CHAPTER 75

Veins of the posterior fossa

Yun Peng Huang and Bernard S. Wolf

According to Padget (1957) the most conspicuous vein in the posterior fossa in an embryo of about 60 to 80 mm is the ventral metencephalic vein. This vein, which drains the anterior aspect of the primitive brainstem and cerebellar plate, becomes the future petrosal vein and superior petrosal sinus. The dorsal metencephalic vein, on the other hand, appears somewhat later than the ventral metencephalic vein and is less conspicuous since the cerebellar plate has not yet developed into the voluminous hemisphere at this stage. This posterior group of veins drains the posterior portion of the cerebellum and opens into the straight and lateral sinuses via tentorial plexuses. Since the venous drainage of the upper part of the cerebellum is usually annexed to the galenic system and drains superiorly, the posterior fossa venous system may most appropriately be classified, on the basis of direction of drainage, into the following three groups: (1) the superior or galenic draining group, (2) the anterior or petrosal draining group, and (3) the posterior or tentorial draining group.

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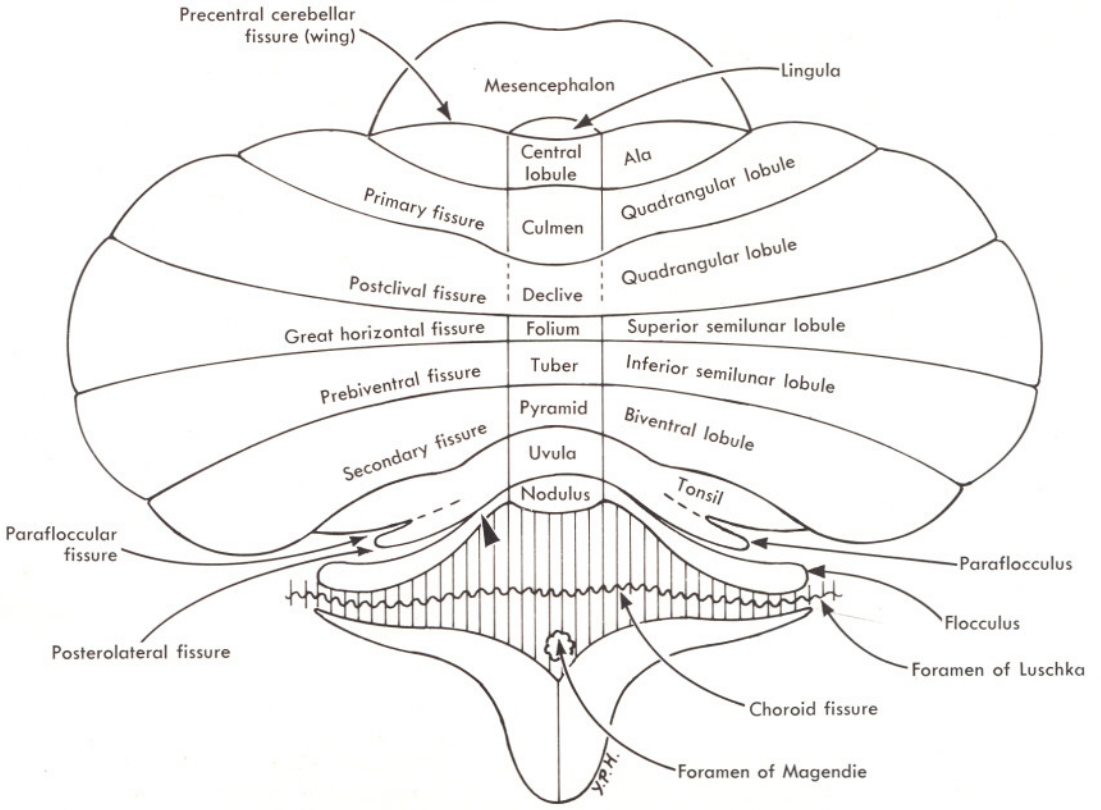

Fig. 75-1. Diagram of the cerebellum showing the divisions of the vermis and the corresponding hemispheric lobules and fissures. The vermian fissures (unlabeled) are medial extensions of the hemispheric fissures. The fissure between the central lobule and culmen is the preculminate fissure. The suprapyramidal fissure is the medial extension of the prebiventral fissure and is also called the tuberopyramidal fissure. The infrapyramidal fissure is the medial extension of the secondary fissure, whereas the uvulonodular fissure is the vermian portion of the posterolateral fissure. The portion of the flocculonodular lobe lateral to the nodulus becomes thinned out at a later stage and forms the posterior medullary velum on either side of the nodulus (large arrowhead). The choroid fissure marks the location of the choroid plexus.

ANATOMY OF THE CEREBELLUM AND BRAINSTEM

Nomenclatures concerning cerebellar divisions into cerebellar lobules by various fissures are numerous and somewhat controversial even among neuroanatomists (Schäfer and Symington, 1908; Ingvar, 1918; Langelaan, 1919; Ziehen, 1934; Dow, 1942). To avoid ambiguity, the terminology used in this chapter concerning fissures and cerebellar lobules is shown diagrammatically in Fig. 75-1.

Description of the veins of the posterior fossa requires detailed knowledge of the surface anatomy of the brainstem and cerebellum (Fig. 75-2).*

The *brainstem* includes the mesencephalon, pons, and medulla oblongata. The mesencephalon is located behind the diencephalon and consists of the paired bases pedunculi, tegmentum, and tectum. On its anterior aspect is located the interpeduncular fossa, which is bordered superiorly by the mammillary bodies, posteriorly by the posterior perforated substance, inferiorly by the superior aspect of the pons, and laterally by the medial aspect of the cerebral peduncle on each side. The interpeduncular fossa is oblique, inclined anteriorly in its upper portion, and deepest inferiorly where a small midline depression, the superior foramen cecum, is present. Laterally the basis pedunculi is separated from the tegmentum by the lateral mesencephalic sulcus on each side, which extends inferiorly and posteriorly to become the interbrachial sulcus. The pontomesencephalic sulcus also joins the interbrachial sulcus posteriorly. Behind the tegmentum the tectum forms the posterior part of the mesencephalon.

*For an explanation of abbreviations used in the figures in this chapter, see end of Chapter 74, pp. 2152 and 2153.

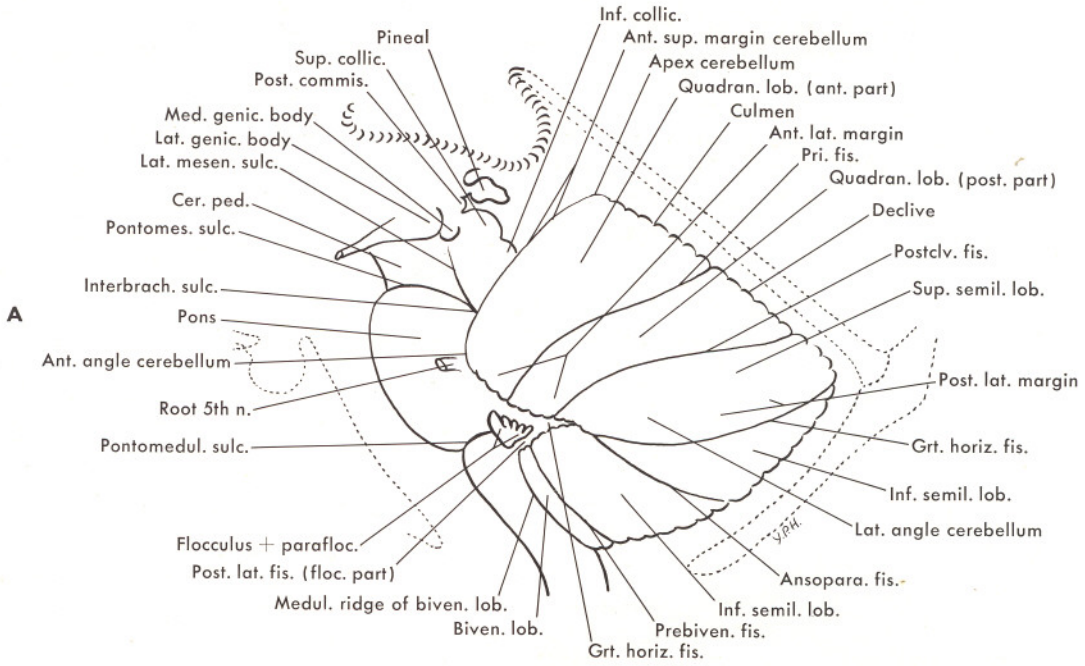

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Fig. 75-2. Diagram of the radiologically pertinent anatomic relations of the brainstem and cerebellum. **A,** Lateral view. The anterosuperior margin of the cerebellum meets the anterolateral margin at the anterior angle (behind and above the origin of the fifth nerve). The anterolateral margin, on the other hand, meets the posterolateral margin at the lateral angle (behind and below the knee of the lateral sinus). The lateral mesencephalic and pontomesencephalic sulci fuse posteroinferiorly to form the interbrachial sulcus. **B,** Medial view, midsagittal section. The posterior superior recess of the fourth ventricle extends posteriorly and inferiorly beyond the fastigium. The medial ends of both anterosuperior margins meet each other at the apex of the cerebellum—the highest point of the culmen. Note that the course of the precentral cerebellar fissure is parallel to the lower end of the aqueduct and the roof of the upper part of the fourth ventricle. **C,** Straight anteroposterior view. The junction between the superior and inferior surfaces of the cerebellar hemisphere extends anteriorly from the anterior angle to the lateral angle. The quadrangular lip is a portion of the quadrangular lobule below the anterolateral margin. The great horizontal fissure of the cerebellum runs between the superior semilunar lobule above and the inferior semilunar lobule below. At the lateral border of the flocculus-paraflocculus complex, the fissure changes its course and runs superiorly, medially, and anteriorly above the flocculus. The fissure between the flocculus-paraflocculus complex and the biventral lobule is the floccular part of the posterolateral fissure. The supraolivary fossette is located above and behind the olive and forms the medial part of the cerebellopontomedullary angle. The medullary ridge of the biventral lobule is a fairly sharp vertical crest on the petrosal aspect of the cerebellar hemisphere. This crest also marks the anterior margin of the cerebellomedullary fissure.

The *pons* has a shape of a potbelly convex from side to side as well as from top to bottom. It is demarcated superiorly by the pontomesencephalic sulcus; laterally from the brachium pontis on each side by a shallow groove, the lateral pontine sulcus; inferiorly by the pontomedullary sulcus, which extends from the midline inferior foramen cecum to the supraolivary fossette (Poirier, 1921; Huang and Wolf, 1967; Huang et al., 1968a). The supraolivary fossette of the medulla oblongata is located behind and above the olive and is continuous inferiorly with the retro-olivary sulcus anterior to the ninth, tenth, and eleventh cranial nerves. The medulla oblongata is widened superiorly. The restiform bodies diverge as they are traced upward. The cerebellopontomedullary region is, in reality, a solid angle and is the area between the pons, cerebellum, and medulla oblongata. The supraolivary fossette occupies the medial and posterior portions of this angle whereas the superficial membranous (or floccular) portion of the lateral recess, together with the ninth and tenth

nerves, forms the lateral wall of the angle. Superiorly the angle is bordered by the undersurface of the brachium pontis whereas inferiorly the angle opens into the anterior part of the cerebellomedullary fissure.

The *cerebellum* has a superior surface and an inferior surface that are separated anteriorly and laterally by the anterolateral margin and posteriorly and laterally by the posterolateral margin. The former margin is related to the superior petrosal sinus whereas the latter margin runs parallel to the transverse sinus. There is

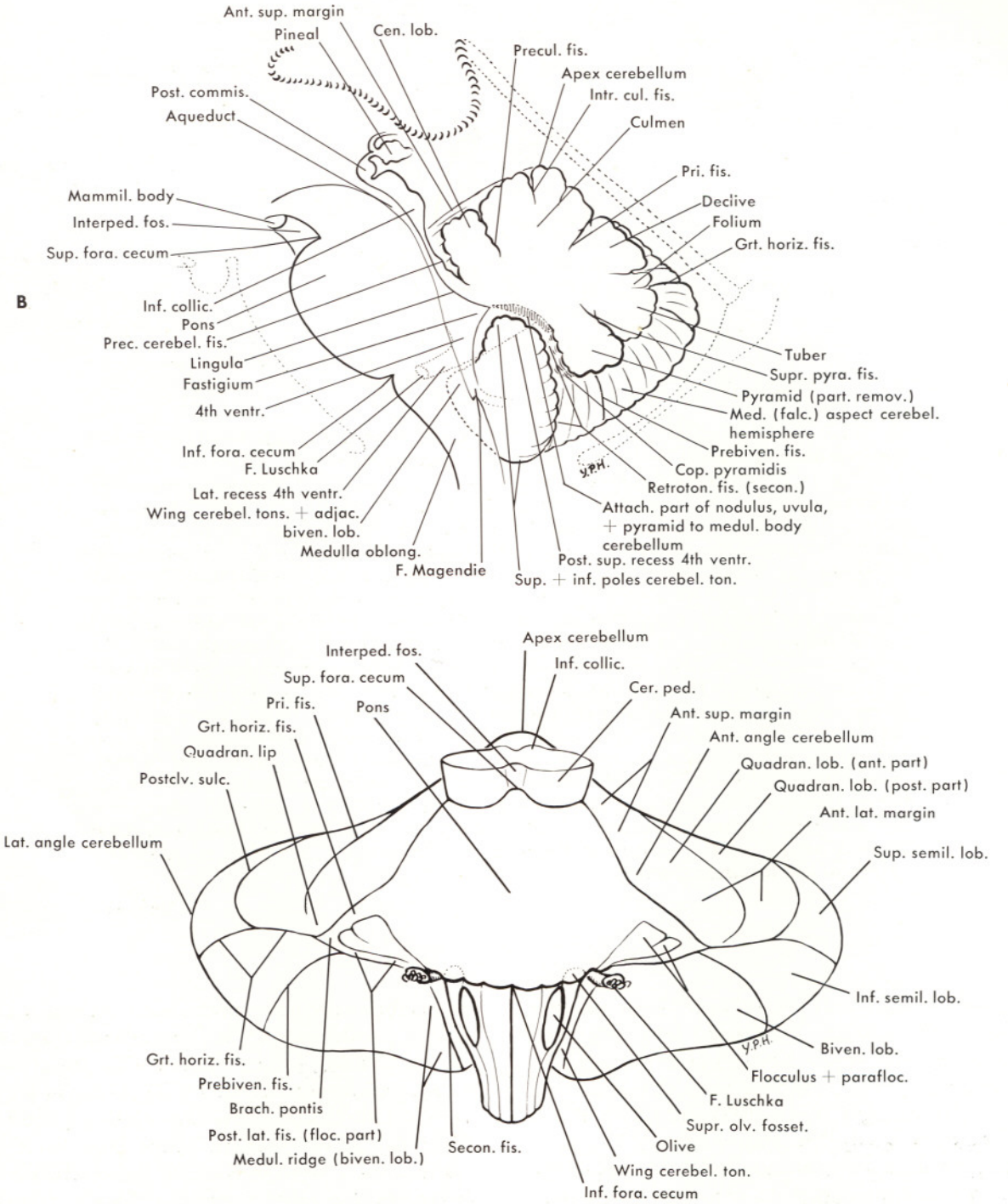

Fig. 75-2, cont'd. For legend see p. 2157.

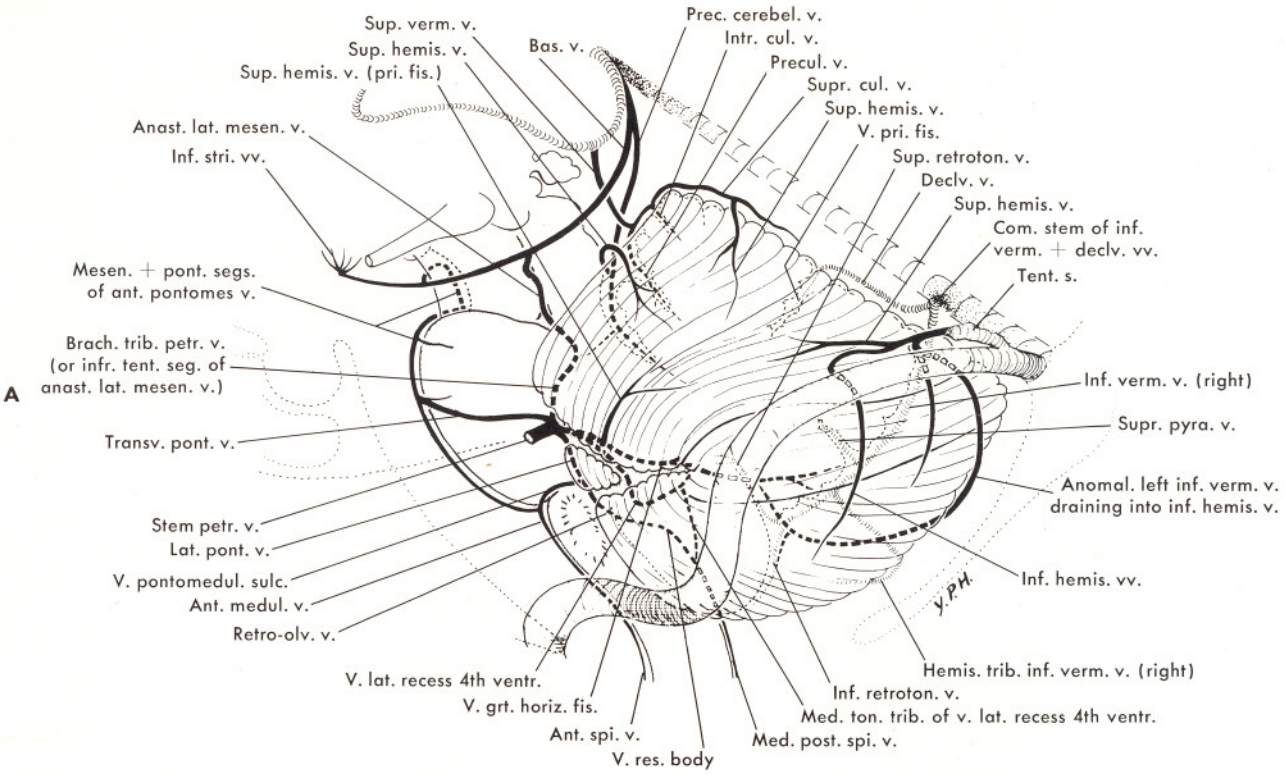

Fig. 75-3. Diagrams of the cerebellum and brainstem showing the superior, anterior, and posterior draining veins of the posterior fossa and related anatomic structures.

A, Lateral view. Covered portions of the veins are dashed. The right inferior vermian vein and its tributaries are lightly shaded. The anterior aspect of the brainstem is outlined by the anterior pontomesencephalic, anterior medullary, and transverse pontine veins. The apex of the hairpin course of the hemispheric tributary of the precentral cerebellar vein indicates the location of the anterosuperior margin of the cerebellum. The depth of the wing of the precentral cerebellar fissure is indicated by the brachial tributary of the petrosal vein. Inferiorly the median posterior spinal vein, vein of the restiform body, and medial tonsillar tributary of the vein of the lateral recess of the fourth ventricle outline the posterior aspect of the lower brainstem. Posteriorly the inferior vermian and declival veins unite to drain into the straight sinus some distance anterior to the torcular. Inferior hemispheric veins run upward, crossing the posterolateral margin of the cerebellum to run onto the superior surface of the cerebellar hemisphere. These veins then run medially and receive one or two superior hemispheric tributaries to form a venous trunk that, in turn, drains into the tentorial sinus and eventually opens into the lateral sinus or straight sinus. Superior and inferior retrotonsillar tributaries of the inferior vermian vein indicate the posterior border of the cerebellar tonsil. Although the vein in the primary fissure may drain into the supraculminate tributary of the superior vermian vein, more often it drains posteriorly to join the declival vein.

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another surface that faces the brainstem—the *anterior cerebellar notch*. This can be divided into upper and lower parts by the cerebellar peduncles. The upper part corresponds to the precentral cerebellar fissure and its wings (Huang and Wolf, 1965, 1966), and the lower part to the cerebellomedullary fissure. The junction between the superior surface and the wings of the precentral cerebellar fissure is the anterior superior margin, which runs roughly parallel to the free margin of the tentorium. These margins meet superiorly and posteriorly at the apex of the cerebellum. Inferiorly they diverge and become continuous with the anterolateral margins at the anterior angles. These angles are located slightly behind and above the emerging roots of the trigeminal nerves from the pons. The lower part of the anterior cerebellar notch is the cerebellomedullary fissure (Hauge, 1954; Greitz and Sjögren, 1963; Huang et al., 1969), which can be divided into the portion

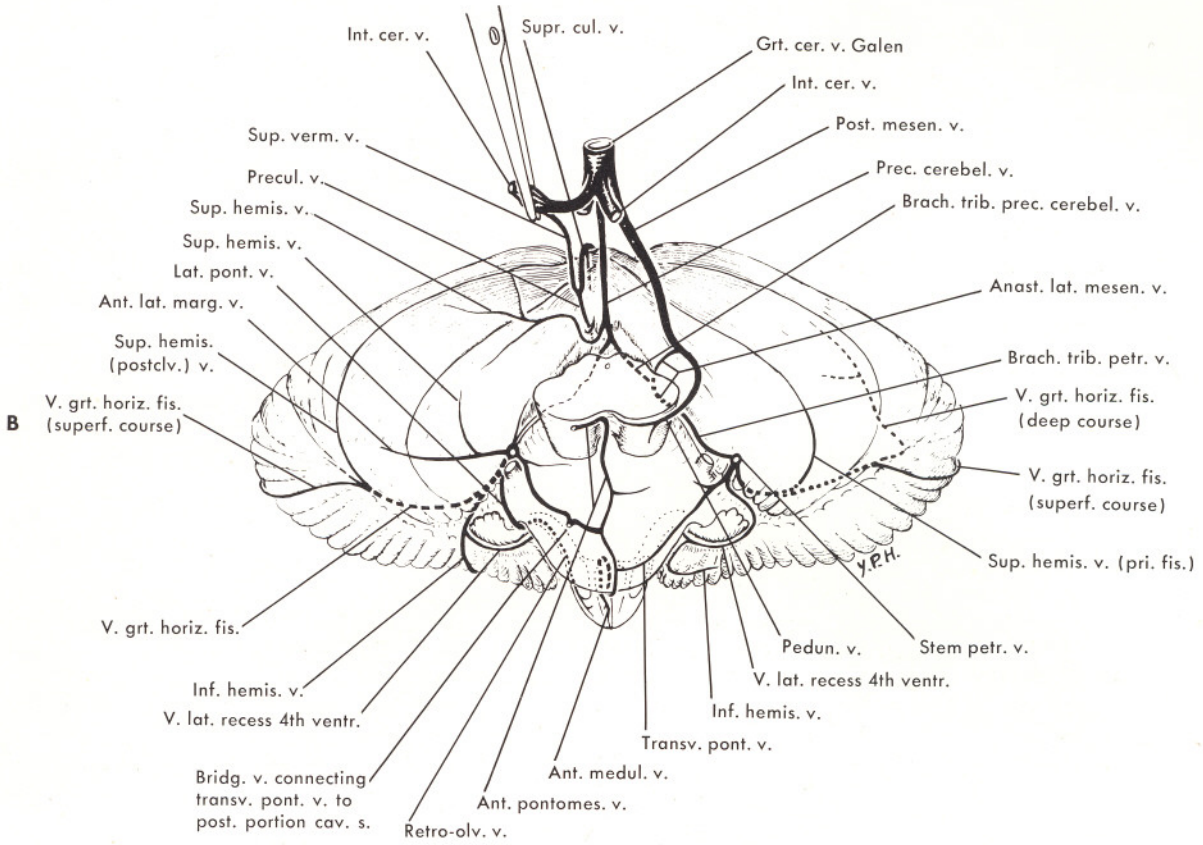

Fig. 75-3, cont'd. B, Semiaxial view. Covered portions of the veins are indicated by dashed lines. The peduncular, anastomotic lateral mesencephalic, and precentral cerebellar veins outline portions of the anterior, lateral, and posterior aspects of the mesencephalon respectively. Inferior dipping of the superior hemispheric tributary of the precentral cerebellar vein into the precentral cerebellar fissure indicates the location of the anterosuperior margin of the cerebellum. The location of the precentral cerebellar fissure and its wing is indicated by brachial tributaries of the precentral cerebellar and petrosal veins. The supraculminate tributary of the superior vermian vein indicates the location of the culmen and apex of the cerebellum. The superior hemispheric tributaries of the superior and anterior draining veins reveal the shape and level of the superior surface of the cerebellum (the superior hemispheric tributaries of the posterior draining veins are not illustrated). Multiple transverse pontine veins outline the belly of the pons at different levels. The retro-olivary vein and its superior extension indicate the lateral border of the medulla oblongata and the site of the cerebellopontomedullary angle. The origin of the petrosal vein is in the region of the anterior angle of the cerebellum (the stem of the petrosal vein draining into the superior petrosal sinus is not illustrated). Inferior hemispheric tributaries of anterior draining veins indicate the petrosal aspect of the cerebellum. The peduncular portion (only partly illustrated) of the vein of the lateral recess of the fourth ventricle also marks the location of the lateral recess and cerebellopontomedullary angle.

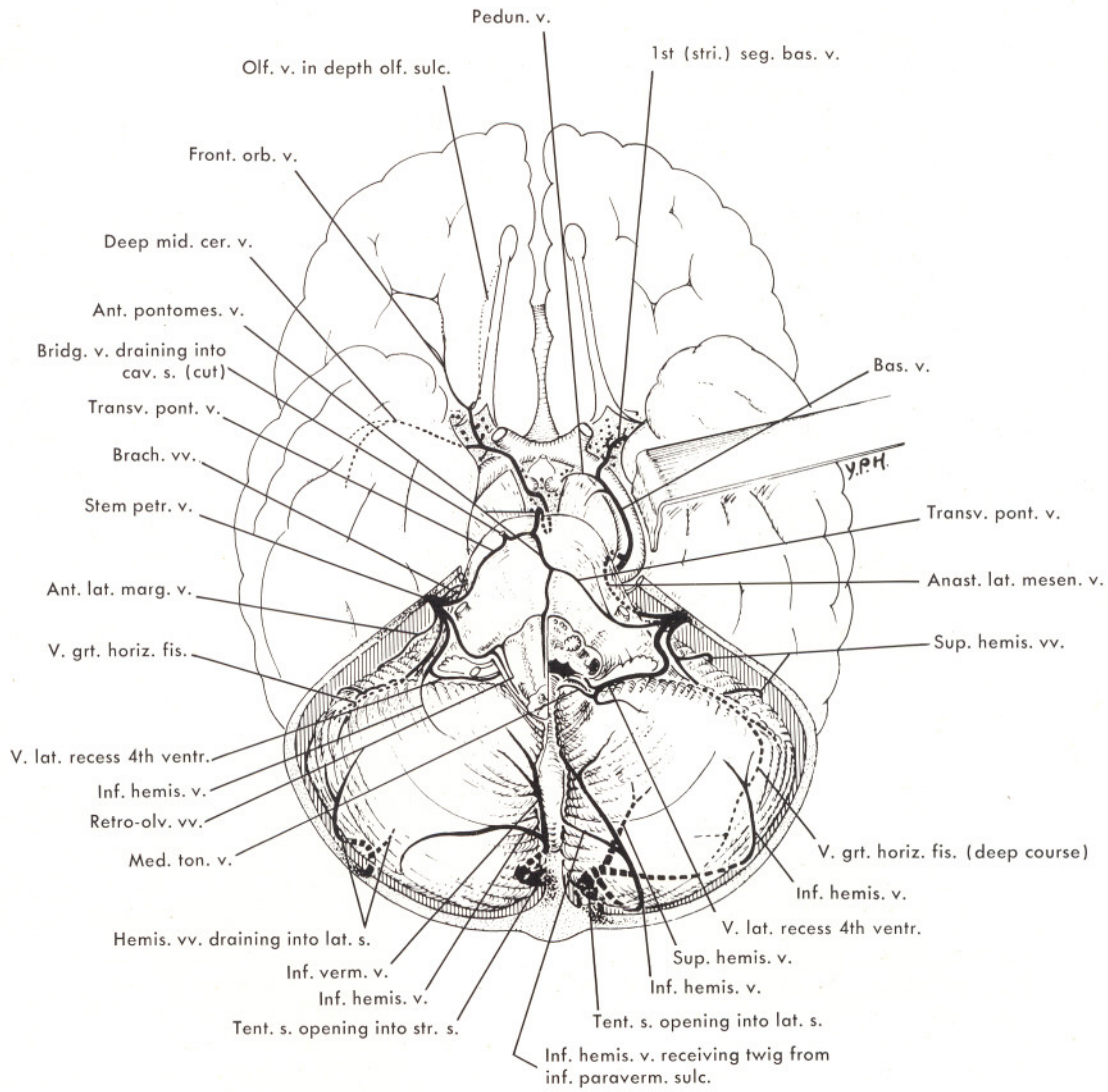

Fig. 75-3, cont'd. C, Submentovertex view. Different variations are shown on the two sides. On the left (reader's right) the basal vein is typical. A complete anastomotic lateral mesencephalic vein is present. The medulla oblongata has been removed to expose the medial tonsillar vein and the peduncular segment of the vein of the lateral recess of the fourth ventricle. Inferior and superior hemispheric veins unite on the superior surface of the cerebellar hemisphere to drain into a tentorial sinus that enters the lateral sinus. An anomalous inferior vermian vein joins an inferior hemispheric vein. On the right side an independent first segment of the basal vein joins the anterior pontomesencephalic vein, which, in turn, drains via transverse pontine veins into the petrosal vein. Many veins join the petrosal vein, which is located somewhat more medially than usual. Superior and inferior hemispheric veins join the lateral sinus directly. The inferior vermian vein joins the straight sinus through a short tentorial sinus.(**C** from Huang, Y. P., et al. In Newton, T. H., editor: Symposium on recent advances in neuroradiology, Tokyo, 1974, Igaku Shoin, Ltd.)

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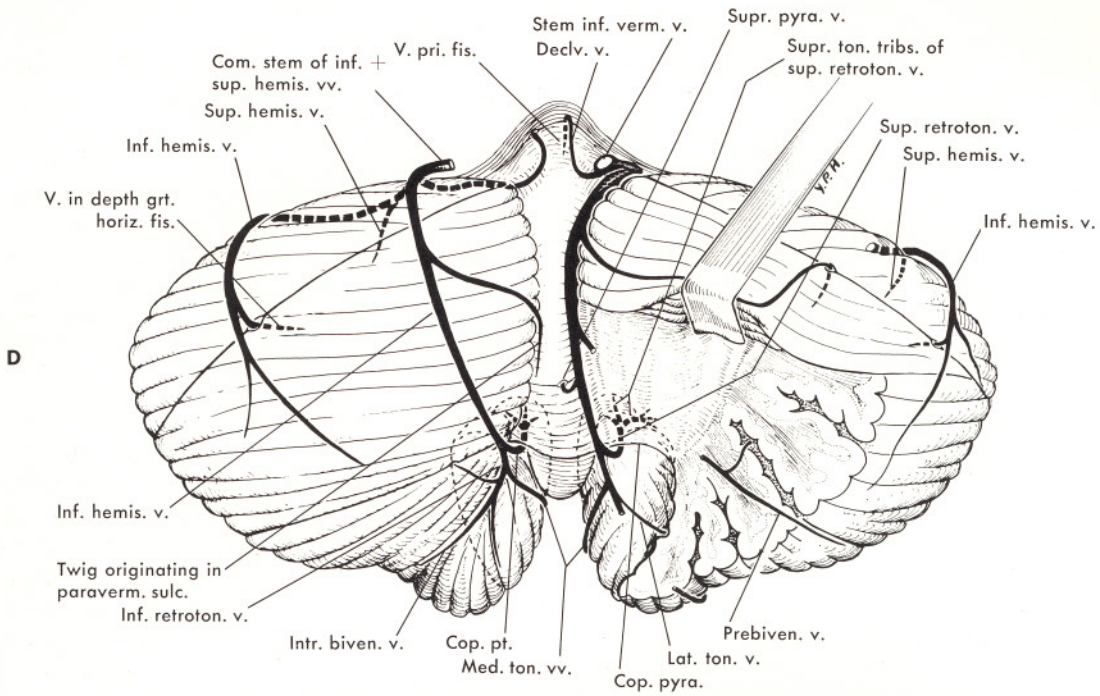

Fig. 75-3, cont'd. D, Reverse Towne view. Portions of the cerebellar hemisphere have been removed on the right side to expose the posterior aspect of the cerebellar tonsil and the copula pyramidis, the connecting bar between the pyramid and the cerebellar hemisphere. On the right side the superior and inferior retrotonsillar and medial and lateral tonsillar tributaries unite to form the inferior vermian vein, which runs in the inferior paravermian sulcus and eventually joins the straight sinus. It receives a declival vein, suprapyramidal vein, and inferior hemispheric veins. On the left side retrotonsillar tributaries run posteriorly, superiorly, and laterally into an inferior hemispheric vein. Note the angular course of the superior retrotonsillar tributaries around the copula pyramidis.

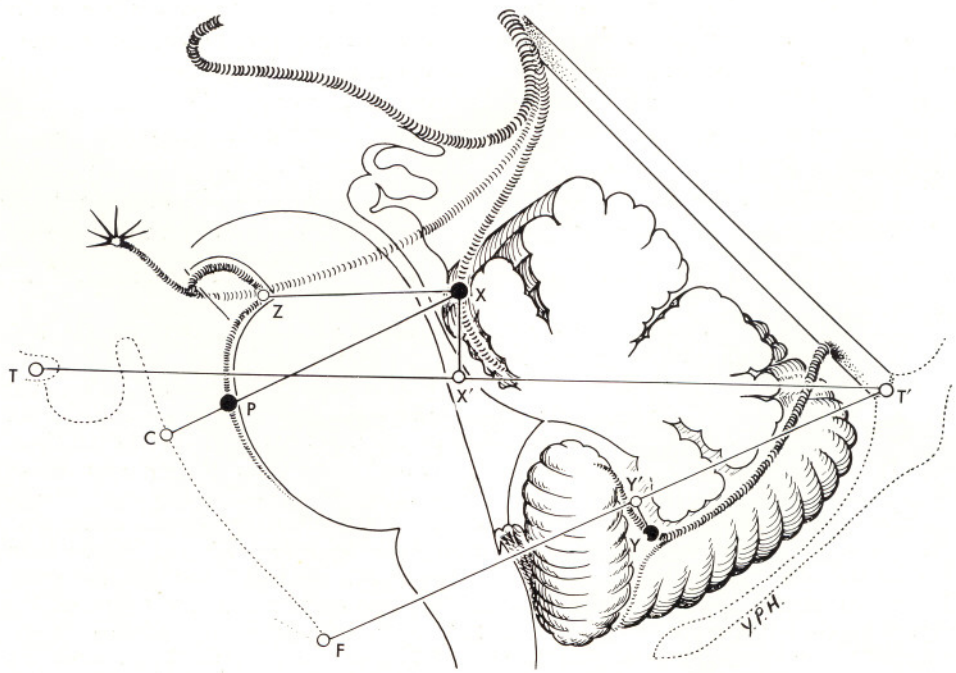

Fig. 75-4. For legend see opposite page.

that faces the lateral aspect of the medulla oblongata (lateral medullary portion) and the portion that faces the posterior aspect (posterior medullary portion). This fissure is continuous posteriorly with the vallecula between the tonsils, and superiorly with the peduncular and supratonsillar portions of the posterolateral fissure (Huang and Wolf, 1967). Anteriorly it is continuous with the lateral medullary cistern. The inferior surface of the cerebellum consists of two portions—petrosal and occipital. The petrosal portion is related to the medial aspect of the petrous pyramid, whereas the occipital portion is related to the occipital squama. No distinct demarcation is present between these two portions. The junction between the petrosal portion of the inferior surface and the cerebellomedullary fissure or anterior cerebellar notch is the medullary ridge of the biventral lobule (Huang et al., 1968a). The *posterior cerebellar notch* is a rather deep cleft between the medial (falcine) aspects of the hemispheres. This cleft is continuous anteroinferiorly with the vallecula and the retrotonsillar, posterolateral, and cerebellomedullary fissures. The internal occipital crest and cerebellar falx are lodged in this notch.

ANATOMY OF THE VEINS OF THE POSTERIOR FOSSA

Superior or galenic draining group (Greitz and Lindgren, 1961; Huang and Wolf, 1964b, 1965, 1966, 1967; Bekov, 1965; Dilenge and David, 1967; Bradac et al., 1969) (Figs. 75-3 to 75-11)

The superior or galenic draining group of veins may be divided into those related to the superior part of the cerebellum and those related to the mesencephalon. Included in the superior cerebellar group are the precentral cerebellar vein, the superior vermian vein and its culminate tributaries (preculminate, intraculminate, and supraculminate), and the superior hemispheric veins. When the precentral cerebellar vein and culminate group of veins form a single trunk, the vessel is designated the superior cerebellar vein. Included in the mesencephalic group are the posterior mesencephalic, anterior and lateral pontomesencephalic, lateral mesencephalic, and quadrigeminal veins.

