THE VENOUS DRAINAGE OF THE BRAIN, WITH SPECIAL REFERENCE TO THE GALENIC SYSTEM.

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On the basis of experiments on dogs, Bedford reported (1937) that a collateral circulation becomes rapidly established after occlusion of the great vein of Galen (*Vena magna cerebri*). He concluded, therefore, that the hydrocephalus which was occasionally found by Dandy and Blackfan (1914) and by Gulecke (1930), in dogs in which the vein had been blocked experimentally, was not directly due to the occlusion of the vein. In a subsequent series of experiments, Bedford (1934) occluded the great vein of Galen in monkeys. These animals likewise failed to show hydrocephalus after a survival period of six weeks, but no evidence was found of the manner in which the collateral circulation had developed in the choroidal plexus and the basal ganglia. Schwartz and Fink (1925-26), who injected the great vein of Galen in human brains, were unable to reach positive conclusions regarding the collaterals of the vein and the venous drainage of the basal ganglia, and they suggested that these investigations required to be further extended. A study of the venous system is also of importance for the question of the localization and pathogenesis of certain infections and other pathological conditions which have been described in the monkey and in Man, and are known to have a definite topographical relationship to the venous channels of the grey and white matter. The present paper comprises a report of an investigation, based on the examination of normal and experimental material, with the object of elucidating these details of the circulation.

**TECHNIQUE.**

The method employed to investigate the problem of the collateral circulation in the monkey was based on the following considerations:

(1) The occlusion of one of the small veins of Galen leads to a unilateral hyperæmia; this allows a comparison between the normal vessels and the venous channels which are dilated in order to cope with an increased amount of blood.
(2) Bedford’s animals were killed after a comparatively long time, and within this period all kinds of vascular adjustments may have taken place, as is suggested by the rather transitory effect which follows the occlusion of the surface veins in the rhesus monkey. In our experience this operation is followed by a very pronounced hyperaemia, producing small cortical haemorrhages, which completely disappears within forty-eight hours. It was decided, therefore, to kill the first of the experimental animals immediately after the operation, the second after twenty-four hours, and the third animal after a longer period of time. The last animal, however, died after a few hours and our observations, therefore, are so far based on acute experiments only.

(3) Instead of injecting the venous system of the monkey, it appeared preferable to stain the vessels with Pickworth’s stain (1934), a method which consists of the histological application of a blood stain. As a result of the reaction between sodium nitroprusside and the haemoglobin of the red corpuscles, the latter appear blue-black. This method is in some respects more reliable than injection, for in the latter case the injection-mass may not always enter the small vessels everywhere. In most cases the manner of arborization which has been so clearly described by Pfeifer (1930) materially aids in differentiating arteries and veins, except in the vessels of very small calibre. However, it is a disadvantage of Pickworth’s method that the degree of the chemical reaction is variable. It may be quite successful in some sections of one single set but it may be very weak in the others: intensive stains may sometimes last for many weeks, whereas other equally well-stained specimens may fade overnight. On the whole Pickworth’s method had distinct advantages, as will become more apparent in the description.¹

(4) The small vein of Galen was coagulated, as it was impracticable to use a silver-clip in the small field between the lower surface of the corpus callosum and the roof of the third ventricle.

A report of the experiment performed in the third animal will serve to describe the operative procedure.

A bilateral skin-flap with a frontal base was reflected and two large bone-flaps were turned down separately, the left flap in the upper part of the field extending across the midline. The dura was incised at a distance of about 1 cm. from the median plane on either side of the longitudinal sinus, and the incision carried upwards towards the edges of the sinus and well down into the temporal region

