Wolfgang Seeger

Endoscopic and microsurgical anatomy of the upper basal cisterns

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In collaboration with
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Dedicated to
Gazi M. Yaşargil

Preface

Microsurgical techniques related to the basal cisterns and their walls were initially developed by Yaşargil based on anatomical and neuroradiological findings. Subsequently, numerous additional authors have contributed to the body of publications concerning the routine application of endoscopic techniques for intraventricular and intracerebral surgery guided by stereotaxy and/or neuronavigation. In the last ten years, transnasal endoscopic approaches for intrasellar target areas have been applied with increasing success. Snyderman and coworkers, as well as Al-Mefty and others have elaborated on these methods to approach areas within other basal cisterns. Today these applications, in particular regarding the problem of CSF-fistulas, are a source of controversy amongst neurosurgeons reminiscent of the scepticism towards microneurosurgery forty years ago. At that time, surgical techniques were developed to approach target areas within the brain, which could not be reached before. Similar aspects today are recognizable with reference to endoscopy.

The author has confined his activities to the description of anatomical aspects of modern endoscopic neurosurgical techniques. The desire to impart this information to others has been the motivation for writing and illustrating this book. Three aspects regarding the present work should be noted:

- The subject of this book is restricted to the presentation of the upper basal cisterns, except to some aspects regarding the fifth and sixth cranial nerves. The descriptions of anatomy and surgery inside the infratentorial cisterns are sufficient.
- The application of MRTs, neuronavigation and of CTs with 3D-reconstruction allow exact measurements and are more helpful for spatial orientation of neurosurgeons and neuroradiologists than are conventional cadaver brain dissections. However, for understanding the endoscopical routes, cadaver head dissections are mandatory, as was demonstrated in Freiburg/Br by Prof. Snyderman and by Prof. Al-Mefty in November 2006.
- Nonetheless, neuroradiological findings are not yet sufficient for defining arachnoid structures, Rr. perforantes and other fine vessels, and their relationships to adjacent anatomical structures. Cranial nerves have to be identified as well as CSF-pulsations which accompany the extradural segments of cranial nerves (N. II, e.g.) However, the exact definition of the roots of cranial nerves at their exit points at the brain and of the arachnoid and dural penetration points are often insufficient (except N. II and V). In order to understand these anatomical relationships, cadaver brain dissections are also mandatory.

The author owes particular gratitude to the chairmen of the neurosurgical departments in Freiburg (Prof. Zentner), Giessen (Prof. Böker), and Göttingen (Prof. Rohde), as well as to the directors of the neurosurgical departments in Zwickau (Dr. Warnke), and Erfurt (Prof. Rosahl), and their coworkers, especially PD Dr. Kaminsky (Freiburg), Dr. Nestler, Dr. Preuß, and the oto-rhinolaryngologist PD Dr. Ulrike Bockmühl (Giessen). Dr. Astrid Weyerbrock (Freiburg) with her knowledge of english language revised and corrected the english manuscript of the author. The author is grateful to Mrs. E. Rotermund, Professor Zentner's secretary, for typing and for better representating the manuscript. I would especially like to thank the Springer Verlag WienNewYork for continuous support and cooperation, and excellent publication of my books for over 30 years.

Freiburg i. Br., January 2008 *Wolfgang Seeger*

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PART I
GENERAL ASPECTS
(Figs. 1 to 34)

Cranial and cerebral base and its landmarks (Figs. 1 to 9)

Neuronavigatory landmarks for surgery are bony structures, as long as bony structures are preserved during surgery.
But bony neuronavigatory landmarks are only related to adjacent cisternal structures, if the covering dural layer is thin.
However, the dural layers close to the upper basal cisterns are usually thickened, especially in the cavernosus area (Fig. 1).
Intradural structures may shift during surgery. Landmarks may be inexact, due to brain shift. Intraoperative orientation using modern ultrasound methods does not allow identification of fine vessels, nerves, or arachnoid structures.