Superior cerebellar tributaries

Precentral cerebellar vein. This vein originates in the fissure between the lingula and central lobule of the cerebellum (precentral cerebellar fissure proper) by union of two brachial tributaries that lie in the wing of the precentral cerebellar fissure between the brachium conjunctivum and wing of the central lobule (Figs. 75-6 and 75-7). The point of union of these brachial tributaries is variable (from low in the depth of the fissure to high in the quadrigeminal cistern) (Figs. 75-9, *A*, 75-14, *B*, and 75-17). In an extreme case they may drain independently into the internal cerebral vein (Huang and Wolf, 1966). The precentral cerebellar vein may be divided into three parts: the first (or fissural) segment is located within the precentral cerebellar fissure proper; the second (or anterior culminate) segment is located in front of the anterior superior aspect of the culmen; and the third (terminal or cisternal) segment lies above the level of the apex of the cerebellum (Figs. 75-4 to 75-6). The point of union and the angle formed by the fissural and anterior culminate segments in the lateral view have been designated respectively the colliculocentral point and colliculocentral angle (Figs. 75-8, *A*, 75-9, 75-10, *A*, and 75-12, *A*). The colliculocentral point is situated in the region between the inferior border of the inferior colliculi and the upper border of the central lobule. The first segment of the vein runs behind and parallel to the roof of the upper portion of the fourth ventricle. Deformities and displacements of the first segment and colliculocentral point therefore may be correlated with changes in the aqueduct and upper part of the fourth ventricle as seen on encephalograms. Normal distances of the colliculocentral point from various structures are shown in Fig. 75-4. Occasionally the parenchymal portion of the precentral cerebellar vein may also be seen

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Fig. 75-4. Normal measurements of the colliculocentral point and copular point. The foot (X') of a perpendicular dropped from the colliculocentral point (X) to the tuberculum-torcular line (TT') approximately bisects the latter (Huang and Wolf, 1966). The foot (Y') of a perpendicular dropped from the copular point (Y) to the line connecting the anterior margin of the foramen magnum (F) and the torcular (T') is located within a circle of 6 mm radius whose center is located 4 mm behind and below the midpoint of this line (FT'), as measured in fifty presumably normal adult angiograms (Huang et al., 1969). The distance between the colliculocentral point (X) and the anterior margin of the pons (P), outlined by the pontine segment of the anterior pontomesencephalic vein, ranges from 29 to 36 mm with a mean of 32 mm, as measured in forty presumably normal adult cases. The isthmus of the rhombencephalon is roughly represented by the minimal distance between the colliculocentral point (X) and the superior foramen cecum (Z) outlined by the anterior pontomesencephalic vein. This distance (XZ) ranged from 18 to 23 mm, averaging 21 mm, as measured in forty normal adult angiograms. (From Huang, Y. P., et al.: Am. J. Roentgenol. Radium Ther. Nucl. Med. **104**:36-56, 1968.)

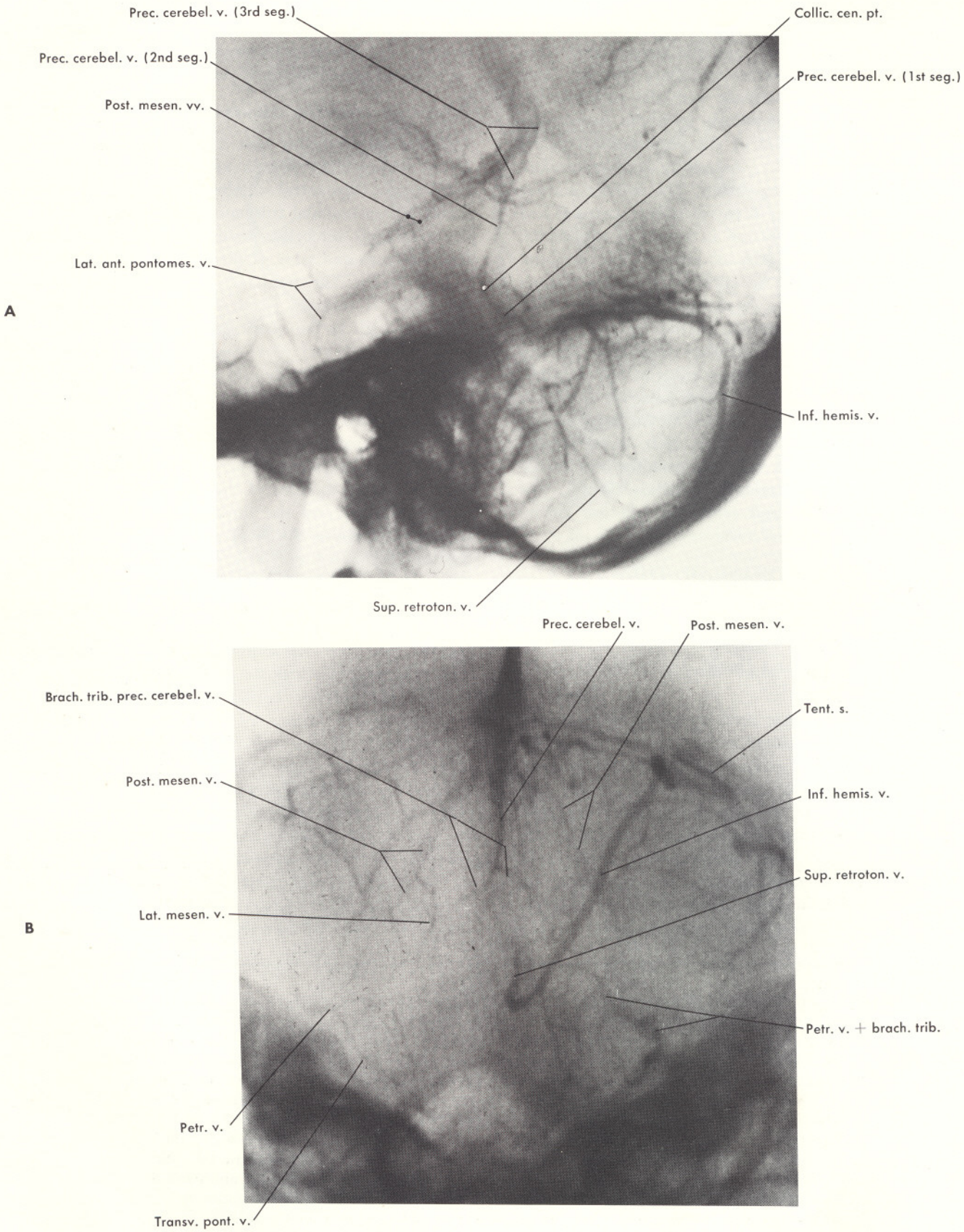


Fig. 75-5. For legend see opposite page.

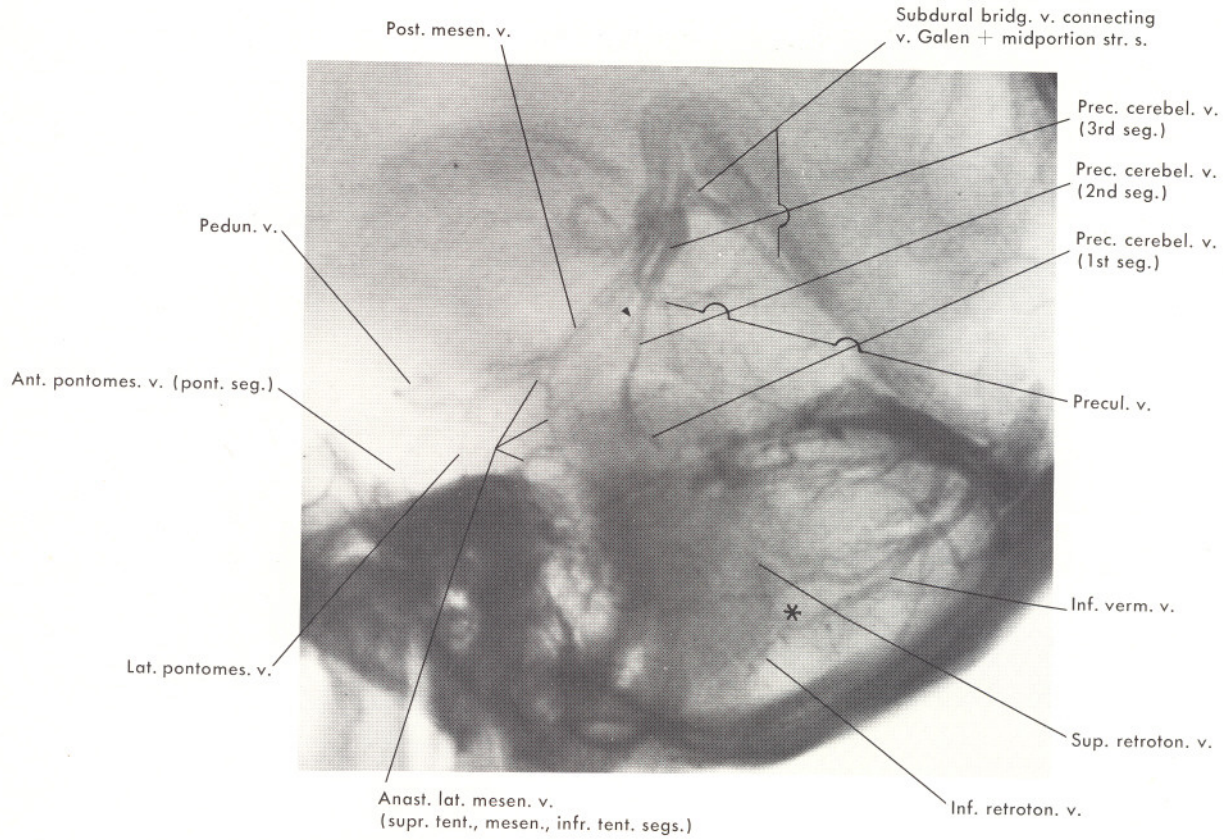


Fig. 75-6. Normal precentral cerebellar vein, lateral view. The first (fissural), second (anterior culminate), and third (cisternal) segments of the precentral cerebellar vein and the colliculocentral point can be identified. A fine quadrigeminal or tectal vein (arrowhead) runs backward and upward to join the precentral cerebellar vein. An anastomotic lateral mesencephalic vein shows clearly the supratentorial, mesencephalic, and infratentorial segments. The mesencephalic portion of the lateral mesencephalic vein indicates the border between the basis and tegmentum of the cerebral peduncle. The inferior vermian vein and its superior and inferior retrotonsillar tributaries outline the inferior paravermian sulcus and retrotonsillar fissure. The copular point, in the course of the superior retrotonsillar tributary around the copula pyramidis (*), is visible.

Fig. 75-5. Classic appearance of the normal precentral cerebellar vein. **A,** Lateral view. The precentral cerebellar vein runs forward and upward in the precentral cerebellar fissure between the lingula and the central lobule (segment 1 or fissural segment). After emerging from the fissure, it turns upward and backward and runs in front of the culmen (segment 2, or the anterior culminate segment). On leaving the superior vermis it continues to run upward and enters the cistern of the vein of Galen, where it joins the great vein of Galen (segment 3, or terminal segment). An obtuse angle, the colliculocentral angle, is formed between the first and second segments of the vein. The apex of this angle, the colliculocentral point (white dot), indicates the region between the inferior colliculi and the upper part of the central lobule. The first segment and colliculocentral point of the vein run parallel and posterior to the roof of the upper part of the fourth ventricle. The lateral anterior pontomesencephalic vein outlines the anterior aspect of a cerebral peduncle and the pons. The course of the superior retrotonsillar vein is anomalous, running backward and downward. After emerging from the posterior cerebellar notch, the vein courses superiorly and laterally on the inferior surface of the cerebellar hemisphere to join the lateral sinus. **B,** Towne view. The precentral cerebellar vein and its brachial tributaries show a typical inverted Y configuration. The superior retrotonsillar vein runs downward and, after emerging from the posterior cerebellar notch, superiorly and laterally to join the lateral sinus, following a short course within the tentorium.

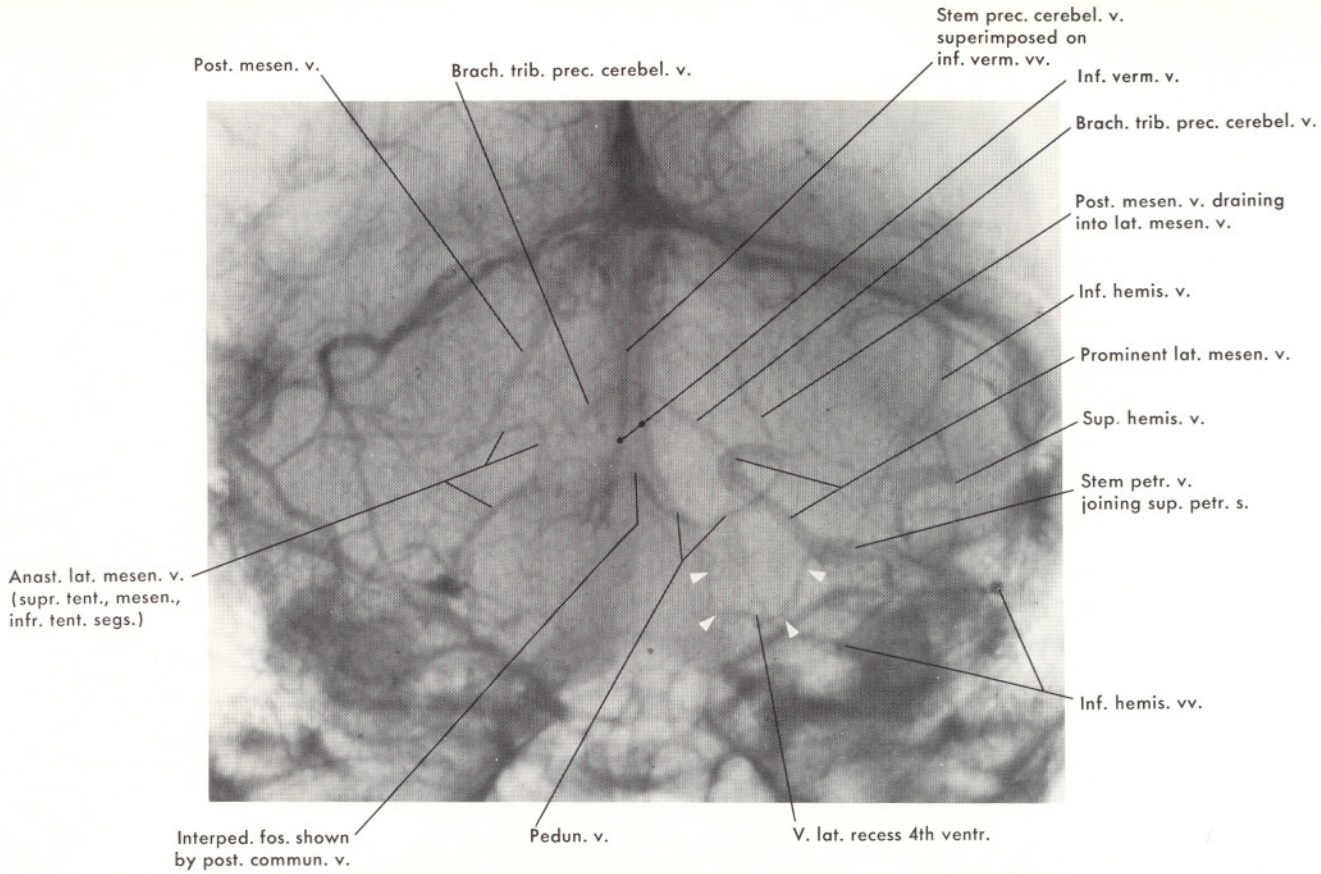
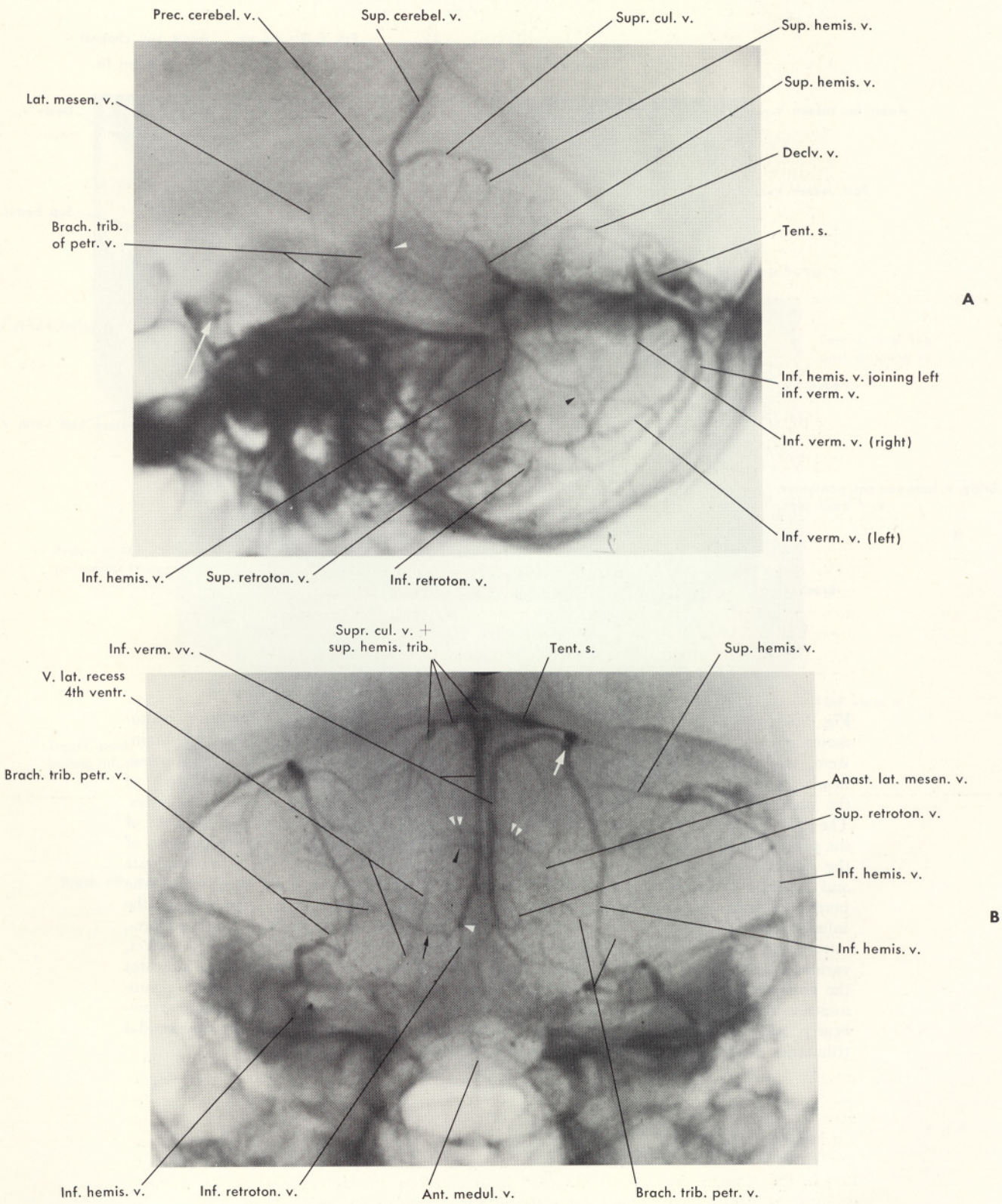


Fig. 75-7. Prominent precentral cerebellar and petrosal veins and their tributaries, semiaxial projection. The precentral cerebellar vein and its brachial tributaries have an inverted Y configuration. Anteroinferiorly the brachial tributaries of this vein continue into lateral mesencephalic veins. The left posterior mesencephalic vein drains forward into the lateral mesencephalic vein with the peduncular vein. The distance between the mesencephalic segments of the anastomotic lateral mesencephalic veins indicates the width of the tegmentum of the mesencephalon. The peduncular and posterior communicating veins outline the anterior aspects of the bases pedunculi and interpeduncular fossa. Inferior hemispheric veins outline the petrosal aspect of the cerebellum. Also visualized is the vein of the lateral recess of the fourth ventricle (arrowheads) on the left, joining the stem of the petrosal vein.

Fig. 75-8. Prominent superior cerebellar vein. **A,** Lateral view. Precentral cerebellar and superior vermian (supraculminate) veins unite at some distance anterior to the apex of the cerebellum to form a prominent superior cerebellar vein, which drains into the posterior part of the vein of Galen. Note the colliculocentral point (white arrowhead). The brachial tributary of the petrosal vein actually joins the precentral cerebellar vein at the colliculocentral point. The anterior aspect of the pons is faintly outlined by a pontine vein that has a bridging connection (white arrow) to the region in which the cavernous, superior, and inferior petrosal sinuses join. The right inferior vermian vein runs in the inferior paravermian sulcus. The left inferior vermian vein runs at some distance behind the sulcus and is joined by an inferior hemispheric vein. The common trunk drains into a tentorial sinus. This sinus, in turn, joins the lateral sinus (refer to **B**). A suprapyramidal vein (black arrowhead) can be identified. **B,** Semiaxial view. Superior cerebellar, precentral, and superior vermian (supraculminate) veins are partly obscured by the torcular. Superior hemispheric tributaries of the supraculminate vein run medially. Posteriorly the left inferior vermian vein runs on the falcine aspect of the hemisphere and then turns laterally and upward to reach the superior surface. It joins a large inferior hemispheric vein (white arrow) and drains into a tentorial sinus. The right inferior vermian vein continues upward to join the straight sinus but is obscured by overlapping vessels and sinuses. An inferior hemispheric vein (black arrow) joins the inferior retrotonsillar vein at the level of the copula pyramidis, creating a dense dot (white single arrowhead). The suprapyramidal tributary (black arrowhead) of the inferior vermian vein and brachial tributaries (white double arrowheads) of the precentral cerebellar vein are visible.



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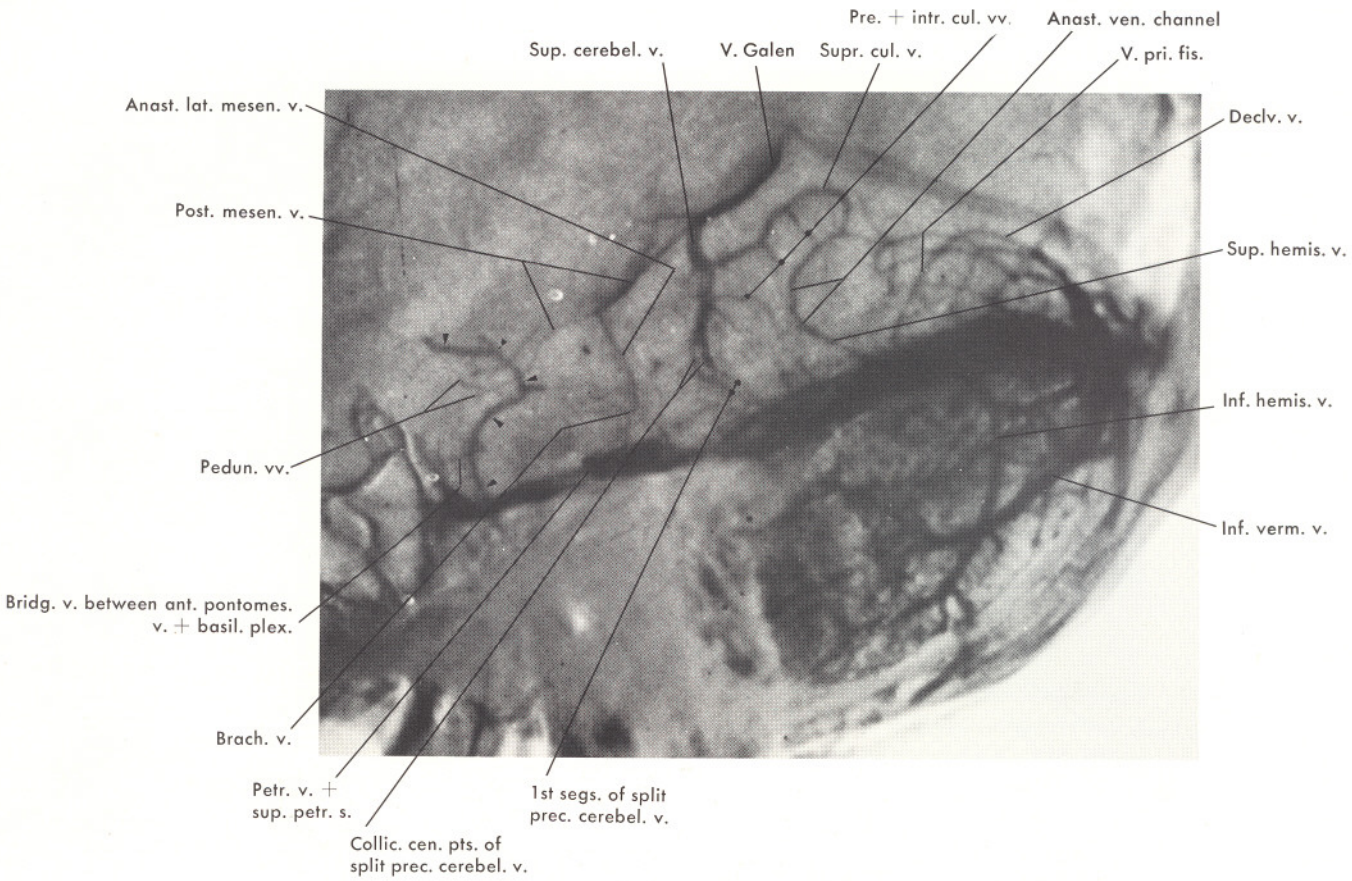

Fig. 75-9. Superior cerebellar, anastomotic lateral mesencephalic, and anterior pontomesencephalic veins outlining the profile of the upper parts of the cerebellum and brainstem, lateral view (two cases). **A,** The anterior pontomesencephalic vein (black arrowheads) outlines the depth of the interpeduncular fossa and anterosuperior aspect of the pons. Several peduncular veins mark the anterior aspect of the cerebral peduncles. The split precentral cerebellar and pre-, intra-, and supraculminate veins and the vein of the primary fissure (the last draining into the declival vein) demonstrate various portions of the superior vermis. Note a prominent anastomotic channel bridging the supraculminate and superior hemispheric veins. The anastomotic lateral mesencephalic vein marks the border between the basis pedunculi and the tegmentum. Retrotonsillar tributaries of the inferior vermian vein can also be identified. **B,** The precentral cerebellar vein and pre-, intra-, and supraculminate tributaries of the superior cerebellar vein outline, in effect, various lobules of the superior vermis. The brachial tributary of the petrosal vein indicates the anterosuperior aspect of the brachium pontis. Various segments of the anterior pontomesencephalic vein outline the interpeduncular fossa, superior foramen cecum (black arrowhead), and anterosuperior aspect of the midline pons. Retrotonsillar and suprapyramidal tributaries (white arrowheads) of the inferior vermian vein are also visible.

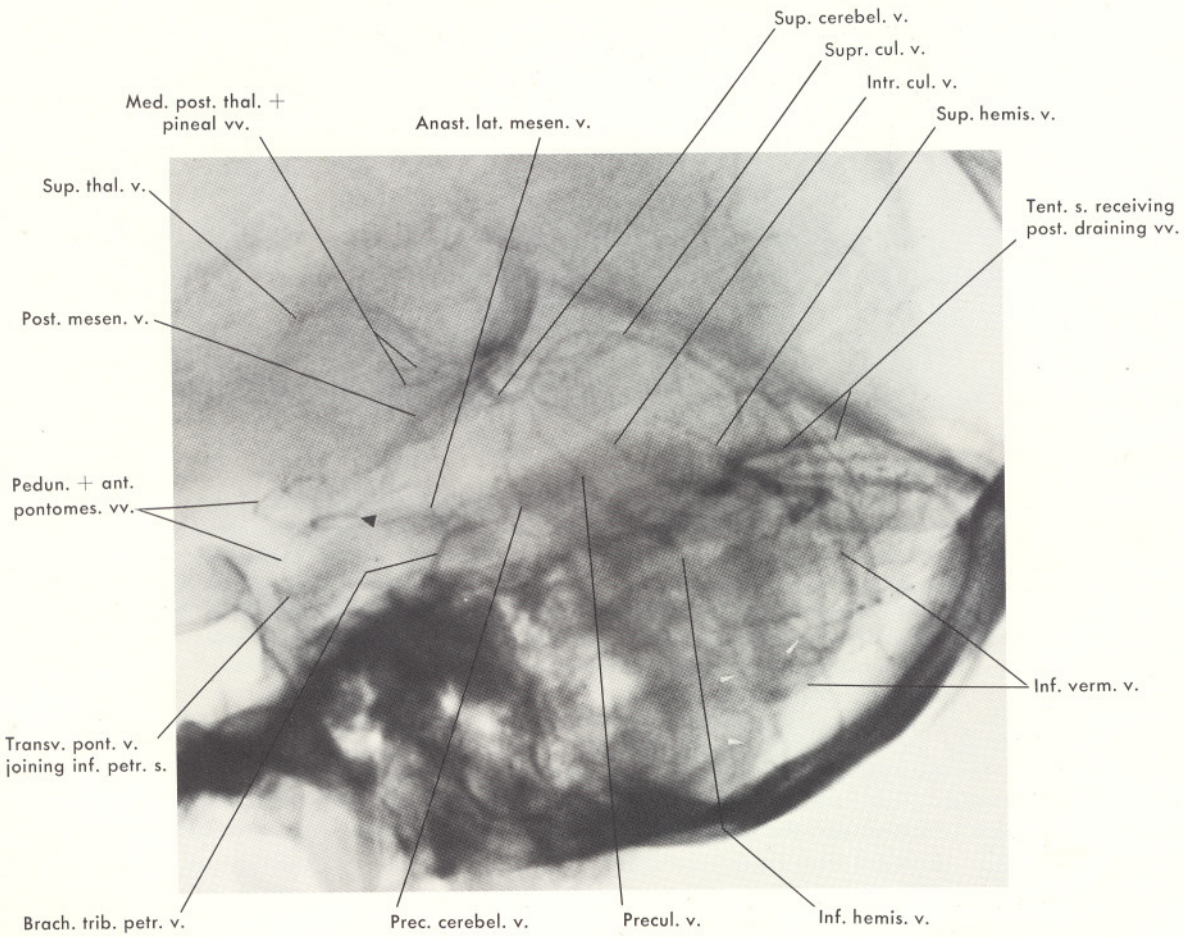

Fig. 75-9, cont'd. For legend see opposite page.

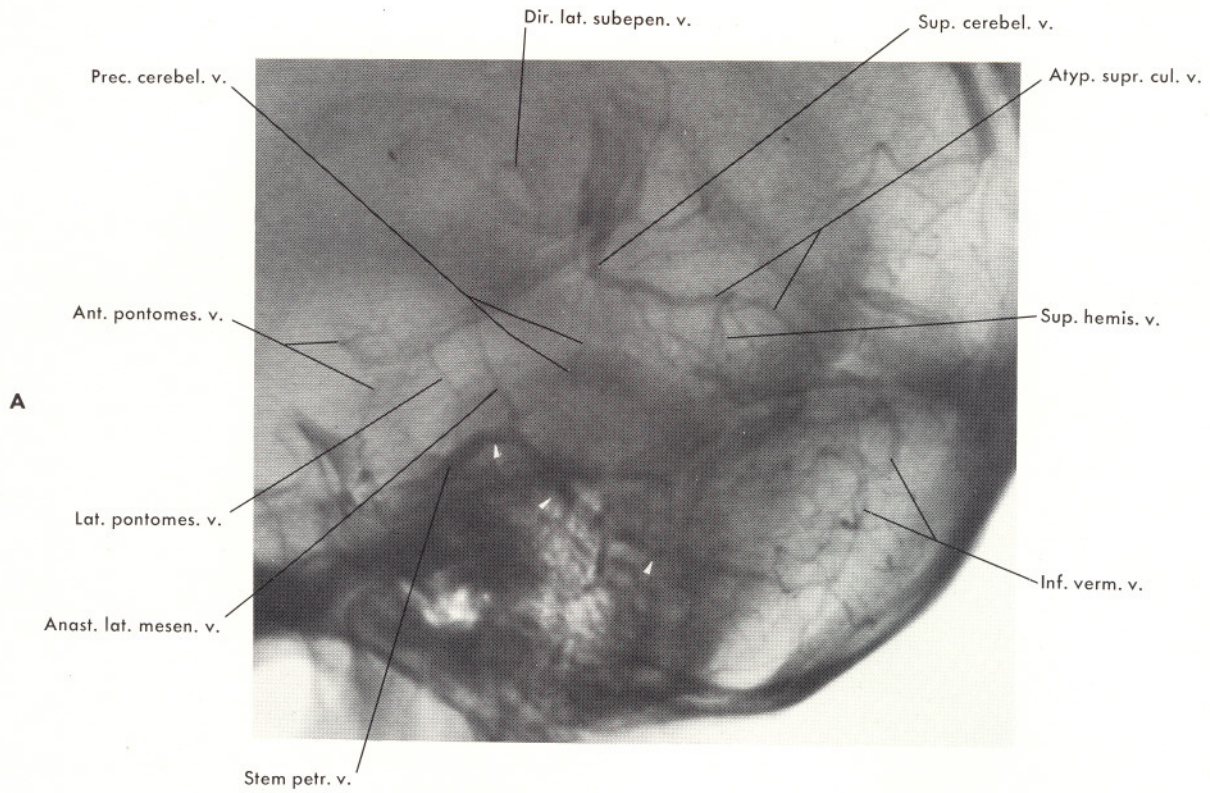

Fig. 75-10. Atypical supraculminate vein and prominent petrosal vein. **A,** Lateral view. The supraculminate vein is atypical and does not outline the apex of the cerebellum. The precentral cerebellar vein is faintly visualized. In addition to a typical anastomotic lateral mesencephalic vein, a more anteriorly located lateral pontomesencephalic vein is seen. It runs on the lateral aspect of the basis pedunculi and joins the proximal portion of a rather prominent vein of the great horizontal fissure (arrowheads). The inferior vermian vein is tortuous. **B,** Towne view. The atypical supraculminate vein (black arrowheads) seen in the lateral view is quite tortuous. On the left side, in addition to a lateral mesencephalic vein, the lateral pontomesencephalic vein (white arrow) can be identified. A prominent vein of the great horizontal fissure, receiving a superior hemispheric tributary, is also visible. On the right side the brachial vein, anterior lateral marginal vein, and vein of the lateral recess (white arrowheads) form the stem of the petrosal vein. A fine retro-olivary vein (left) draining into the inferior petrosal sinus via a vagal vein can also be identified.

on angiography (parenchymal segment). It runs in the substance of the hemisphere with the brachium conjunctivum and joins the fissural segment of the vein at the bottom of the superior paravermian sulcus.

Superior vermian vein. In most striking form this vein results from the union of several veins in the preculminate and intraculminate fissures and on the superior aspect of the culmen (Figs. 75-8 and 75-9). The common stem then runs upward and backward to join the posterior portion of the internal cerebral vein or vein of Galen. Usually the superior vermian vein enters the galenic system more anteriorly than does the precentral cerebellar vein. The precentral cerebellar vein and superior vermian vein may in some cases unite to form a single stem, the superior cerebellar vein. When all tributaries of the superior draining group are visualized, the midsagittal section of the superior vermis is clearly depicted on angiography (Fig. 75-9).

Superior hemispheric veins. Frequently the midline supraculminate tributary of the superior vermian vein is replaced by one or two more laterally located superior hemispheric veins on each side. These veins run medially, anteriorly, and superiorly and then dip into the wing of the precentral fissure after crossing the anterior superior margin of the cerebellum to join one of the culminate tributaries or the stem of the superior ver-

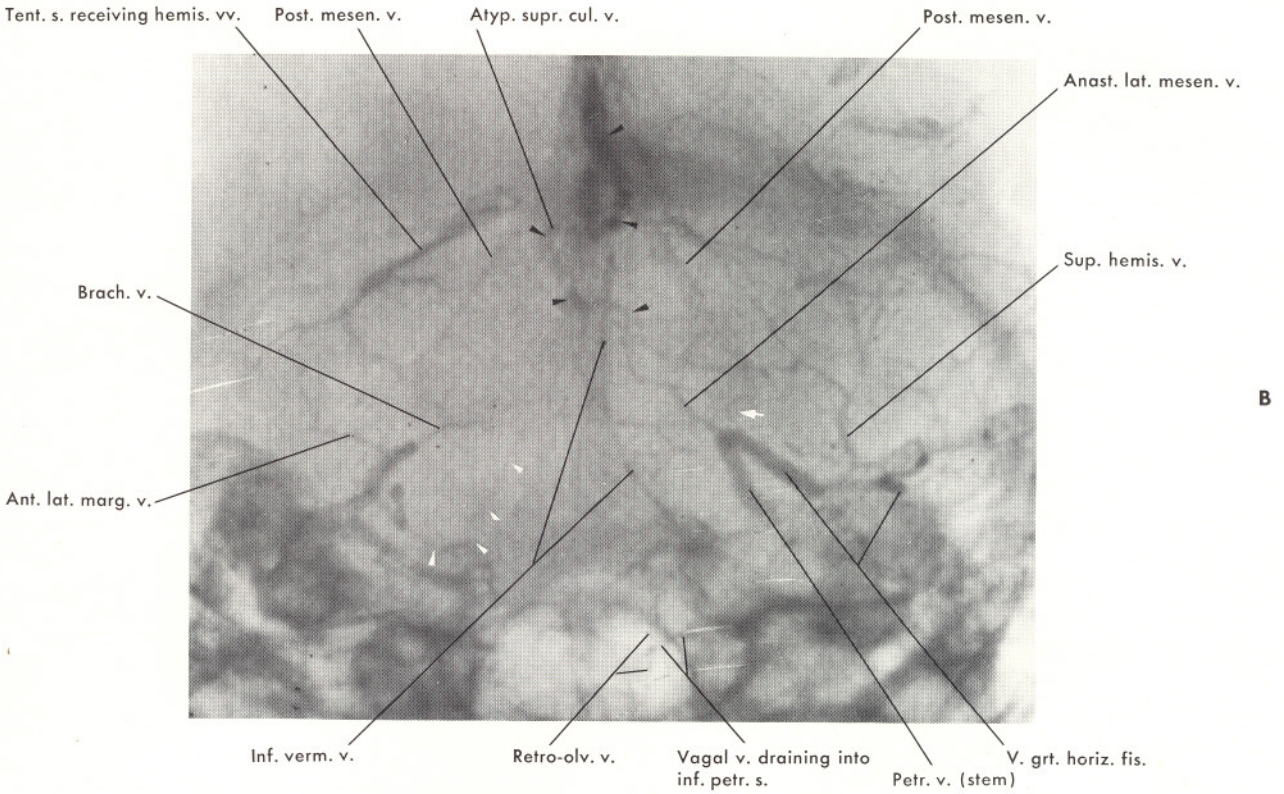

Fig. 75-10, cont'd. For legend see opposite page.

mian vein (Fig. 75-10). Not infrequently a superior hemispheric vein joins the precentral cerebellar vein (Fig. 75-16).