¹ The nerve cells should not stain. In one of our animals, however, a composite picture was obtained and the vessels and the cell-layers could be clearly seen. No explanation for this reaction could be given and the staining of the cells could not be reproduced in other specimens.
after a bilateral decompression had been done. After reflecting the four dural flaps, practically the whole convexity of both hemispheres was exposed together with the frontal, precentral, parietal and occipital veins. The right parietal vein was coagulated and divided. The right hemisphere was gently retracted from the falx in this region and the posterior part of the callosal body exposed and split, with practically no bleeding, by means of a blunt dental needle, the tip of the needle emerging between the two crura fornicis. In order to avoid possible damage to the great vein of Galen, division of the callosal fibres did not include the posterior border of the splenium. After widening the opening, a small amount of cerebrospinal fluid escaped from the 3rd ventricle, the roof of which was opened in one small place. The roof was not injured in the other animals. The fluid was sucked away and the laterally-situated fibres of the corpus callosum pulled to the right until the roof of the ventricle and the plexus, forming a small, brownish, longitudinal strip of tissue, could be seen. On further retraction, the right vein of Galen was brought into view. It was slightly elevated with a small pair of forceps and the coagulating current applied. As a result the distal part of the vessel increased to about twice its size and remained enlarged until the beginning of the closure which was begun a few minutes later. There was no haemorrhage throughout the operation. However, there was some swelling of the brain so that the dura could not be closed. The two bone flaps were sutured in position and the closure of the skin completed. Immediately after death, the brains were fixed in Pickworth's solution for eight hours. They were then cut into frozen sections of 250 μ thickness and stained.

**Examination of Sections.**

A common feature of the sections was a hyperaemia on the operated side which was very marked in the third case and moderate but distinct in the first two animals. The hyperaemia was most obvious in the regions adjacent to the corpus callosum but was hardly evident in the frontal and occipital areas as compared with normal brains and with the corresponding areas of the same brain on the opposite side. There was no hyperaemia in the basal part of the temporal lobe. It is interesting to note that, in the human brains injected through the great vein of Galen, this region of the temporal lobe also showed very little injection. On closer inspection a certain degree of hyperaemia was also found on the unoperated side, which was undoubtedly caused by the edema following the occlusion of the vein and the resulting increase of intracranial pressure. The hyperaemia was manifested in the following changes:

(a) The veins were enlarged and the number of the macroscopically visible vessels was increased.

(b) Some of the veins were tortuous. Although a number of veins in the white matter were found to be somewhat tortuous in the brain of the normal monkey stained by Pickworth's method, as well as in brains of monkeys injected with carmine-gelatine, this tortuosity was less marked than in the operated brains, and is explained by a certain amount of shrink-
The increased tortuosity due to hyperæmia of the veins was accompanied by an enlargement of their calibre and a narrowing of the perivascular space.

(c) Where there is a regular distribution of the vessels, as for instance in the head of the caudate nucleus, a pattern of regularly arranged spots with indistinct outlines was observed when the specimens were looked at under a low power. These spots correspond to the cross-sections of congested vessels which are surrounded by smaller rami and post-capillaries given off in a star-shaped manner.

(d) There were perivascular haemorrhages beneath the ependyma covering the caudate nucleus (fig. 1).

(e) The capillary loops could be beautifully seen and large numbers of them formed continuous black lines, in contrast to the normal picture of a sodium nitroprusside stain in which the capillary vessels almost exclusively form dotted lines (the stained red corpuscles being separated from each other by short irregular intervals). This is a feature which obviously cannot be brought out by injection of the vascular system.

**Distribution of the Veins.**

The small vein of Galen and its tributaries, the anterior and posterior terminal, the septal and epithalamic veins, were grossly dilated, while the

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**Fig. 1.**—Section showing hyperæmic areas in the head of the caudate nucleus and subependymal perivascular haemorrhages. (x 40.)
chorioidal vein and the other vessels in the plexus did not differ in any respect from the normal.

The terminal veins.—The tributaries of the terminal veins cross the surface of the head and the tail of the caudate nucleus, forming the transverse caudate veins (figs. 2 and 3). They disappear in the region of the lateral angle of the lateral ventricle between the lower surface of the corpus callosum and the upper surface of the caudate nucleus. Here, numerous cross-sections of vessels can be seen which lie close together and represent

![Diagram](image)

Fig. 2.—Diagrammatic cross-section through the brain of a Rhesus monkey, showing the connexions between the Galenic system and the veins on the surface of the brain: (1) Great vein of Galen; (2) small veins of Galen; (3) transverse caudate vein; (4) longitudinal caudate vein; (5) venous channels, connecting the great vein of Galen with the superior longitudinal sinus and the superficial Sylvian vein; (6) and (7) superior external and internal lenticular veins; (8) and (9) inferior external and internal lenticular veins; (10) superficial Sylvian vein; (11) deep Sylvian vein; (12) superior sagittal sinus.