Constant neuronavigatory landmarks for intracisternal surgery are
– Canalis opticus
– Dural penetration point of A. carotis int. It is defined by the bony incisure between Processus clinoideus ant. and the lateral shape of Tuberculum sellae (5 and 29 in Fig. 2)
– Dorsum sellae and the posterior clinoid processes
– Tuberculum sellae
– Processus clinoideus ant.

Addendum: Further constant landmarks may be dural folds (tentorial edge, Plica petroclinoidea ant. and post.), if not manipulated by surgery.

Constant neuronavigatory landmarks for extradural transitional areas of surgical approaches to cisternal target areas are
– Fissura orbitalis sup.
– Canalis rotundus (Apertura ext. and int.)
– Canalis caroticus inside petrous bone, especially its Apertura int. (24 in Fig. 2)
– Foramen lacerum, which is a variable bony defect of the roof of Canalis caroticus (12 in Fig. 2)

These landmarks are related to dural and/or cisternal structures along cranial nerves.

Craniobasal and cerebrobasal structures close to basal cisterns (Figs. 10 to 16)

Craniobasal structures (Figs. 10 to 12)

– Supra- and parasellar dorsal dural surface d (Fig. 10)
  After the overview of Fig. 9, variants of the dural exit point of N. oculomotorius and N. trochlearis are selectively presented (Fig. 10). These are common variants.
  A rare variant is the retroposition of A. carotis int. (D at Fig. 10). Dolichoectasy of the carotid siphon and other atypical findings and variants may result in compressions of N. opticus (McLead 1970, Miller 1982, Unsöld 1989).

– Tentorial notch (Fig. 11)
  A small variant of tentorial notch is narrowing Cisterna ambiens. Brain shift by space-occupying lesions compremise the midbrain earlier than other anatomical conditions. A wide tentorial notch is combined with a wide contact of Gyrus parahippocampalis and Lobulus quadrangularis/simplex cerebelli. Cisternal adhesions are typical findings here and might result in damage to N. trochlearis during surgery.

Cranial and cerebral base and its landmarks (Figs. 1 to 9)

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Cerebrobasal structures (Figs. 13 to 15)

Craniobasal structures are easily identified, in contrast to cerebrobasal structures close to cisterns. Kinking of the axis of the brainstem also affects the brain surface. The kinking can be reduced, using an anatomical model (Fig. 15), for a better understanding of the topography. **The dorsal walls (and limit areas) of the cisterns (Fig. 14) and the basal walls (and limit areas)** – see Fig. 7 – **are incongruent.**

An impressive example is Cisterna interpeduncularis. In Fig. 7 the basal cisternal segment is wide and overlaps Cisternae pontis. In Fig. 14 the dorsal cisternal segment is narrow.

Architecture of basal cisterns (Fig. 16)

Cisterns consist of two components: Arachnoid walls and lumina. Walls are well defined by arachnoid membranes. If walls present a high density of trabeculas, and membranes are rare, then the limits may be unclear (limit areas).

Walls and border areas

The outer arachnoid membrane encloses all intracranial and intraspinal structures. The outer Arachnoidea is separated from Dura by the subdural space. Its inside is covered by the walls of cisterns. These walls enclose the subarachnoid space. Brain tissue is separated from the cisterns by Pia mater and inconstant arachnoid membranes. Multiple fine cerebral vessels (at Substantia perforata ant. and post., e.g.), and some larger vessels (at the lateral surface of midbrain, e.g.), penetrate Pia mater. Funnel-like extensions of Pia mater envelope these vessels towards their intracerebral course.
The outer arachnoid membrane can be separated from the cisternal Arachnoidea (at pontocerebellar cistern, e.g.), or the outer and cisternal Arachnoidea is adherent or fused (at the lateral basal wall of Cisterna valleculae = carotid cistern, e.g.). Both types are shown in B and D of Fig. 16.
Cisterns may be separated from each other by duplicate membranes which build the common wall of adjacent cisterns.
These walls can be dissected without opening the CSF-spaces of adjacent cisterns. This procedure and other transarachnoid surgical approaches were created by Yaşargil more than 30 years ago. This is the foundation of modern microsurgery at the basal surface of the brain.