Mesencephalic tributaries

Posterior mesencephalic vein. This vein, or veins, originates in the interpeduncular fossa or on the lateral aspect of the mesencephalon and runs posteromedially and superiorly around the midbrain to join the vein of Galen or posterior portion of the internal cerebral vein (Figs. 75-6, 75-7, and 75-9 to 75-11). It is often fine, sometimes multiple, and usually more closely applied to the brainstem than is the basal vein of Rosenthal. The posterior mesencephalic vein may be present in addition to the basal vein of Rosenthal, or it may replace the posterior part of the basal vein. (See Chapter 74.) It may attain considerable size, especially when the basal vein is absent. In some cases it may originate on the anterior aspect of the upper pons. In rare instances it may drain downward into the lateral mesencephalic vein and then into the petrosal vein (Fig. 75-7). Radiographically in the lateral projection the posterior mesencephalic vein takes a rather straight course upward and backward except for its terminal portion. With bilateral filling, a symmetric inverted V configuration may be seen in the anteroposterior or Towne projection.

Anterior pontomesencephalic vein. This vein is a longitudinal venous channel that runs in the interpeduncular fossa and on the superior and anterior aspects of the belly of the pons in or adjacent to the midline (Bradac, 1970; Bradac and Simon, 1971) (Figs. 75-6, 75-9 to 75-13, 75-14, *B*, and 75-15). Superiorly it is often connected with the basal vein of Rosenthal through a peduncular vein, and inferiorly with the anterior medullary vein on the anterior aspect of the medulla oblongata. In typical form it outlines (together with the uncal vein) the chiasmatic, interpeduncular, and pontine cisterns in the lateral view (Huang et al., 1968a). More often, however, it runs laterally at the level of the midpons to join the petrosal vein. Therefore this vein may also be considered a part of the petrosal draining group of veins, to be described (Figs. 75-12 and 75-14, *B*).

Lateral mesencephalic vein. This vein is a rather constant tributary of the basal vein of Rosenthal, the posterior mesencephalic vein, or the petrosal vein (Figs. 75-6 to 75-14). Although its entire length may not always be located in the lateral mesencephalic sulcus, it serves to identify the lateral aspect of the mesencephalon, specifically the tegmentum, in both anteroposterior and

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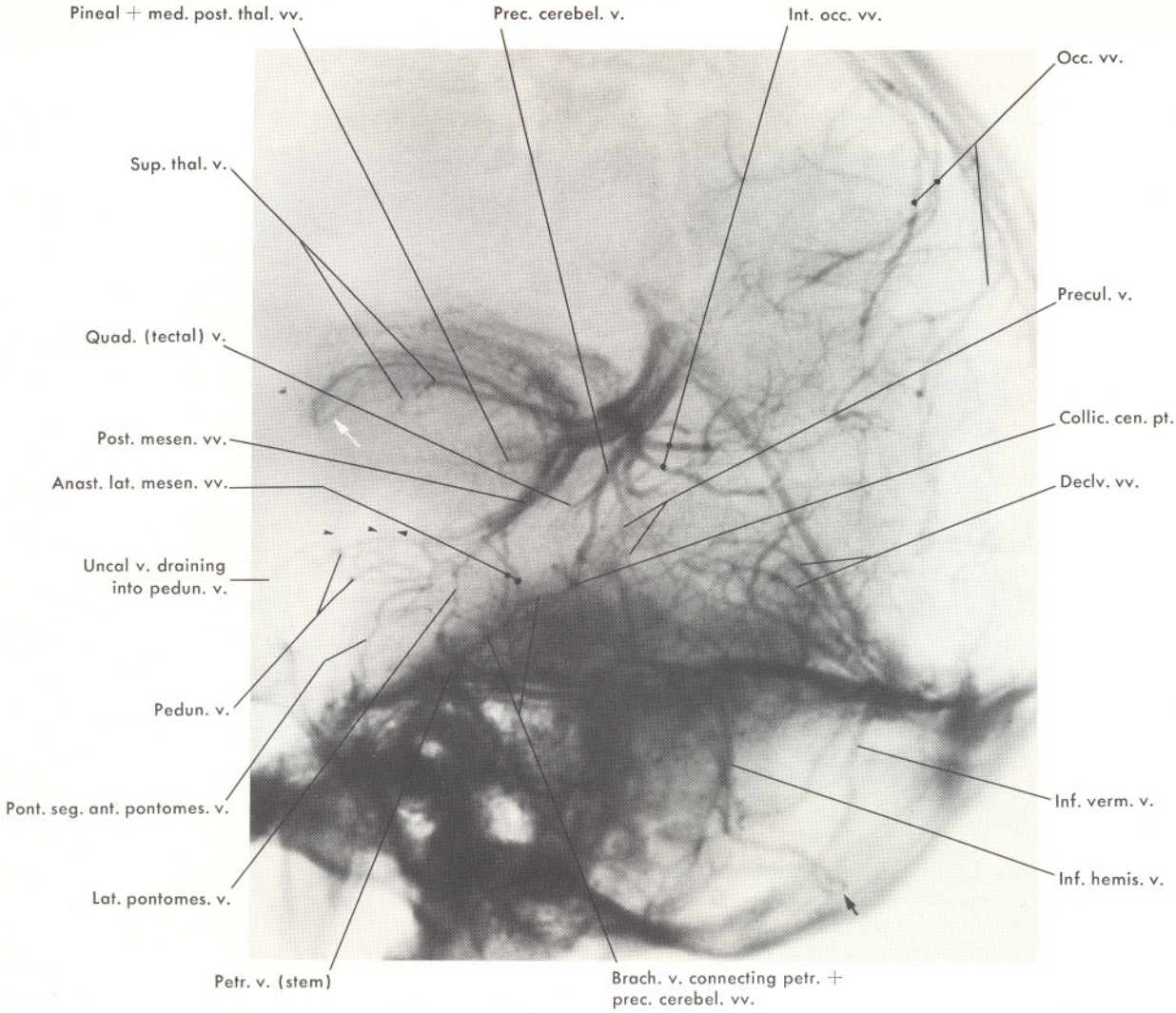
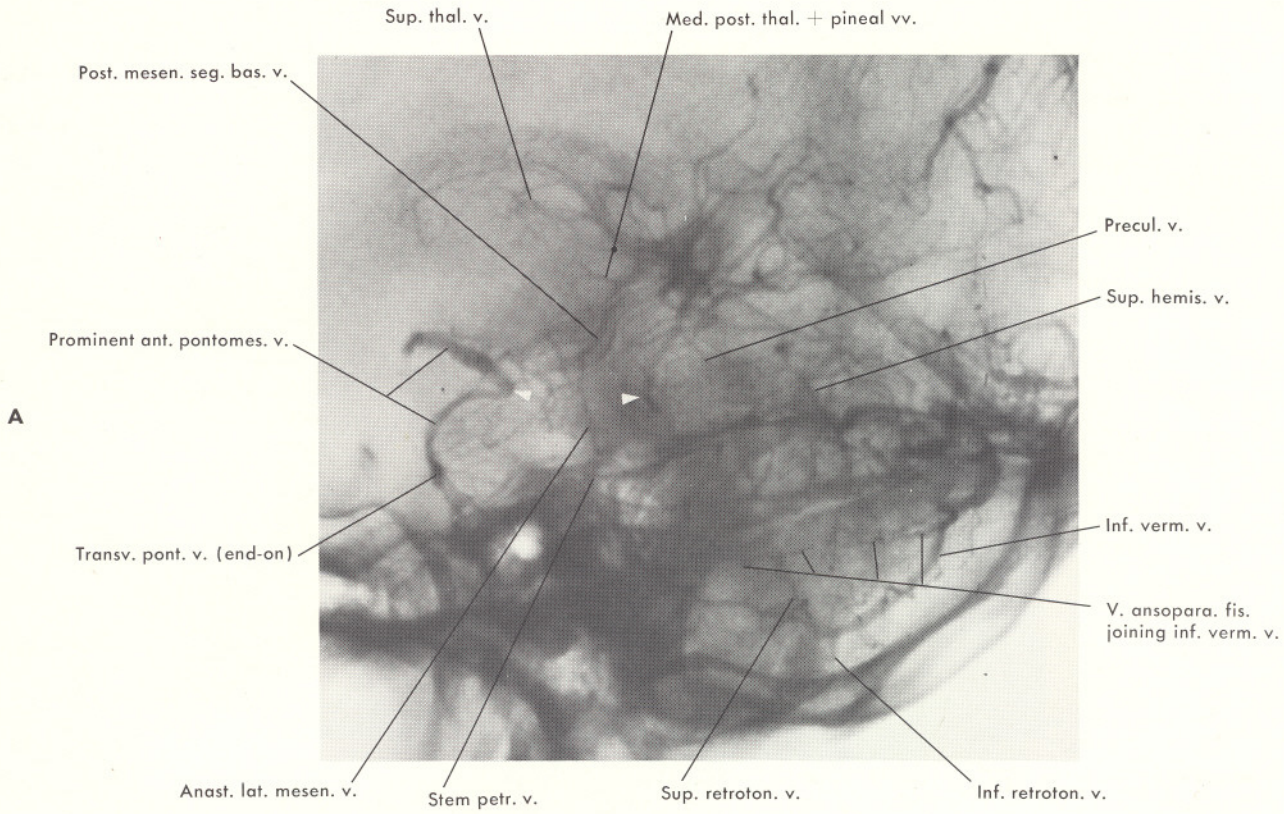


Fig. 75-11. Normal posterior fossa venograms showing supratentorial as well as infratentorial veins, lateral view. Several declival veins originate from the depth of the primary fissure. After emerging from the fissure, they turn backward and downward to join the lower end of the straight sinus. The precentral cerebellar vein, which is somewhat prominent and receives tectal, preculminate, and intraculminate tributaries, has a connection with a brachial tributary of the petrosal vein near the anterosuperior margin of the cerebellum. Note a communicating vein (black arrow) bridging between the inferior vermian vein and an inferior hemispheric vein. Supratentorially the anterior thalamic (white arrow), superior thalamic, medial posterior thalamic, inferior thalamic (black arrowheads), internal occipital, ascending (superficial) occipital, and posterior mesencephalic veins are visualized.

Fig. 75-12. Prominent anterior pontomesencephalic vein. **A,** Lateral view. The anterior pontomesencephalic vein outlines the interpeduncular fossa and anterior aspect of the belly of the pons. The isthmus of the rhombencephalon is indicated by the superior foramen cecum anteriorly and colliculocentral point of the precentral cerebellar vein posteriorly (arrowheads). The superior and inferior retrotonsillar tributaries of the inferior vermian vein and the ansoparamedian vein can also be identified. **B,** Semiaxial view. The anterior pontomesencephalic vein is unusually clearly seen. The superior and inferior retrotonsillar and ansoparamedian tributaries of the inferior vermian vein draining into the tentorial sinus can also be identified on the left. On the right side the anastomotic lateral mesencephalic vein connects the small petrosal vein with the prominent posterior mesencephalic segment of the basal vein.



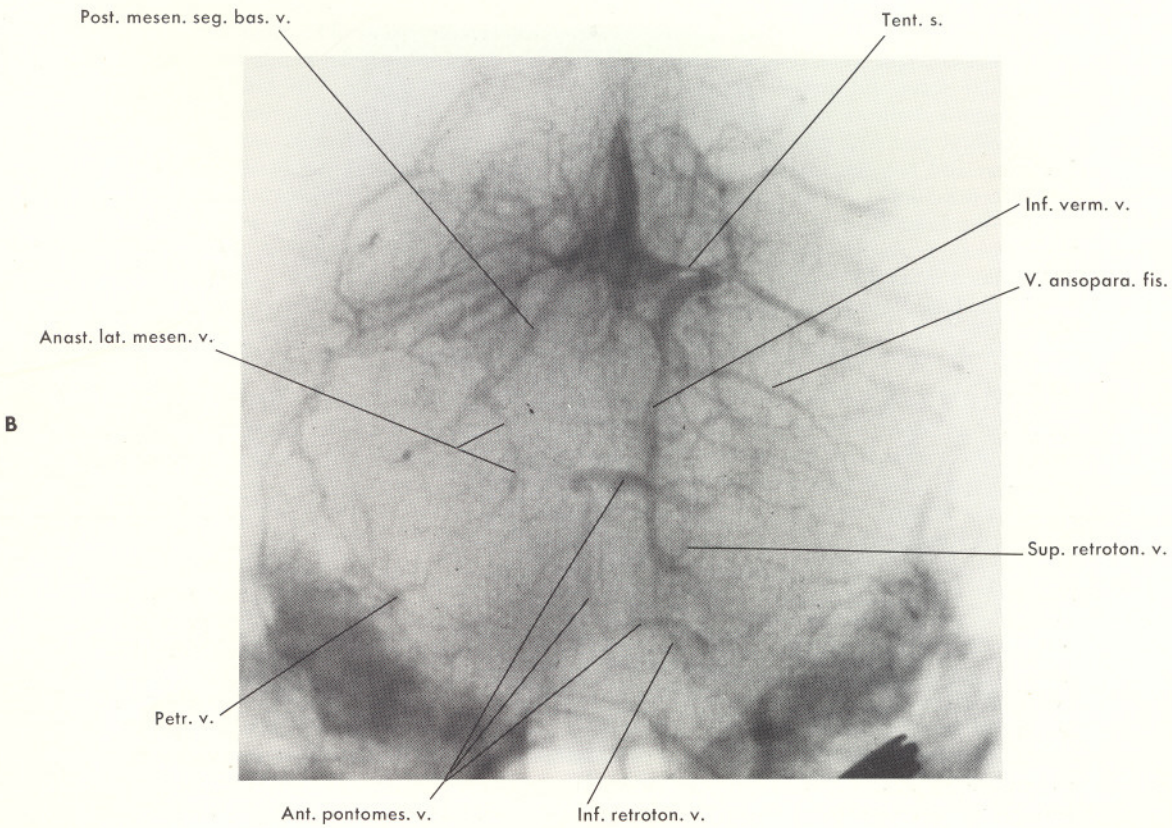


Fig. 75-12. For legend see opposite page.

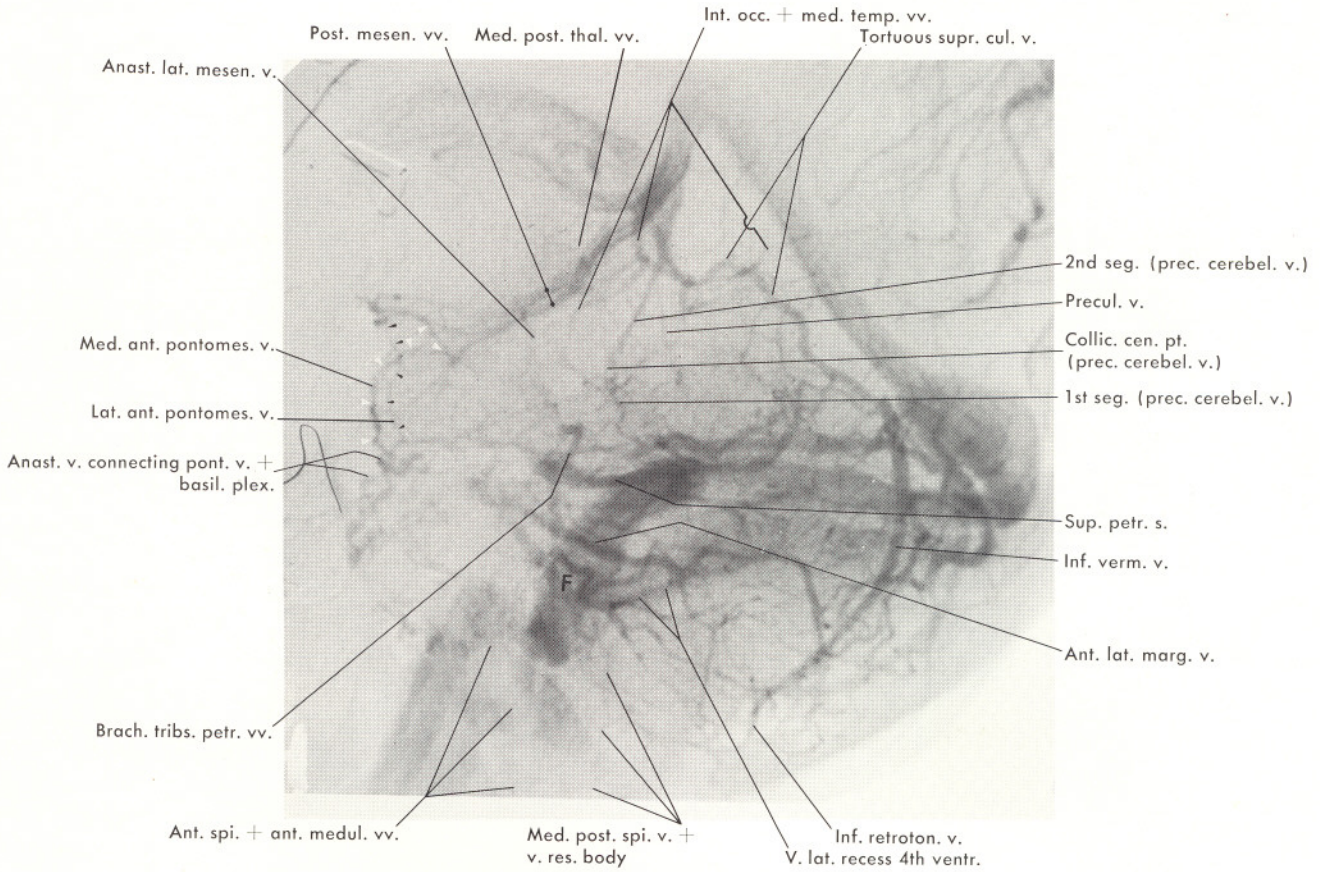


Fig. 75-13. Median and lateral anterior pontomesencephalic veins. The median anterior pontomesencephalic vein (white arrowheads) outlines the profile of the depth of the interpeduncular fossa and anterosuperior aspect of the belly of the pons. The lateral anterior pontomesencephalic vein (black arrowheads), on the other hand, marks the anterior aspect of a cerebral peduncle and the anterolateral aspect of the pons. The prominent precentral cerebellar and fine preculminate veins indicate the anterior as well as the posterior borders of the central lobule. The supraculminate vein is prominent but somewhat tortuous. The vein of the lateral recess of the fourth ventricle, draining into the petrosal vein, shows a tortuous course around the flocculus (*F*). The medulla oblongata and upper cervical cord are outlined anteriorly by the anterior medullary and anterior spinal veins, and posteriorly by the median posterior spinal vein.

Fig. 75-14. Tributaries of the petrosal vein outlining the anterior aspects of the pons and cerebellum, Towne view (two cases). **A,** The anterior aspects of the midpons and cerebellum are outlined by the transverse pontine vein and superior and inferior hemispheric tributaries of the petrosal veins. A fine superior transverse pontine vein can be seen on the left (white arrow) draining into the posterior mesencephalic vein. The brachial tributaries of both petrosal and precentral cerebellar veins (the stem of the latter vein is obscured by the inferior vermian vein) outline the central portion as well as the wings of the precentral cerebellar fissure. Black arrow indicates the brachial tributary of the left petrosal vein. More superiorly the mesencephalon is outlined by both posterior mesencephalic and right peduncular veins. The sigmoid and superior petrosal sinuses are prominent laterally. Note the asymmetry of the lateral sinuses, the left one being considerably higher than the right (unlabeled arrowheads). Although the inferior vermian vein and its superior and inferior retrotonsillar tributaries are clearly seen on the right, those on the left side are poorly developed. Presumptive location of the flocculus is indicated on the right by *F*. **B,** The anterior aspects of the brainstem and cerebellum are outlined by the transverse pontine and anterior pontomesencephalic veins and by the inferior and superior hemispheric tributaries of the petrosal veins, indicating angiographically the posterior wall and lateral extensions (white arrowheads) of the pontine cistern.

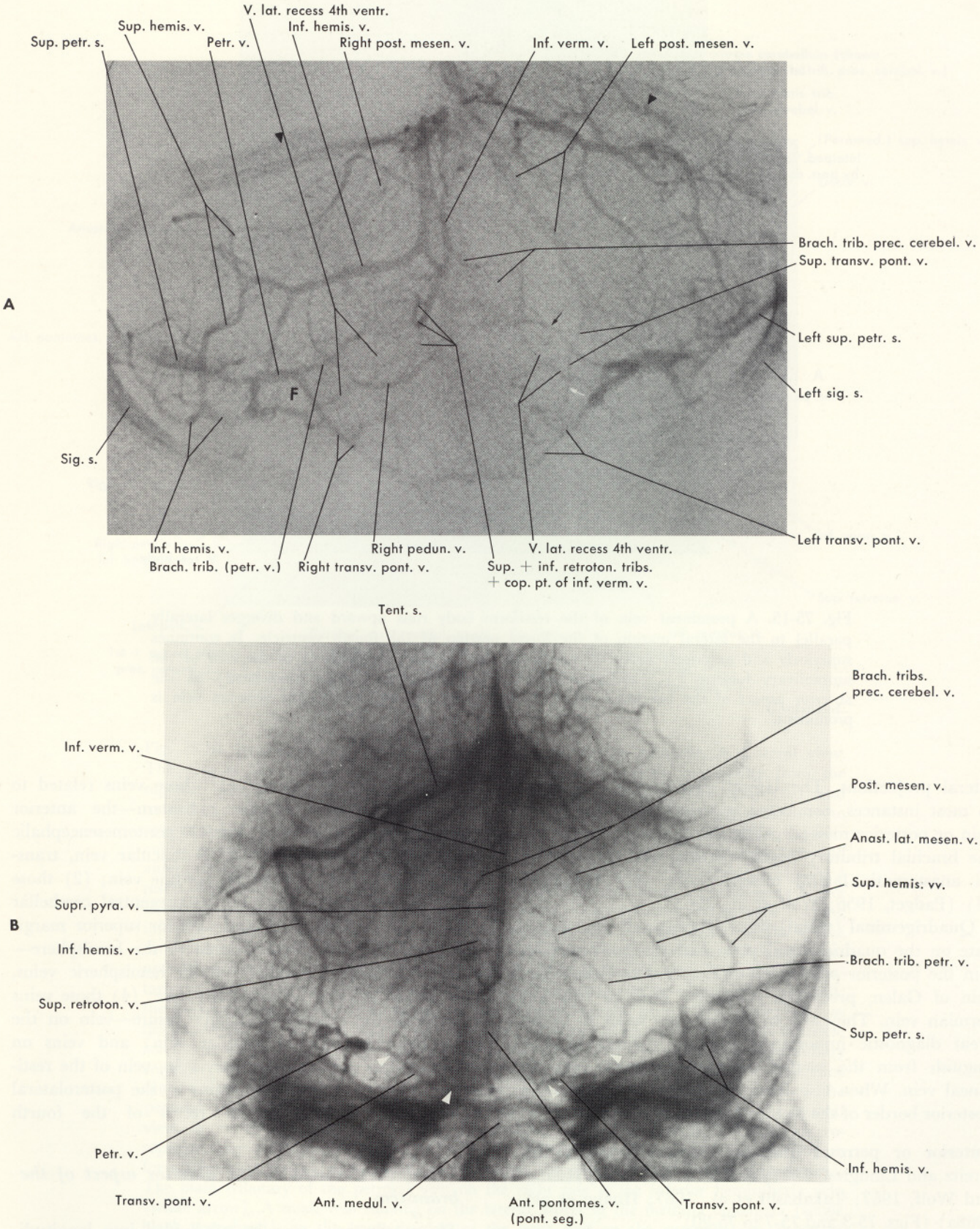


Fig. 75-14. For legend see opposite page.

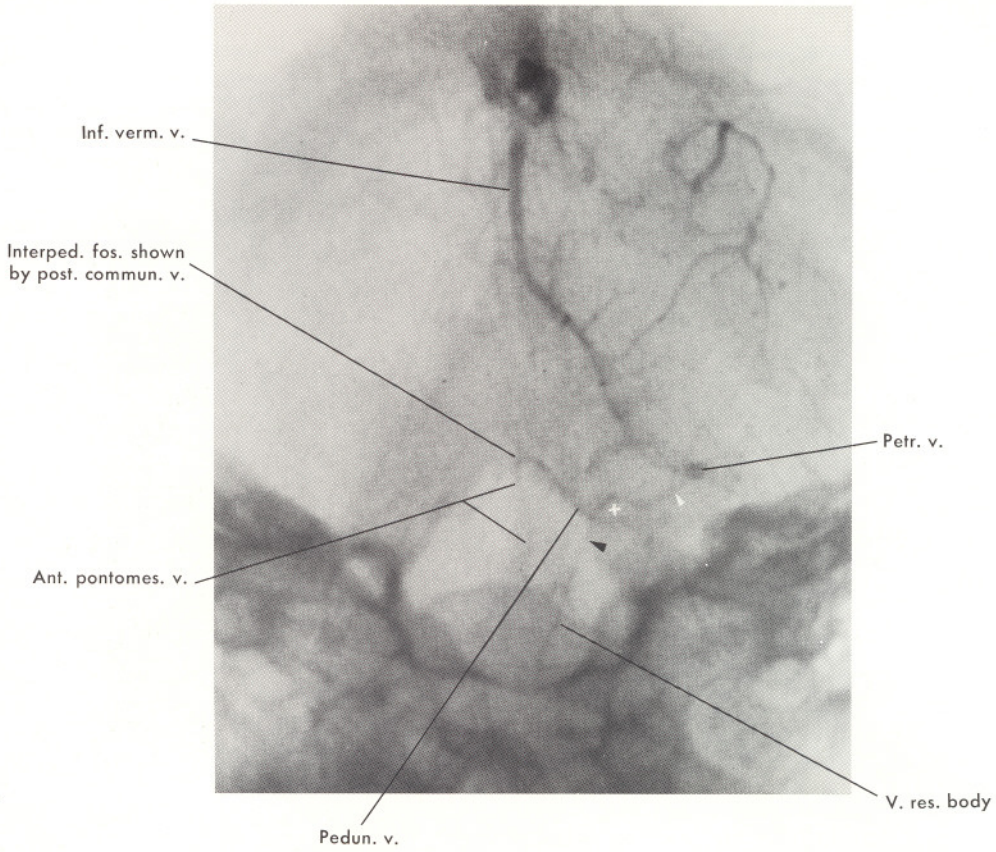


Fig. 75-15. A prominent vein of the restiform body runs upward and diverges laterally parallel to the lateral margin of the lower portion of the fourth ventricle. It continues superiorly and anteriorly in the retro-olivary sulcus (black arrowhead) to the roof of the supraolivary fossette (+) and then laterally and superiorly (white arrowhead) on the anterior aspect of the brachium pontis to the petrosal vein. The inferior vermian vein is prominent.

lateral projections. The lateral mesencephalic vein is, in most instances, connected superiorly with the basal vein or posterior mesencephalic vein and inferiorly with the brachial tributary of the petrosal vein to become an anastomotic lateral mesencephalic vein (Chapter 74) (Padget, 1956; Wolf et al., 1963).

Quadrigeminal (tectal) veins. These small veins originate on the quadrigeminal plate and run backward to join the posterior portion of the internal cerebral vein, vein of Galen, precentral cerebellar vein, or superior vermian vein. They are, in general, too small to be of great diagnostic importance and are difficult to distinguish from the medial posterior thalamic vein or pineal vein. When visualized, they serve to identify the posterior border of the tectum (Fig. 75-11).

Anterior or petrosal draining group (Dandy, 1929; Greitz and Lindgren, 1961; Scatliff et al., 1965; Huang and Wolf, 1967; Takahashi et al., 1967; Huang et al., 1968a) (Figs. 75-3 and 75-7 to 75-20)

The anterior or petrosal draining group of veins may be divided into five parts: (1) those veins related to the anterior aspect of the brainstem—the anterior pontomesencephalic vein, lateral pontomesencephalic vein, anterior medullary vein, peduncular vein, transverse pontine vein, and lateral pontine vein; (2) those veins related to the wing of the precentral cerebellar fissure—the brachial vein and anterior superior marginal vein; (3) those veins related to the hemisphere—superior hemispheric veins, inferior hemispheric veins, and vein of the great horizontal fissure; (4) those veins located in the cerebellomedullary fissure—vein on the cerebellar side (medial tonsillar vein) and veins on the medullary side (retro-olivary vein, vein of the restiform body); and (5) those veins in the posterolateral fissure—vein of the lateral recess of the fourth ventricle.

Tributaries related to the anterior aspect of the brainstem

These tributaries may be subdivided into longitudinally running and transversely running veins.

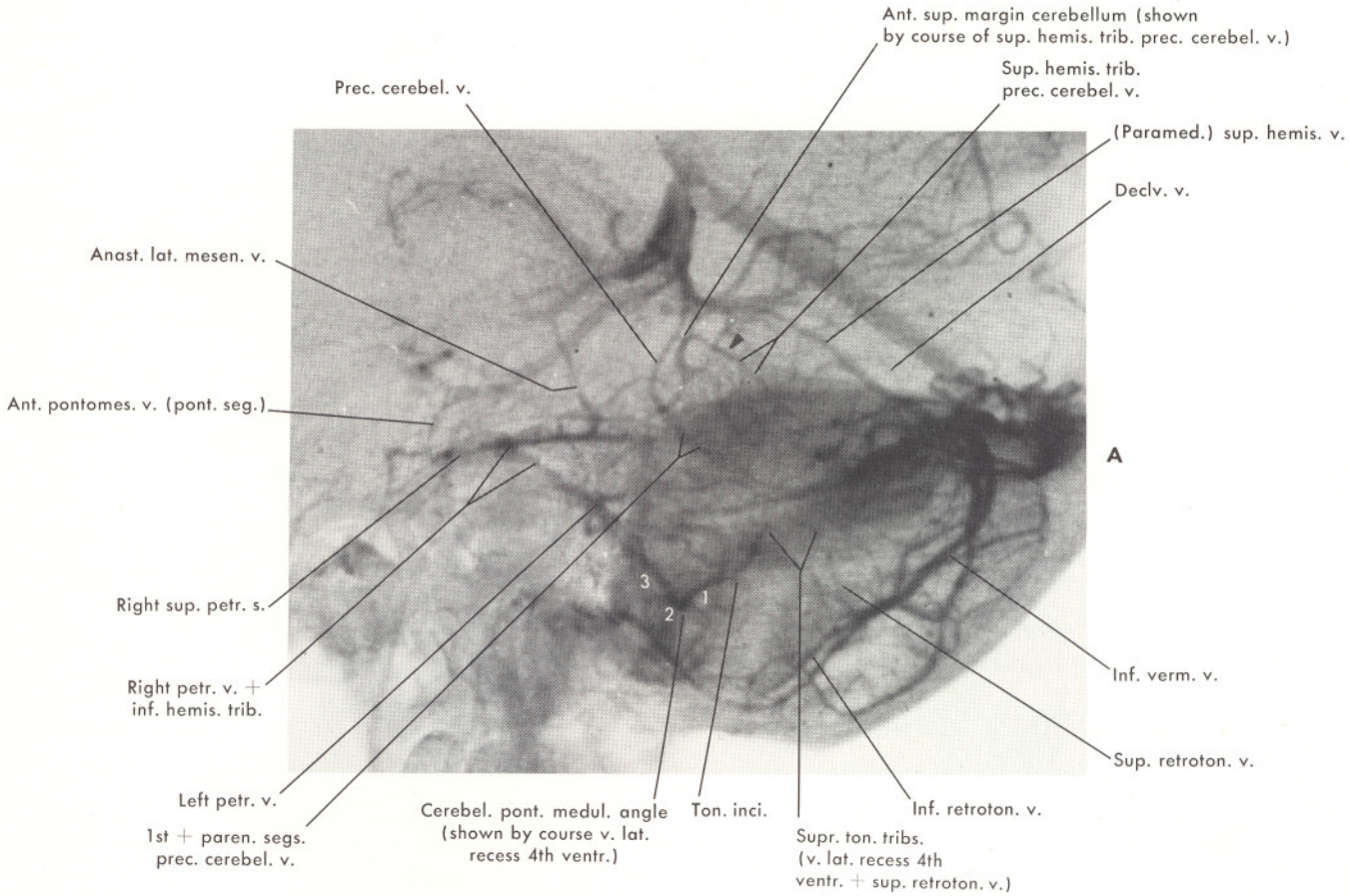


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Fig. 75-16. Prominent vein of the lateral recess of the fourth ventricle. **A,** Lateral view. The vein of the lateral recess of the fourth ventricle (left side), originating from the superior pole of the cerebellar tonsil (supratonsillar tributary), runs downward and toward the tonsillar incisura. It courses forward and downward—first segment (*1*)—to appear in the cerebellopontomedullary angle. It then turns laterally and runs below the flocculus—second segment (*2*)—seen as a dense dot. Beyond this point it courses superiorly and anteriorly (and medially) to join the stem of the left petrosal vein—third segment (*3*). As a result of rotation and tilt of the head, the right superior petrosal sinus is considerably higher than the left. A superior hemispheric vein (arrowhead) runs forward and upward dipping into the precentral cerebellar fissure after crossing over the anterosuperior margin of the cerebellum, and joins the brachial tributary of the precentral cerebellar vein, which then runs upward and backward and drains into the vein of Galen. **B,** Towne view. Two major tributaries of the vein of the lateral recess of the fourth ventricle can be identified on the left: the supratonsillar tributary and a tributary from the nodulouvular fissure. The former receives dentate veins. The first segment (*1*) of the vein of the lateral recess of the fourth ventricle runs anterolaterally as well as inferiorly. After emerging from the cerebellopontomedullary angle, it turns laterally and courses below the flocculus—second segment (*2*)—and then runs upward around the superolateral border of the flocculus to join the stem of the petrosal vein—third segment (*3*). The precentral cerebellar vein, seen in the lateral view, begins on the right as a superior hemispheric vein. After crossing over the anterosuperior margin of the cerebellum, the vein dips down into the precentral cerebellar fissure for a short distance and then turns upward to join the vein of Galen (upper arrowheads). The main tributary of the petrosal vein on the right side is the inferior hemispheric vein (white arrow). A small vein running on the lateral aspect of the medulla oblongata (single black arrowhead), on the lower portion of the pons, and on the anteroinferior aspect of the brachium pontis joins the stem of the petrosal vein.

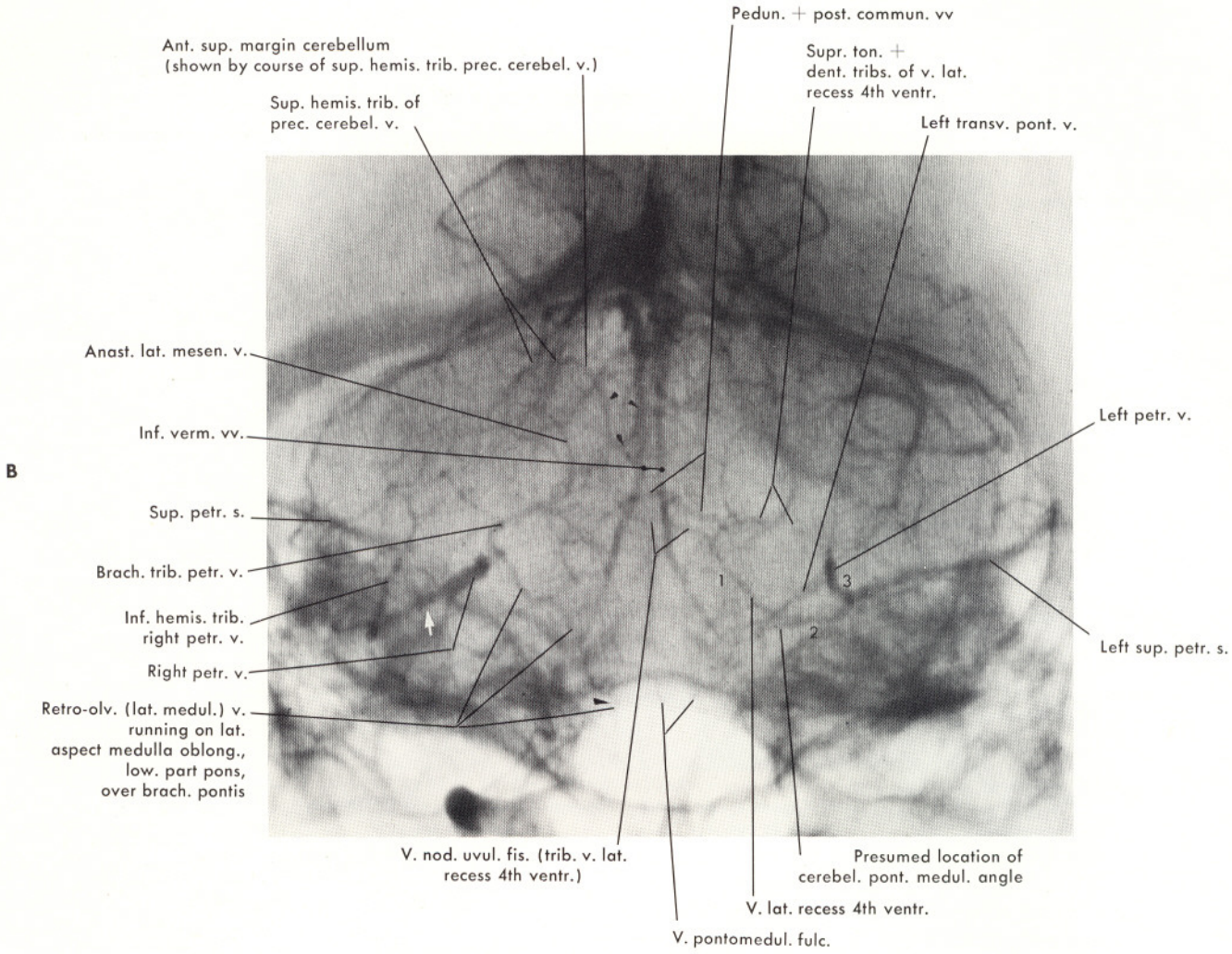

Fig. 75-16, cont'd. For legend see p. 2177.