the continuation of those transverse veins which have changed their direction abruptly to form the longitudinal caudate veins (figs. 2 and 3). The latter skirt the superior border of the caudate body, the bulk of the vessels derived from the anterior terminal vein being directed forwards, whereas most of the veins arising from the posterior terminal vein run backwards.
This arrangement can be more clearly understood from the injection experiments made on human brains where these vessels were dissected out, as will be described later. The longitudinal veins were grossly enlarged in the third animal, and moderately so in the others. They give rise, from a topographical point of view, to two groups of vessels, the first being situated in the white matter, the second in the basal ganglia (fig. 2).

The first group is represented by three different sub-divisions which, however, share the common feature that their course follows, with a few exceptions, the course of the callosal fibres from the lateral angle of the ventricle to the cortex on the medial surface and the convexity of the cerebral hemisphere.

The vessels forming the first group are: (i) Coarse capillary networks which begin a very short distance from the lateral ventricular wall and extend throughout the white matter and the cortex as a continuous plexus (fig. 3). They can be most clearly seen in the suprasylvian region.

(ii) Small subventricular veins which arise from the longitudinal veins in a fan-like manner and soon break up into capillary plexuses which are continuous with the network just described. Deep to the cortex the plexuses are drained by subcortical veins which penetrate the cortex, receive a great number of branches from the dense capillary network of the grey
cortical matter, and finally enter the veins on the surface of the brain. The plexus of the white matter forms, as a whole, an irregular pattern, but the larger postcapillaries, which connect the capillaries with the venules, join the latter very often at right angles (figs. 4 and 7).

(iii) Large veins (fig. 4), some of which are even macroscopically visible over wide areas in suitable sections and which, in the experiments, were very much enlarged and frequently tortuous. The calibre of these veins does not appreciably change during their course. Moreover, they do not break up into capillaries but are joined only at relatively long intervals and in most instances at right angles by short venules and sometimes by capillaries without intervening larger vessels. The larger veins are therefore certainly linked up with the capillary plexus, but there is some disproportion between the size of these vessels and their scanty connexions. Exceptions to this rule are infrequent, and veins of larger size and constant calibre with a great number of connexions are only rarely found. Whatever additional functions they may have, these veins must represent anastomoses between the Galenic system and the veins on the brain-surface. They may therefore be called intracerebral anastomotic veins.
(iv) Numerous transitional types of venous channel. Sometimes veins arising from the capillary network close to the ventricle soon attain a larger size and travel towards the periphery, thus covering, like an anastomotic vein, a considerable distance (fig. 5). In one instance, an anastomotic vein was found to be formed by two larger veins joining each other at an acute angle. While "pure" types are so frequently encountered that they fully justify the establishment of fairly distinct anatomical and consequently physiological units, the frequent occurrence of all kinds of transitional forms must be emphasized.

![Fig. 5.—Section showing a long subcortical vein, arising near the outer ventricular angle. Longitudinal caudate and superior lenticular veins are also seen. (x 25.)](image)

*The second group* of veins is formed by branches of the transverse caudate veins, which enter the brain-substance between the thalamus and the caudate nucleus or the grey matter of the caudate body itself. Other rami of this group come off from the longitudinal caudate veins where they participate in the formation of the "fan-pattern." Common features of these vessels are their large size and their relationship to the basal ganglia (figs. 2, 3 and 5).

(i) The veins which rise in the ventricular angle can be seen in the region of the upper border of the caudate nucleus throughout its curvature. They perforate the internal capsule and reach the lateral surface of the putamen or in some cases actually traverse the outer layers of the latter as *superior external lenticular veins*, to break up into a great number of venules which collect the blood from a very dense capillary network. The
basal layers of these capillary areas are drained by venules which unite and form the *inferior external lenticular veins*. These large vessels converge towards the anterior perforated space, crossing the anterior surface of the anterior commissure where it leaves the substance of the putamen and enters the external capsule. Finally these vessels open into the deep Sylvian vein.