Fusioned cisternal arachnoid membranes are present at the walls of Cisterna chiasmatis and interpeduncularis (all segments of Liliequist's membrane), of Cisterna pontis medialis and lateralis (enclosing multiple regulary shaped fenestrations). See Figs. 23 and 28.
The border areas of some cisterns are not exactly defined because arachnoid membranes may be rare or deficient, at Cisterna laminae terminalis and Cisterna chiasmatis, e.g.. Arachnoid tunnels enclosing cranial nerves or vessels, are inconstant.

Lumina

Lumina of cisterns may contain few trabeculas (Cisterna chiasmatis, e.g.), or trabeculas of variable density (Pars profunda of Cisterna interpeduncularis, e.g.).

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Topography of basal cisterns (Figs. 14 to 30)

The first detailed presentation was given by Key and Retzius (1875). Its principles were confirmed and adapted for microsurgery by Yaşargil a century later (1976).
3 aspects have to be considered: Relationship of cisterns to surrounding structures, contents of the cisterns
and relationship of CSF-flow, vessels and cranial nerves to the walls and contents of cisterns.

Relationship to surrounding structures (Figs. 17 to 24)

– Cisterna laminae terminalis
lateral: Area subcallosa and Gyrus rectus (medial wall)
anterior-basal: dorsal surface of Chiasma, containing Recessus opticus
dorsal: Commissura ant., Cisterna corporis callosi

– Cisterna valleculae (Yaşargil's carotid cistern)
medial: Chiasma, Cisterna chiasmatis
lateral: Uncus and Limen insulae
anterior: Gyri orbitales, Trigonum olfactorium, and Gyrus rectus
posterior: Uncus base
dorsal: Substantia perforata ant.
basal: dural penetration of A. carotis int.

– Cisterna fossae lat. (Sylvii)
medial: Limen insulae, Sulcus inf. insulae
lateral: fronto-parietal and temporal overlapping cortex
anterior: frontal segment of Insula, overlapped by opercular gyri
posterior: Gyrus angularis
dorsal: Sulcus sup. insulae, opercular and parietal gyri
basal: Sulcus inf. insulae, Heschl's gyri and posterior temporodorsal gyri

– Cisterna chiasmatis
medial: inconstant sagittal septum of the midline between Chiasma, and hypophyseal stalk (13 of Fig. 20)
lateral: Cisterna valleculae (carotid cistern) with A carotis int., and N. opticus
anterior: anterior margin of Chiasma
posterior: Liliequist's membrane and its diencephalic portion
dorsal: Chiasma and Infundibulum/Tuber cinereum
basal: Tuberculum and Diaphragma sellae, Dorsum sellae

– Cisterna interpeduncularis (Fig. 48)
Pars superficialis
lateral: Limit area of Cisterna cruralis, tunnel of N. oculomotorius
anterior: Liliequist's membrane, diencephalic portion
posterior: Substantia perforata post.
dorsal: Axial segment of Liliequist's membrane, diencephalic portion
basal: Liliequist's membrane, mesencephalic portion

– Cisterna ambiens – Cisterna cruralis (Fig. 14)
medial: Mesencephalon
lateral: Fiss. chorioidea with lateral margin of Tract. opt.

anterior: Border area of Cist. interpedunc., tunnel of N. oculomotorius
posterior: Cisterna tecti
dorsal: Tractus opticus
basal: Uncus, Gyrus parahippocampalis, Area dentata, Fissura chorioidea

Contents of basal cisterns (Figs. 25 to 30)

– Cisterna laminae terminalis
  Arteries: Aa. cerebri ant., Aa. recurrentes (Heubneri), A. communicans ant., A. corporis callosi mediana (Yaşargil's anterior hypothalamic artery), A. frontobasalis medialis and A. frontopolaris of each frontal lobe.
  Veins: Vv. cerebri antt., V. communicans ant.
  Cranial nerves: None

