THE IMPORTANCE OF THE DEEP CEREBRAL VEINS
IN CEREBRAL ANGIOGRAPHY

WITH SPECIAL EMPHASIS ON THE ORIENTATION OF THE FORAMEN
OF MONRO THROUGH THE VISUALIZATION OF THE "VENOUS
ANGLE" OF THE BRAIN

PAUL M. LIN, M.D., JOHN F. MOKROHISKY, M.D., HERBERT M. STAUFFER,
M.D., AND MICHAEL SCOTT, M.D.

Departments of Neurosurgery and Radiology, Temple University Hospital and School
of Medicine, Philadelphia, Pennsylvania

(Received for publication February 2, 1955)

The emphasis in cerebral angiography has until recently been centered
on the arterial phase.5,8,9,12,17,18,27

Except for the demonstration of tumor stain or arteriovenous
vascular anomalies, the diagnosis of space-occupying lesions had depended
on the displacement of the cerebral arterial system. Venous patterns were
held to be too variable for their displacement to be evaluated in terms of
space-taking lesions. In 1937, Moniz19,20 stressed the value of the venous
phase of the cerebral angiogram in the diagnosis of tumors and more re-
cently, Krayenbühl and Richter,15 Richter,23 Johanson,13,14 Riemenschneider
and Ecker,22 and Wolf et al.28 have emphasized this phase of the angiogram in
their publications.

The value of cerebral angiography in the diagnosis of space-occupying
lesions has often been compared favorably with pneumoencephalography,
except in cases of deep-seated supratentorial and infratentorial lesions, in
which the latter was believed to be superior. The reason for this deficiency
is the fact that sizable branches of the arterial system do not penetrate to
the deeper structures. However, ordinarily, in the brain, the arteries and
veins do not run together and it is, therefore, conceivable that a space-oc-
cupying lesion may displace one system without disturbing the other. As
Richter23 and Johanson13,14 have recently pointed out, the deep cerebral
veins are often well visualized in routine cerebral angiography, especially the
internal cerebral vein and its branches which drain the deeper cerebral area.
Unlike the cortical veins, they are more constant in their appearance and
anatomical location. The deep cerebral veins, therefore, have an important
place in the diagnosis of deep-seated cerebral lesions and possibly in infra-
tentorial lesions.

The purpose of this paper is to stress the importance of cerebral
phlebography and especially the evaluation of the deep cerebral veins in the
diagnosis of brain tumors. A study of the changes of the configuration and
the position of the internal cerebral vein and its branches in various types of
deep-seated lesions is presented. An attempt is also made to assess the signif-
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The significance of the position of the foramen of Monro, localized by visualization of the "venous angle" of the brain, in various types of cerebral space-taking lesions.

ANATOMY OF THE DEEP CEREBRAL VEINS

The deep cerebral veins are the choroid veins, the striothalamic veins, the internal cerebral veins, the great cerebral vein of Galen and the basal vein of Rosenthal\(^1,4,11\) (Figs. 1, 2, 3, 4 and 5). Embryologically,\(^11\) the deep veins take origin from the anterior plexus and the middle plexus of the primary head vein. When the cerebral hemispheres increase in size the dura mater is compressed between them in the form of the fold that later forms the falx. As the fold is formed the conjoined anterior and middle plexuses are carried into contact with their counterpart on the other side and are finally resolved into the superior and inferior sagittal sinuses. The smaller vessels of the plexuses which retain their connections with the pia mater are transformed into the internal cerebral vein and the great cerebral vein of Galen. From some of the ventral tributaries the inferior cerebral vein is formed which later becomes the basal vein of Rosenthal.

The deep cerebral veins receive their arterial blood supply from the anterior choroidal artery of the internal carotid artery, the lenticulostriate artery of the middle cerebral artery, the recurrent artery of Heubner of the

![Fig. 1. Sagittal section of brain showing the deep cerebral veins and their surrounding structures.](image-url)
**Fig. 2.** Normal deep cerebral venogram—lateral view. (Injected specimen.)