Longitudinally running veins. Included among these veins are the anterior pontomesencephalic, lateral pontomesencephalic, anterior medullary, and lateral pontine veins.

The *anterior pontomesencephalic vein* is one of the longitudinal venous channels on the anterior aspect of the brainstem (Figs. 75-6, 75-9 to 75-13, and 75-14, *B*). It may be located in or adjacent to the midline (median anterior pontomesencephalic vein). It may run parasagittally on the anterior aspect of a cerebral peduncle and on the anterolateral aspect of the pons (lateral anterior pontomesencephalic vein). Although the median anterior pontomesencephalic vein may be quite tortuous, its appearance in the lateral view often depicts the profile of the brainstem. Thus the adjacent basal cisterns, the roof (roof segment) and depth of the interpeduncular cistern (mesencephalic or interpeduncular segment), and the posterior wall of the pontine cistern (pontine segment) are also visualized angiographically. The lateral anterior pontomesencephalic vein frequently marks the anterior aspect of a cerebral peduncle (Figs. 75-5, *A*, and 75-13). In the anteroposterior or Towne projection these vessels have little angiographic value because of frequent tortuosity. The peduncular and posterior communicating veins, in the anteroposterior projection, identify the interpeduncular fossa (Figs. 75-12, *B*, and 75-15).

The *lateral pontomesencephalic vein* (Figs. 75-10 and 75-11) not infrequently is found on the lateral aspect of the basis pedunculi extending inferiorly to join the petrosal vein. This vein should not be confused with the more posteriorly located anastomotic lateral mesencephalic vein or the more medially located median or lateral anterior pontomesencephalic vein (Fig. 75-13). The exact location of the lateral pontomesencephalic vein varies—in some on the anterolateral aspect, in others on the posterolateral aspect, of the basis pedunculi.

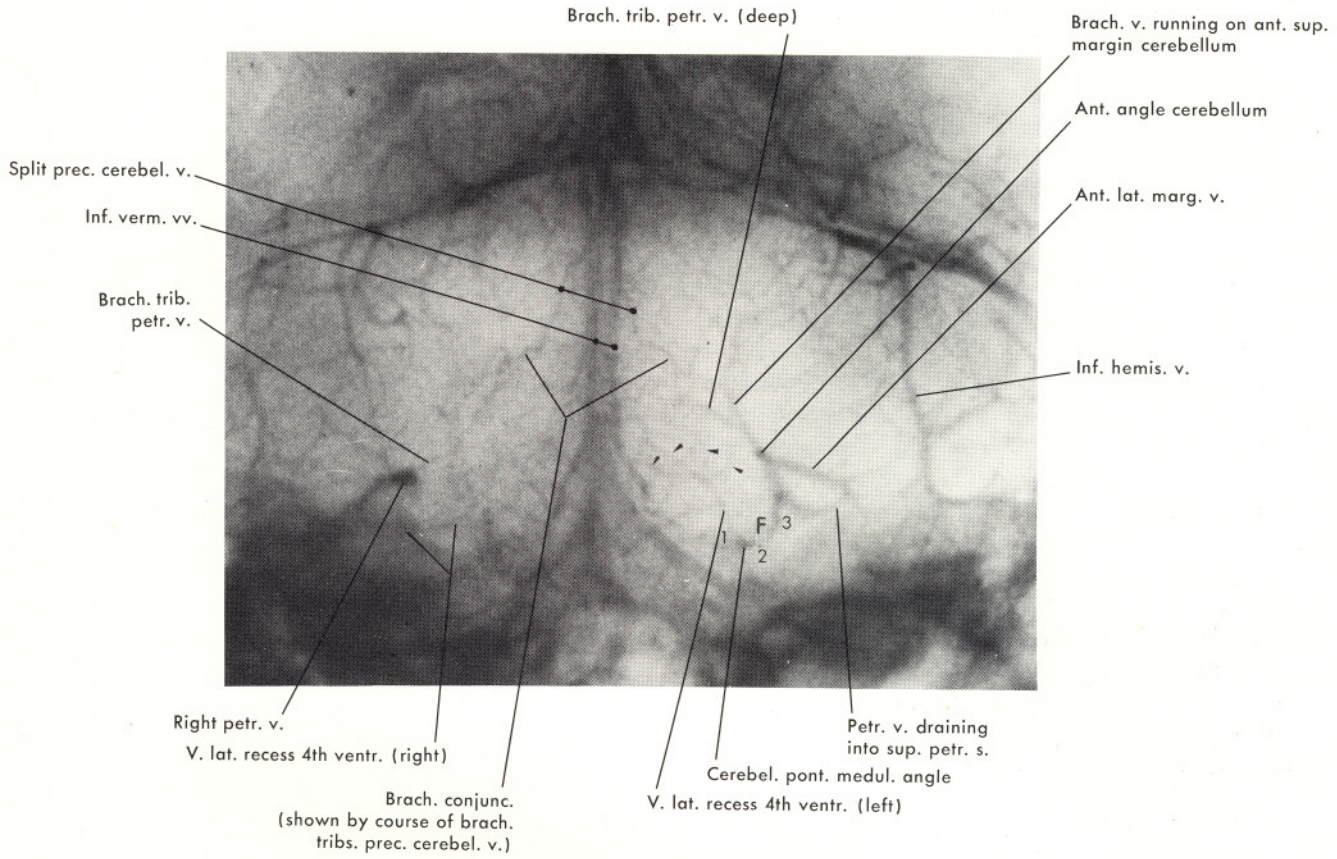

Fig. 75-17. Typical course of the vein of the lateral recess of the fourth ventricle, Towne projection. Several supratonsillar tributaries (black arrowheads) of the vein of the lateral recess of the fourth ventricle unite to form a single trunk. The vein then runs forward, downward, and laterally (*1*). After emerging from the cerebellopontomedullary angle, it turns laterally and courses below (*2*) and around the flocculus (*F*) to join the midportion of the stem of the petrosal vein (*3*). The vein of the lateral recess of the fourth ventricle, on the right, is only faintly visualized. The split precentral cerebellar vein outlines the posterolateral corners of the brachia conjunctiva—indirect landmark for the position of the roof of the upper part of the fourth ventricle. The inferior vermian veins are also visible.

The *anterior medullary vein* is also a longitudinal venous channel, continuous superiorly with the pontine segment of the anterior pontomesencephalic vein (Figs. 75-8, *B*, 75-13, and 75-18, *A*). Inferiorly it is continuous with the anterior spinal vein (Fig. 75-22, *A*). It is often connected with the retro-olivary vein (to be described) at various levels, particularly at the pontomedullary sulcus. Because of superimposition on the dense petrous pyramids, the anterior medullary vein cannot usually be identified in the lateral view without subtraction. This anterior mesencephalicopontomedullary trunk receives numerous parenchymal veins from the brainstem. The most prominent of these are inferior thalamic and central mesencephalic veins, which drain the anteroinferior portions of the thalami and median part of the mesencephalon and run through the posterior perforated substance (Huang et al., 1968a; Giudicelli et al., 1969; Huang and Wolf, 1970a, 1970b). They join the mesencephalic segment of the anterior pontomesencephalic vein.

The *lateral pontine vein* is a vein that runs upward in the lateral pontine sulcus between the pons and brachium pontis. It runs medial to the flocculus and usually joins the petrosal vein at or near the anterior angle.

Transversely running veins. Included in this group are the peduncular and transverse pontine veins, vein of the pontomedullary sulcus, and vein of the pontomesencephalic sulcus.

The *peduncular vein* originates in the interpeduncular fossa and runs laterally on the anterior aspect of the cerebral peduncle to join the basal vein of Rosenthal or posterior mesencephalic vein (Figs. 75-6, 75-7, 75-9, 75-10, *A,* 75-11, 75-14, 75-16, and 75-18). The peduncular veins are frequently connected in the depth of the interpeduncular fossa by a posterior communicating vein (Figs. 75-7 and 75-16, *B*). These venous channels outline the anterior aspects of the cerebral peduncles and the interpeduncular fossa quite faithfully. Occasionally several peduncular veins may be present at different levels (Figs. 75-9, *A,* 75-11, 75-18, *B,* and 75-21).

Transverse pontine veins are often multiple and located at variable levels (superior, middle, and inferior transverse pontine veins). The most prominent one is usually located at the level of the midpons and therefore, in both lateral and semiaxial projections, indicates the size and lateral extension of the pontine cistern (Figs. 75-5, *B,* 75-13, 75-14, 75-19, and 75-20). These transverse pontine veins run laterally to join the petrosal vein usually at the anterior angle of the cerebellum. In some cases they drain into the cavernous sinus, inferior petrosal sinus, or medial part of the superior petrosal sinus through one or two bridging veins (Figs. 75-8, *A,* 75-9, *A,* and 75-13).

The *vein of the pontomedullary sulcus* and *vein of the pontomesencephalic sulcus* are rarely seen at angiography.

Tributaries related to the wing of the precentral cerebellar fissure

These tributaries may generically be designated *brachial veins* because of their relationship to the brachium pontis and/or brachium conjunctivum (Figs. 75-7 to 75-11, 75-14, 75-17, and 75-19 to 75-21). When such a vein is located adjacent to the anterior superior margin of the cerebellum, it may be designated an *anterior superior marginal vein* (Figs. 75-11 and 75-17). A brachial tributary of the petrosal vein frequently communicates with a brachial tributary of the precentral cerebellar vein. The combined channel outlines the anterior cerebellar notch (Figs. 75-7, 75-10, *B,* and 75-14). When veins of both sides are visualized, a typical inverted V configuration may be seen in the Towne projection (Figs. 75-7, 75-8, *B,* 75-10, *A,* and 75-14). In the lateral view the brachial tributary of the petrosal vein runs downward and forward. Frequently in the lateral view it has a small terminal anterior curve that corresponds to the superior and anterior aspects of the brachium pontis (Figs. 75-6, 75-8, and 75-9). Its anterior end, which joins the stem of the petrosal vein, is therefore another landmark for the anterior angle of the cerebellum.

Tributaries related to the cerebellar hemisphere

These include an anterior lateral marginal vein, the vein of the great horizontal fissure, and superior and inferior hemispheric veins.

Anterior lateral marginal vein. This is usually a small vessel that runs medially parallel to the anterolateral margin of the cerebellar hemisphere to the region of the anterior angle to enter the petrosal vein (Fig. 75-10, *B*).

Vein of great horizontal fissure of cerebellum. Beginning posteriorly in the depth of the great horizontal fissure, this vein runs anterolaterally and somewhat inferiorly, becoming more superficial as it turns around onto the petrosal surface. It then continues medially between the inferior semilunar lobule and quadrangular lobule and courses superiorly above the flocculus to reach the anterior angle of the cerebellum, where it joins the petrosal vein (Fig. 75-10). In some cases this vein joins the superior petrosal sinus more laterally. It may bypass the petrosal vein and continue into the lateral mesencephalic vein to join the galenic system.

Hemispheric veins

Superior hemispheric veins run forward and downward usually to join the vein of the great horizontal fissure or anterior lateral marginal vein (Figs. 75-14, *B,* 75-19, *B,* 75-20). In some cases they join the superior petrosal sinus directly. Occasionally a vein may run in the primary fissure (vein of the primary fissure) or the postclival fissure (postclival vein). In some cases superior hemispheric veins may drain medially and superiorly to join the brachial tributaries of the precentral cerebellar vein, culminate vein, or lateral mesencephalic vein.

Inferior hemispheric veins run forward and upward on the undersurface of the inferior semilunar and biventral lobules. Here they join the vein of the great horizontal fissure, vein of the lateral recess of the fourth ventricle, lateral pontine vein, or anterior lateral marginal vein. In the lateral projection these veins are obscured by the petrous pyramids. In the Towne projection hemispheric veins outline the petrosal aspect of the cerebellum (Figs. 75-11, 75-14, 75-19, and 75-20).

Tributaries related to the cerebellomedullary fissure

These include the retro-olivary vein, vein of the restiform body, and medial tonsillar vein (Figs. 75-10, *B,* 75-15, 75-16, *B,* and 75-19, *B*).

Retro-olivary (or lateral medullary) vein. Often a vein runs longitudinally in the retro-olivary sulcus anterior to the rootlets of the ninth and tenth cranial

nerves. On reaching the supraolivary fossette this retro-olivary vein turns anterolaterally and around the inferior aspect of the brachium pontis. Here it becomes the lateral pontine vein, or it joins a vein running in the fissure below the flocculus. In other cases the retro-olivary vein runs anterolaterally along the rootlets of the ninth and tenth nerves to form a single trunk (vagal vein) and joins the inferior end of the inferior petrosal sinus (Fig. 75-10, *B*). In the Towne projection the retro-olivary vein outlines the lateral border of the medulla oblongata. Its upper portion assumes a hockey stick configuration while turning laterally in the cerebellopontomedullary angle (Figs. 75-15 and 75-19, *B*).

Vein of restiform body. A superior extension of the median posterior spinal vein runs upward adjacent to the lateral border of the lower portion of the fourth ventricle behind the restiform body (Fig. 75-15). It may join the retro-olivary vein at variable levels and form a common stem. Not infrequently it may connect with a medial tonsillar tributary of the vein of the lateral recess of the fourth ventricle (Huang and Wolf, 1970a, 1970b).

Medial tonsillar veins. These are located on the medial aspect of the cerebellar tonsil at various levels and are usually not prominent. They run on the lateral and posterior medullary aspects of the cerebellar tonsil. Often they converge toward the incisura of the cerebellar tonsil to join the vein of the lateral recess of the fourth ventricle (Huang and Wolf, 1967). These veins may communicate with the vein of the restiform body or retro-olivary vein, or they may run backward to open into a medial tonsillar tributary of the inferior vermian vein (Huang et al., 1969).

Tributary related to the posterolateral fissure (vein of lateral recess of fourth ventricle)

There is usually a vein in the posterolateral fissure that could be called the vein of the posterolateral fissure but has been designated the vein of the lateral recess of the fourth ventricle to emphasize its close relation to the lateral recess of the ventricle (Figs. 75-7, 75-8, *B*, 75-10, *B*, 75-13, 75-14, *A*, 75-16, 75-17, and 75-19, *B*). It originates in the region of the dentate impression on the superior surface of the cerebellar tonsil (Huang and Wolf, 1967) and runs anterolaterally below and parallel to the lateral recess of the fourth ventricle. This portion of the vein has been designated the first or peduncular segment. At the cerebellopontomedullary angle the vein turns laterally and runs below the flocculus (second or floccular segment). It then turns upward, medially, and somewhat forward above the flocculus and below the overhanging quadrangular lip to join the stem of the petrosal vein at or near the anterior angle (third or supraflocculus segment). Not infrequently the peduncular portion of the vein of the lateral recess of the fourth ventricle, after emerging from the cerebellopontomedullary angle, continues to run forward. It then traverses the subarachnoid and subdural spaces to join the inferior end of the inferior petrosal sinus. In such cases the floccular and supraflocculus segments are replaced by the cisternal segment. When the peduncular segments of the veins of both sides are visualized, a symmetric inverted V configuration may be produced. Since the vein of the lateral recess of the fourth ventricle is related to the posterior superior recess and lateral recess of the fourth ventricle, displacements and deformities of this vein may be interpreted in a fashion similar to changes seen on encephalography. The distance between the first and third segments of the vein of the lateral recess (or between the first segment of the vein and a brachial tributary of the petrosal vein) indicates the thickness of the brachium pontis and restiform body (Figs. 75-7, 75-10, 75-17, and 75-19, *B*).

Tributaries of the vein of the lateral recess of the fourth ventricle include (1) lateral, medial, and transverse supratonsillar veins running on the lateral and medial aspects or across the superior pole of the cerebellar tonsil, (2) medial tonsillar veins that converge toward the vein of the lateral recess at the tonsillar incisura, (3) dentate and other parenchymal veins that drain the dentate nucleus and adjacent white matter, and (4) subependymal veins that drain into the lateral supratonsillar vein. Parenchymal and subependymal veins are usually too small to be seen angiographically. The lateral supratonsillar tributary of the vein of the lateral recess runs below and parallel to the lateral border of the posterior superior recess of the fourth ventricle. When tributaries of both sides are visualized, the distance between them therefore indicates the width of the fourth ventricle.

Posterior or tentorial draining group (Padget, 1957; Greitz and Lindgren, 1961; Bouchet et al., 1963-1964; Huang et al., 1969; Stephens and Stilwell, 1969) (Figs. 75-3, *A* and *C*, 75-4 to 75-9, and 75-11 to 75-23)

Included in the posterior or tentorial draining group are veins related to the posterior cerebellar notch, the inferior vermian vein and its tributaries, and veins related to the cerebellar hemisphere (the hemispheric veins).

Tributaries related to the posterior cerebellar notch

Inferior vermian vein. This vein is formed by the union of superior and inferior retrotonsillar tributaries in the region of the copula pyramidis (Huang et al., 1969a; Wackenheim and Ben-Amor, 1971). The copula pyramidis (or pyramidal band) is a prominent bar that connects the midline pyramid and the laterally located biventral lobule (Angevine et al., 1961). The inferior

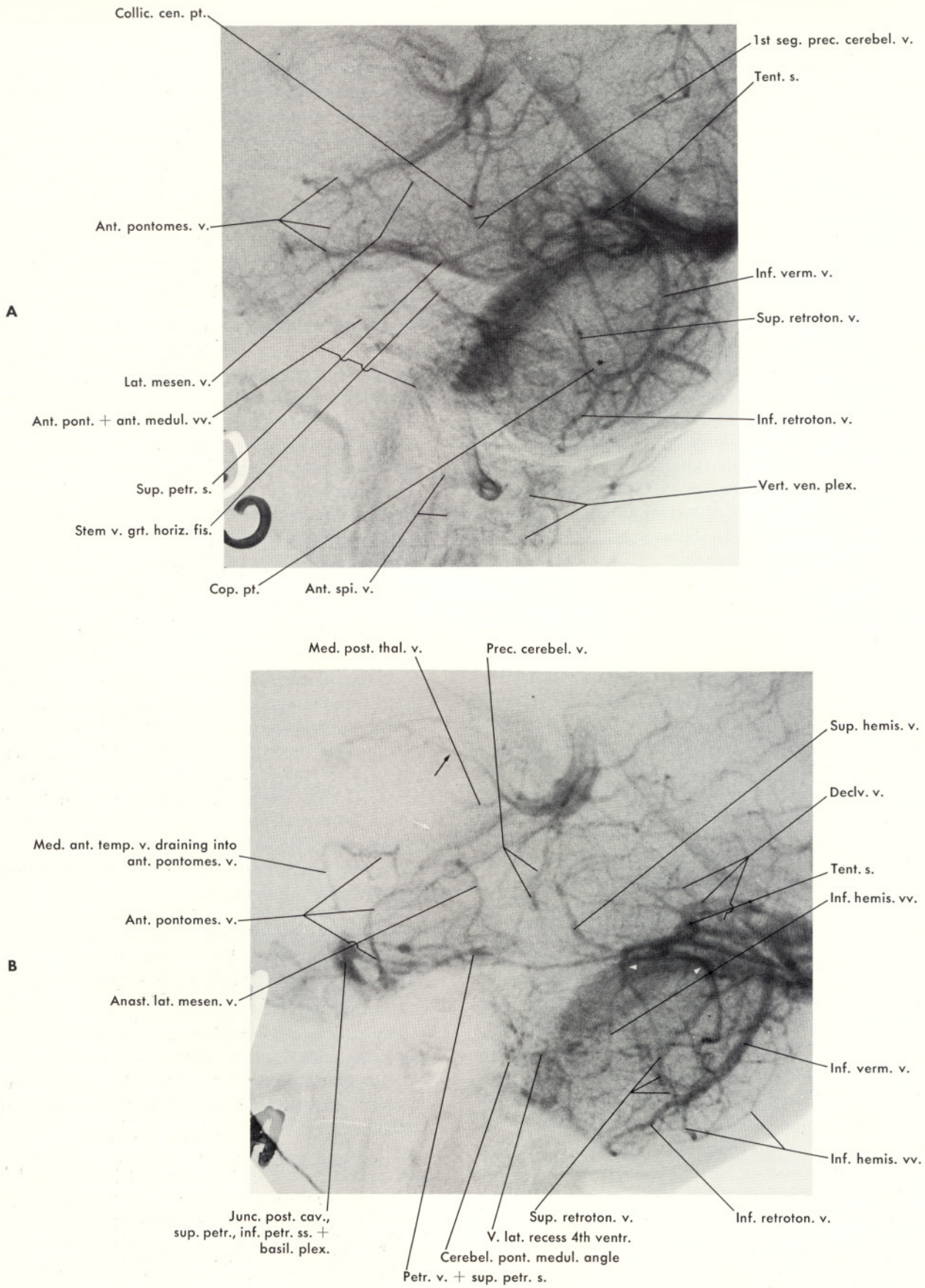

Fig. 75-18. For legend see opposite page.

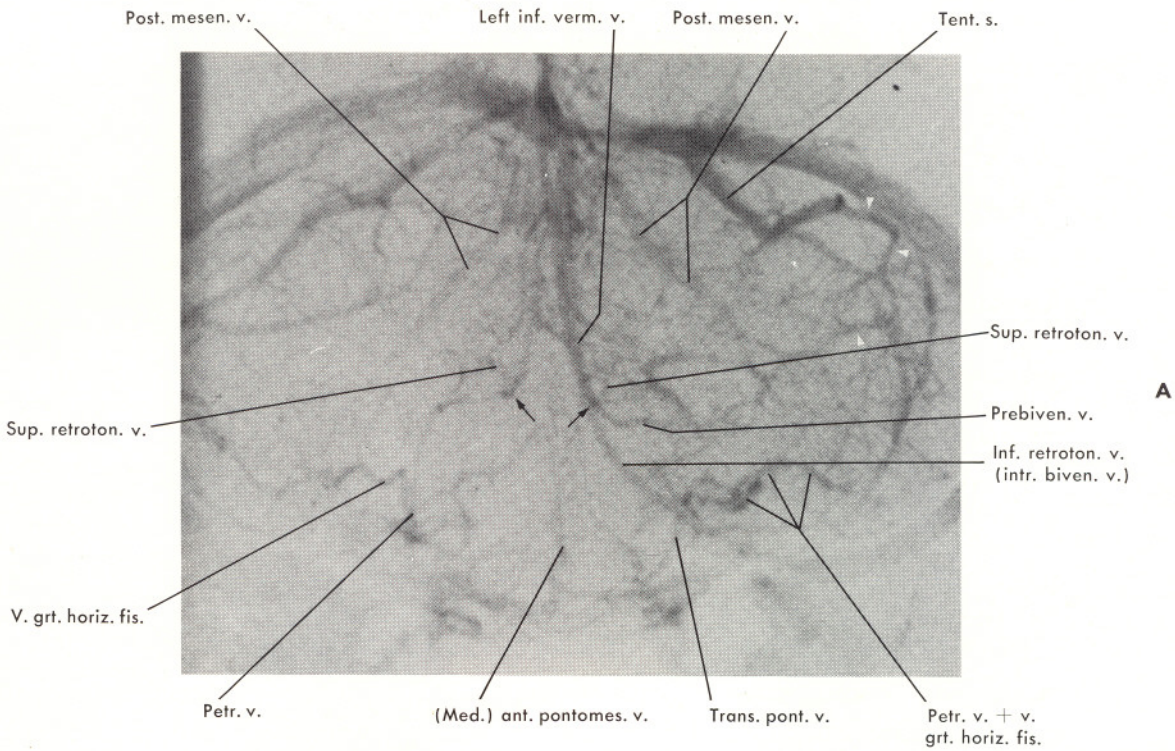

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Fig. 75-19. Inferior vermian vein and other veins of the posterior draining group, semiaxial view (two cases). **A,** The inferior vermian vein on the left is prominent and is formed by the union of small superior retrotonsillar, prominent inferior retrotonsillar (intrabiventral vein), and prebiventral tributaries. The superior retrotonsillar tributary, running around the copula pyramidis to join the inferior vermian vein, can be identified on both sides (copular points, arrows). An inferior hemispheric vein (white arrowheads) runs upward and then onto the superior surface to join a tentorial sinus. Slight elevation of the petrosal vein on the left is from a very small tumor in the left cerebellopontine angle.

Fig. 75-18. Prominent inferior vermian vein, lateral view (two cases). **A,** The inferior vermian vein is formed by the union of the superior and inferior retrotonsillar tributaries at the level of and behind the midportion of the cerebellar tonsil. It then runs in the inferior paravermian sulcus and joins the inferior portion of the straight sinus, following a short course within the tentorium. The copular point below the copula pyramidis (*) can be identified. The anterior pontomesencephalic, anterior medullary, and anterior spinal veins take a continuous curved course outlining the anterior aspect of the entire brainstem. The posterior part of the vertebral venous plexus outlines the posterior aspect of the cervical dura. This should not be confused with the median posterior spinal vein. **B,** Inferior vermian vein and other veins of the posterior draining group. The inferior vermian vein and its superior and inferior retrotonsillar tributaries can be identified. Several inferior hemispheric tributaries drain into it. After crossing over the posterolateral margin of the cerebellum (white arrowheads), several other inferior hemispheric veins run upward to join a prominent tentorial sinus. The posterolateral margin of the cerebellum corresponds to the course of the lateral sinus. The tentorial sinus, in turn, joins the lateral sinus. The anterior pontomesencephalic, lateral mesencephalic, and precentral cerebellar veins and faintly the vein of the lateral recess of the fourth ventricle can be identified. A prominent medial posterior thalamic vein joins the superior thalamic vein (black arrow). There are many lateral posterior thalamic veins (white arrow) too fine to be individually labeled. The confluence of sinuses at the junction between the basilar plexus and the superior and inferior petrosal and cavernous sinuses is clearly seen.

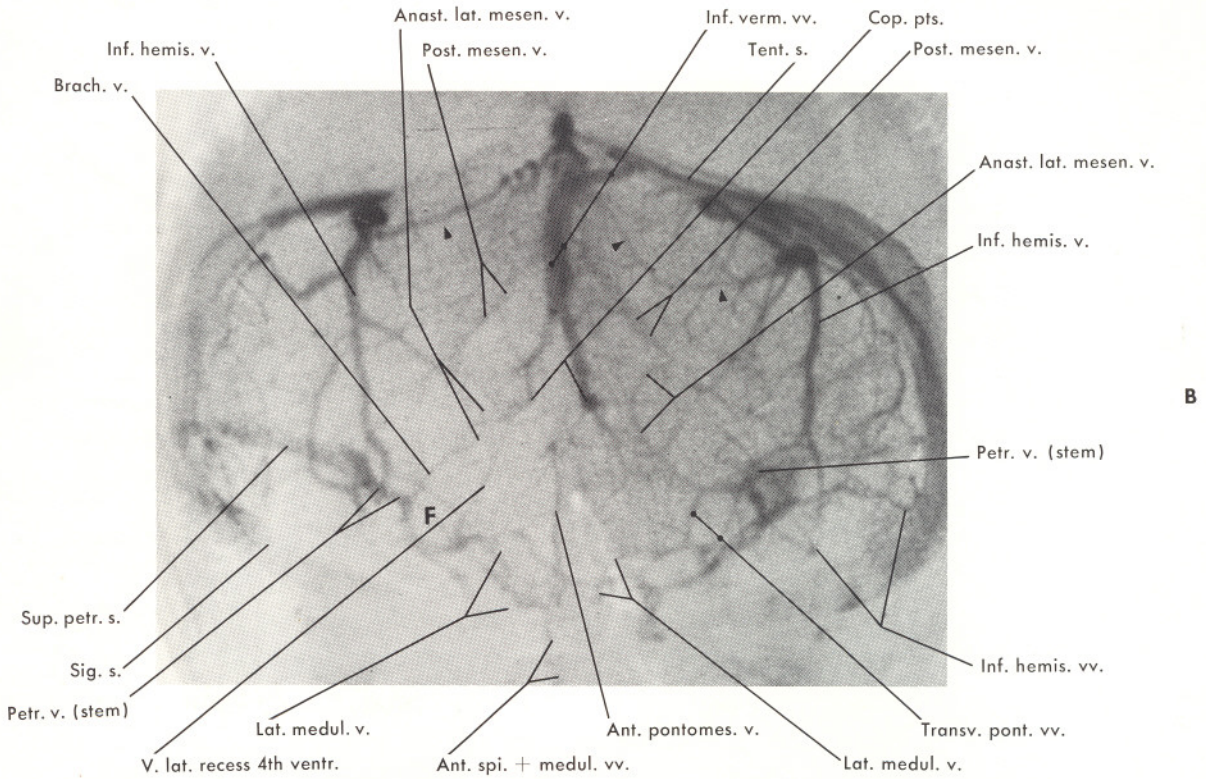

Fig. 75-19, cont'd. B, Both inferior vermian veins are seen. The left one drains into the left lateral sinus, following a short course within the tentorium, whereas the right one opens into the straight sinus. The location of the copular point is well demonstrated on the left (dense dot at the tonsillobiventral notch). Inferior hemispheric veins are prominent and drain upward to join the lateral sinuses directly or indirectly through a tentorial sinus. Several anastomotic channels (arrowheads) between the inferior vermian veins and laterally located inferior hemispheric veins can be seen. The anterior pontomesencephalic vein is continuous inferiorly with the anterior medullary and anterior spinal veins. The lateral borders of the medulla oblongata are faintly demonstrated by retro-olivary (or lateral medullary) veins. On the right side, the retro-olivary vein and the vein of the lateral recess of the fourth ventricle form a single trunk that, in turn, runs around the inferior and lateral borders of the flocculus (*F*). This venous trunk is then joined by a brachial vein to form the stem of the petrosal vein, which courses laterally and opens into the prominent superior petrosal sinus. On the left side the petrosal vein receives tributaries from the lateral mesencephalic sulcus (anastomotic lateral mesencephalic vein), from the superior and midportion of the belly of the pons (transverse pontine veins), and from the inferior aspect of the cerebellar hemisphere (inferior hemispheric veins).

vermian vein runs posterosuperiorly in or adjacent to the inferior paravermian sulcus. It opens directly into the straight sinus 1.5 to 2 cm anterior to the torcular or indirectly through a tentorial sinus into the straight sinus (Figs. 75-6, 75-8, 75-9, *B,* 75-13, 75-14, *B,* 75-18, *A,* and 75-19). Not infrequently, however, the inferior vermian vein drains into the lateral sinus near the torcular, either directly or indirectly after a short course within the tentorium (Figs. 75-8, 75-12, 75-19, *B,* 75-20, and 75-23).

In some instances the inferior vermian vein, after reaching the upper end of the inferior paravermian sulcus, turns forward and upward to continue on the superior surface of the superior vermis and joins the superior vermian vein (Fig. 75-21).

Tributaries of the inferior vermian vein include superior and inferior retrotonsillar, suprapyramidal, hemispheric, and declival veins.

The *superior retrotonsillar tributary* originates on the posterior aspect of the superior pole of the cerebellar tonsil. It runs downward and backward in the retrotonsillar fissure, receiving small tributaries from the superior pole of the tonsil (supratonsillar veins) and from the secondary fissure (infrapyramidal vein) (Huang et al., 1969). The superior retrotonsillar tributary then runs around the anterior and inferior aspects

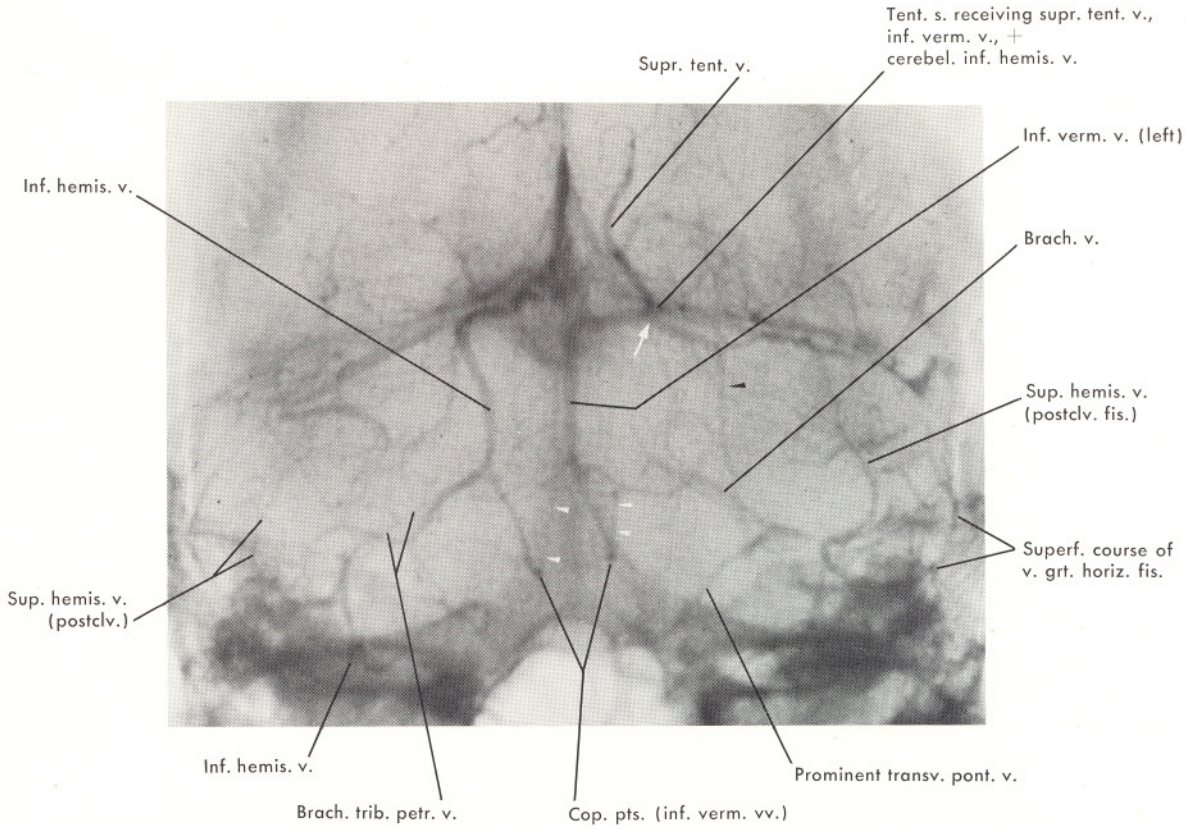

Fig. 75-20. Superior retrotonsillar vein draining into an inferior hemispheric vein. Both superior retrotonsillar veins are visible (white arrowheads). The left one drains into the inferior vermian vein whereas the right one joins an inferior hemispheric vein. The location of the copula pyramidis is indicated by the copular point on both sides. The inferior vermian, inferior hemispheric (black arrowhead), and supratentorial veins converge into a tentorial sinus at one point (white arrow) before opening into the lateral sinus.

of the copula pyramidis to join the inferior vermian vein (Fig. 75-8). The most anteroinferior point of the superior retrotonsillar vein as it turns around the copula pyramidis has been designated the copular point (Huang et al., 1969a) (Fig. 75-4). This point can also be identified in semiaxial views. The angle formed at the copular point by the inferior vermian vein and its superior retrotonsillar tributary is designated the copular point in both lateral and semiaxial views (Figs. 75-3, *D*, 75-4, 75-8, 75-19, and 75-20).

The *inferior retrotonsillar tributary* originates on the posterior aspect of the lower half of the cerebellar tonsil. It receives veins from the medial and lateral aspects of the cerebellar tonsil and from the inferior surface of the biventral lobule (Figs. 75-12, 75-18, and 75-19).

The *suprapyramidal vein* is another fine but rather constant tributary that runs in the fissure above the pyramid, the suprapyramidal fissure (Figs. 75-8 and 75-9, *B*). The distance between the superior retrotonsillar and suprapyramidal tributaries of the inferior vermian vein in the lateral view indicates the size of the pyramid.

The *declival vein* is another frequently seen tributary of the inferior vermian vein. It originates in the depth of the primary fissure (vein of the primary fissure). After emerging from the fissure and reaching the superior surface of the cerebellum, the vein runs backward in or adjacent to the declival sulcus to join the inferior vermian vein (Figs. 75-8, *A*, 75-9, *A*, and 75-11). The vein of the primary fissure may, however, join the superior vermian vein (Fig. 75-22, *A*).