– Cisterna valleculae (Yaşargil's carotid cistern)
  Arteries: A. carotis int. and its bifurcation, Aa. perforantes of different originating arteries, A. comm. ant., A. chor. ant., A. hypoph.sup.
  Veins: Vv. cerebri antt., Vv. fossae lat. profundi
  Cranial nerve: N. olfactorius (Trigonum olfactorium)

– Cisterna fossae lat. (Sylvii)
  Arteries: A.cerebri media and its main branches
  Veins: Vv. fossae lat. profundi and its connections to superficial sylvian veins
  Cranial nerves: None

– Cisterna chiasmatis
  Arteries originating from the anterior segment of Circulus arteriosus: A.communicans post., A. chorioidea ant.. Their perforating branches are in close vicinity to Chiasma, N.opticus, Tractus opt., medial and lateral rim of the tractus, and Tuber cinereum around Infundibulum. Some fine vessels originate from A. carotis int. (A. hypophysialis sup. and Rr. perforantes feeding N. opt. and Chiasma, after penetrating the medial wall of Cisterna valleculae).
  Arteries originating from the posterior segment of Circulus arteriosus: The anterior group of perforating arteries originate from the bifurcation of A. basilaris. It presents the same target area as the perforators of the anterior segment of Circulus arteriosus, but it is located predominantly in the posterior target area of Tuber cinereum and Tractus opticus.
  Veins: A network of predominantly fine veins are located close to the roof of the cistern (cast injections of Duvernoy, 1975).
  Cranial nerves: N. opticus. Distal segments of N. oculomotorius and N. trochlearis are located in Cisterna chiasmatis close to its dural exit points.

– Cisterna interpeduncularis
  Arteries enclosed by Pars superficialis of Cisterna interpeduncularis: Bifurcation of A. basilaris, A. cerebelli sup., A. tecti, A. chorioidea post. med., A. communicans post. enclosed by the diencephalic and by the mesencephalic portion of Liliequist's membrane. Note the gap of the mesencephalic portion of A. basilaris (Figs. 21 and 22)
  Arteries enclosed by Pars profunda of Cisterna interpeduncularis: Anterior group of the perforating arteries of A. basilaris.
  Note: The posterior group of Aa. perforantes (Aa. thalamostriata) is located in the wide CSF-space of Pars superficialis. The anterior group is crossing the narrow space of Pars profunda.

Veins: V. interpeduncularis and its connections to Pons and to the veins which are feeding the venous component of the chorioid point and its draining veins (especially V. basalis Rosenthal).
Cranial nerve: N. oculomotorius.

– Cisterna ambiens and Cisterna cruralis
Arteries: A. cerebri post., A. chorioidea ant., perforating branches of both arteries, A. cerebelli sup. and its perforating branches feeding midbrain (and Pons), A. tecti and A. chorioidea post.med.
The proximal segments of A. cerebelli sup., A. tecti, and A. chorioidea post. medialis are not yet crossing the Cisterna interpeduncularis and Cisterna cruralis. It is enclosed by the mesencephalic portion of Liliequist's membrane (wall of Cisterna interpeduncularis) and its extensions into a lateral direction. This is the border area of Cisterna cruralis to Cist. interpeduncularis.
Veins: Distal bilateral branch of V. interpeduncularis, V. basalis Rosenthal and their feeding veins.
Cranial nerves: N. oculomotorius penetrates the medial wall of Cisterna cruralis. N. trochlearis penetrates the medial segment of Cisterna cruralis, inferior from N. oculomotorius and superior from N. trigeminus. This nerve originates at Cisterna cerebellomedullaris, penetrates via its variable arachnoid tunnel, and crosses the lateral segment of Cisterna pontis lateralis.

