THE ARTERIAL BLOOD SUPPLY OF THE HUMAN HYPOPHYSIS CEREBRI

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ELEVEN FIGURES

The blood supply of the human hypophysis cerebri is of considerable interest, particularly since 1930 when Popa and Fielding reported the existence of a portal system of vessels in the stalk of this gland. Their articles led to considerable discussion, and the studies of Wislocki ('37), Harris ('48) and several other investigators have been directed to the elucidation of this particular system. The subject has recently become of considerable practical importance because of the finding that women at delivery are liable under certain conditions to develop ischaemic necrosis of the anterior lobe. For this reason a detailed study of the blood supply of the human hypophysis has been undertaken.

MATERIAL AND METHODS

The arterial supply of the human hypophysis was studied in adults of both sexes varying in age from 25 to 70 years. In nearly all cases the glands were removed between 1 and 12 hours after death. A total of 50 successful preparations were studied in detail; nearly 100 further glands were partially examined, but the information obtained from them was not very satisfactory owing to technical difficulties.

The following methods of investigation were employed.

(a) Serial sections of uninjected specimens, stained with a modified Weigert elastic tissue stain.

(b) Injection of the internal carotid arteries in the neck with a colored radiopaque injection material, followed by dissection of hypophyseal region.

(c) Selective injection of the inferior and superior hypophyseal arteries, followed either by histological serial sectioning or by clearing of the complete block of tissue.

Injection of thick masses via the internal carotid arteries in the neck

This method consisted of the injection of all the arteries in the cranial cavity, and the subsequent removal of the hypophyseal block.

The cannulae from the injection apparatus were tied into the internal carotid arteries just above their origins, and in some cases also into the vertebral arteries; in other cases the vertebral arteries were merely ligatured. The face was frozen with carbon dioxide alcohol, to prevent any of the injection mass from reaching the skin or the eyes. About 150 to 200 cm^3 of the mass was then injected, under a manometer pressure of 100 to 150 mm Hg. Subsequently the skull was opened, and the hypophyseal block of tissue removed.

The tissue removed for examination consisted of the hypothalamus and all the underlying non-bony structures, dissected in a single piece from the base of the skull. Anteriorly this block included the optic nerves up to the optic foramina, laterally the complete cavernous sinuses, and posteriorly the dura behind the posterior clinoid process. Great care was taken not to stretch the attachments of the hypothalamus to the hypophysis during the removal.

The injection masses used were of such a consistency that they did not leak excessively from the tissues of the neck. The two masses were:

1. Barium sulphate in 1% sodium alginate solution. After the injection, this mass was solidified by placing the block in saturated calcium chloride solution.

2. Red lead in glue; this solidifies on cooling.

In some cases the tissue was examined by radiography or by clearing of the complete block, but the results were very difficult to interpret owing to the extreme vascularity of the region. Dissection, however, gave very satisfactory results and elucidated the course of all the vessels running from the internal carotid artery to the hypophysis. The injection masses used in these investigations were too viscid to demonstrate the small vessels within the hypophyseal stalk or gland.

Selective injections of the hypophyseal arteries

The distribution of the inferior and superior hypophyseal arteries in the gland and the stalk was studied by selective injection of these arteries, using less viscous injection masses and a different technique. The hypophyseal block of tissue was removed from the body without any preliminary treatment, and was injected on the bench.

For injection of the inferior hypophyseal artery, a cannula was tied into the proximal end of the internal carotid artery, which was then ligatured halfway along its course within the cavernous sinus. By this method only the inferior hypophyseal artery and its branches are filled with the injection mass.

Injection of the superior hypophyseal arteries was more difficult to execute, and two methods were used. (a) A cannula was inserted along the middle cerebral artery and tied into the internal carotid artery, proximal to its bifurcation and to the origin of the posterior communicating artery. The ophthalmic artery was ligatured at its origin and the internal carotid artery about halfway along its course within the cavernous sinus. (b) The internal carotid artery was divided about halfway along its course in the cavernous sinus, and a cannula inserted into the proximal end of the distal segment. The internal carotid artery was tied proximal to its bifurcation and to the origin of the posterior communicating artery, and the ophthalmic artery was tied at its origin.

Two types of injection mass were used; these were of sufficiently low viscosity to allow the injection of the small arteries and capillaries:

1. India ink, carmine gelatine, or 0.1% sodium alginate containing monolite fast scarlet or monastral fast blue.[1] For injection, a short piece of rubber tube was attached to the cannula and the entire lumen of tube and cannula was filled with the injection mass. The open end of the rubber tubing was then occluded and further injection mass injected into the rubber tubing by means of a syringe and needle. The various oozing points were clamped or tied with fine ligatures. When the injection was completed, the artery was ligatured and the block fixed in formalin or, in the case of the alginate preparations, in formalin with calcium chloride. After partial dissection, the block was then studied either by serial section or by clearing.

2. Neoprene latex, colored with monolite fast scarlet or monastral fast blue. A small air pressure injection apparatus was used, of a similar pattern to that used for the injection of the internal carotid arteries within the neck. Following the injection, the specimens were macerated, leaving a cast of the vessels. This method did not give very satisfactory preparations.

When both the superior and inferior hypophyseal arterial systems were injected in the same gland, different colored injection masses were used.

ANATOMICAL FINDINGS

Inferior hypophyseal artery

(figs. 1 and 2)

After its first short vertical course, the cavernous portion of the internal carotid artery bends to a horizontal segment which runs forward with a slight downward and inward inclination. Just before the apex of the upward convexity it

[1] These are technical dyes made by Imperial Chemical Industries, England.

gives off a small arterial trunk from about the centre of its medial aspect. This trunk, which is about 0.75 mm in diameter, breaks up, after a short course of about 1 mm, into three arteries:

1. The anterior branch runs downwards and laterally, anterior to the vertical first part of the cavernous portion of the internal carotid artery, to be distributed in the cavernous sinus in the region of the oculomotor nerve.

