nerve bundle is on the surface of the carotid artery in the foramen lacerum. Three rootlets of CN VI are seen passing around the carotid. The outline of the carotid artery is marked with a broken line in the areas where it is out of view in the petrous bone and in the cavernous sinus. The tortuous artery obliterates the posterosuperior and medial venous space but the anteroinferior space is seen in the concavity of the initial curve of the carotid artery within the sinus.}
\end{figure}
FIG. 2. Superolateral view of right cavernous sinus showing the pituitary gland, carotid artery, and second through sixth cranial nerves (CN II through VI). Upper: CN III and IV enter the roof of the cavernous sinus and CN VI enters posteriorly. The intracavernous carotid artery is exposed in the sinus. Broken line outlines Meckel’s cave containing the posterior trigeminal root. The posterosuperior venous space is between the initial intracavernous carotid curve and the dorsum. The carotid does not indent the pituitary as was seen in Fig. 1. Center: The dura of the medial part of the floor of the middle fossa has been removed exposing the second and third trigeminal divisions (CN V2 and V3), the foramen spinosum and middle meningeal artery, the foramen rotundum and ovale, and the foramen lacerum. The carotid artery is exposed in the foramen lacerum lateral to the trigeminal nerve. The inferior hypophyseal artery passes to the pituitary gland. The medial venous space is between the carotid and the pituitary. Lower: The trigeminal nerve is reflected forward to show the carotid artery exposed under the nerve. At the medial margin of the foramen lacerum there is a fibrous bridge over the carotid artery just prior to the point that it enters its intracavernous portion.
Microsurgical anatomy of the cavernous sinus

(Figs. 1 and 2). The meningohypophyseal artery arises in this space. A tortuous elongated carotid artery may obliterate the posterosuperior space (Fig. 1). These three venous spaces are larger than the space between the carotid artery and the lateral sinus wall. The lateral space is so narrow that the sixth nerve which passes through it is adherent to the carotid on its medial side and to the sinus wall on its lateral side. Most investigators regard the sinus as extending lateral to the carotid artery; however, Bedford described the medial side of the carotid as the lateral border of the sinus, and concluded that the internal carotid artery and sixth nerve formed the lateral boundary of the sinus and lay outside the lumen of the sinus except in 8% of 34 adult specimens in which the carotid and abducens nerve were within the sinus.

In our microsurgical dissections, the sinus appeared to be largely an unbroken, trabeculated, venous channel. Parkinson, based on his surgical observation and corrosion studies, disputes the concept that the cavernous sinus is a large venous cavern, and concluded that it is a plexus of various-sized veins which divide and coalesce and incompletely surround the carotid artery. Parkinson's observations mean that it is possible to work within the space commonly known as the cavernous sinus and yet be outside both the arterial and venous compartments of a fistula, and that fistulas can be repaired with a single clip, preserving the carotid artery. Parkinson applied his concepts in treating several carotid-cavernous fistulas, and by using hypothermia and circulatory arrest, was able to occlude the fistula and preserve the carotid artery. Parkinson applied his concepts in treating several carotid-cavernous fistulas, and by using hypothermia and circulatory arrest, was able to occlude the fistula and preserve the carotid artery without trapping it. Bonnet agreed that the cavernous sinus as such did not exist, that the space between the two layers of dura is filled with a plexus of various-sized veins which divide and coalesce and incompletely surround the carotid artery. Bedford, based on a study of 34 sinuses, reached the opposite conclusion that the cavernous sinus was virtually an unbroken venous channel, and not a plexus of veins.

The intrasellar venous connections across the midline are described as intercavernous sinuses and have been the subject of a recent review by Renn and Rhoton. An intrasellar connection between the two cavernous sinuses may exist at any point from the anterior to posterior wall of the sella including the diaphragma, or all connections between the two sides may be absent. Typically there were anterior and posterior intercavernous sinuses. The anterior intercavernous sinus may cover the whole anterior wall of the sella. Concern about the intrasellar connections may lead us to forget that the most constant and largest connection between the two sinuses is the basilar sinus. This connection lies posterior to the dorsum and receives the superior and inferior petrosal sinuses. The sixth nerve often enters the posterior margin of the cavernous sinus by passing through the basilar sinus. One of us (ALR) has seen proptosis due to a fistula between the dorsal meningeal branch of the meningohypophyseal trunk and the basilar sinus.