Relationship of CSF-flow, vessels, and cranial nerves to walls and luminas of cisterns (Figs. 17 to 19, and 21 to 23)

– Usually CSF flows through all cisterns, passing wide or numerous narrow gaps in walls and border areas.
The modern definition of cisterns by Yaşargil is based on injection casts, according to anatomical or surgical dissections. This definition is exact, if arachnoid membranes or double membranes are covering the walls. Border areas between cisterns are unclear if membranes predominantly consist of multiple trabeculas. Walls and border areas are essential for surgery of intracisternal tumors because walls and border areas are barriers against tumor invasion into the adjacent brain. Nowadays, this is the major principle of tumor extirpation, according Yaşargil.
Typical gaps of arachnoid membranes are the wide gap of the mesencephalic portion of Liliequist's membrane (Fig. 21), and the nearly parallel multiple gaps of the wall between Cisterna pontis medialis and lateralis (Fig. 23). Gaps are irregular between the most upper basal cisterns. The border which separates cisterns from each other may consist predominantly of arachnoid membranes or have irregular gaps containing trabeculas. Their density is variable. This type is found between Cisterna valleculae and Cisterna chiasmatis. Unclear border areas present only small segments of membranes. Trabeculas are the predominant structures of these areas. This type is found between Cisterna valleculae and Cisterna laminae terminalis and between Cisterna chiasmatis and Pars profunda of Cisterna interpeduncularis (Fig. 21).
Cisterna chiasmatis contains mostly CSF. Pars profunda of Cisterna interpeduncularis contains predominantly trabeculas and perforating vessels. There is no membrane between both cisterns in contrast to the wall between Cisterna chiasmatis and Pars superficialis of Cisterna interpeduncularis. This wall consists of the diencephalic portion of Liliequist's membrane (Figs. 21 and 22). The penetration point of Liliequist's membrane in Figs. 22 and 23 is indicated (arrows). Variants of the configuration of cisterns should be considered during surgery. For surgical aspects see chapter 5.

Another type of border areas are the variable and inconstant arachnoid tunnels, enclosing arteries (A. cerebri media and main branches) and cranial nerves (N. oculomotorius, N. trigeminus, and N. abducens) as was presented by Key and Retzius in 1876. A simplified illustration is given in Figs. 17 and 18. The large gap of the mesencephalic portion of Liliqequist's membrane may be narrow or obliterated (8 in Fig. 19). Here CSF passes multiple small gaps of the membrane or, lateral from it, adjacent limit areas close to N. oculomotorius.

- Larger arteries cross the cisterns and their walls usually distant to the cerebral surface penetrating arachnoid membranes or gaps. A common large gap of the mesencephalic portion of Liliequist's membrane is crossed by A. basilaris and its terminal branches. A. cerebelli sup. is enclosed by two layers of the pontomesencephalic portion of Liliequist's membrane, close to its insertion into the brainstem. The membrane may be a fusion of two membranes, except its division in two layers enclosing A. cerebelli sup. But this course of the artery is close to the cerebral surface only at a short segment of the pontocerebellar rim (Fig. 21).
- Veins are usually running close to the cerebral surface, covered by profound arachnoid structures or close to the pial layer. Veins which are crossing the cisterns are usually V. interpeduncularis, Vv. hippocampi, and short segments of other cisternal veins. Intraventricular and plexus veins are usually covered by ependyma.
- Cranial nerves. Proximal segments of cranial nerves are located close to the cerebral surface. Distal segments are passing luminas and penetrating walls and/or border areas of cisterns.

Extradural extensions of basal cisterns (Figs. 7, 24, 31, to34)

N. olfactorius (Fig. 31)

Trigonum olfactorium is located in Cisterna valleculae (carotid cistern). Tractus olfactorius is enclosed by Yaşargils olfactory cistern. This cistern is the extension of Cisterna valleculae to the proximal segment of Sulcus rectus. Before Tractus olfactorius is reaching the anterior end of Sulcus rectus, it penetrates the outer Arachnoidea. At this point there is no continuation of the cistern along the subdural space in contrast to other cranial nerves. These cranial nerves are lacking a subdural segment.

