The Arterial Supply of the Human Optic Chiasm

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The visual field changes that accompany pituitary tumors are among the most certain localizing signs in neurology. Most textbooks of anatomy demonstrate the decussation of the medial retinal fibers in the central chiasm by descriptions of the bitemporal field defects that occur in chiasmal compression.

However the distortion of the visual pathways by pituitary tumors is seldom limited to the central chiasm; more often pressure is distributed along the inferior surfaces of the optic nerves, optic chiasm, and optic tracts (Fig. 1). The altitudinal visual field defects that might be anticipated from such compression are rarely found. Moreover, anterior third ventricle tumors, which equally distort the optic pathways from above, cause patterns of visual loss that are less predictable and less regular.7 The central portion of the chiasm in which the decussating fibers are found appears to be especially vulnerable to distortion and compression from below.

This report includes observations at autopsy of the arterial blood supply of the extra-cerebral parts of the visual pathways. The peculiar derivation of the blood supply of the central chiasm suggests that vascular compression rather than neural compression contributes to the bitemporal hemianopsia so commonly seen in pituitary tumors.

Method

The removal of the brain at autopsy by traditional methods involves cutting across the visual pathways and inevitably destroying their vascular relationships. To circumvent this problem, several techniques of obtaining and studying autopsy material were employed.

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Fig. 1. A pathological specimen of a pituitary tumor. The tumor is several centimeters wide and distorts the inferior aspects of the optic nerves, chiasm, and optic tracts. The central chiasm is not selectively distorted, yet “examination revealed a bitemporal hemianopsia with a central scotoma of the right eye.” (Published through the courtesy of Armed Forces Institute of Pathology; Acc. Number 219933-14.)

The initial anatomical observations were made during the course of the dissection of 225 autopsy specimens. These were obtained by removing the brain but leaving the anterior hypothalamus, infundibulum, optic chiasm, and optic nerves in situ. The block of bone containing the pituitary and surrounding structures was then removed with a motor saw for further dissection. These dissections were performed to delineate the patterns and frequency of the anatomical variations that surround the pituitary,1 but there was ample opportunity to observe the vascular anatomy pertinent to the local visual structures.
In 50 additional autopsies the chiasm and optic nerves were left attached to the brain which was removed in the traditional manner by sectioning the optic nerves at the optic foramina and dividing the pituitary infundibulum at the level of the diaphragm. Care was taken to preserve the chiasmal arachnoid and small vessels surrounding the visual pathways. Following fixation in formalin the chiasmal arachnoid was removed and the small arteries surrounding the visual pathways demonstrated by dissections.

In 200 additional autopsy specimens, the brain was removed leaving the anterior hypothalamus, infundibulum, optic chiasm, and optic nerves in situ. The bony blocks were removed with a motor saw and fixed in formalin. Then the pituitary gland and attached infundibulum, hypothalamus, and chiasm were dissected free from the surrounding structures and embedded en bloc in paraffin. Either sagittal or coronal sections of this material were cut to include these several structures and appropriately stained. Only the microscopic observations pertinent to the vascular supply of the visual structures are included in this report.

In five additional blocks of bone, the carotid arteries were injected after removal with red silastic (Microfil) to demonstrate more clearly the arteries surrounding the chiasm.

**Results**

The optic nerves, chiasm, and optic tracts pass through the circle of Willis, coursing below the anterior cerebral arteries and anterior communicating artery and above the posterior cerebral arteries, basilar artery, and posterior communicating arteries (Fig. 2). This allows a natural separation of the chiasmal blood supply into a superior and an inferior group of arteries. The superior group of vessels is derived from the two anterior cerebral arteries and, occasionally, from the anterior communicating artery above the optic pathways. The inferior group is derived from the basilar, the posterior communicating, the posterior cerebral, and the internal carotid arteries.

Invariably during removal of the specimens the vascular relationships were partially disrupted. In the fresh specimens, the specimens for microscopic study, and the injected specimens, those vessels above the optic pathways were partially or totally disrupted by the oblique section through the chiasm. In the fixed specimens, the vessels below the visual pathways were disrupted despite the care during removal. The totality of the blood supply to these structures could be appreciated only by combining the observations from the various specimens.

**Fresh Autopsy Specimens.** These specimens included the posterior portion of the circle of Willis; the small vessels extending from the circle of Willis to the visual pathways were usually preserved allowing dissection and descriptions of the inferior group of arteries. Most if not all of these arteries coursed toward the median eminence and infundibulum and are properly designated superior hypophyseal arteries. Between four and eight small vessels may be found on either side; rarely were these symmetrical in their number, size, or course. Numerous anastomoses were found in this arterial complex, and many small branches were seen to penetrate the inferior surfaces of the optic nerves, chiasm, and optic tracts.