**Fig. 3.** Normal deep cerebral venogram—reverse Water's view. ( Injected specimen.)
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antior cerebral artery, and the posterior choroidal artery of the posterior cerebral artery. The latter may sometimes originate from the basilar artery. From the circle of Willis, numerous small perforating arteries also supply the deep cerebral structures. The posterior choroidal artery serves the choroid plexus of the third ventricle and, with the anterior choroidal artery, supplies that of the lateral ventricle. Besides supplying the choroid plexuses the two choroidal arteries, together with the recurrent artery of Heubner and the

lenticulostriate artery, supply the thalamus, the internal capsule and the basal ganglia (Figs. 1, 3, and 14).

The venous blood from the choroid plexus of the lateral ventricle empties into the striothalamic vein via the superior choroidal vein. The striothalamic vein runs parallel to the terminal portion of the choroidal artery along the lateral inferior wall of the lateral ventricle in the groove formed between the caudate nucleus and the thalamus. The striothalamic vein runs forward and reaches the foramen of Monro where it takes a sharp backward turn and joins at this point with the septal vein (vein of the septum pellucidum) and several small efferent veins from the choroid plexus of the third ventricle.

Fig. 4. Normal cerebral venogram—lateral view. V-A=venous angle. STV=striothalamic vein. ICV=internal cerebral vein. SV=septal vein. GV=great vein of Galen. BV=basal vein of Rosenthal. ISS=inferior sagittal sinus. SS=straight sinus.
The vein continues to form the internal cerebral vein posteriorly and slightly inferiorly.

The "striothalamic vein" (a term widely used in the European literature in describing the deep cerebral veins) is actually the same as the "terminal vein" except that the striothalamic vein includes the superior choroidal vein as its tributary. The terminal vein as a major branch of the striothalamic vein receives the drainage from the deep frontal lobe, the corpus callosum, the corpus striatum, the internal capsule and the thalamus. Its branches run with the calosal fibres above the rostrum and join the rest of the striothalamic vein that runs anteriorly from the choroid vein at or near the foramen of Monro. The terminal vein also receives the transverse caudate vein which drains the caudate nucleus and the thalamus. This runs subependymally, anteriorly and inferiorly between the upper surface of the caudate nucleus and the lower surface of the corpus callosum. The septal vein travels along the anterior and medial aspect of the anterior horn. It is usually curved but can be straight when passing backward to meet the striothalamic vein. This vein receives drainage from the corpus callosum and the deep frontal lobe. The sharp angle, named by Richter the "venous angle of the brain" (Figs. 1, 2, 4, and 6) is the point at which the striothalamic vein

![Diagram of normal cerebral venogram](image-url)
turns mesially and slightly inferiorly, hugging the posterior superior border of the foramen of Monro to form the origin of the internal cerebral vein. The anterior convexity of this turn, or the venous angle, signifies radiographically the posterior border of the foramen of Monro. The paired internal cerebral veins run posteriorly and paramedially within the tela choroidea in the roof of the third ventricle.

The course of the internal cerebral vein in the lateral view has the pattern of a flattened "sine wave" (Figs. 2, and 4). Along their course the internal cerebral veins receive tributaries from the choroid plexus of the third ventricle and from the fornix and corpus callosum. Frequently, the internal cerebral vein receives drainage from the ependymal lining of the posterior horn. Johanson called the vein draining the posterior horn in this fashion, the posterior ventricle vein. This vein usually joins the internal cerebral vein at its posterior third. Johanson also described another branch of the internal cerebral vein which takes its origin usually at the middle or anterior third of the internal cerebral vein. Either of these veins can easily be mistaken for the striothalamic vein if the latter is not filled with the contrast medium.

The paired internal cerebral veins join the basal veins of Rosenthal from each side posteriorly. The four veins eventually drain into a single midline vein, the great cerebral vein of Galen, beneath the splenium and above the

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FIG. 6. Diagrammatic drawing showing relationship of deep cerebral veins with the ventricular system. ISS = inferior sagittal sinus. SS = straight sinus. GV = great vein of Galen. BV = basal vein of Rosenthal. ICV = internal cerebral vein. STV = striothalamic vein. V.A = venous angle. SV = septal vein.
corpora quadrigemina (Fig. 6). The great cerebral vein joins the inferior sagittal sinus at the edge of the tentorium to form the straight sinus which then enters into the confluens sinuum (torcular Herophili). The basal vein of Rosenthal begins at the anterior perforated substance. It is formed by the union of the anterior cerebral vein, the deep middle cerebral vein and the striate vein. It passes backward and upward in the cisterna ambiens around the cerebral peduncle. It receives along its course the tributaries of the choroid plexus of the temporal horn. The basal vein drains the basal portions of the diencephalon and the mesencephalon which include the anterior perforated substance, the tuber cinereum, the mammillary body, the posterior perforated substance, the uncus and the cerebral peduncle.