2. The posterior branch runs backwards and medially behind the posterior clinoid process to the dura on the posterior aspect of the dorsum sellae.

3. The inferior hypophyseal artery continues the course of the main trunk. It runs medially across the cavernous sinus to reach the lateral surface of the posterior lobe of the hypophysis, where it ends by dividing into superior and inferior divisions.

This arrangement is remarkably constant, and only occasional minor variations were observed among 100 inferior hypophyseal arteries examined. In 4 specimens the anterior and posterior branches of the main trunk were absent. In two specimens the inferior hypophyseal artery arose from the internal carotid artery as two roots which joined before reaching the gland. In two specimens the superior division arose directly from the internal carotid.

The superior and inferior divisions run upwards and downwards respectively on the surface of the sulcus between the the anterior and posterior lobes of the gland. Both vessels pursue a somewhat tortuous course. The superior division anastomoses with its opposite fellow behind the attachment of the stalk to the gland; the inferior division anastomoses with its fellow on the under surface of the gland. In this way they form an arterial circle along the interlobular sulcus.

Three groups of arteries arise from this arterial circle:

1. Vessels which supply the posterior lobe. The majority of these (5 to 10 on each side) penetrate at once into the posterior lobe and, running towards its centre, break up into a very abundant capillary network. A smaller number (two

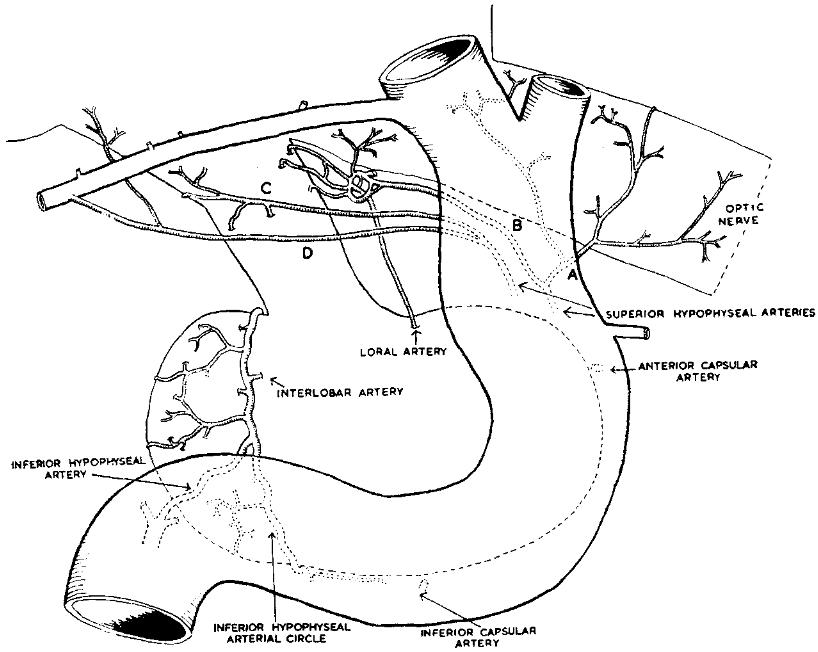

Fig. 1 Lateral aspect of hypophysis, partly covered by the internal carotid artery.

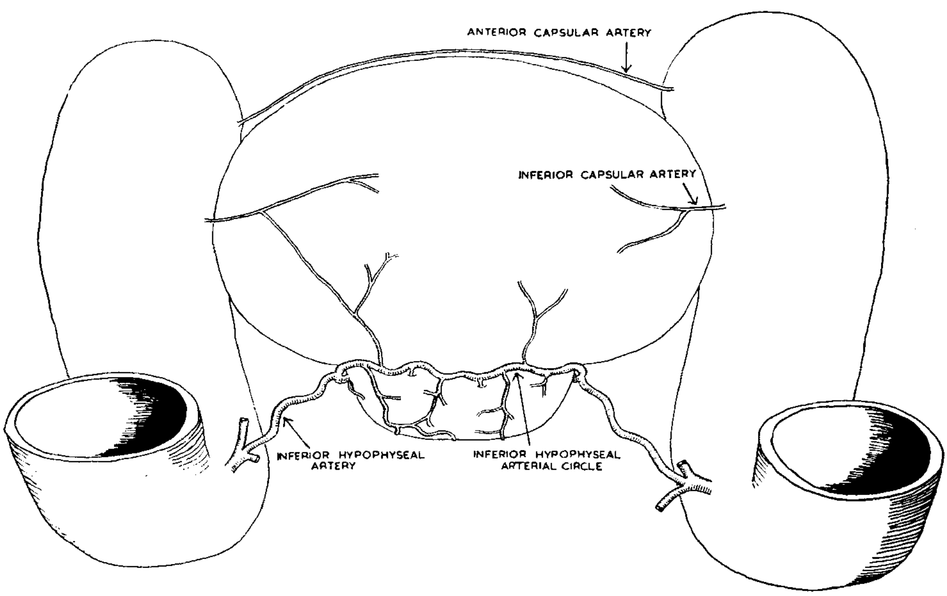

Fig. 2 Inferior aspect of hypophysis and internal carotid arteries.

or three on each side) course backwards over the surface of the posterior lobe, branching and anastomosing with each other and with their opposite fellows. They finally penetrate the surface of the lobe and break up to join the general capillary network. The upper portion of this capillary network of the posterior lobe is continuous anteriorly with the "parallel" vessels (v.infra) of the intraglandular part of the stalk, but does not appear to be directly connected with the sinuses of the anterior lobe.