(ii) The rami of the transverse caudate veins which are given off before the latter reach the outer angle of the lateral ventricle enter the inner layers of the putamen, the medullary lamina of the lenticular body and the globus pallidus. They branch into smaller vessels and finally break up into a capillary network which is continuous with the capillary area just described and the system of the inferior internal lenticular veins which cross the anterior commissure within the substance of the lenticular body and join the deep Sylvian vein more medially. The inferior lenticular veins emerge at the base of the brain where they intermingle with the inferior lenticular arteries entering the anterior perforated space. The more posteriorly placed inferior lenticular veins perforate the roof of the inferior horn of the lateral ventricle and open into the inferior choroidal veins.

*The septal vein.*—The description of this vein will be postponed, as the course of the tributaries of this vessel is rather complicated and can be much better seen in the human brain.

*The epithalamic vein.*—After occlusion of one of the small veins of Galen there was also a certain amount of hyperaemia in the thalamus, particularly apparent in its anterior nucleus, the capillaries of which are very large and densely arranged. The thalamus drains its blood partly into the epithalamic vein and partly through the inferior thalamic veins into the posterior communicating vein which lies underneath the posterior perforated space and connects the two basilar veins.

*The veins of the choroid plexus.*—The appearance of these vessels did not differ from that of those in the normal plexus, nor was there any difference between the two sides in the animals operated upon. The blood of the plexus is partly drained by the small vein of Galen through the superior choroidal vein, as already described by Testut (1929) and by Bedford (1934), and partly by the inferior choroidal vein which joins the basilar vein. There was no asymmetry of the ventricles due to a hydrocephalus on the operated side.

**Injection of Human Brains.**

Two human brains were injected with a hot solution of carmine-gelatine under heavy pressure. The cannula was inserted into the commencement of the straight sinus after the inferior longitudinal sinus had been occluded.
by haemostatic forceps. Two hemispheres were sliced into coronal sections, one was divided into horizontal sections, and in the fourth hemisphere the ventricular veins and their tributaries were dissected out and followed into the brain-substance as far as possible. The findings were identical in the two injected specimens.

(1) *The intracranial anastomoses of the great vein of Galen.*

Transverse caudate veins, corresponding to those already described in the monkey, were demonstrated (fig. 6). They cross the surface of the caudate nucleus and disappear in the region of the angle of the lateral ventricle where they enter the brain-substance. If the ependyma is carefully incised along the upper border of the caudate nucleus after the corpus callosum had been removed, the course of these vessels can be followed further by piecemeal removal of the white matter. At the region of the ventricular angle the veins, the course of which has already been described above, change their direction. The longitudinal veins divide at acute angles into a number of branches, the resulting rami, therefore, lying close

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**Fig. 6.—Diagram illustrating the distribution of the tributaries of the Galenic system of veins: (1) Great vein of Galen; (2) small vein of Galen; (3) posterior terminal vein; (4) septal vein; (5) anterior terminal vein; (6) transverse caudate vein; (7) longitudinal caudate veins; (8) intracerebral anastomotic veins; (9) cut surface of cortex.**
together for relatively long distances. As a result of this peculiar arrange-
ment whole groups of vessels are found in cross-sections through this region
in the monkey as well as in Man, where they are macroscopically visible.
Later on these vessels become directed laterally and upwards, and in the
region of the body of the lateral ventricle their numerous rami, too, are
also seen to lie in the transverse plane. The rami arising in the wall of the
anterior horn are directed forwards, and in the region of the ventricular
triangle and the posterior horn backwards. Just as in the monkey, it could
be seen that whereas the size of many vessels diminishes rapidly in their
course, the larger vessels maintain their size and can be followed into the
white matter for about one inch from their point of origin. The further
course of these vessels (which undoubtedly correspond to the anastomotic
veins seen in the monkey) can be demonstrated much better in horizontal
and coronal sections. The veins closely follow the stream of the callosal
fibres, this arrangement being particularly striking in the regions of the
forceps anterior and forceps posterior where definite "venous radiations"
were encountered. The diameter of these vessels is about half a millimetre
and no ramifications could be seen in the centrum semiovale in micro-
scopical sections stained with picric acid.