The great cerebral vein of Galen is a single midline structure running under the splenium in the cisterna venae magnae cerebri above the quadrigeminal bodies. Occasionally it receives a pair of occipital veins which receive their drainage from the inferior and mesial surfaces of the occipital lobes. The great cerebral vein may also receive tributaries from the posterior cingulate gyri of each side, the pineal body, the corpora quadrigemina and the upper surface of the cerebellum via the superior cerebellar vein. The posterior portion (ampulla) of the great vein of Galen is fixed to the anterior edge of the rigid juncture of the falx and the tentorium. The great vein runs between the corpora quadrigemina and the splenium of the corpus callosum and joins the inferior sagittal sinus at an acute angle. This angle is of little clinical importance as there are too many variations in normal individuals.

The angle is more acute in brachycephaly and wider in dolichocephy.

The inferior sagittal sinus runs along the entire course of the inferior margin of the falx. There is a large number of normal variations in the configuration and course of the inferior sagittal sinus. It is usually curved like a bow with an upward convexity but it may sometimes run in a straight line. The straight sinus, which is situated along the midline of the tentorium, drains into the torcular Herophili at an angle varying considerably in normal subjects.

**IMPORTANCE OF DEEP CEREBRAL VEINS IN DIAGNOSIS OF SPACE-OCCUPYING LESIONS**

Because of their attachment to the stiff falx and tentorium, the great cerebral vein of Galen, the inferior sagittal sinus and the straight sinus do not change their position to any great extent in cases of space-occupying lesions. Tumors in the locality of these structures may distort their normal configuration or sidetrack their normal venous tributaries. In the anteroposterior projection, the inferior sagittal sinus is displaced laterally by hemispheric space-taking lesions to a lesser degree than the corresponding internal cerebral vein and the pineal body. The internal cerebral vein and its branches have a relatively constant anatomical position and configuration with little normal variation. The fact that the great cerebral vein of Galen has a fixed anchorage at its posterior attachment to the border of the tentorium makes
the internal cerebral vein and its tributaries more vulnerable in changing their configuration with any sizable space-occupying lesions. The internal cerebral vein is readily compressed toward, or stretched away from, its fixed dorsal attachment.

The internal cerebral vein, because of its anatomical position in the roof of the third ventricle on the superomedial aspect of the thalamus, plays an important role in the diagnosis of deep-seated tumors including lesions of the third ventricle (Fig. 6). Infiltrating lesions of the basal ganglia and tumors of the third ventricle have a tendency to distort the configuration of the internal cerebral vein without producing visible evidence of a space-occupying lesion in the arterial phase of the cerebral angiogram. This is because of the lack of sizable arteries in these areas, as previously pointed out. Richter described the displacement of the internal cerebral vein as "the displacement syndrome of the venous angle." He emphasized the change of the angle formed by the striothalamic vein and the internal cerebral vein in the presence of lesions in various positions in the brain. The angle may be flattened or become a sharp angle (Fig. 7) when it has been displaced from the periphery. It may be widened when it has been stretched by an infiltrating lesion in the structures lying between the two veins, as in the case of a glioma of the thalamus, a tumor of the third ventricle (Fig. 8) or a tumor of the corpus callosum.

Large space-occupying lesions of the periphery of the cerebral hemisphere can also displace the internal cerebral vein and the foramen of Monro as visualized by the "venous angle," just as a shift of the calcified pineal body may occur.
A tumor of the frontal lobe displaces the internal cerebral vein and the venous angle posteriorly (dorsally). The internal cerebral vein may be shortened and compressed like an accordion ("concertina-like"). The septal vein and the terminal vein may individually be distorted if the tumor is of the deep infiltrating type (Fig. 9).