In some cases the superior retrotonsillar tributary may be absent, whereas in others the inferior retrotonsillar tributary may be rudimentary. In many cases the inferior vermian vein may not run in the inferior paravermian sulcus. Instead it runs in the posterior cerebellar notch on the falcine aspect of the hemisphere at some distance behind the inferior vermis. It may even leave the posterior cerebellar notch shortly after its origin and continue laterally and superiorly on the inferior surface

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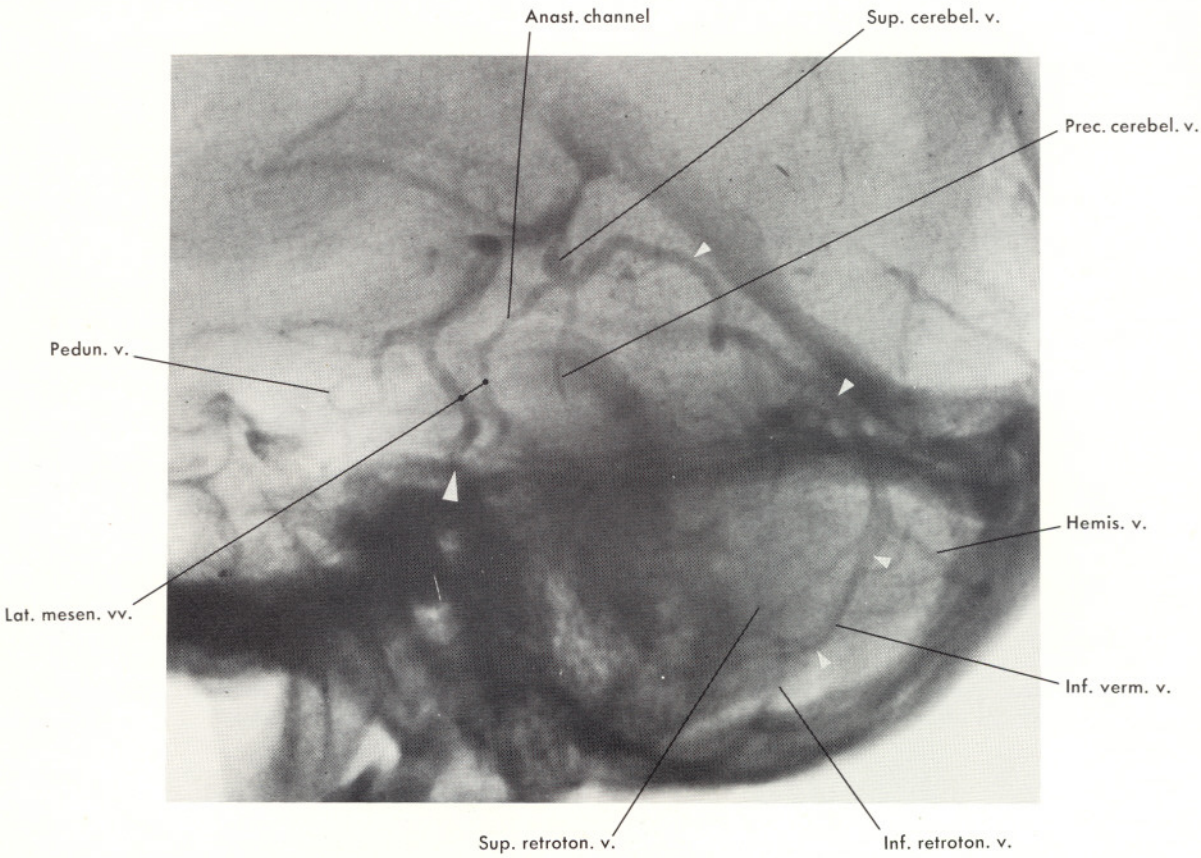

Fig. 75-21. Prominent vermian vein extending from the retrotonsillar fissure to the vein of Galen. Superior and inferior retrotonsillar veins unite to form an unusual vermian vein (small arrowheads) that runs posteriorly and superiorly in the inferior paravermian sulcus, onto the superior surface, forward and upward in the declival sulcus, and then over the culmen. It is joined by the precentral cerebellar vein on the anterior aspect of the culmen. The stem, the superior cerebellar vein, then turns upward and backward to join the vein of Galen. An anastomotic channel connects one lateral mesencephalic vein and the superior cerebellar vein. The other lateral mesencephalic vein (on the opposite side) joins the basal vein and the petrosal vein (large arrowhead).

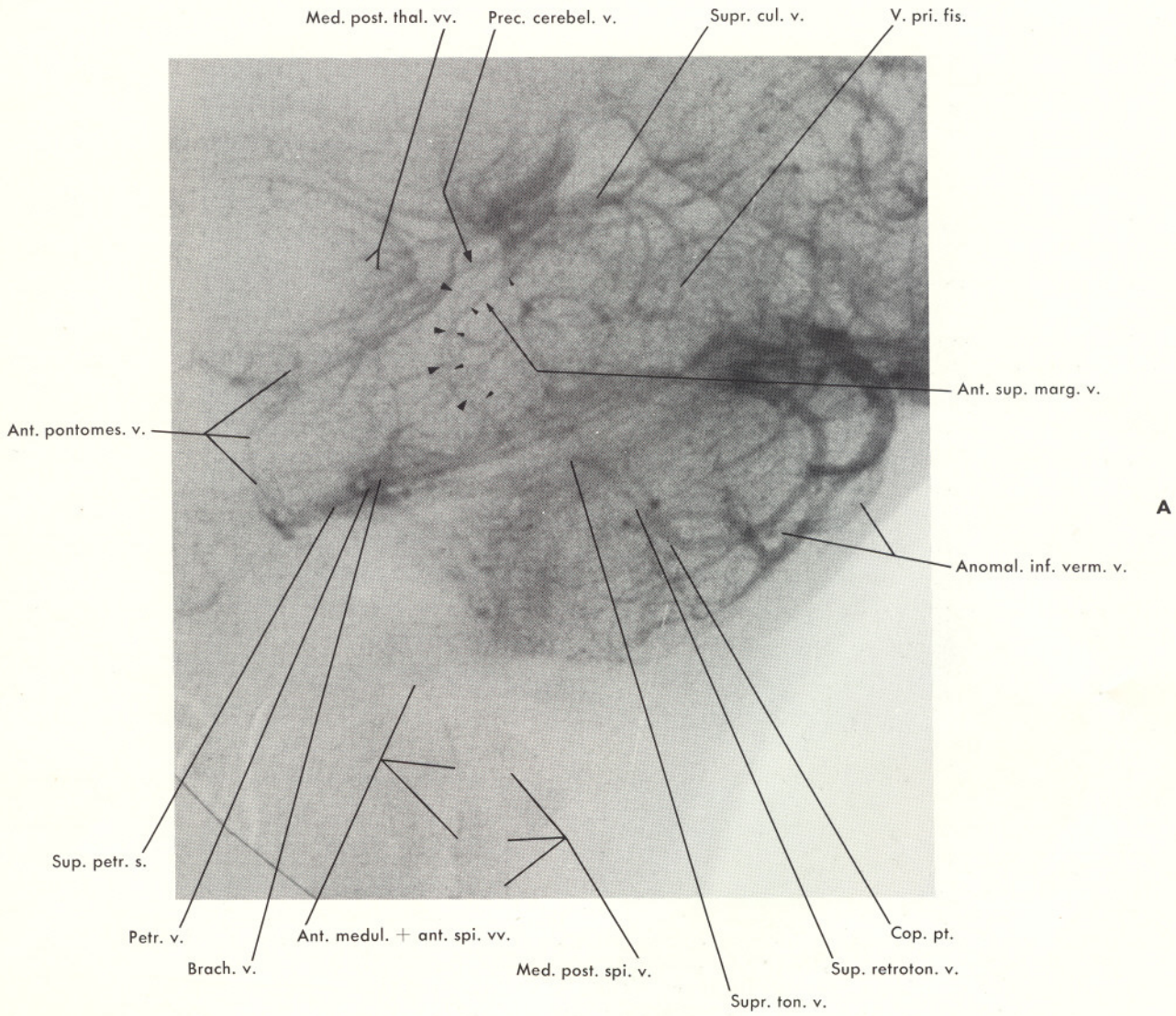

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Fig. 75-22. Value of angiotomography in detecting midline posterior fossa vessels. (See Chapter 50.) **A,** Normal lateral venogram (subtraction). The anterior pontomesencephalic vein is seen running in the midline. A prominent superior retrotonsillar vein runs posteriorly and emerges from the posterior cerebellar notch. However, identification of the precentral cerebellar vein (large arrowheads) is difficult, and distinction from the anterior superior marginal vein (small arrowheads) is practically impossible. **B,** Angiotomogram (same case). Although separation from the precentral cerebellar vein is difficult in **A,** the more laterally located anterior superior marginal vein is eliminated in this angiotomogram. Various segments of the precentral cerebellar vein and veins running in the primary and intraculminate fissures, all of which are difficult to distinguish from superior hemispheric veins on conventional films, are clearly identified. The superior retrotonsillar vein, emerging from the retrotonsillar fissure and posterior cerebellar notch, is also easily recognized with this angiotomographic technique.

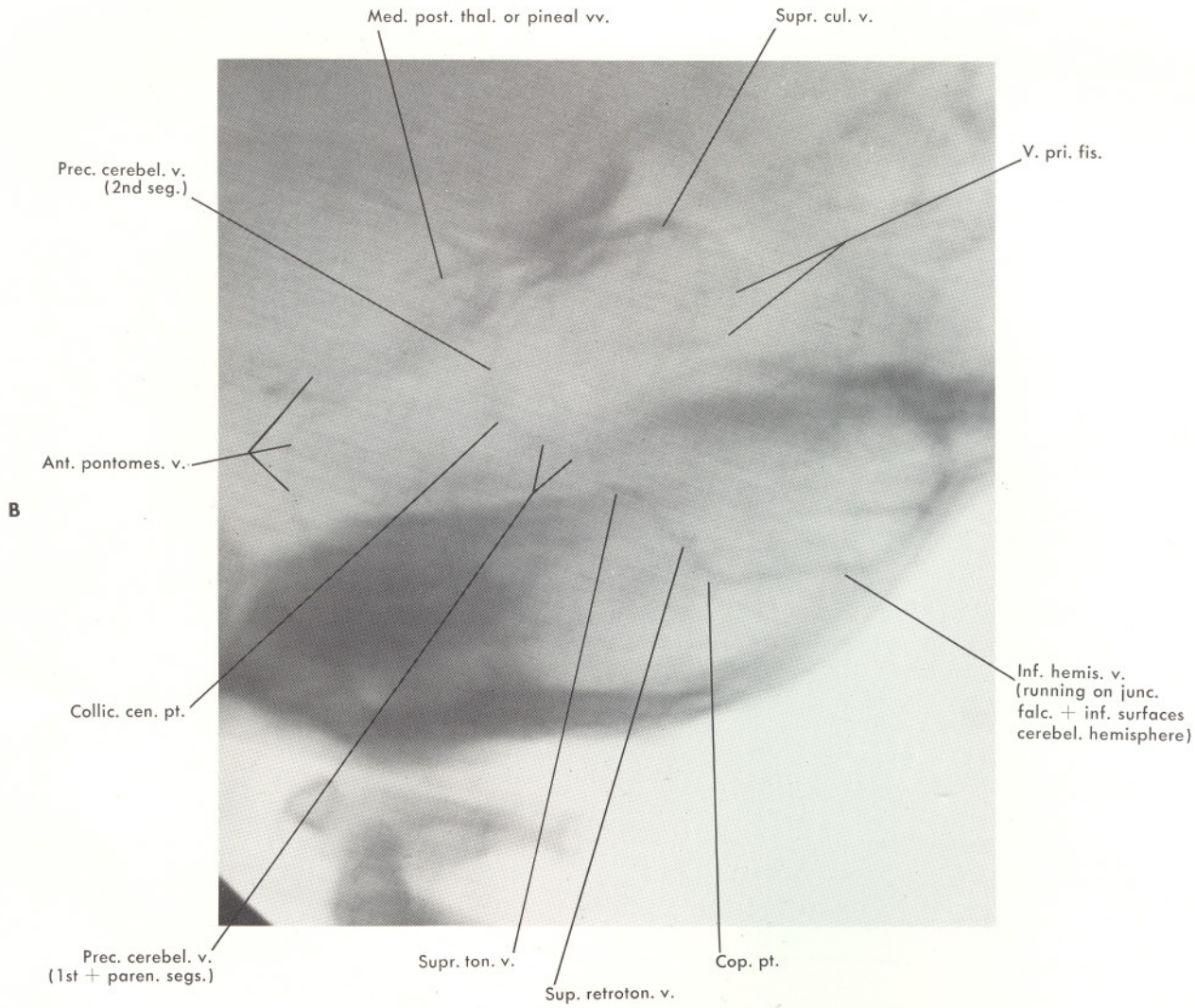

Fig. 75-22, cont'd. For legend see p. 2187.

Fig. 75-24. Diagram showing the normal course of the veins of the posterior fossa in midsagittal section. Covered portions of the veins are shown by dashed lines. A portion of the inferior vermis is removed, and the cut surfaces shaded. Note the veins outlining the body of the tonsil—retrotonsillar veins posteriorly, medial tonsillar vein and vein of the restiform body anteriorly, supratonsillar twig superiorly. The anteroposterior diameter of the body of the cerebellar tonsil corresponds to the maximal height of the fourth ventricle.

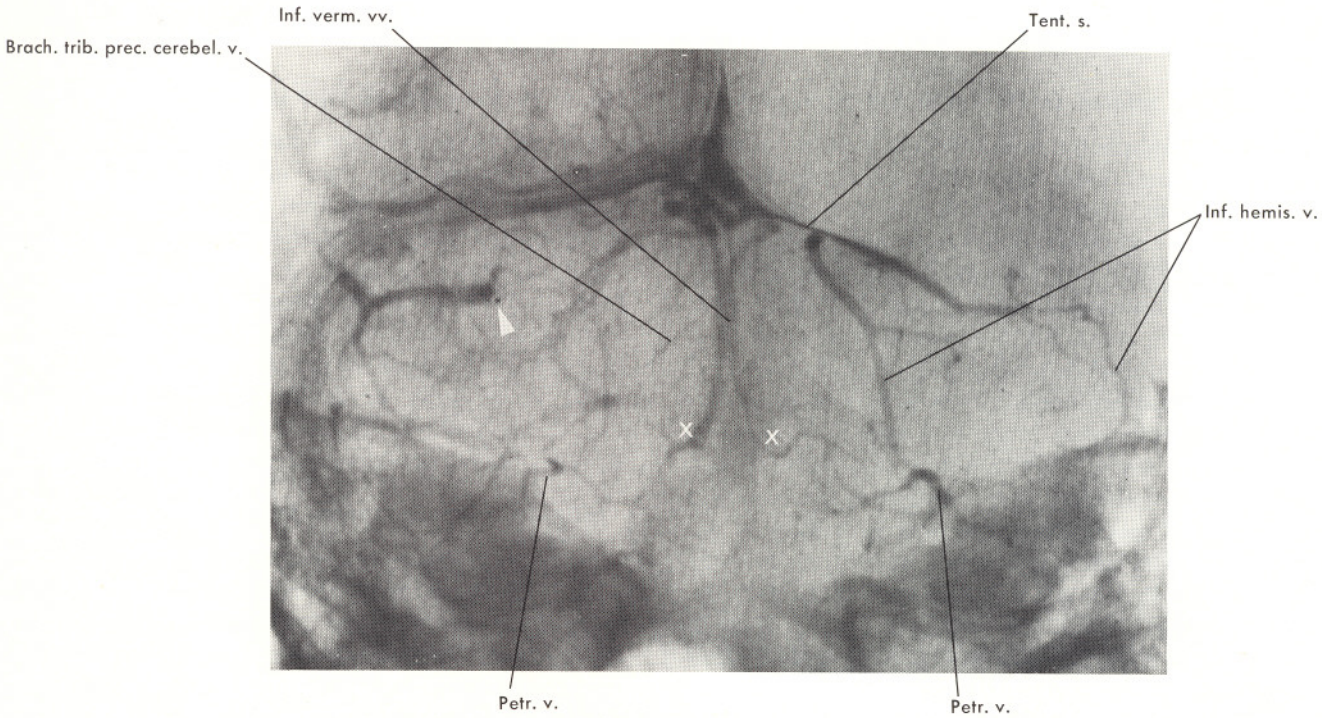

Fig. 75-23. Tentorial sinuses. The lateral sinus on the left side is poorly developed and is replaced by a prominent tentorial sinus that joins the lower end of the straight sinus. On the right side the inferior and superior hemispheric veins form a single stem and enter the tentorium (arrowhead). The channel within the tentorium is not evident probably because it is slitlike and projected *en face*. The location of the copula pyramidis is indicated on both sides by **x**.

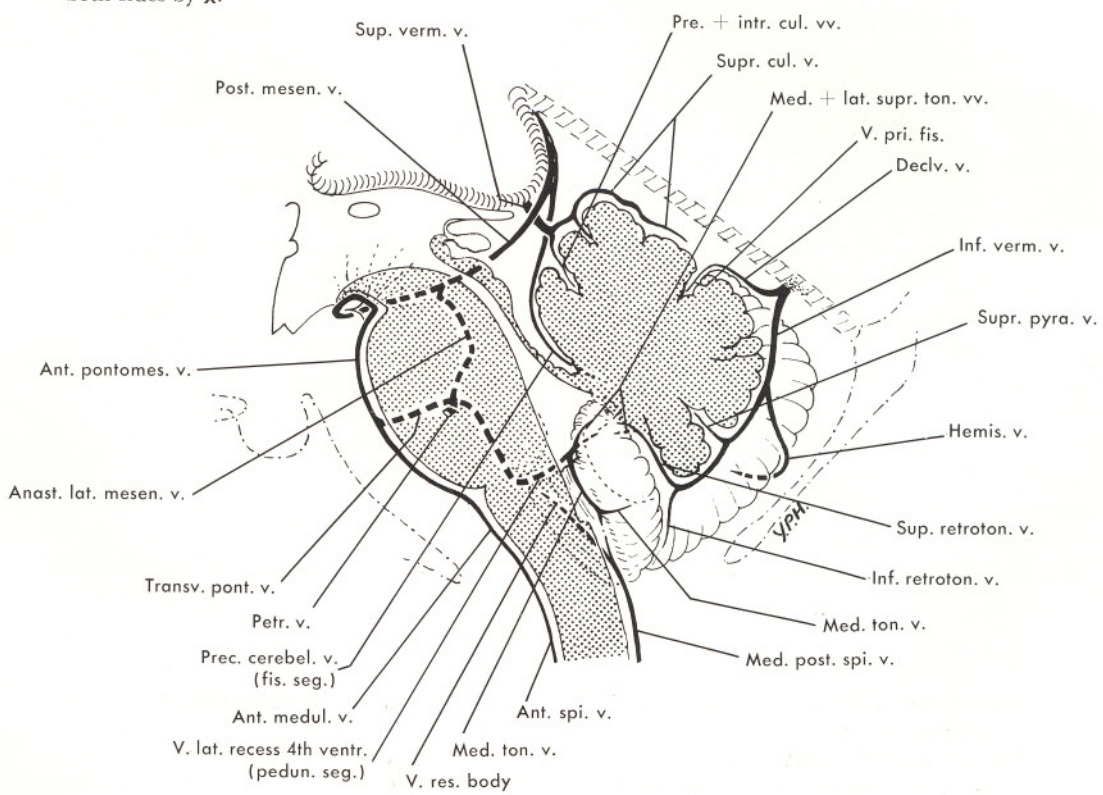

Fig. 75-24. For legend see opposite page.

of the cerebellar hemisphere before joining the lateral sinus (Figs. 75-5, *B*, 75-20, and 75-22).

Tributaries related to the cerebellar hemisphere

Superior hemispheric veins. On the superior surface of the cerebellum, these veins often drain directly into the lateral sinus. More frequently, however, they converge medially and posteriorly to form one or two venous trunks (particularly with the inferior hemispheric veins) and drain into a tentorial sinus (Figs. 75-7, 75-8, 75-9, *B*, 75-10, *B*, 75-19, and 75-23). The tentorial sinus then opens into the lateral or straight sinus near the torcular.

Inferior hemispheric veins. These veins run upward to join the transverse sinus (Figs. 75-8 and 75-9). Not infrequently, however, after crossing the posterolateral margin of the cerebellum, they continue to run medially, anteriorly, and superiorly on the superior surface of the cerebellum. They then join other inferior or superior hemispheric veins to form a venous trunk that enters the tentorium (Figs. 75-7, 75-8, 75-10, 75-14, *B*, 75-18, *B*, 75-19, and 75-23). The number of such venous stems and tentorial sinuses varies—rarely are there as many as five or six.

Communications among the superior, anterior, and posterior draining veins are frequently observed although one group of veins may be more prominent than the other.

PATHOLOGIC CHANGES

Since venous channels can be recognized on the surface of all the posterior fossa structures, deformities and displacements of these vessels are extraordinarily useful in reconstructing gross pathologic changes. When combined with changes in the arterial phase, most expanding lesions can be identified and outlined (Aubin et al., 1972; Bradac et al., 1972). Normal venous channels of greatest importance are illustrated in Fig. 75-24.

Any mass lesion of sufficient size in the posterior fossa ultimately results in a *tight* posterior fossa. The size of the cisterns is diminished and nonspecific herniation of the brainstem and cerebellum upward through the tentorial notch and downward through the foramen magnum occurs. Pathologic changes in the veins of the posterior fossa may be divided into those related to (1) direct displacements and deformities, (2) indirect displacements and deformities, including herniations, (3) anomalies, and (4) abnormal patterns of circulation.

Direct displacements and deformities

For the purpose of localization, space-occupying lesions in the posterior fossa may be divided into (a) those located in and adjacent to the midline, and (b) those located laterally. Midline masses may be subdivided into those situated (a) anterior to the brainstem, (b) within the brainstem, (c) within the fourth ventricle, (d) within the vermis, (e) behind the vermis, and (f) in the region of the pineal gland. Laterally located masses may be subdivided into those located (a) within the parenchyma (intrinsic), and (b) outside the brain parenchyma (extrinsic).

Midline space-occupying lesions

Prepontine space-occupying lesions (Figs. 75-25 and 75-26). Masses anterior to the brainstem displace all the veins of the posterior fossa backward. Maximal displacement occurs in veins located on the anterior aspect of the brainstem, specifically the anterior pontomesencephalic and transverse pontine veins. The brachial tributaries of the petrosal vein are often symmetrically laterally displaced. The precentral cerebellar vein is displaced backward with flattening of the colliculocentral angle. The colliculocentral point may be slightly elevated but is displaced predominantly posteriorly. When the tumor projects upward through the tentorial notch, the basal veins of Rosenthal or posterior mesencephalic veins may be elevated (Wolf and Huang, 1966). Downward extension may cause posterior displacement of the anterior medullary and anterior spinal veins.

Brainstem space-occupying lesions (Huang and Wolf, 1969b, 1970a, 1970b; Braun and Wackenheim, 1972) (Figs. 75-27 to 75-30). With enlargement of the brainstem, veins on the anterior aspect are displaced forward and veins behind the brainstem are displaced backward. Veins located on or adjacent to the lateral aspect are displaced outward. The anterior pontomesencephalic, anterior medullary, and transverse pontine veins are therefore anteriorly displaced. Retromedullary veins, including the vein of the restiform body, the median posterior spinal vein, and the medial tonsillar vein, are displaced backward. Unfortunately the veins in the floor of the fourth ventricle are not sufficiently large to be

Fig. 75-26. Example of a prepontine mass lesion: chordoma of the clivus. Venous phase, lateral view. The anterior pontomesencephalic and other pontine veins are markedly displaced backward, and therefore the distance from the clivus (retouched) to these veins is increased. To a lesser degree the anastomotic lateral mesencephalic, precentral cerebellar, declival, and retrotonsillar veins are displaced backward. Although more difficult to identify, the anterior portions of the veins of the lateral recesses of the fourth ventricle are also crowded posteriorly. Note the deformed interpeduncular fossa outlined by the median anterior pontomesencephalic vein (arrowheads).

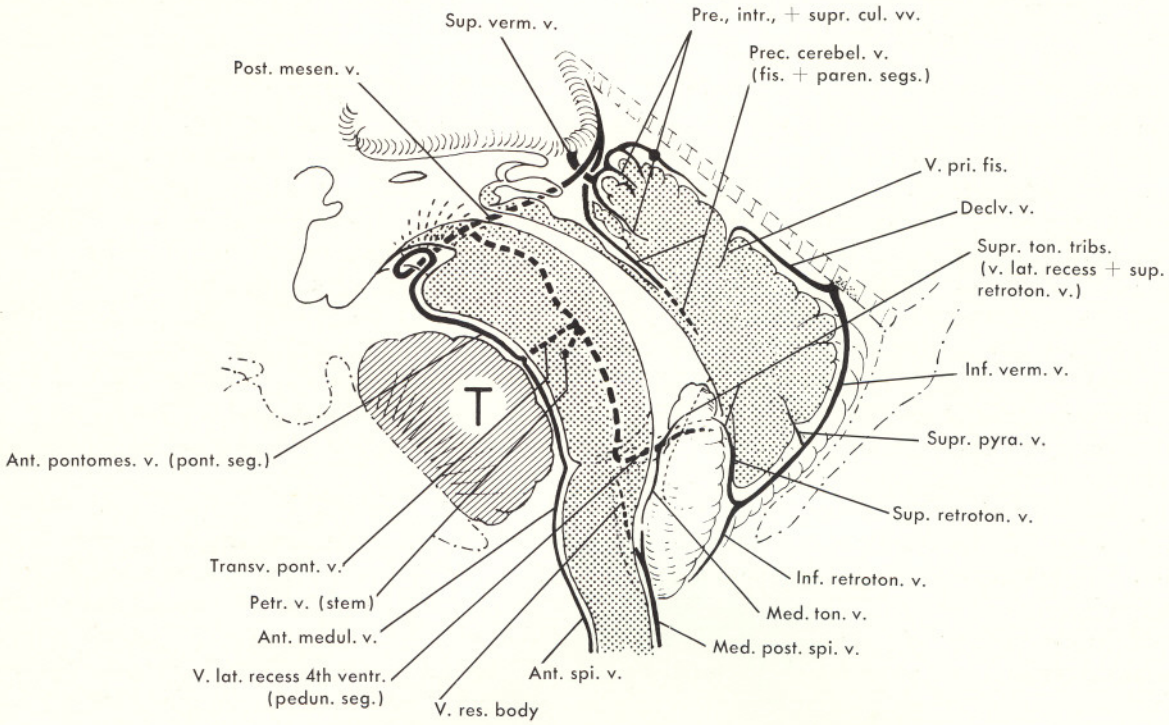

Fig. 75-25. Diagram showing displacements and deformities of the veins of the posterior fossa in prepontine space-occupying lesions. Part of the inferior vermis is removed. (For description see text.)

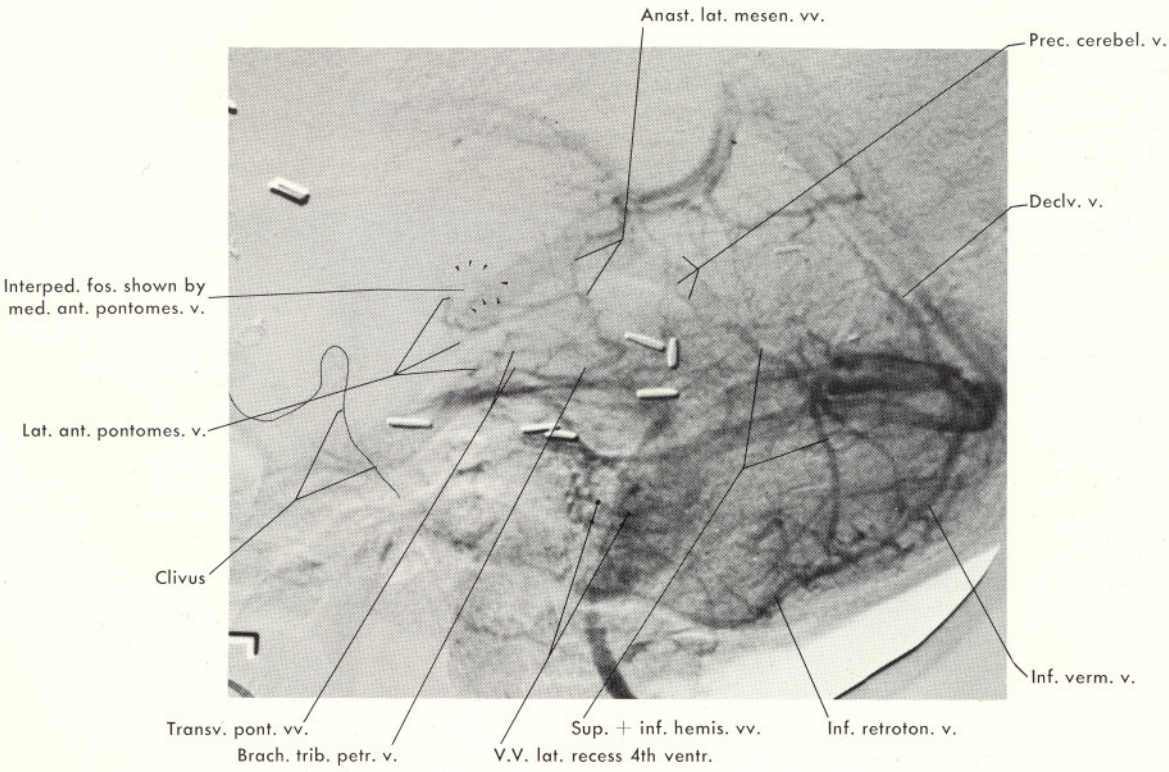

Fig. 75-26. For legend see opposite page.

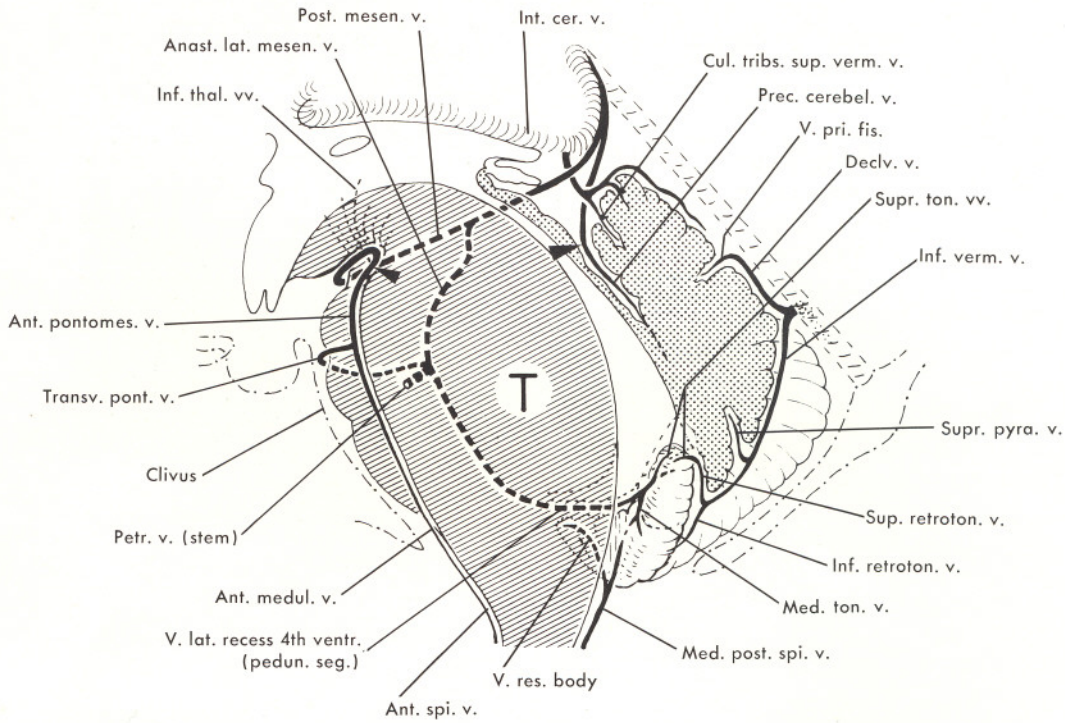

Fig. 75-27. Diagram showing displacements and deformities of the veins of the posterior fossa in extensive brainstem tumors (astrocytoma). (For description see text.)

Fig. 75-28. Example of a brainstem mass lesion: pontine glioma. Venous phase. **A,** Lateral view. The anterior pontomesencephalic vein is displaced forward, whereas the precentral cerebellar vein is markedly displaced backward with resultant increase in the anteroposterior diameter of the upper brainstem. The faintly visualized declival vein is also posteriorly displaced. There is evidence of a small hypertrophic nodule projecting forward from the anterior surface of the enlarged pons. The brachial tributary of the petrosal vein is anteriorly displaced. The vein of the lateral recess of the fourth ventricle (row of black arrowheads) appears markedly stretched and displaced downward in arcuate fashion. **B,** Towne view. The posterior mesencephalic veins are stretched and displaced outward, more so on the right. This indicates a greater involvement of the mesencephalon on the right. The location of the interpeduncular fossa is demonstrated by the posterior communicating vein. The brachial tributary of the petrosal vein, visualized on the left, is markedly elevated and laterally displaced, indicating infiltration of the tumor into the brachium pontis.

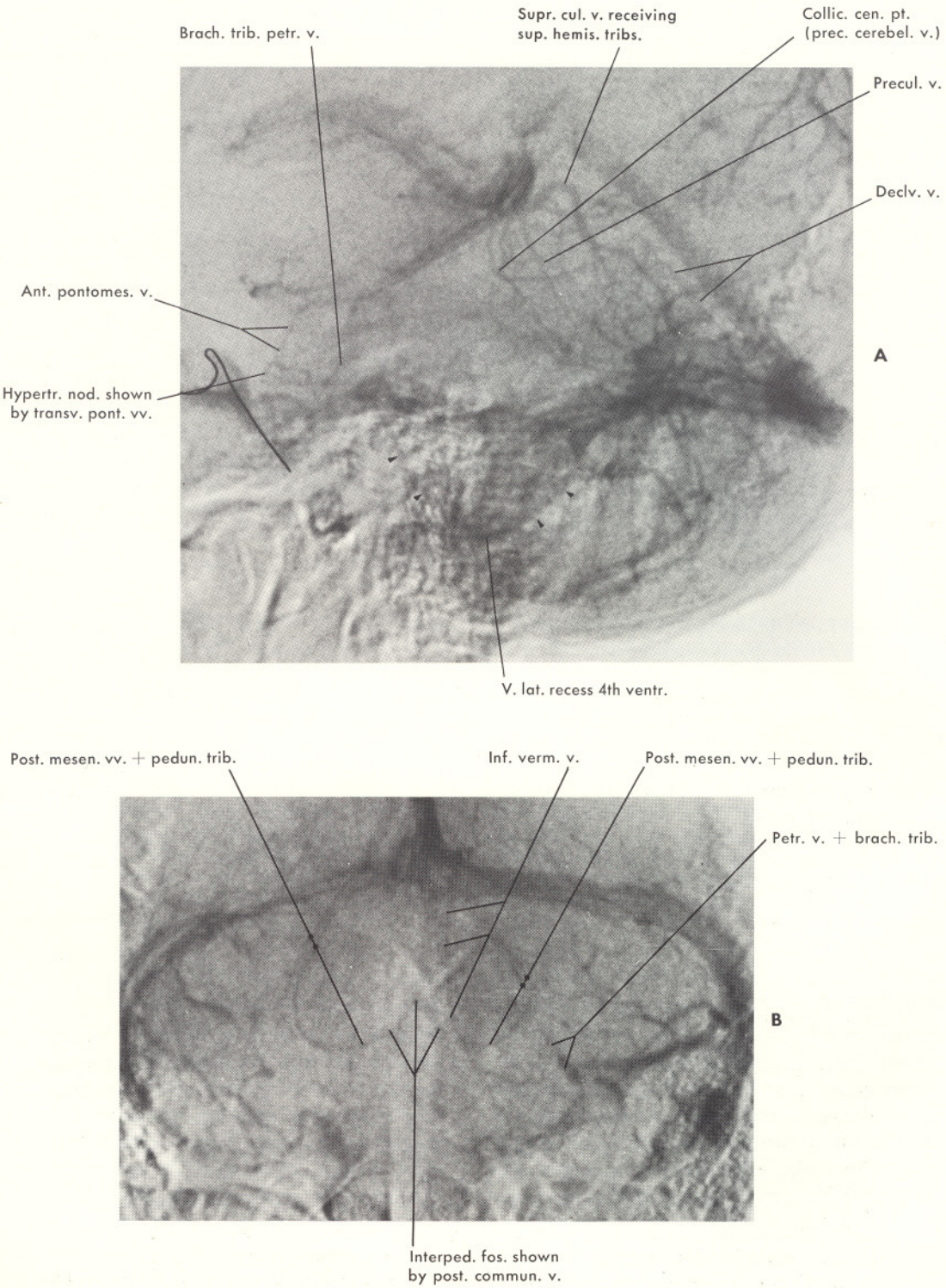

Fig. 75-28. For legend see opposite page.