The system of the septal veins deserves a special consideration. It was
rather difficult to get a clear idea of the arrangement of the tributaries of
the septal vein in the monkey, but a more definite conception applicable
to both monkey and Man was finally gained by correlating the histological
findings in the monkey with the macroscopical features elicited by slicing
and dissecting the human brain. In the injected brains the communicating
rami derived from the septal vein and the most anteriorly placed branches
of the anterior terminal vein dive down under the base of the head of the
caudate nucleus and the putamen where they are caught by rostral fibres of
the corpus callosum and carried towards the base of the frontal lobe. The
remaining branches of the anterior terminal vein travel chiefly with the
callosal fibres above the rostrum to the convexity of the frontal lobe.

A large vein is evident in the anterior part of the internal capsule in the
monkey and in Man, an illustration of which is given in Testut's textbook
(1929). This vessel connects the system of the superior lenticular veins,
where they penetrate the internal capsule, with the veins on the surface of
the frontal lobe. It has no relationship to the callosal fibres but is
embedded in the anterior peduncle of the thalamus and the region of the
fronto-pontine tract.

On cutting the brain in the median plane a great number of veins were
encountered in the splenium, while the remaining part of the callosal body
showed only a few vessels. The splenial veins are directed downwards and forwards towards the posterior part of the commissure of the fornix. They connect the veins of the fornix with the posterior callosal vein, thus draining the blood from the medial wall of the lateral ventricle into the Galenic system. The question of a possible connexion of the splenial veins with the veins of the plexus of the 3rd ventricle, however, could not be decided.

The gross appearance of the injected veins in the basal ganglia in Man resembles that seen in the monkey. The injection of the caudate and the lenticular nuclei is fairly uniform, whereas, in the thalamus, the injection-mass is confined to its superior half which corresponds to the territory of the epitheralamic vein. The hypothalamus, however, shows a more marked injection, derived from the veins at the base of the brain which communicate with the great vein of Galen through the extracerebral anastomoses of this vessel.

(2) The extracerebral anastomoses of the great vein of Galen.

The injection-mass was found to have entered the following areas:—

(1) The whole occipital lobe and large parts of the adjacent parietal region through the occipital vein. In one case, almost the whole posterior part of the hemisphere, including the Rolandic vein, was filled with carmine-gelatin.

(2) The medial surface of the brain above the posterior half of the callosal body and the splenium through the posterior callosal vein.

(3) Through the basilar vein, the region of the limen insulae, and the inferior half of the superficial Sylvian and the whole of the deep Sylvian vein, the veins on the orbital surface of the frontal lobe, the inferior lenticular veins and the veins supplying the pes pedunculi, the substantia nigra, the corpus Luysii, the nucleus ruber, the zona incerta, and probably also the basal part of the thalamus.

(4) Part of the inferior half of the cerebellum and a number of pontine vessels through the superior cerebellar vein.

Discussion.

Lorenz de Nò (1928), Luna (1928), Cobb (1931) and Pfeifer (1930) have shown that the capillaries of the cerebral vessels form a large common network, and the last-named was able to demonstrate anastomoses between precapillaries and vessels of even larger size, arteries as well as veins. The results of our investigations may be applied to certain aspects of the cerebral circulation, without going into details which have already been described
and discussed by Pfeifer such as, for instance, the so-called pressure-veins, suction-arteries, and so forth.

There is some controversy in the literature about the relationship of the intracerebral vessels to the fibre-systems. Duret (1874) claimed that the vessels closely follow the paths of the fibres, whereas, in the opinion of Pfeifer, the arrangement of the vessels is largely independent of the fibres. The study of our material suggests that, on the whole, the veins are more apt to follow the fibre systems than the arteries, particularly the venules, the medium-sized veins and the vast majority of the anastomotic veins. Exceptions are the most medially placed anastomotic veins in the region of the angle of the lateral ventricle, and the superior lenticular veins, the course of which is almost at a right angle to the fibres of the callosal body and the internal capsule respectively. The arrangement of the postcapillaries, likewise, is largely independent of the fibre-systems.

We cannot agree with Schwartz and Fink, who claim that the territory of the vein of Galen is chiefly represented by the white matter and that this vein drains only comparatively small parts of the basal ganglia, for the large size of the superior lenticular veins, found in our specimens, is against such an assumption.