**Fixed Specimens.** The fixed brains included the optic nerves and pituitary infundibulum in continuity with the rest of the brain. Despite careful removal, the inferior group of vessels was often disrupted, but those vessels above the visual pathways were invariably preserved and could be studied in detail. Moreover, these fixed specimens included the third ventricle and lamina terminalis, structures which bear important relationships to the superior group of vessels.

**Superior Arteries.** The superior group of arteries consisted of several small vessels that were derived from the two anterior cerebral arteries as they pass above the optic pathways. Between one and four small vessels arose from either anterior cerebral, more often than not the number was symmetrical. These vessels extended to the upper surfaces of the optic nerves and optic tracts but only to the lateral portions of the chiasm (Figs. 3-5). Occasionally a single small artery arose from the anterior communicating, but in most instances this artery was not present and it was always of much smaller diameter than the vessels in the lateral groups.

The lamina terminalis, covering the supra-chiasmal extension of the third ventricle,
invariably separated the lateral groups of arteries that descend from the anterior cerebral arteries to the lateral portion of the chiasm. Indeed, the lamina terminalis and underlying recess preclude the superior group of vessels from directly contributing to the arterial supply of the central portion of the chiasm. Occasionally small vessels were found immediately anterior to the lamina terminalis, but these were most often derived from the inferior group of vessels which have extended up the anterior part of the chiasm (Fig. 6). Only rarely did the small artery which sometimes arose from the anterior communicating artery remain above the lamina terminalis; most often it extended either to the right or left.

Most of the specimens utilized for micro-

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**Fig. 2.** Illustrations of the visual pathways and their arterial supply. It is apparent that the visual pathways pass through the circle of Willis, and the arterial supply can be divided into a superior and an inferior group. The superior group of vessels is derived from the anterior cerebral arteries (ACA) and spares the central chiasm. The inferior group of vessels is derived from the internal carotid artery (ICA), the posterior cerebral artery (PCA), and the posterior communicating artery. The central chiasm containing the decussating fibers derives an arterial blood supply only from the inferior group of vessels.
Fig. 3. A fresh autopsy specimen to show the superior group of arteries descending from the anterior cerebral arteries (ACA). The absence of arteries above the lamina terminalis (LT) and underlying central chiasm is apparent.

Fig. 4. The inferior aspect of the chiasm after injection with Microfil. The rich arterial supply and frequent anastomoses are evident. The median eminence and transected pituitary stalk (arrow) are especially vascular; most of the arteries in this area extend to these structures and are properly designated superior hypophyseal arteries.

Fig. 5. A sagittal view of the human chiasm, median eminence and attached pituitary which has been injected with Microfil. The arrows denote arteries extending from the median eminence upward into the central chiasm.
Fig. 6. A sagittal section of the central chiasm and infundibulum. Several arteries are seen below and anterior to the chiasm and numerous vessels extend up into the central chiasm from below (arrows). The single artery anterior to the lamina terminalis is derived from the inferior group of vessels. The supra-optic recess precludes the superior vessels from reaching the central chiasm.

scopic examination were sectioned in the sagittal plane making it possible to study the relationships of the third ventricle, hypothalamus, optic chiasm, infundibulum and pituitary gland. The sections generally included the inferior group of vessels that surround the infundibulum; these vessels were especially numerous in the angle formed by the anterior aspect of the infundibulum and the inferior aspect of the chiasm. Many of these vessels entered the substance of the infundibulum at this point to form the vascular coils that make up the beginning of the pituitary portal system. Of particular interest is the regularity with which small arterial branches extended up into the chiasm. Some of these vessels angled posteriorly, others coursed directly superiorly, and sometimes small branches extended along the anterior surface of the chiasm before penetration (Fig. 6).

In the sagittal sections the extensions of the lamina terminalis and supra-optic recess above the chiasm were apparent. As in the gross dissections, vessels were seldom seen above the lamina terminalis. Rarely small vessels were noted in the ependyma of the supra-optic recess but these vessels were neither as numerous or as large as the vessels which penetrated the chiasm from the inferior surface.

On coronal section the vascular pattern was even more apparent (Fig. 7). The numerous vessels entering the central portion of the chiasm from below were readily apparent and the paucity of vessels in the ependyma of the supra-optic recess above the central chiasm became more obvious. These coronal sections also included the superior group of vessels and support the gross anatomical observation that these arteries enter the lateral portions of the chiasm to the left and right of the lamina terminalis.