2. An artery, which in this paper is termed the "interlobar" artery, originates on each side from the upper half of the arterial circle about halfway along the course of the superior division of the inferior hypophyseal artery. It enters the gland at the lateral margin of the stalk, and runs forwards and downwards in the connective tissue between the anterior lobe and the side of the intraglandular stalk. When it reaches the lower border of the intraglandular stalk, it turns to run medially in the angle between the lower surface of the stalk and the junction between the anterior and posterior lobes. At the midline it anastomoses with its opposite fellow. The interlobar artery gives off (fig. 3): (a) several small branches which run backwards to the general capillary network of the posterior lobe, (b) several branches which run slightly forwards, and then turn upwards and backwards to traverse the intraglandular part of the stalk to its posterior surface and (c) in some cases a vessel to the fibrous core in each side of the anterior lobe.

The branches described under (b) form part of a very characteristic arrangement of small vessels in the lower part of the stalk, including both the intraglandular stalk and a short portion of the extraglandular stalk (i.e. that part of the stalk lying above the gland proper). The vascular pattern here consists almost entirely of straight capillaries running at right angles across the stalk from front to back. In general they run parallel to each other, and are referred to here as the "parallel" vessels. Some of these vessels certainly originate from the branches of the interlobar artery;

others originate from the lower ends of the long stalk arteries which will be described later; others are of uncertain origin, but certainly communicate with the large sinuses in the neighbouring part of the anterior lobe. Posteriorly these parallel vessels connect with the capillary network of the posterior lobe, and superiorly they merge into the vessels of the extraglandular stalk (fig. 8).

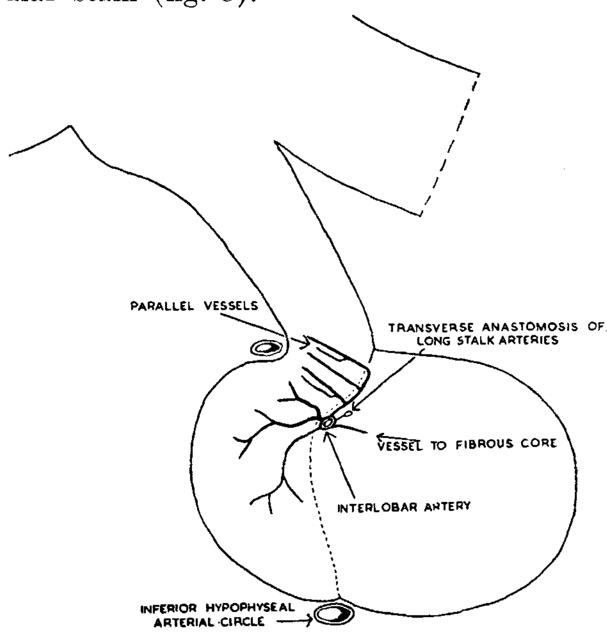

Fig. 3 Midline section of hypophysis, showing the distribution of the interlobar arteries.

A communication is usually present between the anastomosis of the interlobar arteries and the transverse anastomosis of the stalk arteries. This will be described later.

3. The remaining vessels which arise from the circle of the inferior hypophyseal arteries are very small branches which run forwards from the lower half of the arterial circle in the dural covering of the undersurface of the anterior lobe. These are about three in number; they supply small subcapsular areas of the inferior surface of the anterior lobe and also give branches into the floor of the sella turcica.

Intermediate minor branches of the internal carotid artery

(figs. 1 and 2)

Two small vessels arise from each internal carotid artery as this vessel lies within the cavernous sinus. These run in very close proximity to the hypophysis, but do not appear to play an important part in its vascularisation.

The first of these vessels, which is termed here the "inferior capsular artery," arises from the inferomedial aspect of the internal carotid artery about halfway along its course through the cavernous sinus. It runs medially in the dural covering of the inferior surface of the anterior lobe of the gland, anastomosing with the branches of the inferior hypophyseal arterial circle found in this part. The artery supplies small subcapsular areas of the inferior surface of the anterior lobe, and also gives branches to the floor of the sella turcica.

The second minute vessel, which is termed here the "anterior capsular artery," arises from the medial aspect of each internal carotid artery immediately before this vessel pierces the dura mater roofing over the cavernous sinus. It runs medially in the dura mater at the anterior margin of the roof of the sella turcica, and anastomoses with its fellow. This artery does not appear to play any part in the blood supply to the gland.

These small arteries are difficult to inject; the second particularly so. They were observed in about half the specimens; the failure to observe them in the remainder may have been due to technical difficulties.

Superior hypophyseal arteries

(figs. 1, 4 and 5)

Immediately after the internal carotid artery has emerged through the dura mater at the medial side of the anterior clinoid process, it gives off a group of "superior hypophyseal arteries'' from its posteromedial aspect. This group is made up of 4 small arteries, each about 0.5 mm in diameter. These arteries are designated in the present paper as A, B, C, and D according to their distribution. They usually arise from the internal carotid artery as two, less commonly as one or three, short trunks. These trunks run upwards and medially to the inferior surface of the optic nerve, and split up into their components at any point between the carotid artery and the optic chiasma. The arrangement of the joint origins in 100 superior hypophyseal artery groups (i.e. 50 glands) is summarized in the following table. (The symbol ABCD indicates that the 4 arteries came from one common trunk; the symbol A-BC-D indicates that arteries A and D originated from the carotid artery as individual branches, whereas arteries B and C came from a common trunk.)

ARRANGEMENT			NUMBER
AB	CD		60
ABCD (single trunk)			20
A	BC	D	7
A	B	CD	4
ACD	B		2
AC	B		2
AB	C		1
ABD	BC		1
AB	BCD		1
A	ABDC		1
A	AB	ACD	1

The last 4 examples show double or even treble origins of arteries A or B. It will be noticed that artery D was absent three times; the corresponding vessel on the opposite side was, however, always present in these cases.

The distribution of the 4 arteries is remarkably constant, despite the somewhat irregular grouping at their origins.