A precentral lesion or tumor of the convexity naturally would depress the
internal cerebral vein, the striothalamic vein and the venous angle (caudal displacement). The laterally placed striothalamic vein may run at the same level as the internal cerebral vein in the lateral projection, or may be even lower than the internal cerebral vein (Fig. 7), especially in the case of a tumor within the lateral ventricle, such as an ependymoma.

An occipital tumor (Fig. 10) would displace the venous angle anteriorly (ventrally), but would rarely distort its configuration. This is probably because of the inclined stiff tentorium which serves as a hard partition between the occipital lobe and the deep cerebral veins. A tumor of the splenium of the corpus callosum has a tendency to depress the internal cerebral vein or flatten it, while in the presence of a pinealoma both internal cerebral veins would be displaced upward (cephalad) and laterally in their posterior portions. In a recent publication, Riemenschneider and Ecker\(^2\) mentioned displacement of the great vein of Galen by a pinealoma. However, their schematic drawing of the roentgenogram shows that the great vein of Galen is in a relatively normal position while the actual displacement appears to have occurred in the posterior third of the internal cerebral vein. Johanson, in his monograph on the deep cerebral veins,\(^1\) stated that the internal cerebral veins rather than the vein of Galen are displaced by pinealomas. As previously noted, the great vein of Galen is a short structure fixed at the junction of the tentorium and the falx. It is for this reason that little or no displacement of this structure occurs when there is a nearby space-taking lesion; it is more likely that the adjacent tributaries such as the internal cerebral vein and the basal vein of Rosenthal will exhibit more definite and significant changes as visualized in the phlebogram.

In the case of a tumor of the third ventricle, one would expect the two

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**Fig. 10.** D.S. Huge meningioma of right occipital lobe. The internal cerebral vein and venous angle are displaced anteriorly and inferiorly.
internal cerebral veins to be elevated, stretched and displaced laterally in the anteroposterior projection. This is contrary to the situation occurring with a deep-seated tumor of the thalamus, when the internal cerebral vein is displaced upward and mesially toward the midline or across the midline to the other side as visualized in the anteroposterior projection. In the case of a colloid cyst of the third ventricle (Fig. 8) the internal cerebral vein is stretched and displaced anteriorly and inferiorly by the cyst, which supposedly originates from the paraphysis in the tela choroidea.

Temporal lobe lesions, because of their anatomical location, may show a marked displacement of the internal cerebral vein toward the opposite side in the anteroposterior projection (Fig. 11) without any displacement of the venous angle in the lateral projection; the internal cerebral vein, however, is commonly markedly stretched and loses its smooth sinuous configuration.

Craniopharyngiomas, pituitary tumors, aneurysms or other basal tumors may displace the internal cerebral vein and the venous angle cephalad and dorsad. The septal vein and the internal cerebral vein are elevated while the internal cerebral vein and the striothalamic vein may appear to be displaced toward each other in lesions of this character.

Since we do not perform carotid angiograms routinely in patients with infratentorial lesions, we have not encountered any displacement of the internal cerebral vein in such cases. However, it is conceivable that in the

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Fig. 11. T.S. Right temporal lobe glioblastoma. The internal cerebral vein is displaced to the left of the midline. Anteroposterior view.
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A case of a large tumor of the pons or of the vermis of the cerebellum, the internal cerebral vein might be displaced upward and forward (cephalad and ventrad). Also one would expect to see some significant changes in the basal vein of Rosenthal.

Each internal cerebral vein runs paramedially along the roof of the third ventricle. The anterior part of the vein is in the axis of the roentgen beam in the anteroposterior projection and therefore in this view this part of the internal cerebral vein is visualized as a dense round spot beneath a similar one formed by the inferior sagittal sinus. The paired internal cerebral veins are 2 to 3 mm. apart so that, for all practical purposes, each may be considered to be situated at a distance of 1 mm. from the midline (Figs. 3 and 4). This position is of importance in measuring the lateral displacement of these veins in the anteroposterior projection. When the head is rotated at the time the angiogram is exposed, stereoscopy aids in determining the presence or absence of lateral shift of these veins through the relationship of the internal cerebral vein to other fixed midline structures such as the superior and inferior sagittal sinuses, the tuberculum sellae and the crista galli.