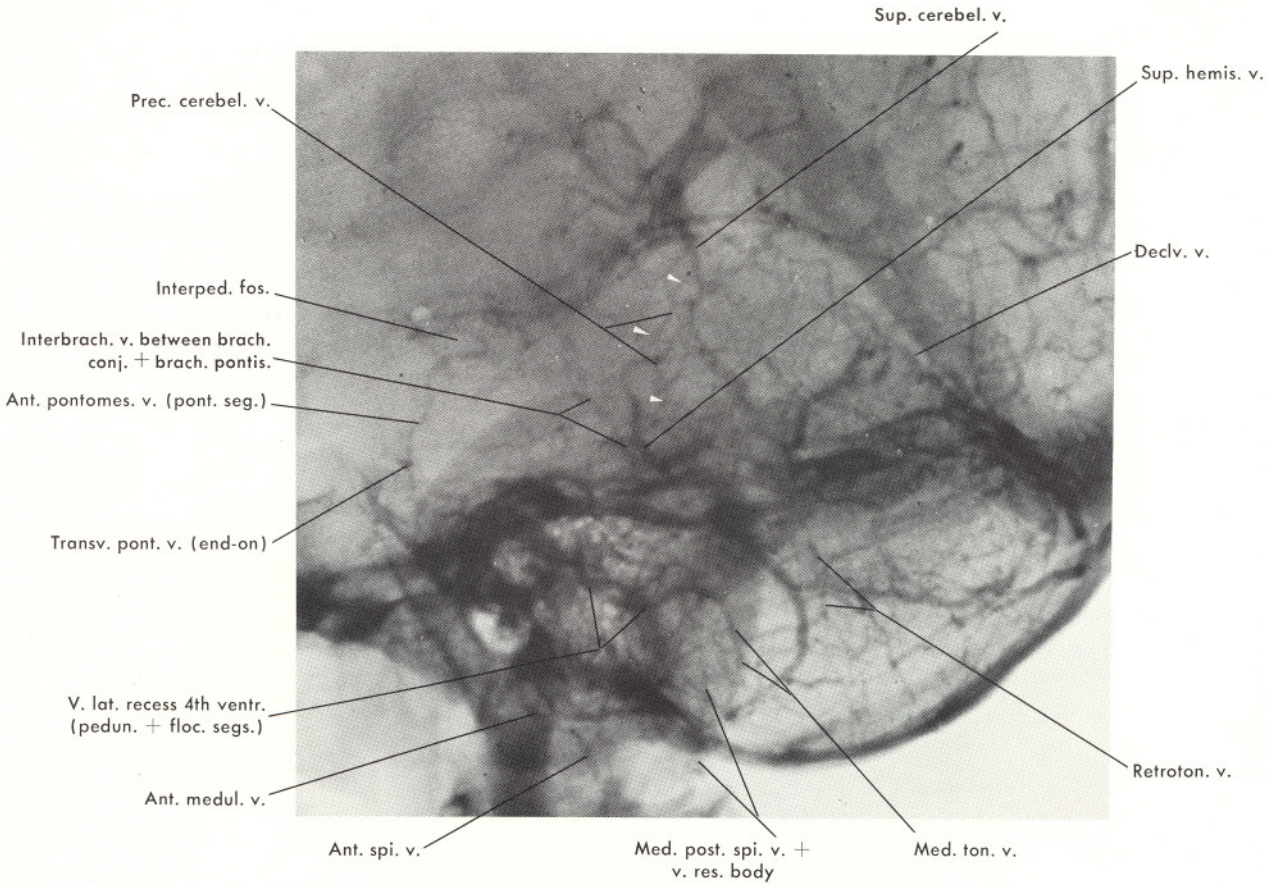

Fig. 75-29. Brainstem tumor with greatest involvement inferiorly. Venous phase, lateral view. The anterior pontomesencephalic vein is displaced forward and upward. The precentral cerebellar vein (white arrowheads) is slightly posteriorly displaced. The anterior medullary vein bulges somewhat forward, whereas the median posterior spinal vein and the medial tonsillar tributary of the vein of the lateral recess of the fourth ventricle are displaced backward. The peduncular segment of the vein of the lateral recess of the fourth ventricle is stretched and depressed, and the angle formed by the peduncular and floccular segments is blunted. Faintly visualized retrotonsillar tributaries of the inferior vermian vein are also displaced backward. The above findings indicate the presence of a brainstem tumor with greatest involvement inferiorly and with extension into the cerebellar hemisphere through the brachium pontis and restiform body. (From Huang, Y. P., and Wolf, B. S.: Am. J. Roentgenol. Radium Ther. Nucl. Med. **110**:1-30, 1970.)

visualized angiographically (Hassler, 1967). Other vessels must serve therefore to determine the location of the floor of the fourth ventricle. With posterior displacement of the floor of the fourth ventricle, the vein of the lateral recess and its supratonsillar tributaries are displaced backward. As a result the peduncular segment of the vein of the lateral recess of the fourth ventricle is elongated posteriorly. The retrotonsillar veins are also displaced posteriorly but to a lesser degree than the supratonsillar and retromedullary veins. Since the anteroposterior diameter of the body of the cerebellar tonsil is decreased, the distance between the retrotonsillar veins and the retromedullary veins anterior to the tonsil is diminished. The precentral cerebellar vein, although more intimately related to the roof of the fourth ventricle, nevertheless reflects enlargement of the brainstem posteriorly. It is displaced backward, with flattening of the colliculocentral angle. The culminate tributaries of the superior vermian vein are also displaced posteriorly but to a lesser degree. Elongation of the brainstem in a vertical direction is indicated by (a) downward displacement of the peduncular segment and supratonsillar tributaries of the vein of the lateral recess and (b) upward displacement of the posterior mesencephalic vein, lateral mesencephalic vein, and mesencephalic segment of the anterior pontomesencephalic vein. Wher

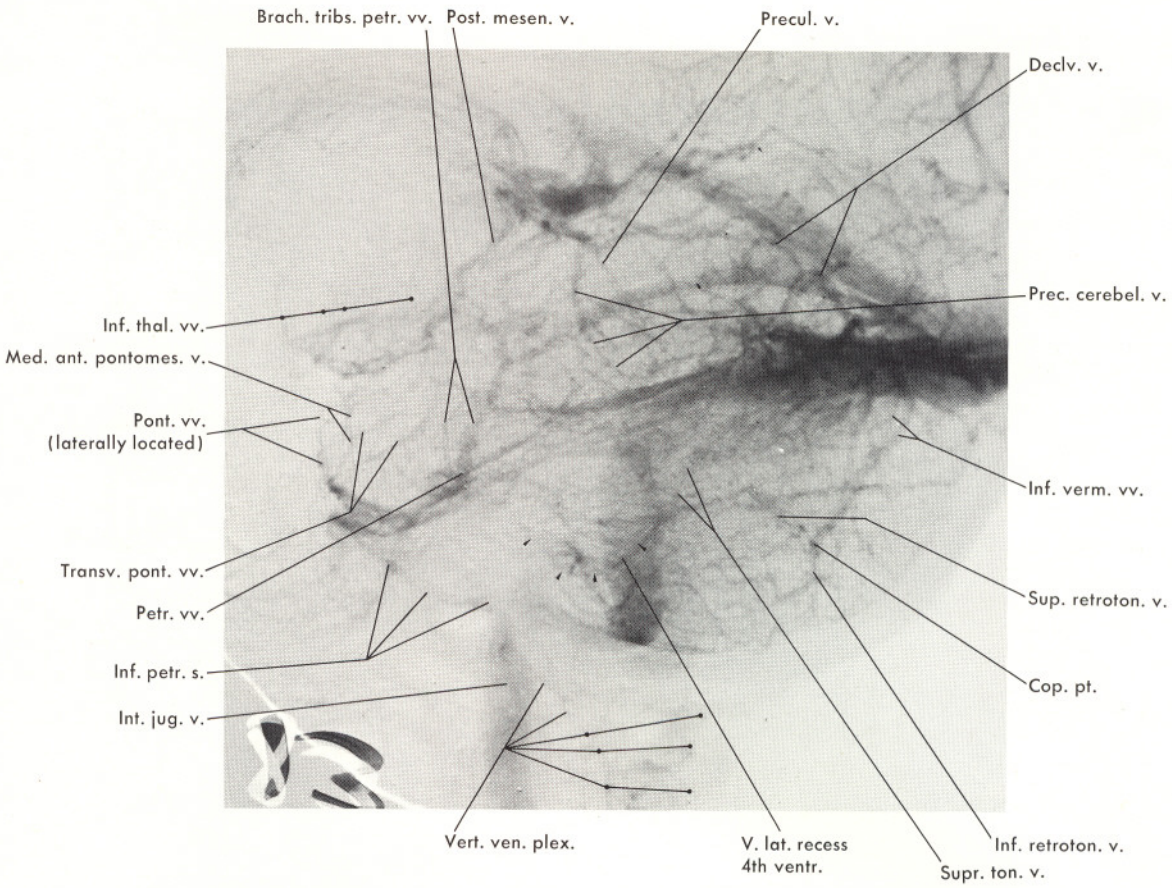

Fig. 75-30. Brainstem glioma with angiographic evidence of grooving of the anterior aspect of the enlarged pons by the basilar artery. Venous phase, lateral view. The median anterior pontomesencephalic vein maintains some distance from the clivus, whereas the more laterally located pontine veins are stretched and much closer to the clivus. These findings indicate nodular hypertrophy of the tumor, projecting forward on both sides of the midline from the anterior aspect of the enlarged pons. The precentral cerebellar vein is markedly displaced backward with resultant increase in the anteroposterior diameter of the brainstem. Retrotonsillar tributaries of the inferior vermian veins are displaced backward. Considerable stretching and arcuate downward displacement of the vein of the lateral recess of the fourth ventricle (arrowheads) indicate infiltration of the tumor into the cerebellar hemisphere through the brachium pontis and restiform body. Also visualized is the inferior petrosal sinus, draining into the internal jugular vein at the level of the jugular foramen. Note the prominent inferior thalamic veins, indicating upward extension of the brainstem tumor into thalamic and hypothalamic areas.

the mass extends further upward into the cerebral peduncle and subthalamic area, the peduncular, central mesencephalic, and inferior thalamic veins may be displaced upward and forward. Widening of the brainstem in a transverse direction is indicated by lateral displacement and separation of the posterior and lateral mesencephalic veins, the brachial tributaries of the petrosal and precentral cerebellar veins, the veins of the lateral recess, and the retro-olivary veins. The exact changes in these vessels depend on the portion of the brainstem maximally involved. When the tumor extends into the cerebellar hemisphere through the brachium pontis and restiform body, a paradoxical displacement of the vein of the lateral recess inferiorly and medially in arcuate fashion may be apparent. In addition, under such circumstances the angle formed between the peduncular and floccular segments of the vein of the lateral recess may be rounded or effaced in the lateral view. Elevation of the brachial tributaries of the petrosal vein may be more marked on one side than on the other. Astrocytomas of the brainstem often show nodular protrusions forward into the pontine cistern on both sides of the basilar artery (Russell and Rubinstein, 1959). As a result the basilar artery and the anterior

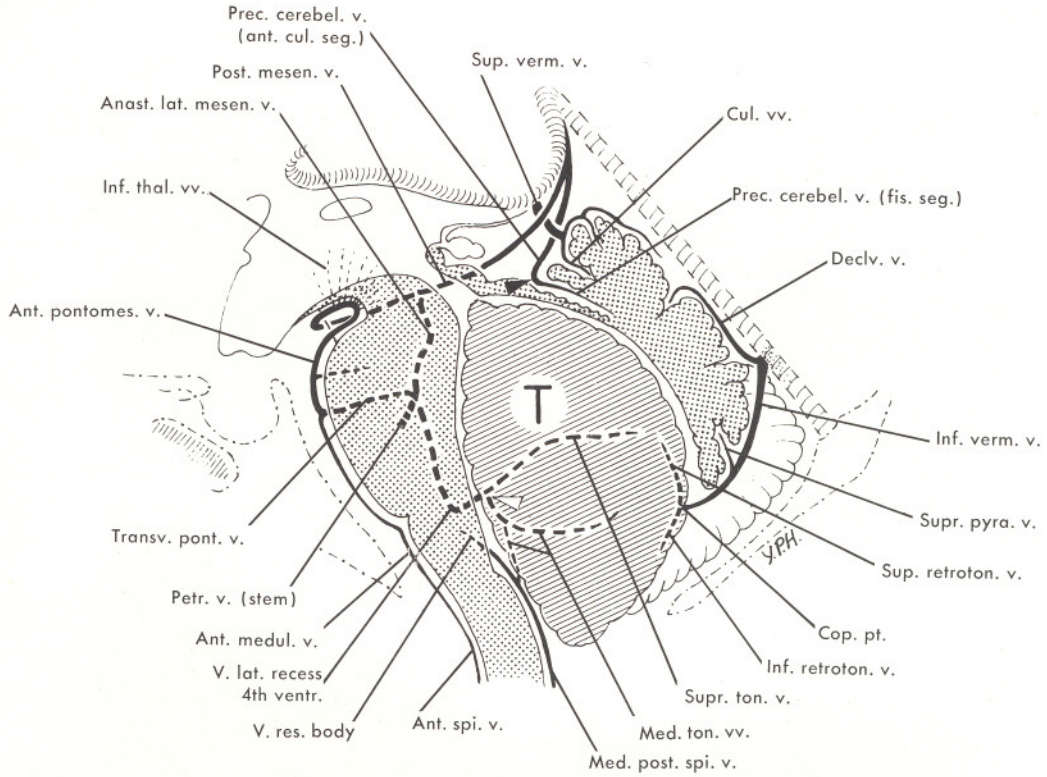

Fig. 75-31. Diagram showing displacements and deformities of veins of the posterior fossa in fourth ventricle tumors. (For description see text.) The colliculocentral point (black arrowhead) and junction (white arrowhead) between the supratonsillar and medial tonsillar tributaries of the vein of the lateral recess are illustrated.

pontomesencephalic vein may occupy a deepened median sulcus on the anterior aspect of the belly of the pons. When the nodular mass, as it continues to grow forward, impinges on the clivus, these midline vessels may be displaced backward (paradoxical displacement). The discrepancy in location between the smaller paramedian vessels, both arteries and veins, lying on the anterior surface of these nodules and the midline vessels is characteristic of this type of tumor.

Fourth ventricle space-occupying lesions (Huang and Wolf, 1967, 1969b, 1970a, 1970b) (Figs. 75-31 to 75-33). A typical tumor of the fourth ventricle balloons the ventricle and protrudes downward into the vallecula and cisterna magna. The floor of the fourth ventricle and, to a lesser degree, the anterior aspect of the brainstem are displaced and arched forward. The veins on the anterior aspect of the pons and medulla oblongata show similar displacements. Retromedullary veins, in contrast to brainstem tumors, are displaced forward. As a result of forward displacement of the floor of the fourth ventricle, the origin of the peduncular segment of the vein of the lateral recess is displaced forward and the total length of this segment, as seen in the lateral view, is shortened. The anterior ends of the medial tonsillar and supratonsillar tributaries at the tonsillar incisura are also displaced forward. Since the cerebellar tonsils are elongated in an anteroposterior direction, the posterior portions of these tributaries are displaced posteriorly. A markedly elongated and stretched appearance of the supratonsillar and medial tonsillar tributaries is therefore evident in the lateral view. In the semiaxial view the veins of the lateral recess and the supratonsillar veins are laterally displaced and separated. The retrotonsillar veins are displaced posteriorly and laterally to a much greater degree than in brainstem tumors. As a result of ballooning, the roof of the upper portion of the fourth ventricle is frequently markedly arched and displaced backward. Corresponding to this displacement, the fissural and parenchymal segments of the precentral cerebellar vein swing markedly upward and somewhat backward. The colliculocentral angle therefore becomes more acute. The colliculocentral point shows predominantly *superior* displacement. The culminate veins are also displaced upward and somewhat backward but to a lesser degree than the precentral cerebellar vein. In fourth ventricle tumors little evidence of elongation of the brainstem is noted, although minimal transverse widening may be seen. The interpedun-

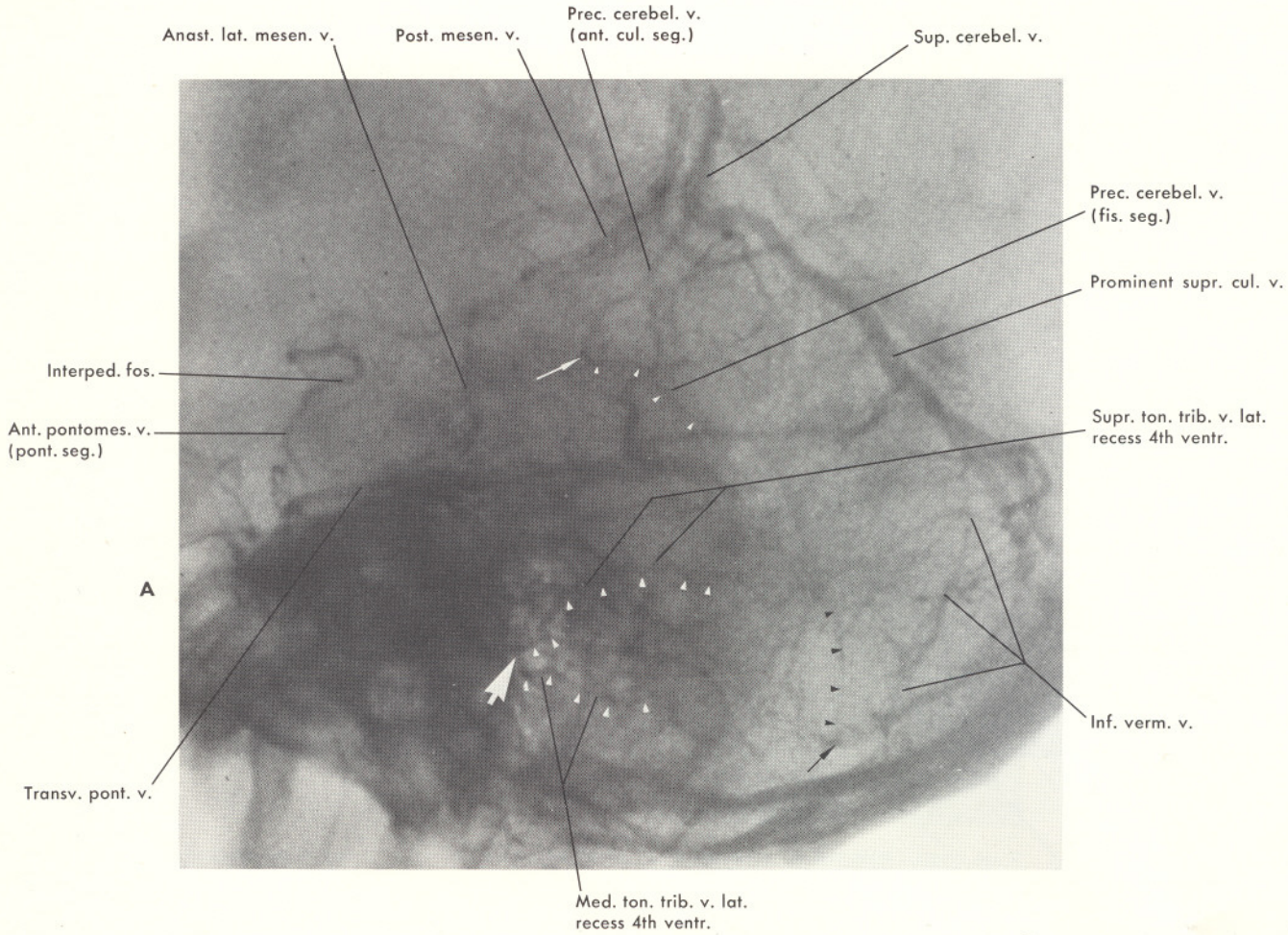

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Fig. 75-32. Examples of fourth ventricle tumors. Lateral view, venous phase (two cases). **A,** Cholesteatoma of the fourth ventricle. The fissural segment (top row of white arrowheads) of the precentral cerebellar vein is displaced and arched upward and backward with maximum displacement of its lower end. The colliculocentral point (thin white arrow) is markedly elevated but only minimally posteriorly displaced. Inferiorly, the superior retrotonsillar tributary (row of black arrowheads) of the inferior vermian vein is displaced markedly backward and its upper end is tilted posteriorly. The copular point (black arrow) is displaced backward with resultant decrease in the copular angle. The supratonsillar and medial tonsillar tributaries (bottom two rows of white arrowheads) of the vein of the lateral recess are markedly stretched and elongated. Their junction or the origin of the vein of the lateral recess (large white arrow) is markedly anteriorly displaced. This indicates that the floor of the fourth ventricle is displaced forward. The interpeduncular fossa is narrowed from below but has a normal depth. The pontine segment of the anterior pontomesencephalic vein is, however, displaced forward. **B,** Sarcoma of the fourth ventricle extending into the vallecula. The anterior pontomesencephalic, anterior medullary, and anterior spinal veins are markedly displaced anteriorly. The first segment of the precentral cerebellar vein is stretched and displaced upward and backward with resultant decrease in the colliculocentral angle. The colliculocentral point is elevated and only minimally posteriorly displaced. Retrotonsillar tributaries of the inferior vermian veins are displaced backward and downward. The junction (arrowhead) of the first (or peduncular) segment of the vein of the lateral recess of the fourth ventricle with its medial tonsillar tributary is displaced anteriorly. The posterior aspect of the upper cervical cord and medulla oblongata, outlined by the median posterior spinal vein, is also displaced anteriorly. These findings indicate that the flattened brainstem is arched anteroinferiorly. (**A** from Huang, Y. P., and Wolf, B. S.: Am. J. Roentgenol. Radium Ther. Nucl. Med. **101**:543-564, 1969.)

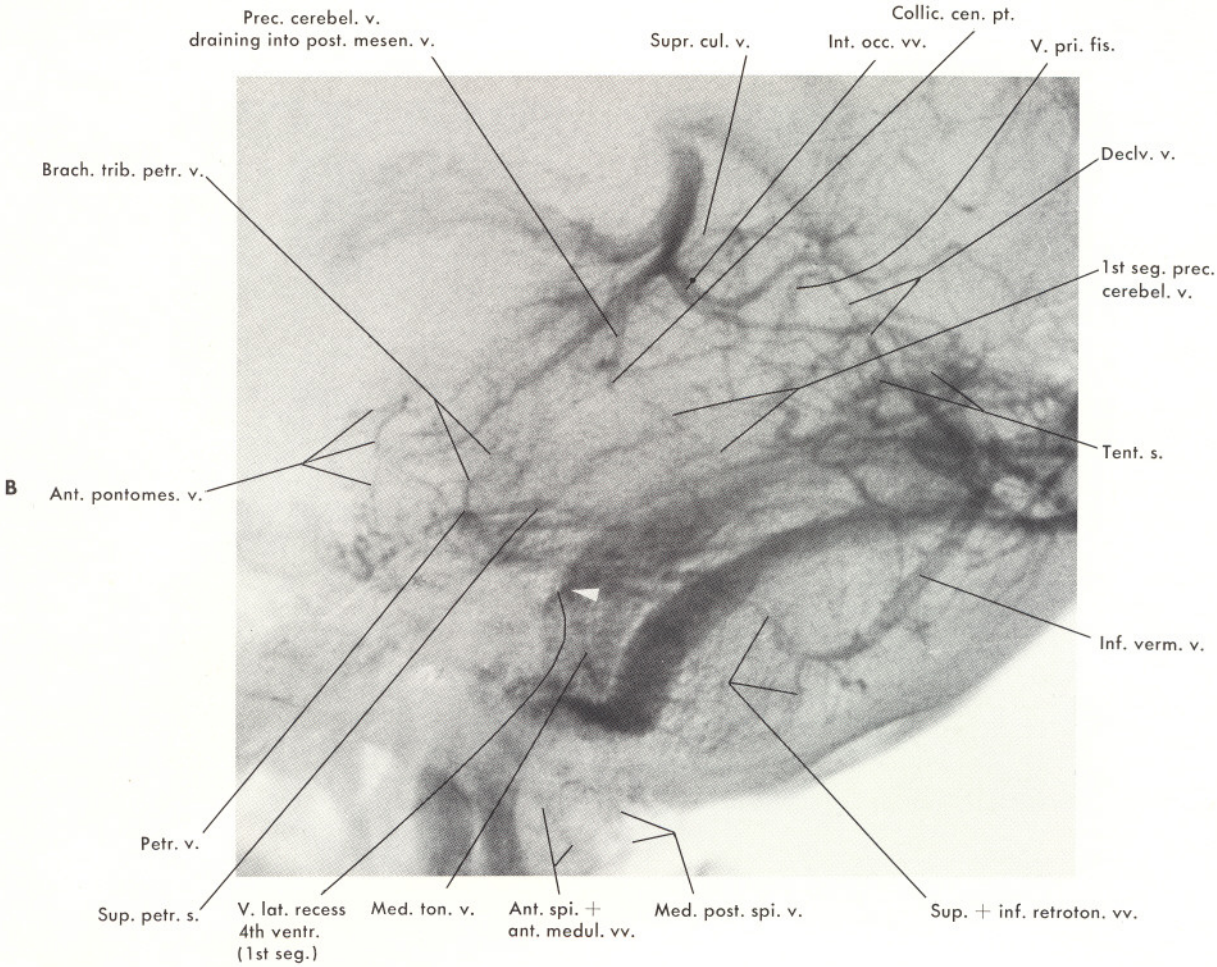

Fig. 75-32, cont'd. For legend see p. 2197.

Fig. 75-33. Examples of fourth ventricle tumors in the semiaxial projection. Venous phase (two cases). **A,** Ependymoma of the fourth ventricle. The superior retrotonsillar tributary of the right inferior vermian vein is displaced and rotated laterally with resultant increase in the copular angle (*). The vein of the lateral recess of the fourth ventricle can be seen on the right and is markedly laterally displaced. The two components of the split precentral cerebellar vein (arrowheads) are separated and laterally displaced. The anastomotic lateral mesencephalic vein, visualized on the left, is laterally displaced (more so in its lower portion). **B,** Subependymoma of the fourth ventricle. The precentral cerebellar vein is split (arrowheads). The lower portions (lower arrowheads) and connecting vein (arrow) related to the brachia conjunctiva are separated from each other. The vein of the lateral recess of the fourth ventricle, visualized on the left, is markedly laterally displaced (especially in its posterior portion). The transverse pontine vein, receiving the lateral anterior pontomesencephalic vein, is displaced anteriorly, indicating narrowing of the pontine cistern. (**A** from Huang, Y. P., and Wolf, B. S.: Am. J. Roentgenol. Radium Ther. Nucl. Med. **107**:543-564, 1969.)

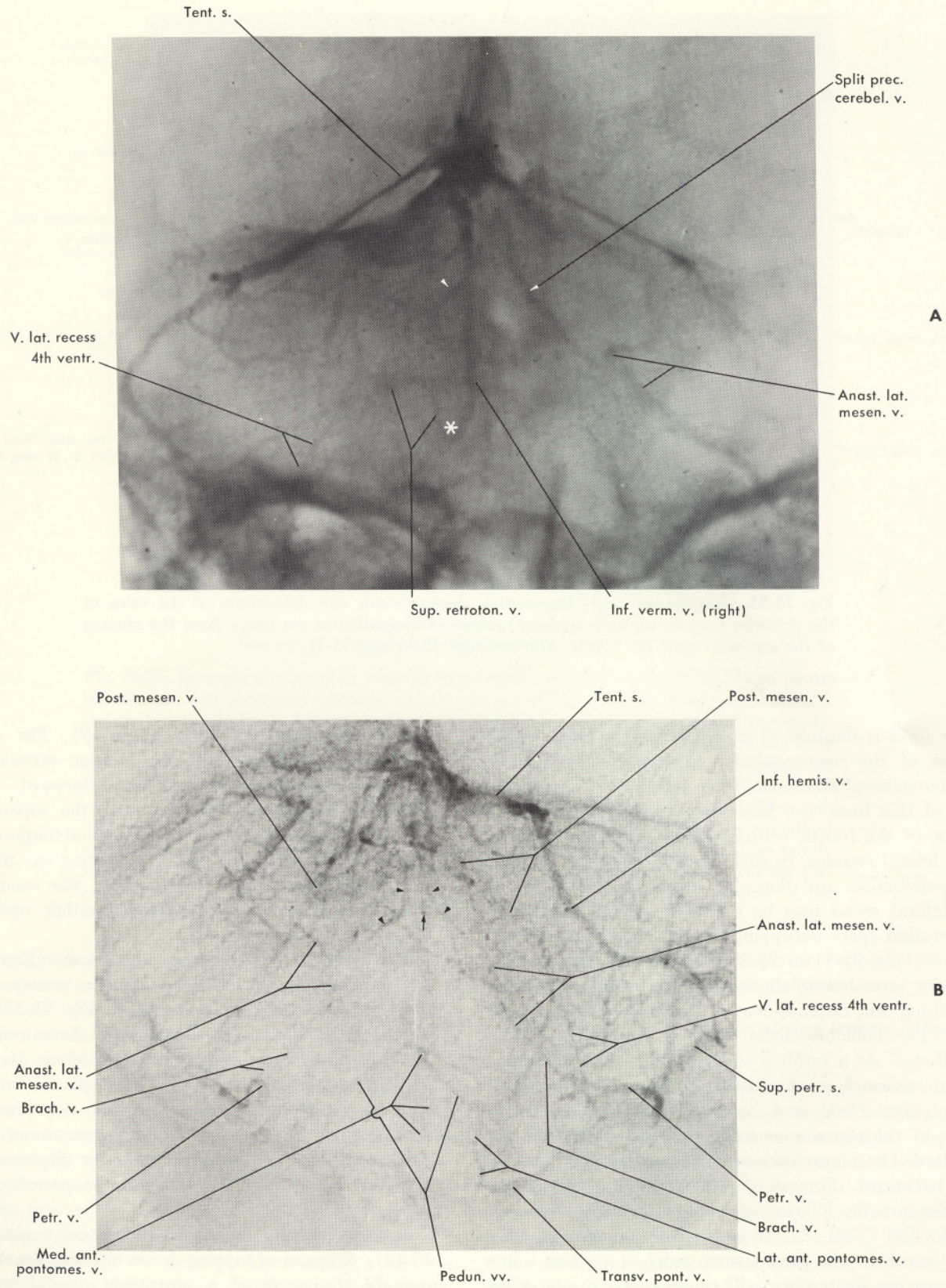

Fig. 75-33. For legend see opposite page.

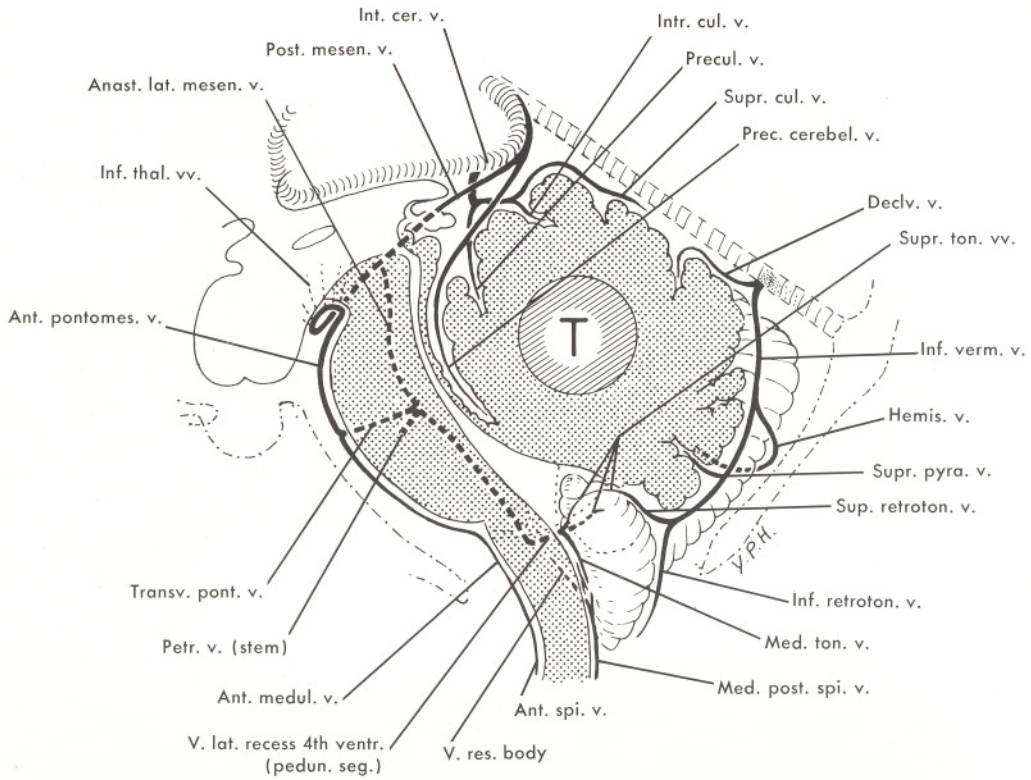

Fig. 75-34. Diagram showing characteristic displacements and deformities of the veins of the posterior fossa in superior vermian tumors. (For description see text.) Note the kinking of the aqueduct near the aditus. Also see Figs. 75-35 and 75-42.

cular fossa is diminished in height, as indicated by the course of the mesencephalic segment of the anterior pontomesencephalic vein. The depth and horizontal axis of this fossa are, however, usually maintained. A tumor of the fourth ventricle may extend into one or both lateral recesses. In such cases the junction between the peduncular and floccular segments of the vein of the lateral recess may be markedly laterally displaced.

Vermian space-occupying lesions (Huang and Wolf, 1965) (Figs. 75-34 to 75-36). Tumors that involve the superior vermis cause characteristic forward and upward stretching and displacement of the precentral cerebellar vein. The colliculocentral angle is widened and may be effaced. As a result a single continuous semicircular venous channel convex anterosuperiorly surmounts the mass (Figs. 75-34 and 75-35). The culminate tributaries of the superior vermian veins are separated and elevated. The supraculminate tributary is arched upward and backward. Tumors originating in the inferior vermis displace the inferior vermian veins markedly downward (Fig. 75-36, *A*). Since the inferior vermian veins usually run in the paravermian sulci, a midline tumor that reaches the surface will cause lateral displacement of each vein, with marked separation of the vessels in the Towne projection (Fig. 75-36, *B*). The superior retrotonsillar tributaries of the inferior vermian veins are frequently displaced and tilted forward. Midline cerebellar tumors may involve both the superior and the inferior vermis and produce a combination of the displacements just described. Depending on the location, hemispheric veins (for example, the veins of the primary fissure) may be displaced either upward or downward.

Retrovermian space-occupying lesions (Figs. 75-37 to 75-39). Masses located behind the vermis displace the inferior vermian veins forward (Fig. 75-37). With an extradural mass, e.g., an epidural hematoma (Fig. 75-38), the torcular and adjacent portions of the lateral and occipital sinuses may be displaced anteriorly. A congenitally large cisterna magna may simulate a retrovermian tumor or a subdural hematoma on angiography because of apparent anterior displacement of vermian and hemispheric veins of the posterior draining group (Fig. 75-39).

Space-occupying lesions in the pineal region. (Fig. 75-40). A space occupying lesion in the pineal region may be the result of a pinealoma, pineal teratoma, aneurysm of the vein of Galen, arachnoid cyst, menin-

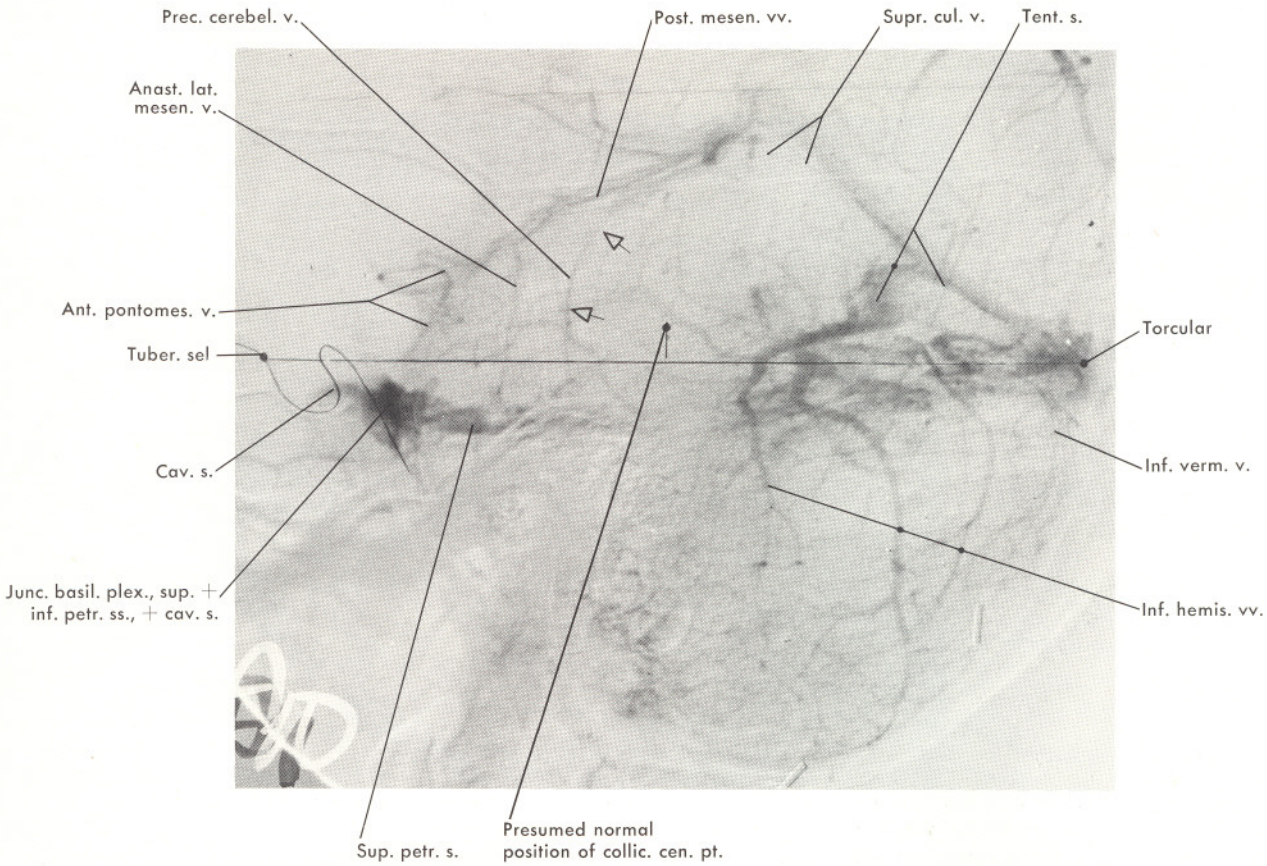

Fig. 75-35. Example of a superior vermian mass lesion: vermian astrocytoma, venous phase, lateral view. The precentral cerebellar vein (open arrows) is markedly stretched, elongated, and uniformly displaced, forming a continuous large arc convex anteriorly and superiorly. The lower part of the arc, particularly the first segment of the vein, is displaced inferiorly as well as anteriorly, assuming a more vertical course. One can presume from this angiogram that the aqueduct is elongated and kinked near the aditus (refer to Fig. 75-42 for comparison). The posterior and lateral mesencephalic veins are crowded upward and forward. The anterior pontomesencephalic vein is displaced directly forward. The faintly visualized supraculminate vein bulges upward and backward. The inferior vermian veins are faintly seen and are stretched and displaced backward. A prominent tentorial sinus, receiving several superior and inferior hemispheric tributaries, is labeled. The normal position of the colliculocentral point is identified in accordance with Fig. 75-4.

gioma originating from the falcotentorial junction, anterior superior extension of a superior vermian tumor, or tumor of the quadrigeminal plate. Backward displacement of the precentral cerebellar vein, often with a reversal of the normal colliculocentral angle, is characteristic of all such lesions (Peeters, 1973). The posterior portions of the basal veins of Rosenthal or the posterior mesencephalic veins are frequently displaced laterally and separated from each other. Depending on the exact origin of the tumor, they may be displaced upward or downward (Fig. 74-27). In almost every case, however, the posterior portions of the internal cerebral veins are elevated. Occasionally a tumor that originates in the superior vermis extends upward and forward and simulates a pinealoma. In such cases, however, tributaries of the superior vermian and precentral cerebellar vein are also elevated.