Artery A runs upwards and medially to reach the inferior surface of the optic nerve. It supplies the optic nerve and chiasma, and also anastomoses with branches from the anterior cerebral arteries.

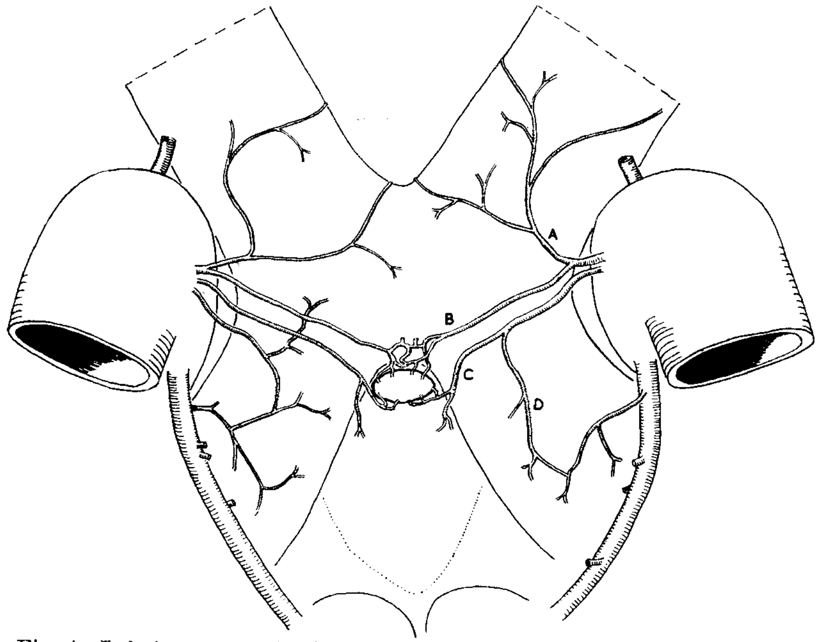

Fig. 4 Inferior aspect of chiasma and hypothalamus, showing the superior hypophyseal arteries.

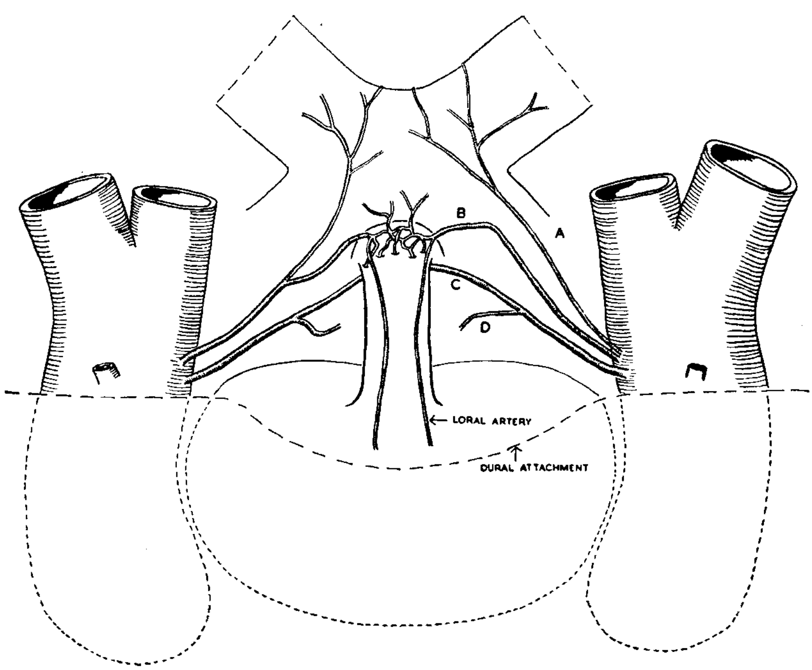

Fig. 5 Anterior aspect of hypophysis and stalk, showing the superior hypophyseal arteries.

Artery B having reached the inferior surface of the optic nerve, runs medially and backwards in the arachnoid space between the inferior aspect of the optic chiasma and the anterior aspect of the hypophyseal stalk. In this space it subdivides and forms a plexus with its corresponding artery from the opposite side. From the plexus three groups of vessels arise:

1. One to 4 small branches, which pass upwards to supply the inferior aspect of the optic chiasma.

2. About 6 arteries, which enter the anterior and lateral aspects of the upper part of the stalk. This important group comprises the majority of the vessels arising from the plexus; their course within the stalk will be described later.

3. A pair of small arteries, which travel directly to the anterior lobe. These vessels lie free in the arachnoid space like a pair of reins, and are therefore termed the "loral arteries." Each of these runs about 2 mm lateral to the midline and about 2 mm in front of the stalk, and enters the anterior lobe just anterolateral to the junction of the stalk with the anterior lobe (figs. 1 and 5).

Artery C runs backwards along the inferior surface of the optic nerve and chiasma to a point slightly posterior and lateral to the stalk. It then divides into (1) a few short branches which supply the tuber cinereum, and (2) about three other branches which run forward to enter the posterolateral aspect of the upper part of the stalk. The subsequent course of these branches to the stalk will be described later.

Artery D runs under the optic nerve and the chiasma to the inferior surface of the anterior part of the optic tract, which it supplies.

The internal carotid artery and the posterior communicating artery also give off a series of 4 to 10 small branches which run medially to supply the optic tracts, the tuber cinereum, the mamillary bodies and the posterior perforated substance. The most anterior branch of this series anastomoses with artery D.

As will be seen from the above description, arteries B and C are the only ones concerned with the blood supply of the anterior lobe and the stalk.

The vessels of the stalk

The branches of arteries B and C, which are concerned with the blood supply of the stalk and the anterior lobe, can be divided into the two groups which are designated here as the "long stalk arteries" and the "short stalk arteries." These arteries run along the stalk, the former near the surface and the latter more deeply.