The internal cerebral vein, the anterior cerebral artery and the pineal body are considered midline structures as visualized in the anteroposterior projection. All three of these midline structures may be visualized. Displacement of one without displacement of the other may help in localization of a tumor, since the three structures are situated in various positions along the mid-sagittal plane.

The basal vein of Rosenthal, which originates in the anterior perforated space from the union of the anterior cerebral vein, the deep middle cerebral vein and the inferior striate vein, travels around the cerebral peduncle in the cisterna ambiens and receives along its course the choroid veins from the choroid plexus of the temporal horn. The visualization of this vein in cerebral phlebogram in the anteroposterior projection has a significance similar to the demonstration of calcified choroid plexuses in determining whether a tumor in the temporal area is situated in the temporal lobe or in deeper structures. The vein would be expected to be displaced laterally in a mid-brain lesion and displaced upward in a basal space-occupying lesion or a massive infratentorial tumor.

LOCALIZATION OF FORAMEN OF MONRO THROUGH VISUALIZATION OF "VENOUS ANGLE" OF BRAIN

The importance of the orientation of the calcified pineal body as an aid in the roentgenologic localization of space-occupying lesions is well known.6,7,10,21 Despite the recent advances in pneumoencephalography and angiography, in many instances the combination of a significant pineal shift in addition to an accurate history and neurologic findings, provides sufficient diagnostic evidence to warrant neurosurgical intervention in the case of a suspected intracranial space-occupying lesion.

We know that only approximately 50 per cent of all pineal bodies are
sufficiently calcified to permit radiographic visualization and only 50 to 70 per cent of those visualized exhibit calcification sufficiently discrete to permit adequate orientation measurements in both the anteroposterior and lateral projections. The "anterior convexity point" of the striothalamic vein or the "venous angle" of the brain (V-A) localizes the posterior border of the foramen of Monro which, in normal subjects, is an anatomically constant structure with a constant position just as is the pineal body. If orientation measurements in the lateral projection using the anterior convexity point of the "venous angle" can be made as has been done for the calcified pineal, it would help in localization of space-occupying lesions by cerebral angiography, especially in the following situations:

1. Infiltrating deep-seated lesions when the arterial pattern is not disturbed.
2. When the internal cerebral vein is displaced but not distorted.
3. When the anterior projection is unsatisfactory because of rotation, especially when stereoscopic projections are not available.

The Vastine-Kinney chart for the orientation of the pineal body is most widely used today, despite many modifications added since the original article was published in 1927. The following is a study of the orientation of the anterior convexity point of the venous angle of the brain employing a method similar to that of Vastine and Kinney for pineal body orientation (Fig. 12).

(1) Select the anterior convexity point along the "venous angle" (A). This is the point at which the striothalamic vein joins the internal cerebral vein and is called the "venous angle" of the brain. The anterior convexity point is usually directed anteriorly but sometimes it may point antero-inferiorly. The angle is
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usually quite acute so that there is no difficulty in choosing this point. If the angle takes the form of a large arc, one should choose the anterior inferior convexity point of the arc for the orientation study since the internal cerebral vein has a relatively straight course until it reaches the foramen of Monro where it begins the sweep that forms the venous angle.

2. Draw the base line (B), the line that joins the nasion and the tuberculum sellae, and extend the line beyond the tuberculum sellae.

3. Draw a perpendicular line from the base line (B) passing through point (A) to reach the inner table of the skull at the vault. The distance from the inner table of the vault to point (A) is called C and the distance from the inner table of the vault to the base line (B) is called C'.

4. The distance from point A to the inner table of the frontal bone (the longest distance) is called D.

5. The longest anteroposterior diameter of the skull (D') is measured from the inner table of the frontal bone to the inner table of the occipital bone. In the event that slight rotation of the skull has resulted in visualization of two inner tables of the frontal bone, the midpoint between the two is employed for measurement.