Injections of red silastic (Microfil) were

Fig. 7. A coronal section of the chiasm. The superior group of vessels (top arrows) are separated by the lamina terminalis and supra-optic recess. The central chiasm has several vessels penetrating from below (bottom arrows); none from above.
performed after bony blocks of tissue had been removed with the motor saw and the superior group of vessels was most often partially disrupted during removal. However, the inferior group of vessels remained intact and the injections graphically confirm the previous descriptions of this group of arteries. It was apparent from these injection specimens that the majority of the vessels extend to the median eminence or infundibulum which were revealed as remarkably vascular structures (Figs. 4 and 5). The rich arterial network of the inferior surfaces of the optic nerves, chiasm, and optic tracts was especially obvious by this technique.

**Discussion**

Several clinical observations suggest that other factors than nerve compression might be involved in the bitemporal hemianopsia caused by pituitary tumors. First and foremost is the repeated observation of pressure upon the inferior aspect of the optic nerves, chiasm, and optic tracts, yet a virtual absence of altitudinal visual defects (Fig. 1). Second, despite numerous variations in the normal anatomy of the chiasm and great variation in the degree and pattern of chiasmal distortion, the patterns of visual loss remain monotonously similar. Third, compression of the chiasm from above by anterior third ventricle tumors is attended by patterns of visual loss that are much less frequent and much more irregular even though the degree of chiasmal distortion often equals that seen in pituitary tumors. Fourth, the rapid recovery of vision that attends decompression of pituitary tumors implies that factors other than nerve compression are involved.

Other anatomical observations pertinent to chiasmal distortion have stressed the possibility of blood vessels playing a role in the visual loss seen with pituitary tumors. Rucker and Kernohan have pointed out that the prechiasmal mesial retinal fibers may be compressed between the tumor and the yoke formed by the elevated anterior cerebral arteries; this situation is seldom noted during pituitary surgery and does not apply in the majority of cases. Dawson described the blood supply of the chiasm and concluded that many instances of visual loss resulted from vascular rather than neural compression. His drawing and photographs reveal an absence of arteries above the lamina terminalis, but no significance was attached to this observation. François, et al., employed microradiography to show 11 separate vascular areas of the chiasm but did not specify whether in the vascular supply the inferior or the superior arteries were more crucial; they concluded that it is difficult to sort out the effects of vascular compression from the effects of neural compression. Hughes recorded his neurosurgical experience and related anatomical studies to conclude that the visual losses seen with pituitary tumors were often of vascular origin.

The anatomical observations from this autopsy study support the validity of dividing the chiasmal arterial supply into a superior and an inferior group of vessels. The superior group of arteries supplies the optic nerves, and optic tracts, but only the lateral portions of the optic chiasm. The inferior group of vessels supplies the optic nerves, optic tracts, and all of the optic chiasm. The central portion of the chiasm derives its blood supply only from the inferior vessels (Fig. 2).

Observations during craniotomy confirm these autopsy findings. During third ventriculostomy (our experience includes 36 operations), the approach through the lamina terminalis is virtually bloodless and the vessels extending from the anterior cerebral arteries to the superior surface of the chiasm can be seen on either side. During hypophysectomy (our experience includes 950 operations), numerous small vessels, the inferior group of arteries, are encountered beneath the chiasm.

During pituitary tumor surgery (our experience includes 250 operations), the inferior group of arteries is often found to be distorted by the tumor mass; the vessels commonly appear less numerous, more stretched and of smaller diameter than normal (Fig. 8). The optic nerves, optic chiasm, and optic tracts may be distorted in a variety of ways, but seldom is the distortion limited to the central chiasm. Almost without exception the inferior group of vessels is distorted by the underlying tumor to a greater degree than are the visual structures.

**Summary**

Autopsy examinations of 480 human
brain specimens to study the arterial blood supply of the extra-cerebral parts of the visual pathways have led to the following conclusions. The visual pathways course through the circle of Willis and receive an arterial blood supply from a superior and an inferior group of vessels. The decussating fibers in the central chiasm receive their arterial supply solely from the inferior group of vessels. During pituitary tumor surgery these inferior vessels are commonly distorted suggesting that the bitemporal field defects caused by pituitary tumors results from ischemia rather than from neural compression.

References
1. BERGLAND, R. M., RAY, B. S., and TORACK, R. M. Anatomical variations in the pituitary gland and adjacent structures in 225 human