1. The long stalk arteries. There are 2 to 5 of these arteries on each side. They reach the stalk in its upper third and run downwards, just beneath the surface of the stalk, amongst the large vascular sinuses which are present there. They maintain their original size and follow a straight course as far as the lower fifth of the stalk, where all the posterior vessels turn forwards around the lateral surface of the stalk and become grouped on the anterior surface of the stalk with the remainder of the long stalk arteries. At the junction of the stalk with the gland, the long stalk arteries give off their first branches; these form part of the series of parallel vessels and run upwards and backwards, some within the lower part of the extraglandular stalk and the remainder within the intraglandular stalk. The long stalk arteries are now appreciably diminished in size.

After the loral arteries have entered the superior surface of the anterior lobe, they run backwards about 1 mm below the surface of the anterior lobe, to meet the long stalk vessels in front of the intraglandular stalk. All these vessels then unite to form a single artery on each side. This vessel runs medially and backwards, just in front of the antero-inferior surface of the intraglandular part of the stalk, and anastomoses with its fellow. This "transverse anastomosis" lies just above the anastomosis of the interlobar arteries, and there is frequently a connection between the two vessels (fig.

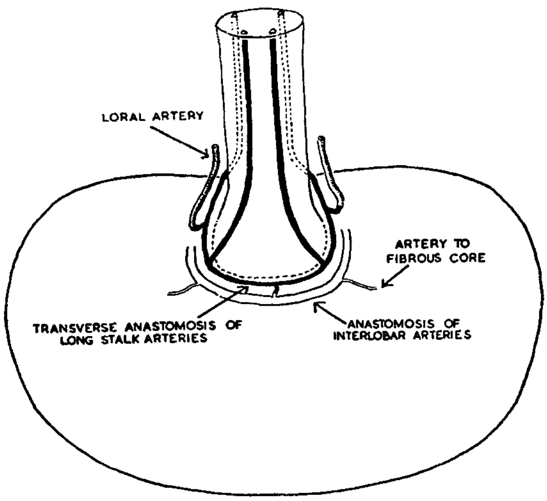

Fig. 6 Coronal section of hypophysis, showing the vessels around the intraglandular stalk.

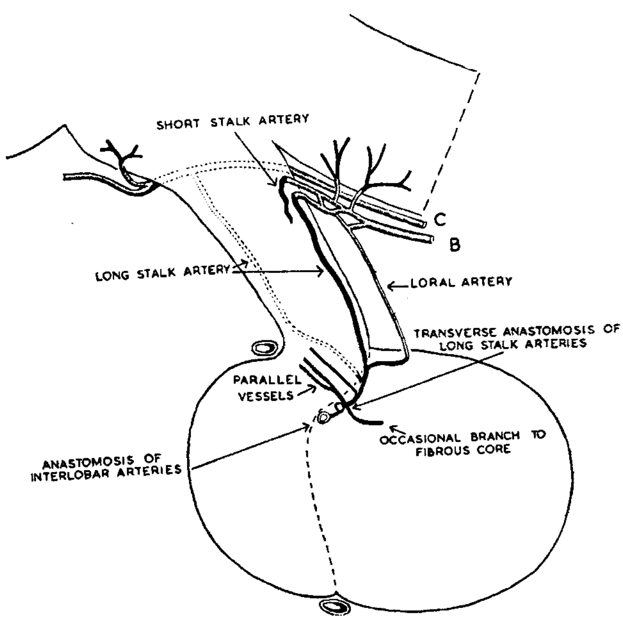

Fig. 7 Midline section of hypophysis, showing the branches of the superior hypophyseal arteries.

6). This connection with the interlobar arteries varies in size, and is sometimes little more than a capillary. Along its course the transverse anastomosis also gives off small branches which run upwards and backwards as parallel vessels within the intraglandular part of the stalk, and a small inconstant vessels which runs outwards and forwards within the fibrous core of the lateral part of the anterior lobe (fig. 7). This latter vessel is present in most of the cases in which the interlobar artery does not give a branch to the fibrous core.

2. The short stalk arteries. The short stalk arteries fall into two groups:

(a) The arteries which enter the uppermost part of the stalk; either the anterior and lateral aspects of the stalk proper, or its tongue-like prolongation posteriorly over the tuber cinereum. These arteries run medially and upwards for a short distance, and then turn downwards in the substance of the stalk or near the surface of the tuber cinereum to give rise to the "tufted vessels" (v.infra). The uppermost of these arteries may make this downward bend just below the third ventricle, and in this region they give off a few capillary branches which form the only vascular connection between the upper part of the stalk and the hypothalamus. The lower arteries perform the bend in the upper one-eighth of the stalk.

(b) The remainder of the short stalk arteries enter the stalk rather lower down but still in the upper half, run for a short distance within its substance, and then break up into the capillaries of the "pampiniform network."

The fine vascular architecture of the stalk

The intraglandular part of the stalk is characterized by the parallel vessels which run anteroposteriorly across it. These have been already described.

The whole of the lower three-quarters of the extraglandular stalk shows a mesh of large coiling capillaries which branch and unite with each other. This is described here as the "pampiniform network" (fig. 8). In the lower half of the upper quarter of the stalk, the pampiniform network continues up the centre of the stalk as a gradually narrowing cone.

The "tufted vessels" occupy the whole of the upper one-eighth of the stalk, including its posterior prolongation over the tuber cinereum, and a gradually thinning mantle of tissue on the surface of the next one-eighth of the stalk (i.e. over the cone of the pampiniform network). The name "tufted vessel" was given to them by Green ('48); its adoption here must not be taken to imply that the vessel is in fact tufted. The structure is a peculiar vascular complex forming the termination of a short stalk artery of group (a). This artery runs in the centre of a bundle of spiralling thin-walled sinusoidal capillaries (figs. 9 and 10). As the vessels run downwards there are occasional small gaps in the wall of the central artery, so that there is a direct communication between the lumen of the artery and the adjacent sinusoidal capillary (fig. 11). About one-quarter of the way down the stalk, the central arteries are no longer distinguishable and soon afterwards the sheath of sinusoidal capillaries is distributed, either by becoming continuous with the pampiniform network or by emptying into the large sinuses of the stalk.