6. Chart C against C' for determination of cephalic and caudal displacement of the venous angle.

7. Chart D against D' for determination of ventral and dorsal displacement of the venous angle.

8. The angle formed between the floor of the anterior fossa and the base line at the tuberculum sellae is O. The average of this angle O is 23 degrees. Should the nasion not be visualized either because of poor penetration of this portion of the skull or because this point is projected beyond the border of the film, one can reconstruct the base line utilizing the average angle O (23 degrees) and a line corresponding to the floor of the anterior fossa.

MATERIAL

The measurements for this study were made from cerebral angiograms exposed in the biplane stereoscopic serial device (Chamberlain). This device consists of two Fairchild roll film magazines and two rotating anode roentgen tubes arranged at right angles to each other so that simultaneous anteroposterior and lateral projections can be secured. A mechanism shifts both roentgen tubes between exposures and during the film transport so that, in each projection, each exposure on the roll is stereoscopic with the exposure preceding it and following it. The time lapse between exposures is 0.6 second. The distance from the target of the roentgen tube to the film is 40 inches, and the distance from the center of the patient's head to the film in the lateral projection is approximately six inches resulting in a magnification factor of approximately 46/40. For cerebral angiography 12 exposures in both the anteroposterior and lateral projections are made routinely. The injection of the contrast material begins immediately after the first film is exposed; an 18 gauge needle is employed and 10 cc. of 30 per cent Urokon sodium solution are injected as rapidly as possible. 

Two hundred cerebral angiograms, including both normal and abnormal
cases, have been studied. The visualization of the various deep cerebral veins obtained is analyzed in Table 1.

**TABLE 1**

*Frequency of visualization of deep cerebral veins in a study of 200 cases*

<table>
<thead>
<tr>
<th>Deep Cerebral Veins</th>
<th>Cases</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial cortical veins</td>
<td>179</td>
<td>89</td>
</tr>
<tr>
<td>Septal vein</td>
<td>61</td>
<td>30</td>
</tr>
<tr>
<td>Striothalamic vein</td>
<td>131</td>
<td>65</td>
</tr>
<tr>
<td>Internal cerebral vein</td>
<td>153</td>
<td>76</td>
</tr>
<tr>
<td>Great vein of Galen</td>
<td>143</td>
<td>71</td>
</tr>
<tr>
<td>Basal vein of Rosenthal</td>
<td>136</td>
<td>69</td>
</tr>
</tbody>
</table>

Since cerebral angiograms are not performed knowingly in normal individuals, it is extremely difficult to compile a group of normal cerebral angiograms. The "normal" angiograms in this study are those of patients with normal or insignificant neurological findings, normal electroencephalograms, and normal cerebrospinal fluid studies. It was not, of course, possible to do pneumoencephalograms in all of these patients to verify their normality. Patients with histories of old spontaneous subarachnoid hemorrhage with or without demonstrable aneurysms are also included in this series of normal angiograms, provided that at the time of examination there was no evidence of fresh hemorrhage, hematoma formation or abnormal neurological sign.

Charts were made of the orientation of the venous angle of the brain using the same principles employed in construction of the Vastine-Kinney chart for pineal body orientation (Fig. 13). The two limiting lines designat-
ing the normal limits of position of the venous angle are 12 mm. apart in the dorsal-ventral orientation chart (Fig. 14)—11 mm. apart in the Vastine-Kinney chart—with 92.3 per cent of the normal falling between these lines. In the cephalic-caudal orientation chart (Fig. 15) the distance is also 12 mm. apart—12 mm. in the Vastine-Kinney chart—with 98.7 per cent of the normal cases falling between the lines. The larger variation in dorsal-ventral orientation is caused by the variation in the shape of the skull (brachycephaly and dolichocephaly). In dolichocephaly the venous angle has the tendency to be displaced ventrad while in brachycephaly the venous angle tends to be displaced dorsally. There is the same difficulty in orientation of

Figs. 14 and 15. Seventy-seven normal venous angle measurements plotted on chart to determine the normal range of deviation. The limiting lines denote the maximum deviation in (left) ventrodorsad and (right) cephalocaudad direction.

the pineal body in the presence of extreme dolichocephaly and brachycephaly.