One of the authors (ALR) had the opportunity to review the records of four patients with pulsating exophthalmos who were treated with "trapping" by ligation of the internal carotid artery above and below the cavernous sinus and who became hemiplegic after the procedure, which did not alter their proptosis or bruit. All four had the fistulas demonstrated prior to their surgery on common carotid angiography and it was incorrectly assumed that the fistulas were fed by the internal carotid. Subsequent angiography revealed that the fistulas were fed from the external carotid. These cases and other reports illustrate the need for careful selective internal and external carotid angiography prior to making a decision about the surgical therapy of fistulas in the cavernous sinus. In dealing with a carotid-cavernous fistula it is important to remember that the proptosis may occur on the side opposite the cavernous sinus harboring the fistula, as was seen in some of Dandy's cases.

Proptosis may occur with arteriovenous fistulas in intracranial locations other than the cavernous sinus. We have seen two patients present with proptosis caused by fistulas between the branches of the external carotid artery and the lateral sinus. Serial angiography in one showed flow from the fistula through the vein of Labbé to the Sylvian veins and then into the cavernous sinus and ophthalmic veins. The other drained through the petrosal sinuses into the cavernous sinus and then to the orbit.
F. S. Harris and A. L. Rhoton, Jr.

**Fig. 3.** Superolateral view of the left cavernous sinus. *Upper:* Carotid artery is exposed lateral to the trigeminal nerve in the foramen lacerum. The middle meningeal artery and foramen spinosum are seen posterolateral to the foramen ovale. The initial curve of the intracavernous portion of the carotid artery projects upward above the level of the interclinoid ligament and obliterates the posterosuperior venous space. The carotid also indents the lateral margin of the pituitary gland and obliterates the medial venous space. *Lower:* With the trigeminal nerve reflected forward, a bridge of bone is seen over the carotid between foramen lacerum and intracavernous portion of the carotid.

**Neural Relationships**

The location of the nerves from superior to inferior were the third nerve superiority with the trochlear, abducens, and ophthalmic division of the trigeminal nerve (Figs. 1, 2, 6, and 7). The oculomotor, trochlear, and first trigeminal division lie between the two dural leaves of the lateral sinus wall. The abducens was within the sinus being adherent to the carotid artery medially and the lateral sinus wall laterally. The third and fourth nerves are closely approximated and run together within the dural roof of the cavernous sinus.
Microsurgical anatomy of the cavernous sinus

**Fig. 4.** Superior view of the cavernous sinus, anterior and posterior lobe of pituitary, the intracavernous portion of the carotid artery and the meningohypophyseal trunk with its three branches, the inferior hypophyseal, the tentorial, and dorsal meningeal arteries. The ophthalmic artery arises from the anterior surface of the carotid artery above the clinoid and enters the optic canal under the optic nerve. The dorsum was removed to expose the posterior lobe of the pituitary. The sixth cranial nerve (CN VI) receives a branch from the dorsal meningeal artery and courses laterally around the carotid artery. The dural ostium of CN III, left, is in the roof of the cavernous sinus and CN III, right, enters its dural ostium. The carotid artery is exposed in the medial part of the foramen lacerum, left.

Throughout their course to the superior orbital fissure. The third and fourth nerves enter the dural roof of the cavernous sinus with the third nerve in front and slightly lateral to the fourth nerve. Both are medial to and slightly beneath the ridge of the free edge of the tentorium at their point of entry. The third nerve entered the cavernous sinus slightly lateral and anterior to the dorsum sellae almost directly above the meningohypophyseal trunk. The oculomotor nerve pierced the sinus roof between 2 and 7 mm posterior to the initial supraclinoid segment of the carotid artery; the average separation was 5 mm. Just above its point of entry into the sinus the third cranial nerve is compressed by internal carotid aneurysms.

The ophthalmic division of the fifth cranial nerve enters the cavernous sinus wall inferiorly and slopes slightly upward to depart through the superior orbital fissure. The sixth nerve enters from the clivus and bends laterally around the proximal portion of the cavernous carotid artery and runs medially and parallel to the ophthalmic division of the fifth nerve. It is within the cavernous sinus. The sixth nerve is occasionally double up to its point of entrance to the dura. We found that the abducens nerve was not always a single trunk in the cavernous sinus but that it frequently split into multiple rootlets. In the majority of cases there was only one rootlet, but a maximum of five were seen. This nerve consisted of one rootlet in 34 specimens, two in 13, three in two, and five in one.