The formation of the pampiniform network is first seen in the upper part of the stalk, where the sinusoidal capillaries of the tufted vessels give off coiling branches to unite with neighbouring complexes. As the process is followed further down the stalk, these uniting branches dominate the picture more and more until finally there is merely the pampiniform network without any tufted vessels. In the lower part of the stalk the anteroposterior components of the pampiniform network gradually became more prominent and less coiled, and then merge insensibly into the straight vascular structure of the parallel vessels (fig. 8).

There are about 20 large sinuses which run along the long axis of the stalk, just beneath its surface. These are formed by the fusion of branches from the tufted vessels and from the pampiniform network. In the upper part of the stalk, the sinuses on the posterior surface have a different arrangement from those on the anterior and lateral surfaces. The posterior sinuses are larger and run the whole length of the stalk from the tuber cinereum down to the gland. Two of these posterior sinuses are very large and at intervals give off short broad loops which dip a little way into the substance of the stalk. The anterior and lateral sinuses follow a straighter course, and are much less prominent in the upper part of the stalk than further down. Just above the entrance of the stalk into the gland, the posterior and lateral sinuses run forwards around each side of the stalk just beneath the surface and give branches to the anterior lobe. Their most anterior branches reach the front where they become congregated with the anterior sinuses and with the long stalk arteries which have followed a similar course. All these vessels thus come to lie in the small wedge of anterior lobe tissue which lies in front of the lower part of the stalk. The distribution of these sinuses in the anterior lobe will not be considered any further in the present paper.

STUDIES OF THE COURSE OF INJECTION MASSES

The enormous vascularity of the hypophysis, and the relative independence of the distribution of the superior and inferior hypophyseal arteries, is very well demonstrated by means of separate injection of either of these arteries.

The course of the injection mass can be followed by direct observation during the injection and also by a comparative study of a series of injected glands. In such a series there are some specimens in which the injection mass has passed only into the first part of the vessels, others in which it has passed further along, and others with a complete injection of all the finest branches. The distribution of the injection progresses according to a very regular pattern, so that the order of filling of the vessels can be ascertained.

Injection of inferior hypophyseal artery. In 14 specimens the mass was injected along the inferior hypophyseal artery. The vessels were filled in the following order:

1. The arterial circle around the sulcus between the anterior and posterior lobes.

2. (a) The small branches penetrating the posterior lobe either directly or after following a course over its surface.

(b) The small twigs running forwards over the lower part of the anterior lobe. From these twigs, minute subcapsular areas of anterior lobe tissue are injected both in the midline and laterally.

(c) The interlobar arteries.

3. (a) The parallel vessels running acros the intraglandular stalk. Some of these vessels are apparently filled from behind by the capillary network of the posterior lobe, others from in front by the interlobar arteries.

(b) When the vessel running in the fibrous core of the anterior lobe arises from the interlobar artery, it is filled at this stage.

4. (a) The vessels of all types in the lower part of the extraglandular stalk. The injection mass fills these by three channels: firstly up the lower ends of the long stalk arteries from their anastomosis with the interlobar arteries; secondly by branches from the upper parallel vessels which communicate with the pampiniform network of capillaries; thirdly along the sinuses from below upwards. The first sinuses to fill are the two large sinuses which run on the posterior surface, one on each side of the midline; these are injected very easily, possibly from the parallel vessels. These and the remaining sinuses appear also to be filled from the pampiniform network and, to a lesser extent, from the capillary network of the posterior lobe.

(b) Many of the large sinuses in the wedge of anterior lobe tissue directly in front of the intraglandular stalk. These sinuses appear to be filled mainly from the parallel vessels of that part of the stalk.

5. The plexus of artery B, which is filled from below by means of the long stalk arteries.

6. The vessels of the upper part of the stalk. The injection mass reaches these by two channels; firstly by a gradual filling of the tufted vessels from below via the pampiniform network and the large sinuses of the stalk; secondly from above via the plexus of artery B.

The injection mass does not spread into the anterior lobe apart from (a) the large sinuses in the small wedge in front of the stalk, and (b) a very small area on the lower surface in front of the interlobar sulcus, where the capillaries are filled from the capsular branches of the arterial circle of the inferior hypophyseal arteries.

Injection of superior hypophyseal arteries. It is difficult to inject these arteries, and it is even more difficult to follow the course of the injection mass. The following course was observed in 12 successful injections:

1. (a) Artery A is injected, and, from this, the capillaries of the optic nerve.

(b) Artery B is filled, and the injection spreads throughout the arterial plexus in the arachnoid space anterior to the upper end of the stalk.

(c) Artery C is injected, and the capillaries of the tuber cinereum and the vessels supplying the posterior part of the stalk are filled from this.

(d) Artery D is filled and, from it, some of the capillaries in the optic tract.

2. (a) The injection mass spreads down all the long stalk arteries and fills them rapidly along their whole length.

(b) The mass also passes along the short stalk arteries, and from these it passes very easily into the tufted vessels of the upper quarter of the stalk and into the pampiniform network in the middle third of the stalk.

3. (a) From the pampiniform network in the middle third of the stalk, it spreads downwards into the pampiniform network further down the stalk.

(b) From the tufted vessels and from the pampinform network, several or all of the large sinuses in the stalk become filled from above downwards.

4. (a) The injection mass thus reaches the large sinuses in the wedge of anterior lobe tissue in front of the intraglandular stalk.