The displacement of the venous angle in cases of intracranial space-taking lesions is shown in a study of 26 selected cases of proved space-occupying lesions (including 3 cases of internal hydrocephalus). In only 3 cases was the position of the venous angle within normal limits.

Seven cases of proved frontal lobe tumors are charted (Fig. 16). The venous angles are uniformly displaced posteriorly (dorsad). The internal cerebral vein may also be displaced upward (cephalad) or downward (caudad), depending on whether the tumor is situated at the convexity of the frontal lobe or at the base of the frontal lobe.

In cases of internal hydrocephalus with block either at the foramina of Magendie or Luschka, the aqueduct of Sylvius, or at the foramen of Monro, the internal cerebral vein and the venous angle are depressed (Fig. 17). Three cases of internal hydrocephalus and 5 cases of parietal convexity and
parasagittal tumors are plotted in the cephalocaudal orientation chart showing their downward (caudal) displacement (Fig. 18).

Eight cases of parieto-occipital tumors are plotted (Fig. 19), 2 of which fall within the normal limiting lines of the dorsal-ventral orientation chart. The lack of ventral displacement of the internal cerebral vein and venous angle in these cases, as has been discussed previously, is attributed to the rigid partitioning effect of the tentorium. Associated downward (caudal) displacement of the venous angle is commonly seen.

Three cases of basal tumors are charted. They show slight upward (cephalic) shift of the venous angle (Fig. 20).

One point of importance in identifying the venous angle is that frequently the vein of the posterior horn or a branch of the internal cerebral vein may be mistaken for the striothalamic vein. The following observations

Fig. 16. Seven cases of frontal lobe tumors plotted on chart, showing posterior displacement of the venous angle.

Fig. 17. I.S. Hydrocephalus. The internal cerebral vein is flattened and displaced downward because of enlargement of the lateral ventricles.
should aid in differentiating the two veins:

1. The vein of the posterior horn takes off from the middle of the internal cerebral vein and should the internal cerebral vein beyond this point not be filled, one would observe that the internal cerebral vein appears unusually short (Fig. 21). Although one can find the internal cerebral vein shortened in cases of large frontal lobe tumors, in these cases the internal cerebral vein loses its smooth sinuous configuration and, instead, it is often compressed together in accordion-fashion ("concertina-like," Johanson).

2. The junction of the striothalamic vein and the internal cerebral vein ordinarily appears in the lateral projection as a smooth though fairly sharp curve and the veins then run parallel to each other. The other branches of the internal cerebral vein usually take off at a right angle or a sharp acute angle.

3. The presence of the septal vein helps to identify the striothalamic vein.

4. The vein of the posterior horn is usually present when the posterior cerebral artery of that side is filled in the arterial phase.
FIG. 21. False venous angle. The true venous angle (TV-A) is 17 mm. antero-inferior to the false venous angle (FV-A).

DISCUSSION

The study of the deep cerebral veins in the cerebral phlebogram is extremely important in the roentgen diagnosis of deep-seated space-occupying lesions. Large space-occupying lesions of the periphery of the cerebral hemispheres usually show sufficient displacement in the arterial phase even though they also show definite demonstrable displacement of the deep cerebral veins. However, there is one exception to this statement: occasionally, an occipital lobe tumor may not be visualized by the carotid angiogram when there is a lack of filling of the posterior cerebral artery and the anterior cerebral artery is not displaced to the opposite side, the lesion being situated too far posteriorly. A significant forward (ventral) shift of the venous angle in these cases in addition to the presence of a definite homonymous hemianopsia may warrant further contrast study such as pneumoencephalography.

The internal cerebral vein has a constant anatomical configuration and position. However, there are normal deviations. To establish a diagnosis of a deep-seated lesion on radiographic findings with respect to the internal cerebral vein and its branches alone, without any knowledge of a complete neurological examination would be hazardous. Because of the compactness of the anatomical structures in the deep cerebral area, a space-occupying lesion in these areas invariably presents a neurologic deficit. Therefore, when one encounters slight change in the configuration or slight displacement of the internal cerebral vein the latter can only be interpreted as of significance.
when there are compatible neurologic findings. There is no substitute in the
diagnosis of deep-seated space-occupying lesions or, for that matter, of any
neurologic lesion for a careful, methodical and complete neurological exami-
nation. Roentgen studies may verify or supplement the clinical neurologic
diagnosis; however, a definitely abnormal roentgenologic finding must,
even though it may not conform entirely to the clinical neurological find-
ings, be given great weight in arriving at the final diagnosis.