The general arrangement of the blood-vessels in the white matter suggest that the circulation takes place in the following way. Blood entering the white substance through a cortical artery is distributed to the capillaries from which it enters the nearest vein to return to the brain-surface (fig. 7). Blood reaching the periventricular white matter through the basal arteries is drained by the great vein of Galen. The individual arteries and veins are connected by the common capillary network supplying and draining certain areas within the white matter. The boundaries of these regions must be considered as more or less variable. The regional independence of the arteries is greater than that of the veins, as evidenced by the pathological effects following the occlusion of an artery; on the other hand, the venous territories reveal a very marked degree of overlapping since connecting links trespass across the boundaries of the venous territories at frequent intervals. Between the territories of the basal and cortical arteries no distinct anatomical boundaries exist, but there is a definite physiological boundary: in contrast to this, the territory of the cortical veins extends, in certain regions, far down to the ventricular wall, while the drainage area of a vein opening into a vessel in the neighbourhood of the ventricle may extend far up towards the subcortical layers. In still other regions, the territories of the cortical veins and the ventricular veins may even be identical. The manner in which the large anastomotic
Fig. 7.—Diagram showing the venous circulation in the white matter and the connexions between the superficial cortical and the ventricular veins through the intra- and extracerebral anatomic veins: (1) Pial artery; (2) pial vein; (3) basal artery; (4) basal vein; (5) cortical artery; (6) cortical vein; (7) cortical and long subcortical vein; (8) subventricular artery; (9) subventricular vein; (10) intracerebral anatomic vein; (11) extracerebral anatomic vein; (12) great vein of Galen; (13) intervenous anastomosis; (14) junction of cortex and white matter.
veins are joined by the small venules suggests that the direction of the blood-flow in the big veins may normally proceed in either direction. Through the connecting vessels the blood is conducted directly, making a short-cut into the cortical and ventricular veins respectively. The network-like arrangement prevailing in the venous system makes it evident that the blood may be shifted from one more or less arbitrarily outlined area into other regions as necessity may arise. The function of the large intracerebral veins would be, as a whole, to facilitate the drainage of the capillary areas, to cope with a temporary increase in the blood-flow, and to connect the large ventricular with the surface veins. By these anastomotic veins, therefore, pressure-difference between these territories can readily be equalized. The function of the intra- and extra-cerebral anastomotic veins, as for instance the basal vein of Rosenthal, are probably quite similar.

The intracerebral anastomotic veins were seen by Pfeifer (1930) and other investigators (in the human and in the cat's brain). Pfeifer, however, makes only a general statement that a small amount of the venous blood of the white matter is not drained by the surface veins but flows towards the ventricles where there are various possibilities of connexion with the basal veins. Duret (1874) succeeded in injecting the great vein of Galen from one of the cortical veins, and mentions the anastomotic veins as "veins médullaires" (Pfeifer's "Markvenen"), but he does not describe their topographical arrangement and the manner in which they are linked up with the large tributaries of the great vein of Galen in the region of the lateral ventricle and with the venules and capillaries of the white matter.

The anastomotic veins seem to be completely absent where there are many vessels of varying calibre in a given area, as for instance in the basal ganglia. The same applies to a still greater degree to the plexus choriodeus with its rich system of communicating blood-vessels. This plexus, therefore, shows no evidence at all of hyperæmia if one of its venous outlets is blocked. Bedford, having occluded the great vein of Galen, did not find an enlargement of the ventricular system six weeks after the operation, but mentions that a transitory hyperæmia might have been present a short time after the operation. The anatomical and clinical evidence, however, in our experimental animals in which the ventricle was not opened does not suggest an increased production of cerebrospinal fluid.

The effects following the occlusion of a vein in the grey and the white matter are, as a rule, transitory, and changes affecting circumscribed areas following venous occlusion are infrequent; their occurrence depends on the rate at which the occlusion takes place. No account of untoward results
following the occlusion of one small vein of Galen in man could be found in
the literature, the vessels and their tributaries being able to adjust them-
selves to gradually increased local as well as general pressure. In conditions
of acute or sudden occlusion, or suddenly increased pressure, however, as in
a case of thrombosis in adults (A. Meyer—personal communication), birth-
imjuries (Schwartz and Fink, 1927), and, in our experiments, haemorrhages
in the soft substance of the caudate nucleus occur. The author has in his
collection encephalograms showing the very uncommon feature of a grossly
irregular outline of the shadow of the caudate nucleus in an enlarged
anterior horn; this can best be explained by the presence here of old scar-
tissue, formed as a result of a considerable haemorrhage having occurred in
the subependymal layers of the caudate body at birth.