(b) The parallel vessels of the intraglandular part of the stalk become filled from two sources: the long stalk arteries and the pampinform network of the stalk higher up.

5. The sinuses and capillaries throughout the anterior lobe are filled by the injection which has passed down the large sinuses of the stalk.

6. Occasionally (two specimens in the present series) the injection mass passes, apparently from the transvers anastomosis, into the capillaries of a wedge of posterior lobe, running from the interlobar septum in the middle third backwards about halfway to the posterior surface.

7. In one specimen the anastomosis between the long stalk arteries and the interlobar arteries was very large, so that the latter vessels were easily filled. The injection then spread to the arterial circle of the inferior hypophyseal arteries and thus to the entire capillary network of the posterior lobe.

From the results of the injection of the individual hypophyseal arteries, the following conclusions may be reached:

1. The inferior hypophyseal arteries constitute the principal blood supply to the posterior lobe. They may play some minor part in the blood supply of the stalk, of the wedge of anterior lobe which lies in front of the intraglandular stalk, and of small areas of anterior lobe tissue in front of the lower part of the posterior lobe and on the inferior surface. They take no part in the blood supply to the bulk of the anterior lobe.

2. The superior hypophyseal arteries constitute the principal blood supply to the stalk and anterior lobe. They do not give any significant blood supply to the posterior lobe.

3. There is no anatomical impossibility in the occurrence either of an ascending or a descending blood flow within the stalk.

In an effort to ascertain whether there were two systems of vessels within the stalk, one fed by the superior and the other by the inferior hypophyseal arteries, simultaneous injections of these arteries with different colored injection masses were carried out in 6 specimens. It was technically difficult to arrange that the two arteries were injected at identical pressures, so that the results are not very conclusive. After the injection, any vessel was found to contain either of the injection masses, depending on the different pressures used. The meeting point of the two injection masses was in almost any vessel in the stalk, but much the commonest place for this intermingling was in the parallel vessels of the lower part of the stalk.

LITERATURE

The inferior hypophyseal artery was first identified in man by Luschka (1860), and its course in the cavernous sinus was well described by Gentes ('03). A very clear account of the arterial circle in the groove between the anterior and posterior lobes was given by Benda ('32). The interlobar artery and its anastomosis with the long stalk arteries was described by Winterstein ('37), though his interpretation of the course of the blood flow is not acceptable. Several other authors have described the inferior hypophyseal artery in man but without adding anything significant to the above-mentioned accounts: Mudd ('18), Fuchs ('24), Nikolskaia ('29), Popa and Fielding ('30), Popa ('34), and Wislocki and King ('36). Certain of these (Luschka, Gentes, Popa, Popa and Fielding, Benda, and Winterstein) considered that the inferior hypophyseal arteries consituted the principal blood supply to both the anterior and posterior lobes. The remaining authors (Mudd, Fuchs, Wislocki and King, Nikolskaia and Harris) considered that the inferior hypophyseal arteries were distributed mainly to the posterior lobe.

Luschka (1860), first described the superior hypophyseal arteries. Other authors — Thaon ('07a, b), Fuchs ('24), Nikolskaia ('29), Benda ('32), Wislocki and King ('36), Green ('48) — recognized these arteries, though they sometimes included vessels from the posterior communicating artery as taking part in the blood supply of the hypophysis. The importance of the superior hypophyseal arteries in the blood supply to the gland and stalk was not recognized until the work of Wislocki and King.

Tello ('12) observed the tufted vessels in the stalk of the human hypophysis though he did not know their source, and Popa and Fielding ('30) also described them, but it was not until 1936 that Wislocki and King gave the first good description of these arteries within the stalk. Winterstein ('37), Harris ('48) and Green ('48) have also described the distribution of these arteries within the stalk.

The blood supply of the hypophysis cerebri of lower animals has been described by Trautman ('09), Haller ('09), Dandy and Goetsch ('10), Basir ('30), Wislocki and King ('36), Wislocki ('37, '38a, b), Green and Harris ('47), Harris ('47, '48), and Green ('51).

DISCUSSION

1. Inferior hypophyseal artery. The studies reported in this communication lead to the conclusions that the inferior hypophyseal artery constitutes the principal blood supply (a) to the posterior lobe, where it is distributed in the form of a capillary network, and (b) to the intraglandular part of the stalk, by means of the interlobar branch which gives rise to most of the parallel vessels running posteriorly across this part of the stalk. The only areas of the anterior lobe supplied in part by the inferior hypophyseal arteries are (a) the wedge of tissue lying in front of the intraglandular stalk, and (b) small areas of tissue in front of the lower part of the posterior lobe and on the inferior surface.

The capillary network of the upper pole of the posterior lobe, and the posterior ends of certain of the parallel vessels of the intraglandular stalk, have some connection with the large sinuses running up the posterior aspect of the stalk. The upper ends of these posterior sinuses arise by the fusion of small sinuses from (or subdivide into branches to) the substance of the upper part of the stalk. Some of these small sinuses are in open communication with the other large stalk sinuses that pass down to the anterior lobe. No recognizable connection can be found between the upper part of the posterior sinuses and any of the vessels of the hypothalamus. There is no clear evidence as to the course of the blood in the posterior sinuses of the human hypophysis during life, as these vessels can be injected equally easily from the inferior and from the superior hypophyseal arteries. Nevertheless there is possibly some significance in the fact that injection of the inferior hypophyseal arteries will fill these posterior sinuses at a time when none of the other stalk sinuses are filled.

2. Superior hypophyseal artery. The present work supports the view that the superior hypophyseal arteries form the principal blood supply to the stalk and the anterior lobe of the hypophysis. The only direct arterial supply to the anterior lobe from the superior hypophyseal artery is the small branch to the fibrous core from the transverse anastomosis of the long stalk arteries. The superior hypophyseal arteries are distributed in the main to the portal system of vessels within the stalk, the sinuses of which pass down to supply the anterior lobe.