Laterally located space-occupying lesions (Figs. 75-41 to 75-44)

Masses that are more laterally located produce a shift of the midline structures. Precise venographic landmarks for the midline, however, are not available. The precentral cerebellar vein is the most useful when clearly visualized. However, a lateral precentral cerebellar vein may be confused with a displaced midline precentral cerebellar vein (Huang and Wolf, 1966). The peduncular veins and posterior communicating vein are helpful in identifying midline shifts when distinct asymmetry is evident. The pontine segment of the anterior ponto-

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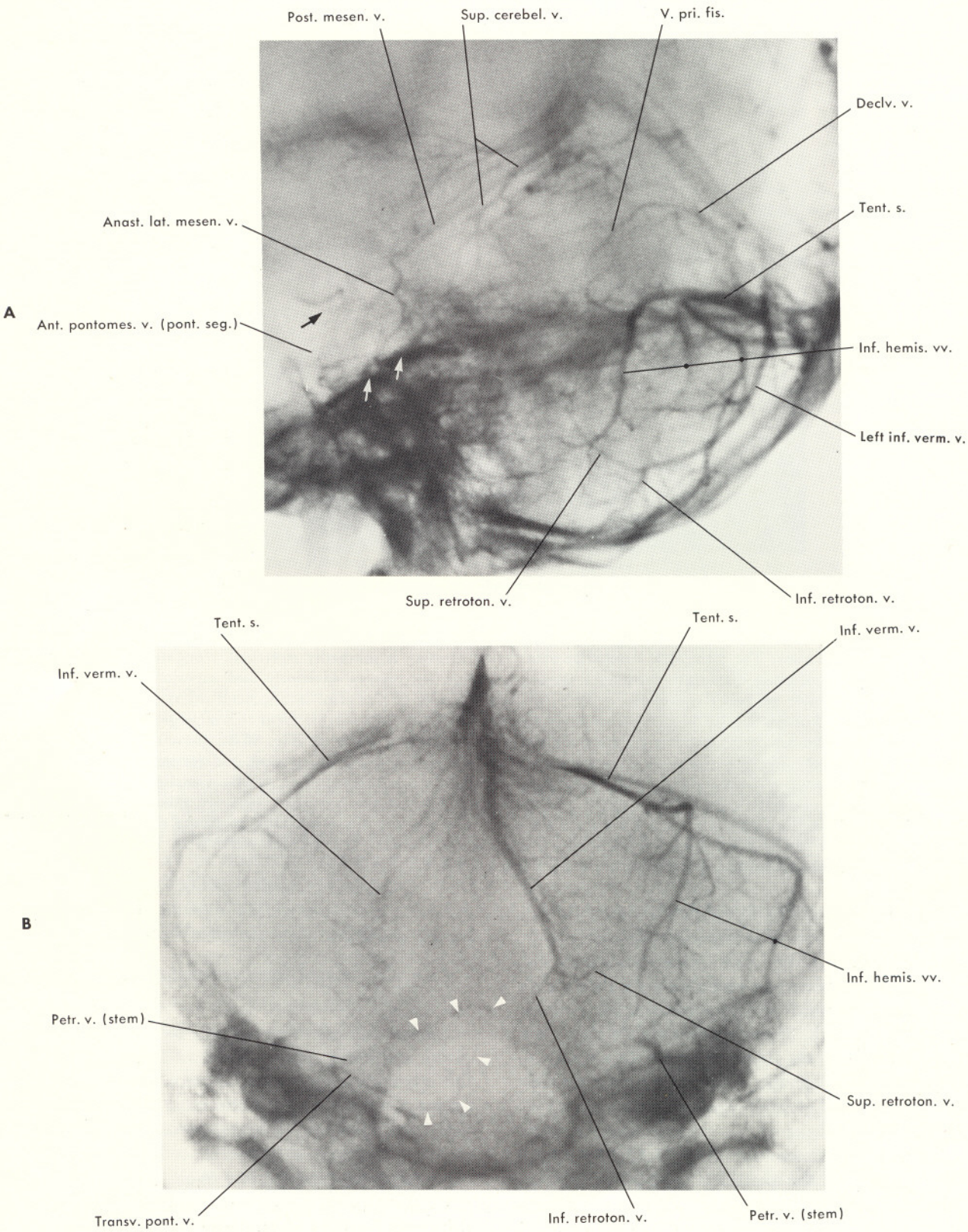

Fig. 75-36. For legend see opposite page.

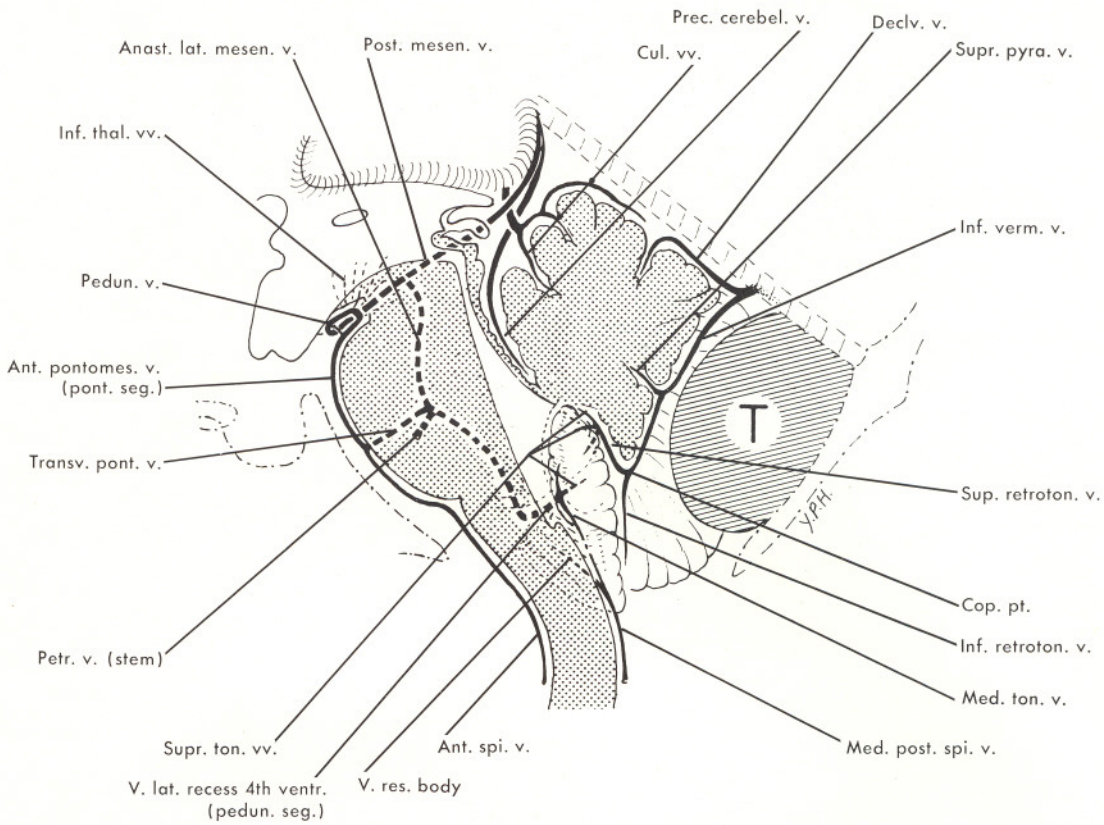

Fig. 75-37. Diagram showing displacements and deformities of veins of the posterior fossa in retrovermian space-occupying lesions. (For description see text.)

Fig. 75-36. Astrocytoma involving posterior portions of the superior and inferior vermis. Venous phase. **A,** Lateral view. The inferior vermian vein is markedly displaced downward and its superior retrotonsillar tributary, in addition, is tilted and displaced forward. The vein and tributary form a single continuous curve convex inferiorly. The vein of the primary fissure and the declival vein are elevated and displaced forward and form a continuous curve convex superiorly. The superior cerebellar vein and its tributaries, including the precentral cerebellar tributary, are displaced forward and upward. The posterior portion of the posterior mesencephalic vein is somewhat elevated, and this vein therefore appears straight. The anterior pontomesencephalic, anastomotic lateral mesencephalic, and petrosal veins (white arrows) are displaced forward. The height of the interpeduncular fossa (black arrow) is decreased. **B,** Towne view. The left inferior vermian vein and its superior retrotonsillar tributary are markedly laterally displaced. The inferior retrotonsillar tributary is displaced laterally in its upper portion. The faintly visualized right inferior vermian vein also shows lateral displacement, indicating enlargement of the inferior vermis. Inferior and superior hemispheric veins draining into the tentorial sinuses can also be identified. The pontine cistern, outlined by the transverse pontine vein, is narrow. The anterior pontomesencephalic vein (white arrowheads) is visible and its lower or transverse pontine segment is unusually close to the clivus.

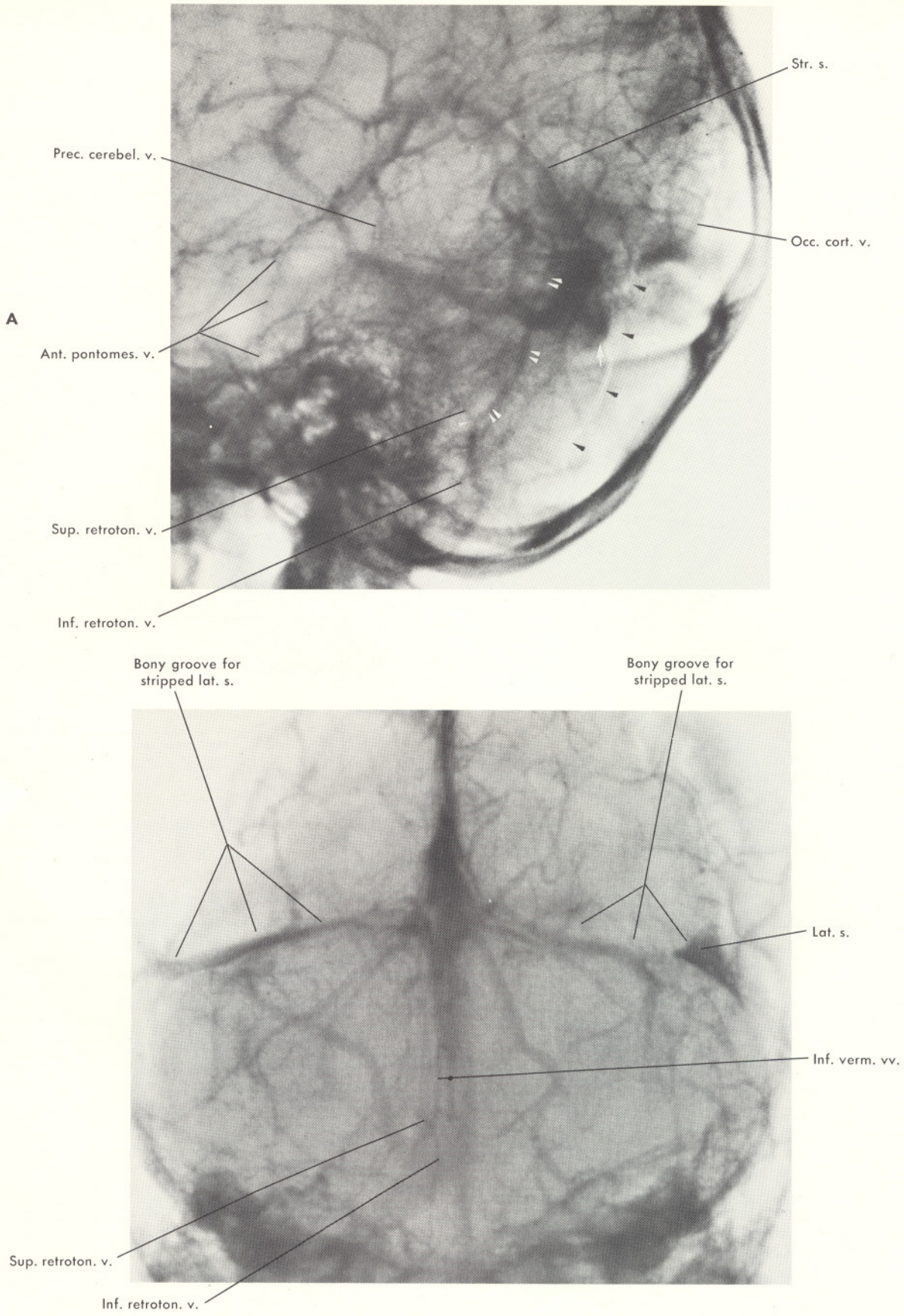

Fig. 75-38. For legend see opposite page.

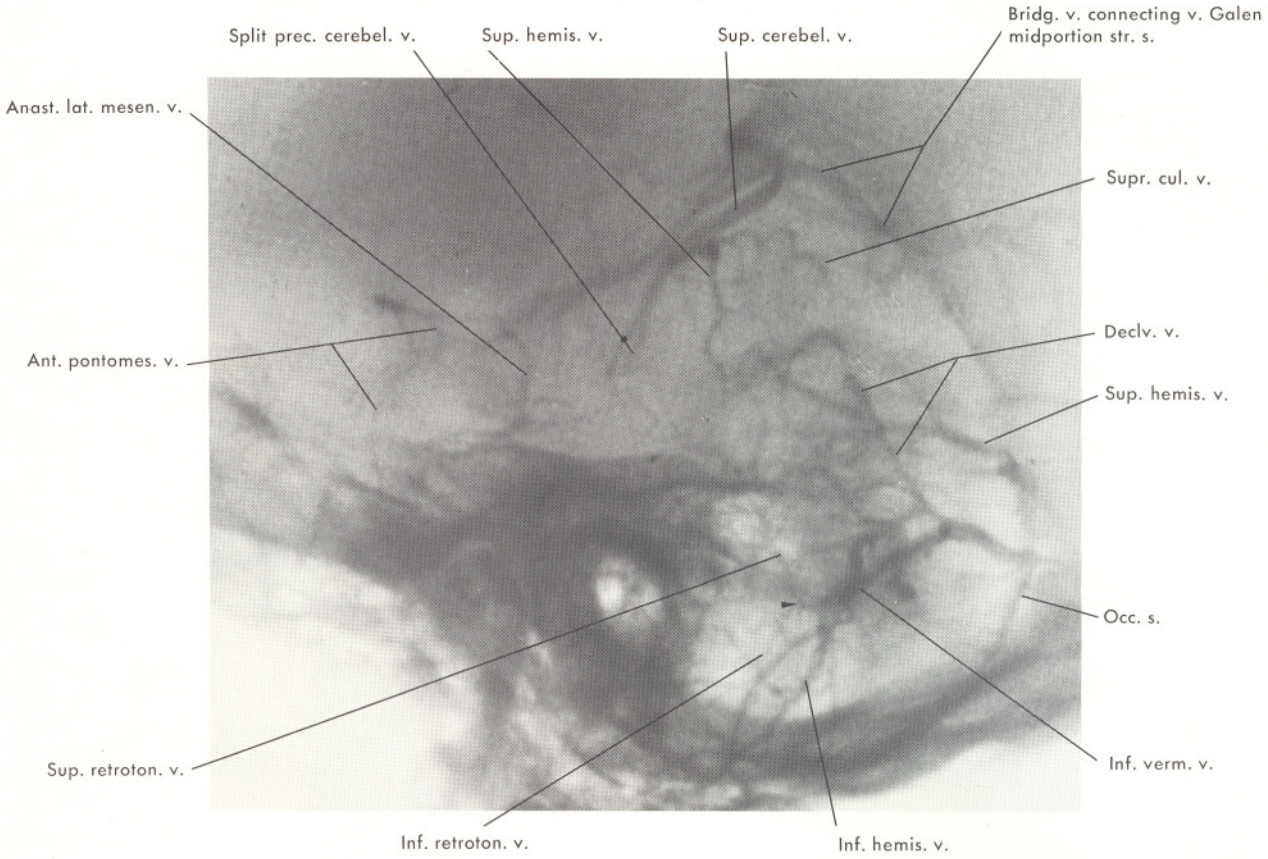

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Fig. 75-39. Huge cisterna magna. **A,** Lateral venogram. The supraculminate vein and superior and inferior hemispheric and declival tributaries of the posterior draining veins are located unusually far forward, indicating considerable separation of the posterior aspect of the cerebellum from the tentorium as well as from the occipital squama. The inferior vermian vein and its superior and inferior retrotonsillar tributaries and copular point (black arrowhead) are also unusually anteriorly located. The occipital sinus is not displaced. These findings suggest a huge subarachnoid cistern or a subdural hematoma. **B,** Pneumoencephalogram, lateral view, erect position (same case). A huge cisterna magna outlining the posterior border of the cerebellum (black arrowheads) is noted. White arrow indicates the belly of the pons, outlined by air.

Fig. 75-38. Example of a retrovermian mass lesion: epidural hematoma extending above and below the torcular and lateral sinuses. Venous phase. **A,** Lateral view. The faintly visualized inferior vermian vein (double white arrowheads), including superior and inferior retrotonsillar tributaries and copular point (single white arrowhead), is markedly displaced anteriorly and therefore appears straight. The inferior portion of the straight sinus, the torcular, and the adjacent portions of the lateral sinuses (white arrow) are stripped and separated from the inner table of the skull, indicating the presence of a supra- and an infratentorial epidural mass. Occipital cortical veins are also visualized and are separated from the inner table of the skull. A fracture line (black arrowheads) crossing the lateral sinus is noted. Faintly visualized anterior pontomesencephalic and precentral cerebellar veins are displaced upward and forward. **B,** Semiaxial view. The inferior vermian veins are symmetric and are unusually close to each other. The portions of the lateral sinuses stripped and separated from their bony grooves are seen on both sides, more clearly on the left. The preoperative diagnosis of epidural hematoma was confirmed at surgery.

B

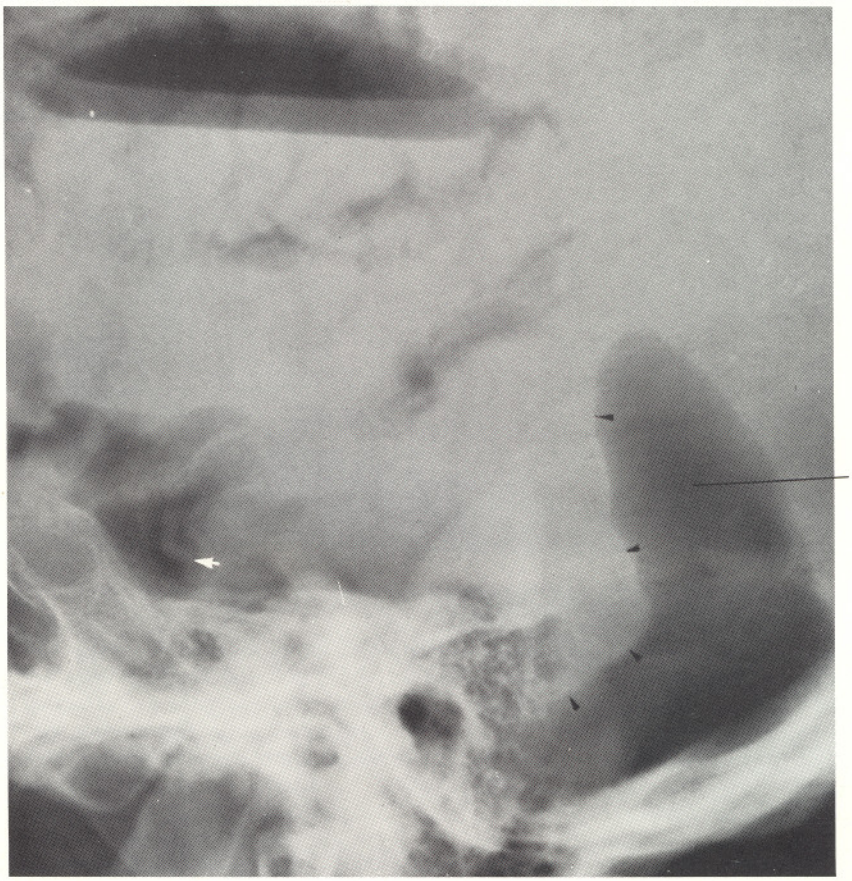
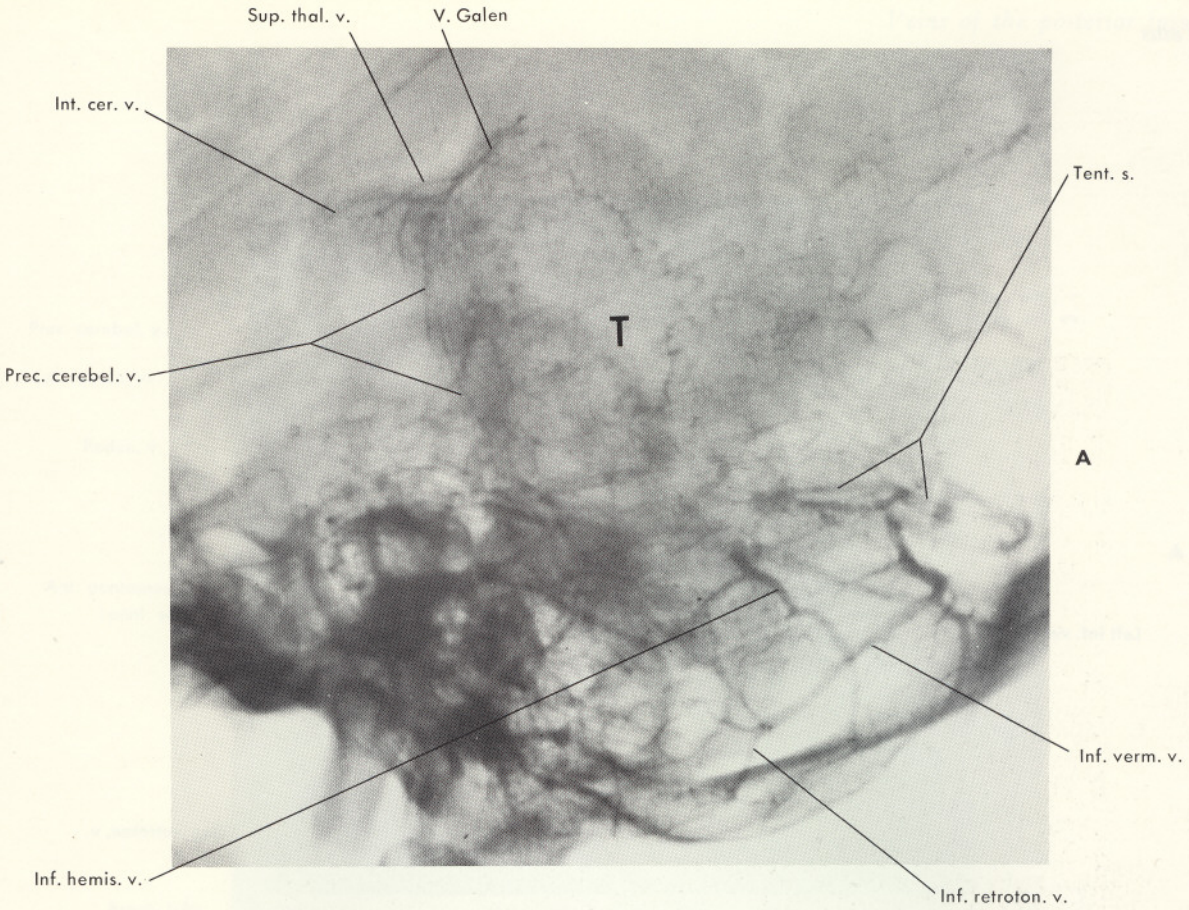
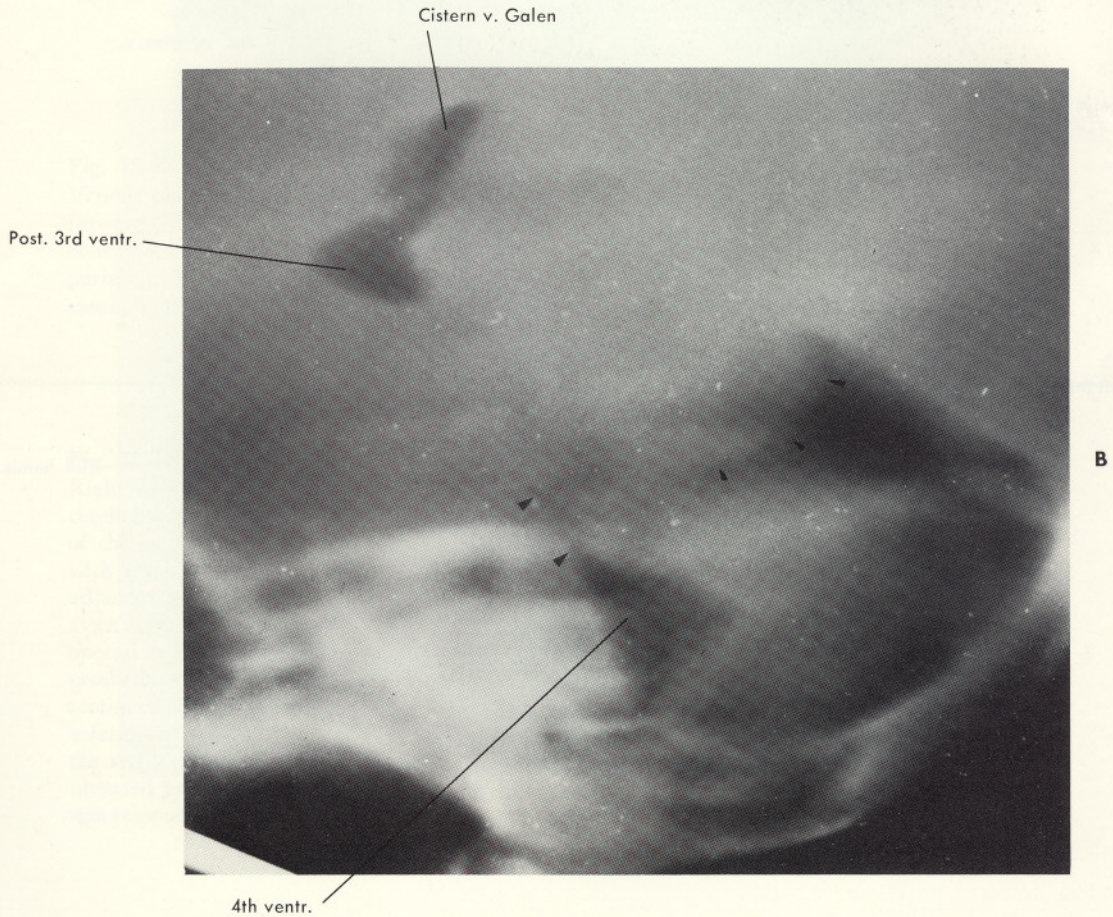


Fig. 75-39, cont'd. For legend see p. 2205.

Fig. 75-40. Meningioma of the falcotentorial junction. **A,** Lateral venogram. The split precentral cerebellar vein is markedly stretched, elongated, and anteriorly displaced in arcuate fashion. The posterior portion of the vein of Galen is elevated and anteriorly displaced. Abnormal vasculature characteristic of a meningioma blush outlining the tumor (*T*) is also evident. The inferior vermian vein and its superior and inferior retrotonsillar tributaries are depressed. This vein drains into a tentorial sinus. **B,** Pneumoencephalogram, erect lateral view. The cistern of the vein of Galen and the posterior third ventricle are markedly elevated and anteriorly displaced. The fourth ventricle is depressed. The partially visualized elongated aqueduct (two arrowheads) is displaced forward and downward. Subdural air under the tentorium outlines the posterior border (three arrowheads) of the meningioma. (**A** from Huang, Y. P., and Wolf, B. S.: Acta Radiol. [Diagn.] **5:**250-262, 1966.)





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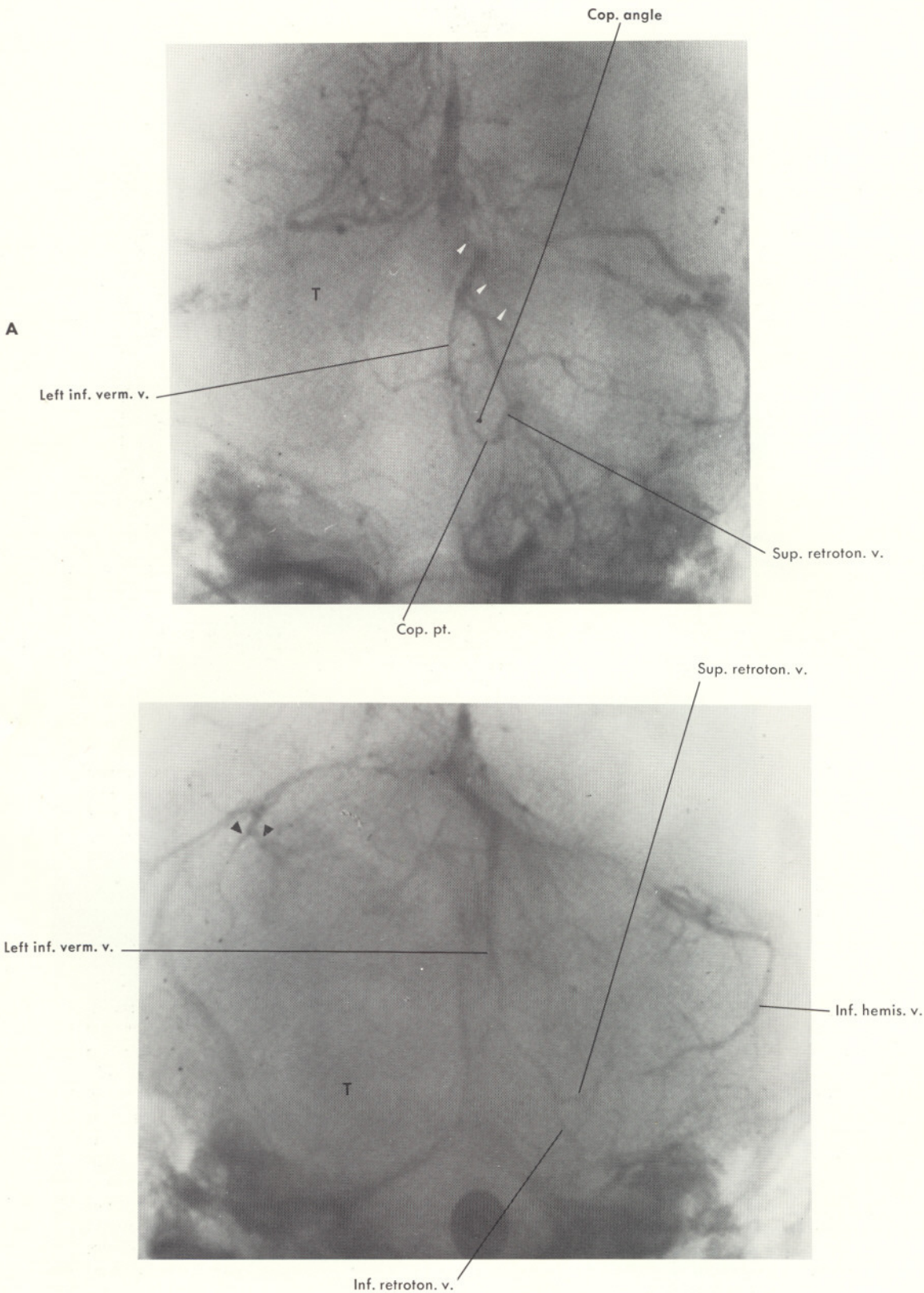

Fig. 75-41. For legend see opposite page.

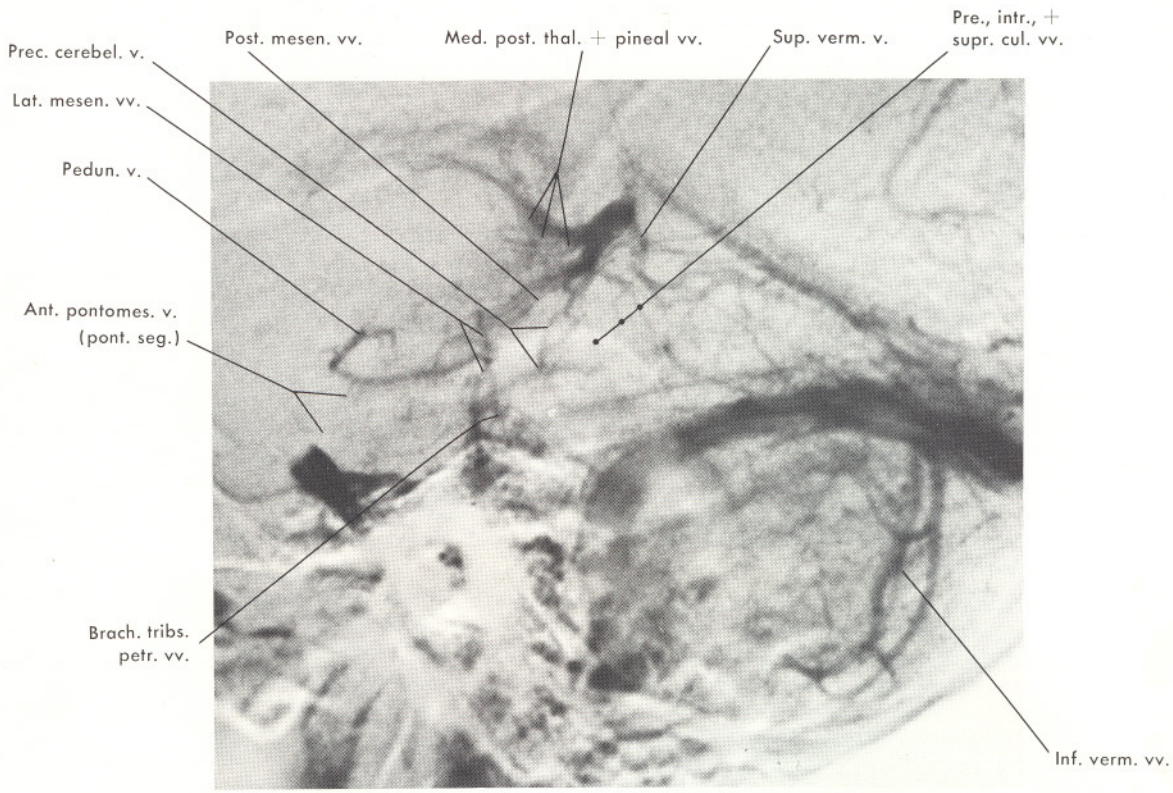

Fig. 75-42. Metastatic cerebellar hemispheric lesion simulating a superior vermian tumor. Venous phase, lateral view. The anterior pontomesencephalic vein is displaced upward and forward. The precentral cerebellar vein is displaced forward and slightly upward forming a continuous but small arc convex anteriorly and superiorly (refer to Fig. 75-35 for comparison). The superior vermian vein is displaced upward and comes close to the straight sinus. The inferior vermian veins are posteriorly and inferiorly displaced.

Fig. 75-41. Cerebellar hemispheric space-occupying lesions (two cases). Venous phase. **A,** Right cerebellar hemispheric hematoma. Semiaxial view. The faintly visualized precentral cerebellar vein (arrowheads) is markedly shifted toward the left. Similarly the upper end of the superior retrotonsillar tributary of the inferior vermian vein is displaced to the left, with resultant increase in the copular angle. The inferior vermian vein proper, which lies adjacent to the cerebellar falx, is not displaced. The posterior fossa on the right side is avascular in spite of good filling of the arteries on the right as seen in earlier films. At operation a large somewhat superiorly located hematoma (*T*) was removed from the right cerebellar hemisphere. **B,** Large cystic astrocytoma involving the right cerebellar hemisphere, semiaxial view. The lower portion of the inferior vermian vein, particularly the superior and inferior retrotonsillar tributaries, is markedly displaced to the left. The lower two thirds of the right posterior fossa are avascular. Superior hemispheric veins (black arrowheads) are elevated as compared with those on the left. A large tumor (*T*) containing 20 ml of fluid was removed at surgery.