**Fig. 5.** Posterior view of the cavernous sinus showing the initial segment of the carotid artery in the posterior part of the cavernous sinus. The sixth nerve (CN VI) passes from the posterior fossa around the lateral margin of the carotid artery. The dorsal meningeal artery has a separate carotid arterial origin from the meningohypophyseal trunk. The meningohypophyseal trunk gives rise to the inferior hypophyseal and the tentorial artery. A sympathetic nerve bundle is seen passing around the carotid on the medial side of CN VI.
FIG. 6. Lateral view of the right cavernous sinus showing the intracavernous carotid and the third through sixth cranial nerves (CN III through VI). The artery of the inferior cavernous sinus consistently passes over the upper surface of CN VI and downward medial to the first division of CN V. The anteroinferior venous space is below the carotid.

Parkinson described a triangle through which the intercavernous portion of the carotid artery could be surgically approached. In this study, the superior margin of the triangle formed by the lower margin of the fourth cranial nerve ranged in length from 8 to 20 mm, the average being 13 mm; the inferior margin formed by the upper margin of the fifth cranial nerve ranged in length from 5 to 24 mm, the average being 14 mm; the posterior margin represented by the slope of the dorsum and clivus ranged from 3 to 14 mm, the average being 6 mm. The average triangle measured $13 \times 14 \times 6$ mm; however, it could be very small, measuring only $8 \times 5 \times 3$ mm. It may not be large enough to provide a good surgical exposure of all of the arterial branches within the sinus. Through an incision starting 4 mm beneath the dural entrance of the third nerve and extending anteriorly approximately 2 cm parallel to the slope of the third and fourth nerve, Parkinson could expose the meningohypophyseal trunk and the artery of the inferior cavernous sinus. The sixth nerve at the bottom edge of the exposure was seen upon retracting the superior aspect of the fifth cranial nerve. The most forward aspect of the cavernous carotid as it turns upward was not seen through this exposure unless the artery was grasped and pulled backward. Parkinson felt that the triangle would provide access to most spontaneous fistulas assuming that they are due to ruptured aneurysms developing at the point of departure of the meningohypophyseal trunk or artery of the inferior cavernous sinus, but that this is not the case if McConnell's arteries are involved.

FIG. 7. Lateral view of the right cavernous sinus with the trigeminal ganglion removed, showing the carotid artery medial to the trigeminal ganglion. The artery of the inferior cavernous sinus passes over the sixth nerve (CN VI). A sympathetic bundle is seen leaving the anterior surface of the carotid artery and passing upward to join CN VI. A small ganglion rests on the artery of the inferior cavernous sinus. CN III and IV pass through the roof of the cavernous sinus. The sympathetic bundle passes through the anteroinferior venous component of the sinus.
Microsurgical anatomy of the cavernous sinus

Sympathetic fiber bundles large enough to be recognized without the microscope were seen traveling on the surface of the carotid as it emerged from the foramen lacerum. They jumped over to the sixth nerve within the sinus before ultimately being distributed to the first division of the trigeminal nerve (Figs. 1 and 7). It is assumed that these nerves pass to the internal carotid artery from the superior cervical ganglion and enter the carotid canal where the latter forms a plexus around the carotid artery. The caroticotympanic and deep petrosal nerves arise from the plexus within the carotid canals. Within the cavernous sinus the plexus sends filaments to the trigeminal nerve via the sixth nerve and from it to the ciliary ganglion. The remainder of the plexus continues upward around the artery as it emerges from the cavernous sinus. No sympathetic fibers have been traced to the third and fourth nerves.

Pituitary Relationships

The mean distance between the medial margin of the carotid artery and the lateral margin of the pituitary gland in the group in which the carotid did not indent the gland was 2.3 mm; however, in 28% of the specimens, the artery protruded through the medial wall of the sinus and indented the gland. The maximal separation between the pituitary and carotid was 7 mm. Frequently, a tongue of gland overlapped the artery superiorly. There is a tendency to think of the pituitary as roughly spherical, however, this is not uniformly true. The pituitary gland overlapped the carotid in 28% of the cases (Fig. 8) with a tongue-like projection which would be difficult to remove during transsphenoidal hypophysectomy. Such residual fragments may explain the pituitary function which remains after attempted hypophysectomy. Heavy arterial bleeding has been reported during transsphenoidal hypophysectomy. This has been reported as due to carotid artery injury but may also have arisen from a tear in an arterial branch of the carotid such as the inferior hypophyseal artery or by avulsion of a small capsular artery from the carotid artery.
References

3. Bonnet P, cited in reference 1
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