Contrary to the view held by Popa and Fielding and by Winterstein, the only vascular connections between the stalk and the hypothalamus are capillary in nature.

The superior hypophyseal arteries take no part in the blood supply to the posterior lobe.

3. Direction of the blood flow within the stalk. There are two hypotheses regarding the direction of blood flow within the stalk, one that there is an ascending hypophyseo-portal system, and the other that the direction of the blood flow within the stalk is towards the anterior lobe.

Popa and Fielding ('30, '32), and Popa ('34, '37), based their hypothesis of an ascending hypophyseo-portal system in man on their belief that the blood supply to the hypophysis was by means of a vessel arising on each side from the internal carotid artery within the cavernous sinus. There seems to be no doubt that this vessel was in fact the inferior hypophyseal artery. Popa and Fielding do not seem to have appreciated that the superior hypophyseal arteries provide the blood supply to the stalk and anterior lobe.

The evidence that the blood flow within the stalk is towards the anterior lobe falls into three groups:

(a) Injection experiments in the human hypophysis show that the sinuses and smaller vessels in the stalk are always filled before the vessels in the anterior lobe. This is in agreement with the injection experiments of Wislocki ('37) on cats, and of Green and Harris ('47) on various mammals.

(b) Serial injections of colored oils into the circulation of living cats and dogs by Morato ('39) showed that the oil first injected had reached the anterior lobe, while the oil injected subsequently was still in the stalk sinuses.

(c) Green and Harris ('49) observed the hypophyseal stalk of anesthetised rats while India ink was being injected into the general circulation. The ink appeared first in the stalk and subsequently in the anterior lobe.

These experimental findings are in accord with the anatomical findings of the present paper. The superior hypophyseal arteries enter the stalk and break up there, after a course of variable length, into the various capillary systems of the stalk. From this complex vascular network the blood is collected into the large vascular sinuses which run down near the surface of the stalk to discharge into the sinuses of the anterior lobe. There can be little doubt that the direction of the blood flow in these stalk sinuses must be towards the anterior lobe. The reason for this portal system is not clear; but there is presumably some particular endocrine reason why the capillary system of the stalk should be interposed in the blood supply to the anterior lobe. The three different types of capillaries in the different parts of the stalk suggest the possibility that there may be correspondingly different function of these parts of the stalk. These considerations can only be very speculative. The course of the blood in the adrenal, first through the cortex and then to the medulla raises analogous problems.

SUMMARY

1. Three methods have been employed in the study of the blood supply of the human hypophysis: (a) serial sections of uninjected glands with their associated structures; (b) injection of the hypophyseal arteries via the internal carotid arteries within the neck, followed by examination of the vessels to the gland and the stalk; (c) selective injection of the superior and inferior hypophyseal arteries using various injection masses.

2. These investigations lead to the following conclusions:

(a) The anterior and posterior lobes have a relatively independent blood supply. The anterior lobe is supplied by the superior hypophyseal arteries, which arise on each side from the internal carotid artery immediately after this vessel has pierced the dura mater. The posterior lobe is supplied by the inferior hypophyseal artery, which arises on each side from the internal carotid artery as this vessel lies within the cavernous sinus.

(b) The blood supply of the anterior lobe passes first through three different types of capillaries in the stalk, and is then collected again by portal sinuses which pass down the stalk to the anterior lobe.

(c) There is an overlap of distribution of the superior and inferior hypophyseal arteries in the region of the stalk, in the small wedge of the anterior lobe which lies in front of the intraglandular stalk, and in a few small subcapsular areas of the anterior lobe.

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PLATE 1

EXPLANATION OF FIGURES

8 The stalk curves down from the upper right corner to the posterior lobe at the middle of the left border. The stalk shows the parallel vessels near the posterior lobe, the venous sinuses passing as a broad leash to the anterior lobe, the pampiniform network at the centre of the stalk, and the tufted vessels of the upper stalk and tuber cinereum. × 15.

9 Upper part of the stalk. In the top half of the picture and along the surface of the stalk there are several tufted vessels. The pampiniform network of capillaries is seen below and to the left. × 28.

10 Tufted vessels from the upper part of the stalk. × 90.

11 Transverse section of a tufted vessel, showing the communication between the central artery and an adjacent sinusoidal capillary. Elastic tissue stain. × 400.

Figure 8

Figure 9

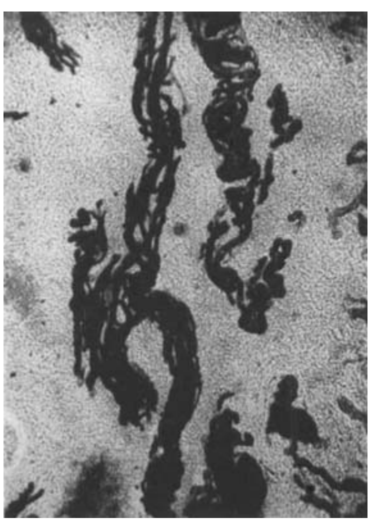

Figure 10

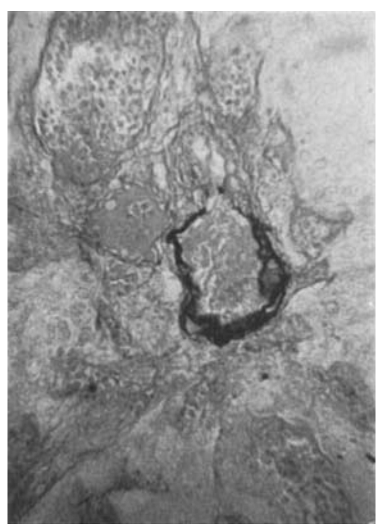

Figure 11