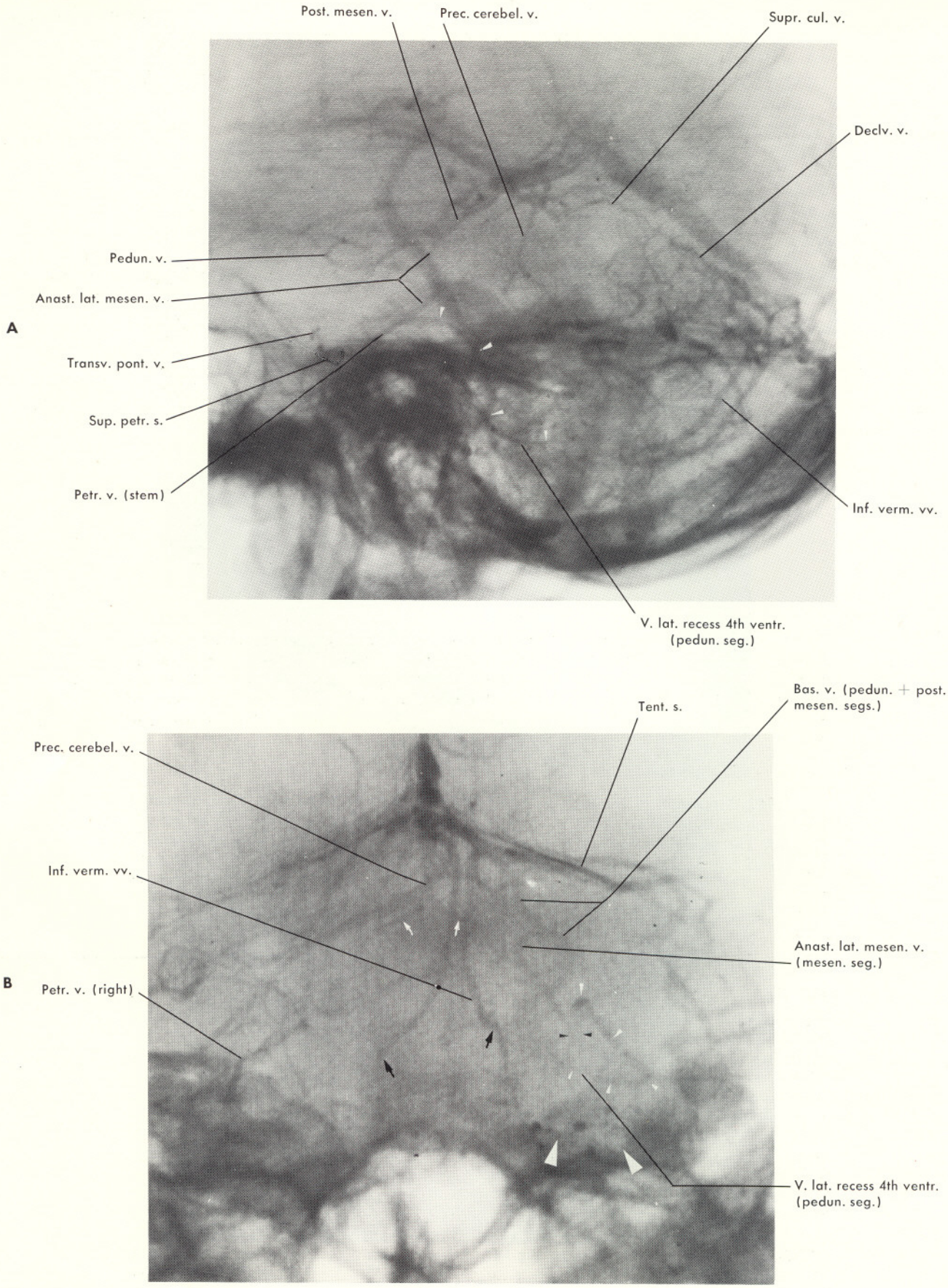

Fig. 75-43. For legend see opposite page.

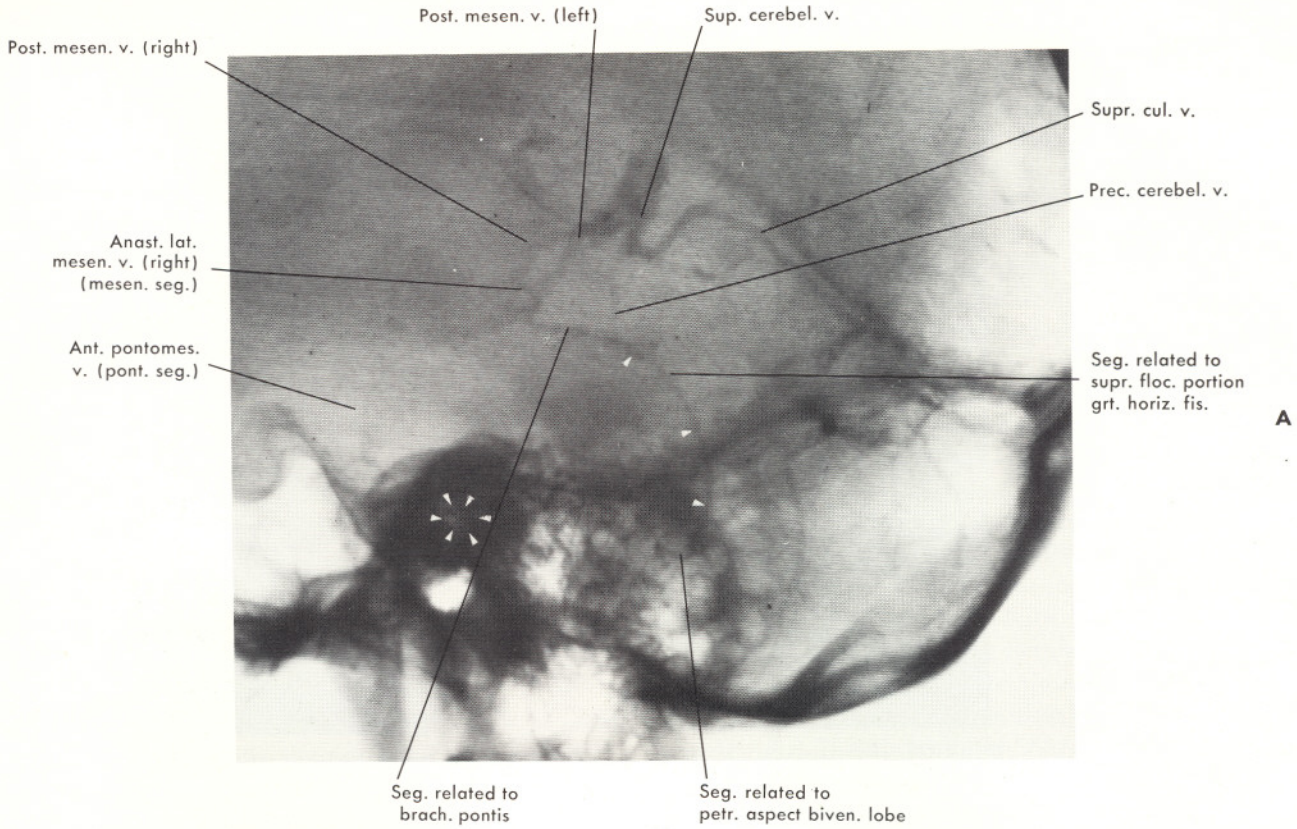

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Fig. 75-44. Large acoustic neurinoma. Venous phase. **A,** Lateral view. A prominent markedly stretched arcuate vein (semicircular row of arrowheads) convex posteriorly begins as an inferior hemispheric vein on the petrosal aspect of the biventral lobe and runs medially and superiorly on the medial petrosal aspect of the great horizontal fissure, then in the wing of the precentral cerebellar fissure, to join the anastomotic lateral mesencephalic vein (anomalous drainage of the petrosal vein into the galenic system). The internal auditory meatus (small circle of arrowheads) is labeled. The mesencephalic portion of the anastomotic lateral mesencephalic vein is shortened and elevated. Faintly visualized anterior pontomesencephalic and supraculminate veins are displaced forward and backward respectively, indicating a tight posterior fossa. The precentral cerebellar vein is somewhat posteriorly displaced. The internal cerebral vein is not depressed. **B,** Semiaxial view. The markedly stretched elongated and elevated anomalous petrosal vein (arrowheads), draining into the lateral mesencephalic vein and galenic system, can also be identified in this view on the right. The internal auditory canal and meatus are slightly widened. The petrosal vein, identified on the left, shows no abnormality.

Fig. 75-43. Relatively small acoustic neurinoma. Venous phase. **A,** Lateral view. The vein of the lateral recess of the fourth ventricle is markedly displaced backward in arcuate fashion (white arrowheads) and is joined by an elevated infratentorial segment of the anastomotic lateral mesencephalic vein (or brachial tributary of the petrosal vein). These veins unite to form the stem of the petrosal vein and open into the superior petrosal sinus. Angiographic evidence of a tight posterior fossa is indicated by close relationships of transverse pontine veins to the clivus and of the declival and supraculminate veins to the straight sinus. The inferior vermian vein and its tributaries show no definite abnormalities. **B,** Semiaxial view. The vein of the lateral recess (small white arrowheads) is displaced superiorly and laterally away from the eroded internal auditory meatus and canal (large white arrowheads). The poorly visualized stem of the petrosal vein, formed by the union of the infratentorial segment of the anastomotic lateral mesencephalic vein and the supraflocculcar portion of the vein of the lateral recess of the fourth ventricle (small black arrowheads), is markedly stretched and elevated. The faintly visualized precentral cerebellar vein and its brachial tributaries (white arrows) show no abnormality. The upper parts of the inferior vermian veins appear displaced to the left, but this is a normal variant. There is, however, slight elevation of the copular point on the left as compared with the right (black arrows).

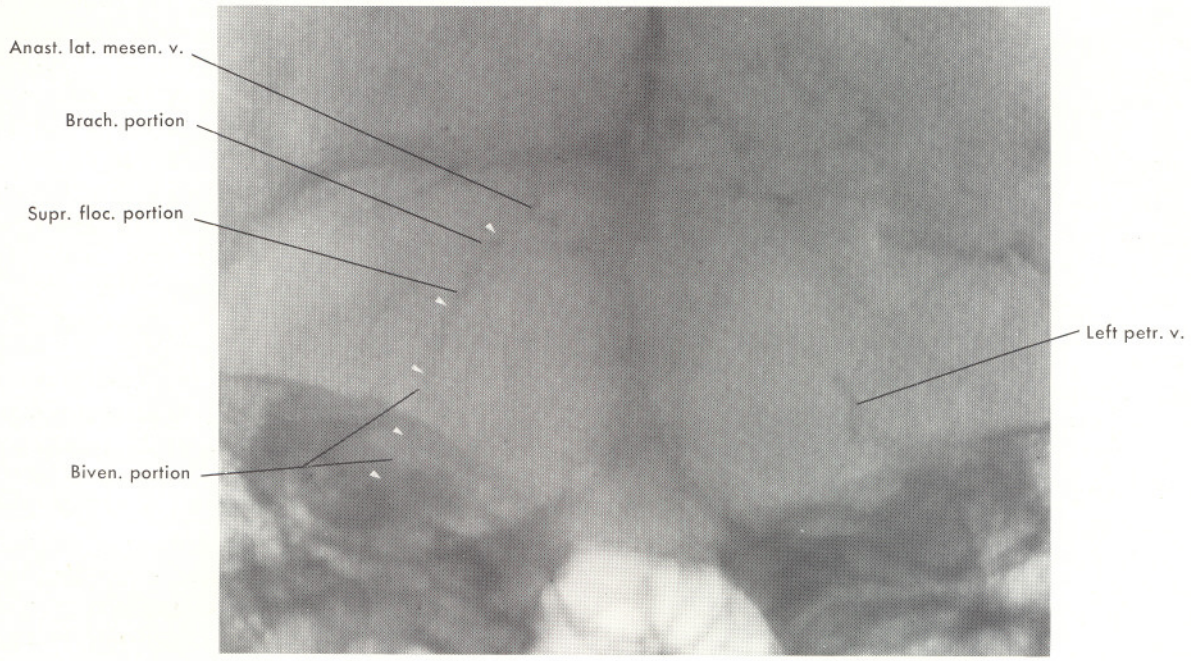

Fig. 75-44, cont'd. For legend see p. 2211.

mesencephalic vein is usually too tortuous to be of diagnostic value for this purpose; and often the mesencephalic segment lies not in the midline but in a paramedian location within the oculomotor sulcus. A single midline supraculminate vein, although not uncommon, is also tortuous so that only gross displacements of this vessel can be identified (Figs. 75-8 and 75-10). In practice, contralateral shift is usually more evident by comparison of veins ordinarily symmetrically located. The two veins of the lateral recess of the fourth ventricle, brachial tributaries of the petrosal and precentral cerebellar veins, and retrotonsillar tributaries of the inferior vermian veins are most useful in judging such shifts. The degree of contralateral shift of median or paramedian veins is generally most pronounced in those vessels that are located near the middle of the posterior fossa. The posterior portions of the inferior vermian veins can be displaced contralaterally to only a limited degree because of the presence of the cerebellar falx and internal occipital crest. On the other hand, the upper ends of the superior retrotonsillar veins and supratonsillar tributaries often show considerable contralateral shift. Particularly with laterally located tumors, complete filling of both the arteries and the veins on the two sides is necessary. This filling can be achieved by bilateral retrograde brachial angiography using two pressure injectors or by catheter techniques with reflux filling of the posterior inferior cerebellar artery on the opposite side.

Cerebellar hemispheric masses (Figs. 75-41 and 75-42). These produce contralateral shift of median and paramedian vessels as just described. Veins running on the surface of the cerebellum at the site of the tumor are displaced outward toward the bony walls or the tentorium in arcuate fashion. Moreover, a similar arcuate upward shape of the tentorium may be evident when the tentorial sinus is visualized. When the tumor is located superficially, separation of hemispheric veins surrounding the mass may be evident, particularly if stereoscopic views are available. In unilateral posterior fossa space-occupying lesions filling of veins on the side of the lesion may be delayed.

Kinking of the aqueduct is a common feature of unilateral cerebellar hemispheric lesions as seen on encephalography or ventriculography (Hilal et al., 1969). In contrast to the kinking at or near the aditus of the aqueduct produced by lesions of the superior vermis, the angulation in hemispheric tumors is said to occur primarily in the course of the aqueduct. The configurations of the precentral cerebellar vein in these two types of lesions are also different (Figs. 74-35, 75-34, 75-35, and 75-42). When a tumor occupies the superior vermis, the anterior culminate and fissural segments are displaced forward and form a single continuous arcuate curve convex anteriorly. In effect, the anterior culminate segment is displaced superiorly and the fissural and parenchymal segments inferiorly. Both segments are displaced anteriorly as well. In contrast, with a hemi-

spheric tumor the culminate and fissural segments are displaced forward and upward in an arched fashion. The fissural segment is not displaced inferiorly. The radius of the curves formed by the segments of the precentral cerebellar vein is small with a hemispheric tumor (Fig. 75-42).

Extra-axial or extraparenchymal masses. Located laterally in the posterior fossa, these include a large variety of expanding processes. The most common example is the cerebellopontine angle tumor (Greitz and Lindgren, 1961; Scatliff et al., 1965; Takahashi et al., 1967; Huang et al., 1968a; Bull and Kozlowski, 1970; Ben-Amor et al., 1971; Lehman, 1972) (Figs. 75-43 and 75-44). The most striking feature in such cases is usually marked stretching of the stem of the petrosal vein over the superior portion of an acoustic neurinoma. The veins that converge to the stem of the petrosal vein and comprise the tributaries on the petrosal aspect of the cerebellar hemisphere are displaced backward in arcuate fashion, indicating the posterior extent of the tumor. The distance between these vessels and the posterior bony surface of the petrous bone and internal auditory meatus is obviously increased. When retroolivary (or lateral medullary) and transverse pontine veins are visualized, they may be displaced medially as seen in the semiaxial projection. Sometimes, presumably as a result of compression, the petrosal vein and its tributaries on the side of the tumor may be poorly filled despite satisfactory visualization of the anterior inferior and posterior inferior cerebellar arteries. In other cases tumor vessels or blush may be seen, particularly in instances of neurofibroma and meningioma. When the tumor is large and extends upward, the peduncular and lateral mesencephalic veins may be elevated and displaced medially.

Indirect displacements—tight posterior fossa and herniations (Figs. 75-32, 75-42, 75-45, and 75-46)

As a result of a space-occupying lesion in the posterior fossa, the subarachnoid cisterns become smaller. Narrowing is usually most marked in the cisterns adjacent to the lesions but may involve all the subarachnoid channels, indicative of a *tight* posterior fossa. Narrowing of the pontine cistern and its lateral extension is manifested in the venous phase by decreased distance between the tributaries of the anterior pontomesencephalic and petrosal veins and the clivus and adjacent aspect of the petrous pyramid. Narrowing of the anterior medullary cistern is indicated by anterior displacement of the anterior medullary vein. Elevation of the culminate tributaries, particularly the supraculminate tributaries, of the superior vermian vein indicates narrowing of the superior cerebellar cistern. The declival vein also approaches unusually close to the straight sinus. Narrowing of the cisterna magna is manifested by posterior and inferior displacements of the inferior vermian veins and downward displacement of the retrotonsillar tributaries. As described by Greitz (1969), the circulation time of the veins of the posterior fossa may be increased. The infratentorial veins may appear later and persist longer than the supratentorial veins as shown by rapid serial angiography. *Upward transtentorial herniation* is frequently observed in posterior fossa space-occupying lesions (Fig. 75-45). This herniation is indicated by upward displacement of the superior part of the anterior pontomesencephalic vein (Figs. 75-32 and 75-42). In addition, the superior vermis outlined by the adjacent venous channels is also displaced upward and forward. The posterior mesencephalic veins and basal veins of Rosenthal are elevated and separated (Fig. 75-45). The posterior portions of the internal cerebral veins and the vein of Galen may also be displaced upward when herniation is severe.

Downward transtentorial herniation as a result of a large supratentorial space-occupying lesion or aqueductal stenosis (Fig. 75-46) produces inferior displacement of the roof and mesencephalic segments of the anterior pontomesencephalic vein. The precentral cerebellar vein and the superior vermian vein and its culminate tributaries are also displaced downward. Unilateral downward transtentorial herniation may produce a contralateral shift of the precentral cerebellar vein as well as the superior vermian vein and its culminate tributaries. (Fig. 75-46, *B*). The peduncular and posterior mesencephalic veins and basal veins of Rosenthal may be displaced medially as well as inferiorly.

Tonsillar herniation is more difficult to detect in the venous phase than in the arterial phase. When the inferior retrotonsillar tributary of the inferior vermian vein is displaced downward below the level of the foramen magnum, herniation of the tonsil can be identified. This herniation is usually associated with downward and backward displacement of the stem of the inferior vermian vein. The superior pole of the cerebellar tonsil, outlined by supratonsillar tributaries and the superior retrotonsillar vein, is also displaced downward.

Anomalies (Figs. 75-47 and 75-48) (See Chapter 87.)

Anomalies of the posterior fossa include (among others) aqueductal stenosis, Arnold-Chiari malformation, Dandy-Walker syndrome, basilar impression, and communicating hydrocephalus (Raimondi and White, 1967). Only the venographic features of aqueductal stenosis will be described. In *aqueductal stenosis* the upper brainstem (midbrain and upper pons) is flattened from above, displaced downward, and widened transversely as well as anteroposteriorly (Liliequist, 1960;

Text continued on p. 2218.

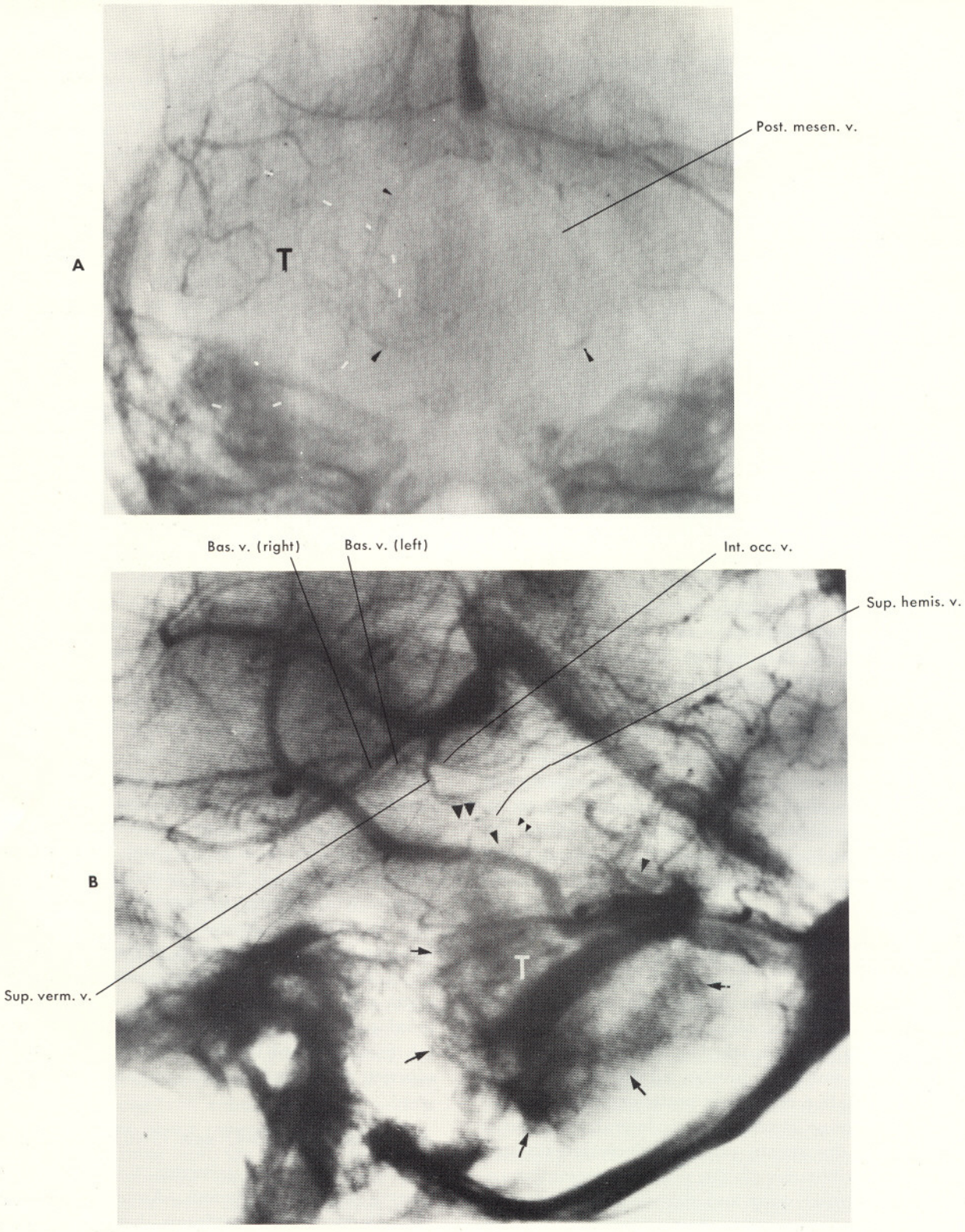

Fig. 75-45. Upward transtentorial herniation indicated by elevation, lateral displacement, and separation of posterior mesencephalic veins, simulating an enlarged midbrain. Venous phase. **A,** Semiaxial view. The posterior mesencephalic veins, draining into the posterior portions of the internal cerebral veins, are visualized on both sides (black arrowheads) and are markedly displaced outward, especially posteriorly. Abnormal vasculature related to a large posterior fossa meningioma (*T*, line of white dashes) can also be seen on the right. **B,** Lateral view. A large tumor (*T*) with characteristic meningioma blush (black arrows and single arrowheads) is seen elevating the superior hemispheric tributaries (double arrowheads) of the superior vermian vein. The posterior portions of the basal veins are elevated, more so on the right.

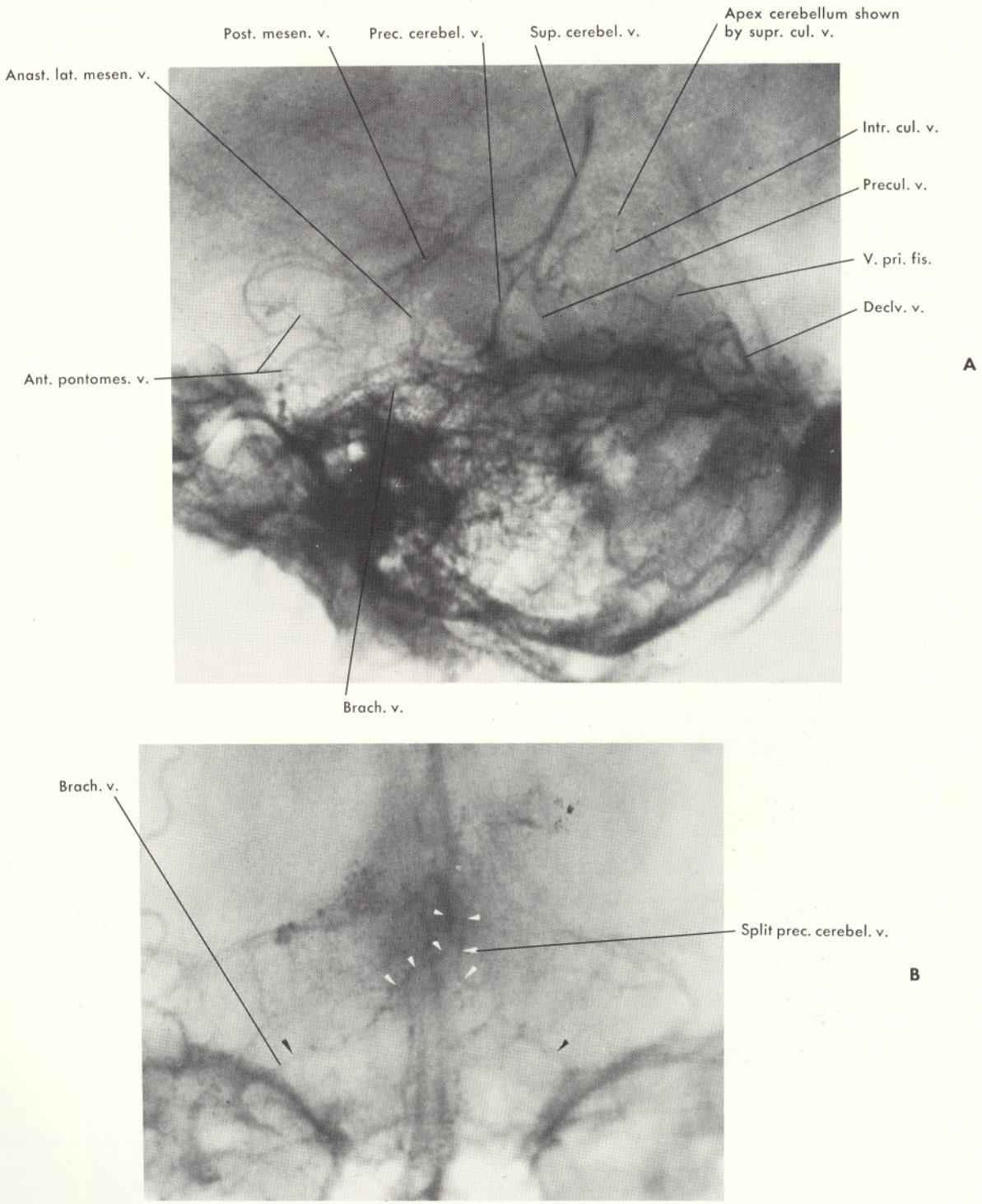

Fig. 75-46. Downward transtentorial herniation from a right parietal mass lesion. Venous phase. **A,** Lateral view. The anterior pontomesencephalic vein is depressed and somewhat anteriorly displaced. There is moderate downward displacement along with stretching of the superior cerebellar vein and its precentral and culminate tributaries. **B,** Anteroposterior view. The split precentral cerebellar vein (white arrowheads) appears shifted from right to left. The anterior extensions of this vein into brachial tributaries (black arrowheads) of the petrosal veins can also be identified. The brachial tributary on the right is depressed and medially displaced. These findings indicate downward transtentorial herniation on the right.

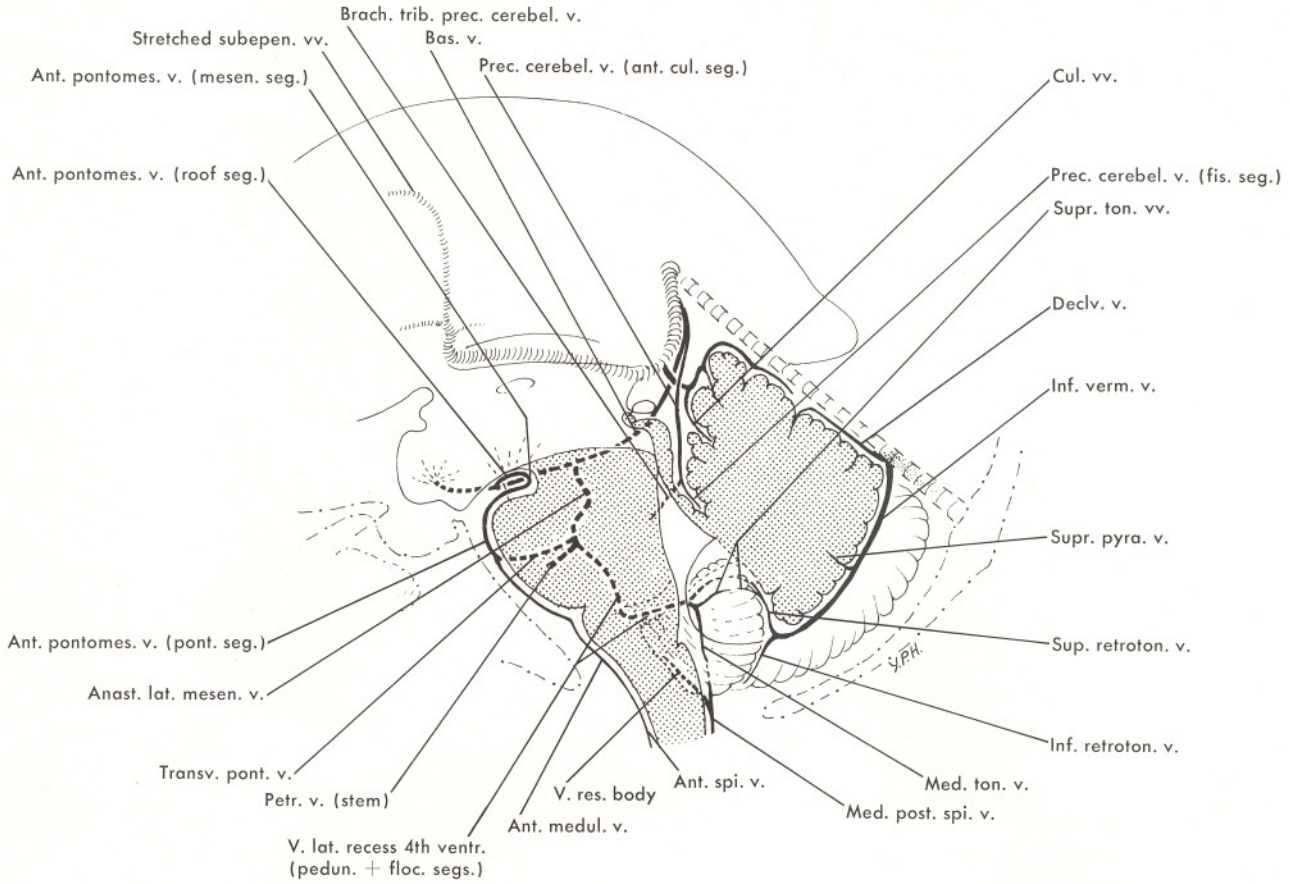

Fig. 75-47. Diagram showing changes in the course of veins of the posterior fossa in aqueductal stenosis. (For description see text.)

Fig. 75-48. Aqueductal stenosis (two cases). Venous phase, lateral view. **A,** Low aqueductal stenosis. The pontine segment of the anterior pontomesencephalic vein bulges forward. Its upper end or the region of the superior foramen cecum (single arrowhead) is depressed. A vein in the pontomesencephalic sulcus (double arrowheads) is also depressed and elongated. The precentral cerebellar vein (four arrowheads) is stretched downward and arched somewhat backward. The colliculocentral angle is reversed. These features indicate widening and downward displacement of the flattened upper brainstem. The internal cerebral vein is depressed, and its subependymal tributaries elongated. The inferior vermian vein is not remarkable. **B,** High aqueductal stenosis. Depression of the internal cerebral vein and stretching and elongation of its subependymal tributaries indicate hydrocephalus. The interpeduncular fossa, outlined by the anterior pontomesencephalic vein (black arrowheads), is depressed; and the pontine cistern, outlined by the pontine segment of the vein, is markedly narrowed. The precentral cerebellar vein is straightened inferiorly (small white arrowhead), and its colliculocentral point (large white arrowhead) is located considerably lower than usual. Although this point is not appreciably displaced posteriorly, the distance between the anterior aspect of the pons, outlined by the anterior pontomesencephalic vein, and the colliculocentral point is still slightly increased. The inferior vermian vein and its retrotonsillar and hemispheric tributaries show no abnormality. Enlargement of the sella with erosion of the posterior clinoids is caused by an enlarged third ventricle and increased intracranial pressure. The difference in the course of the precentral cerebellar vein between this case and the previous case (**A**) is related to the site of the obstruction. Pantopaque ventriculography confirmed the findings in both cases.

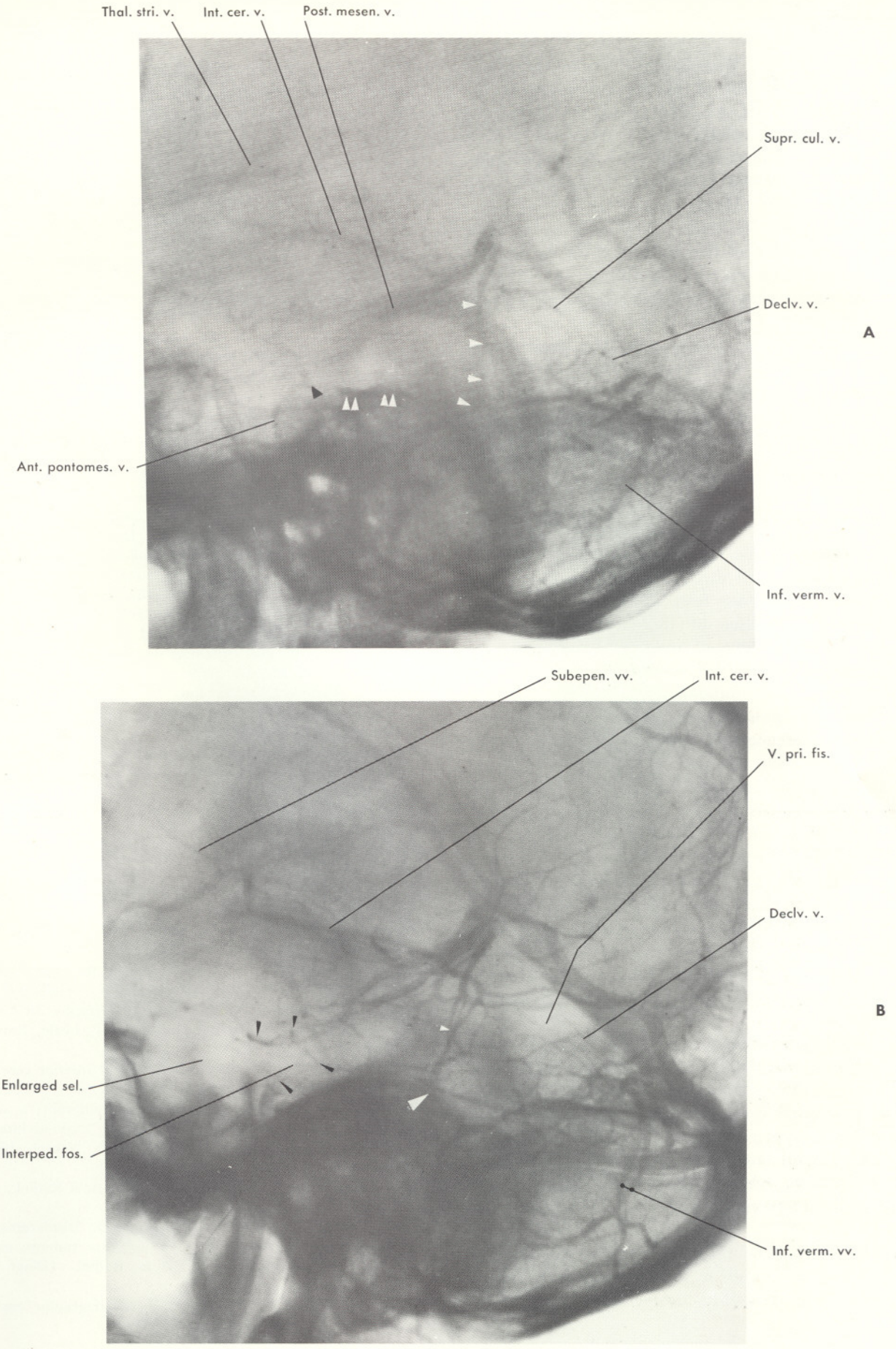

Fig. 75-48. For legend see opposite page.

Huang et al., 1968b). Widening of the upper brainstem is greater when the site of the stenosis is low in the aqueduct (Fig. 75-48, *A*). The upper portion of the anterior pontomesencephalic vein is depressed and its pontine segment bulges forward. The precentral cerebellar vein is stretched downward, straightened, and displaced posteriorly (Huang and Wolf, 1964b; Krayenbühl and Yaşargil, 1965). This change is most marked in the region of the colliculocentral point. The colliculocentral angle may be slightly reversed. Median and paramedian veins are not laterally displaced and remain symmetric. The veins in the lower part of the posterior fossa show no abnormality. The stretching of the internal cerebral and subependymal veins of the lateral ventricles confirms the presence of symmetric hydrocephalus (Huang and Wolf, 1964a; Wolf and Huang, 1964; Huang et al., 1968b).

Abnormal patterns of circulation

The circulation time in the posterior fossa when a catheter technique is used is approximately the same as in the supratentorial regions (3.5 seconds) (Greitz, 1969). In our series of thirty adult patients with presumably normal posterior fossa angiograms, the angiographic circulation time of the posterior fossa was measured from the time of maximal opacification of the vertebral arteries at the level of C1 to the time of maximal filling of the individual veins of the posterior fossa. The method we employed was bilateral retrograde brachial angiography utilizing two pressure injectors, one on each side, with a 0.2-second delay on the left side to ensure maximal opacification of the vertebrobasilar system through simultaneous filling of the two vertebral arteries. The exposures of the first nine films in each series were made at 0.5-second intervals. The remaining five to eight films were exposed at 0.7-second intervals. In the semiaxial projection the carotid artery was manually compressed in the neck on the right side to avoid superimposition of the supratentorial vessels on the posterior fossa vessels. This resulted in simultaneous compression of the right jugular vein.

The average circulation time of the posterior fossa in the semiaxial projection ranged from 4.0 to 4.4 seconds, whereas that related to the ascending parietooccipital and basal cerebral veins was slightly shorter (3.5 seconds). The circulation time related to veins of the mesencephalon and upper part of the cerebellum was slightly shorter, whereas that related to the medulla oblongata and upper cervical cord was longer by about a second.

The circulation time may be increased in posterior fossa masses or as a result of arterial stenoses or spasm associated with bleeding from aneurysms or with meningitis. The circulation time may be decreased locally by tumors in the posterior fossa. Arteriovenous malformations show the same features as seen in the supratentorial region.

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