The study of the orientation of the foramen of Monro through visualiza-
tion of the venous angle of the brain in the cerebral phlebogram shows that a
good correlation exists between the displacement of the venous angle and the
various positions of intracranial space-taking lesions. Basal tumors do not
show any remarkable displacement of the venous angle cephalad to the
normal limiting lines of the cephalocaudal orientation chart. This is to be
expected as the lesions in this area are relatively small when discovered.
Hence, a more refined method of measurement, such as determining the aver-
age normal distance from the venous angle to the posterior clinoid, might be
of value in orientation of lesions in this area.

It is extremely important to take into consideration normal variation in
the position of the foramen of Monro as visualized through the venous angle
of the brain in the cerebral phlebogram. If one is familiar with the normal
position and configuration of the deep cerebral venous system, it should be
possible to detect any gross displacement or alteration of its general con-
figuration from the normal in the case of an intracranial space-occupying
lesion. This is probably more important in arriving at a diagnostic opin-
ion from a cerebral phlebogram than relying completely on measurements of
a point or a structure.

Since visualization of the deep cerebral veins can be obtained in a rela-
tively high percentage of cases in routine cerebral angiography (75 per cent)
and since cerebral phlebography has a definite place in the diagnosis of brain
tumors, one should certainly always try to obtain a satisfactory venous
phase of the cerebral angiogram.

The time of the appearance of the venous phase in cerebral angiography
varies tremendously from individual to individual. It may vary from 2 sec-
onds to 8 seconds. The reason for the marked variations in the circulation
time may be found in the variation of individual response to the contrast
material, sensitivity of the cerebral vascular system, the rate of injection
and the effect of the various types of intracranial lesions. Serial angiography
with an exposure interval of 1 second or less is desirable. If serial angiography
is not available, it is suggested that films be exposed at 2, 4, 6 and 8 seconds
from the beginning of the injection in an effort to include satisfactory visuali-
ization of the venous phase. Special attempts should be made to obtain a
satisfactory phlebogram when a deep-seated cerebral lesion is suspected.
SUMMARY

The anatomy of the deep cerebral veins has been discussed.

The importance of the deep cerebral veins in the diagnosis of space-occupying lesions by cerebral angiography has been stressed. The need for obtaining a technically satisfactory phlebogram in routine cerebral angiography then becomes obvious.

Cerebral phlebograms with satisfactory visualization of the internal cerebral vein and the venous angle of the brain were obtained following a single injection of 10 cc. of 30 per cent “Urokon sodium” in 75.5 per cent of cases in the study of a series of 200 cerebral angiograms performed with the stereoscopic serial angiographic device (Chamberlain): 10.5 per cent showed no visualization of the venous phase; 13 per cent showed visualization of the superficial cortical veins without satisfactory visualization of the deep cerebral veins.

An attempt was made to establish an orientation chart for the foramen of Monro through the visualization of the “venous angle” of the brain in the cerebral phlebogram, using the same principles employed in constructing the Vastine-Kinney chart for the position of the pineal body. Seventy-seven “normal” cerebral phlebograms were used to establish the normal limits of position for the venous angle. The normal deviation is 6 mm. in any direction.

Twenty-six cases of proved space-occupying lesions were studied. The orientation of the venous angle in this group indicates that the foramen of Monro can be displaced by any sizable space-occupying lesion.

While the orientation chart so constructed provides a useful basis for study of the position of the foramen of Monro, it is pointed out that, with experience, inspection of the phlebogram and evaluation of the relationship of the internal cerebral vein and its tributaries to the landmarks in the skull, as well as the configuration of the internal cerebral vein itself, may be of greater diagnostic value than any absolute measurement made from the roentgenograms.

REFERENCES

IMPerIAL OF DEEP CEREBRAL VEINS IN ANGIOGRAPHY