The importance of the venous system of the brain has been realized for
some time, not only in relation to traumatic but also to other pathological
conditions. Meyer and Cook (1936) have put forward the view that the
peculiar network-like localization of hypermyelinized scars in cases of
status marmoratus may be due to peculiarities in the arrangement of the
venous blood-vessels. In post-vaccinal encephalitis and in encephalitis
following measles the characteristic lesions are situated around the veins
of larger calibre (Pette, 1931). The same applies to the demyelination of
the white matter as described in monkeys by Schob (1931). Meyer and
Cook believe that in diffuse sclerosis also the veins are related to the localiza-
tion of the process. Putnam (1937) has called attention to a possible venous
origin of disseminated and diffuse sclerosis. Finley (1937) found that the
distribution of encephalitis associated with vaccination, variola and measles
was dependent primarily on the distribution of the larger veins, and
suggested the injection of a contrast-medium into the cerebral vessels,
believing that it would be found that certain types of veins are more likely
to be involved. While injecting human brains, we made the following
observations which may have a bearing upon this and similar questions:
when, in brains removed some time after death and in which the brain-
substance has undergone some softening, hot carmine-gelatine solution is
forced into the great vein of Galen under heavy pressure, extravasations
may be produced, chiefly in the region of the angle of the lateral ventricle.
These extravasations closely simulate the distribution and even the shape
of plaques in advanced cases of multiple sclerosis. Some authors claim
that the ventricular fluid plays a part in determining the localization of the
disease, but it seems possible that the plaques may only be found in this
area of the ventricular wall because they have a definite topographical
relationship to the veins which are crowded together in the region of the
lateral ventricular angle. Further, the flat plaques which are sometimes situated in the subependymal region above the ventricle can be accounted for by the presence of veins which run parallel to the roof of the lateral ventricle, in association with the callosal fibres.

Summary.

(1) The occlusion of one small vein of Galen after splitting the posterior part of the corpus callosum in a series of monkeys produces a unilateral hyperaemia in certain parts of the brain-stem and of the hemispheres on the operated side, and facilitates the investigation of the vessels draining the blood from this and the neighbouring areas.

(2) The great vein of Galen drains partly the capillary network of the white matter of the cerebral hemispheres in the region of the lateral ventricle, the basal ganglia, and the chorioid plexus of the forebrain, but these structures can also be drained under certain circumstances by veins situated on the surface of the brain.

(3) The Galenic system, therefore, is not an anatomical and much less a functional unit, and forms no exception to the general principle of the plexiform arrangement of the venous system.

(4) In the more extensive areas of white matter, where the capillaries are scanty, large venous channels, referred to as intracerebral anastomotic veins, are present. They arise in the region of the angle of the lateral ventricle from the anterior horn backwards as far as the posterior horn, their distribution following the arrangement of the callosal fibres. They establish the main intracerebral connexions between the great vein of Galen and the veins on the surface of the brain.

(5) No anastomotic veins were found in the basal ganglia where their absence may be related to the density and the richness of the capillaries and the larger vessels.

(6) The distribution of the larger veins in the basal ganglia is described, and attention is called to differences in the angio-architecture of the thalamus.

(7) The drainage areas of the great vein of Galen and the large veins of the brain-surface overlap to a very large extent, and widely separated areas, as for instance the pons, the frontal and occipital lobes, can be injected through the surface communication of this vein.

(8) There was no hyperaemia in the chorioid plexus and no hydrocephalus as the result of the occlusion of the vein. There were, however, numerous haemorrhages in the head of the caudate nucleus, which were
analogous to haemorrhages observed in various clinical conditions related to a suddenly increased intravenous pressure.

(9) Artificially produced perivenous extravasations of a contrast-medium closely simulate the shape and the distribution of plaques in advanced stages of multiple sclerosis.

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LITERATURE.


Testut, L. (1929), Traité d'anatomic humaine, II/1, 1242.