The subdural location of Tractus and Bulbus olfactorius enables the surgeon to elevate the frontal lobe in a dorsal direction, without shifting Tractus and Bulbus from the basal bed of Bulbus (Lamina cribrosa). The proximal segment of the nerve may be preserved by incision of the outer and cisternal Arachnoidea of the proximal segment of Sulcus rectus, if necessary. Vessels of Tractus olfactorius must be spared (Samii*).

N. opticus (Fig. 31)

The extension of the Dura along Canalis opticus is called Vagina externa n. optici. After entering Orbita, Vagina externa continues to Periorbita (= Periosteum of Orbita). N. opticus is enveloped by this fusioned outer and cisternal Arachnoidea, called Vagina interna n. optici. Between Vagina int. and the nerve is located the subarachnoid space which continues into the lumen of Cisterna chiasmatis. Growth of intracisternal tumors along this CSF space and pulsations of CSF along N. opticus are well known in Neuro-

* and personal communication 1976

Another type of border areas are the variable and inconstant arachnoid tunnels, enclosing arteries (A. cerebri media and main branches) and cranial nerves (N. oculomotorius, N. trigeminus, and N. abducens) as was presented by Key and Retzius in 1876. A simplified illustration is given in Figs. 17 and 18. The large gap of the mesencephalic portion of Liliqequist's membrane may be narrow or obliterated (8 in Fig. 19). Here CSF passes multiple small gaps of the membrane or, lateral from it, adjacent limit areas close to N. oculomotorius.

- Larger arteries cross the cisterns and their walls usually distant to the cerebral surface penetrating arachnoid membranes or gaps. A common large gap of the mesencephalic portion of Liliequist's membrane is crossed by A. basilaris and its terminal branches. A. cerebelli sup. is enclosed by two layers of the pontomesencephalic portion of Liliequist's membrane, close to its insertion into the brainstem. The membrane may be a fusion of two membranes, except its division in two layers enclosing A. cerebelli sup. But this course of the artery is close to the cerebral surface only at a short segment of the pontocerebellar rim (Fig. 21).
- Veins are usually running close to the cerebral surface, covered by profound arachnoid structures or close to the pial layer. Veins which are crossing the cisterns are usually V. interpeduncularis, Vv. hippocampi, and short segments of other cisternal veins. Intraventricular and plexus veins are usually covered by ependyma.
- Cranial nerves. Proximal segments of cranial nerves are located close to the cerebral surface. Distal segments are passing luminas and penetrating walls and/or border areas of cisterns.

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radiology and Neurosurgery. The first detailed illustration was given by Key and Retzius in 1875 (Band I, Tafel XXXII).

N. oculomotorius, N. trochlearis, and N. abducens (Fig. 32)

Its CSF-containing sheaths are located between dural layers of the cavernosus area.

N. trigeminus (Figs. 23 and 32 to 34)

Its Portio major and minor penetrate a wide dural gap which is located close to Incisura trigeminalis of Apex ossis petrosi before the nerve enters Cavum Meckeli. The dural and bony ground is covering Foramen lacerum and its cartilaginous layer, close to Canalis caroticus and its Apertura int. Between Foramen ovale and Canalis caroticus and basal from it is located Tuba Eustachii.

Errors during puncture of Cavum Meckeli may be followed by damage to the Tuba Eustachii and A. carotis int.. Hematotympanon and consecutive anacusis may occur. Formerly this was a complication at Kirschner's coagulation of Ganglion Gasseri for therapy of tic douloureux (Schenk and Seeger, 1968).

The cistern of Cavum Meckeli extends along the main branches of N. trigeminus. For surgical aspects see Part. III.

N. abducens to N. trigeminus

Its anatomical and surgical aspects were described by Yaşargil (1976*). These presentations are up-to-date until today.

PART II
SPECIAL ASPECTS
(Figs. 35 to 60)

Space-occupying lesions of the cerebral base tend to expand into one or more adjacent cisterns. The intracisternal topography of blood-vessels and cranial nerves must be considered during surgery. These are the guiding aspects of the following chapters.

Cisterna laminae terminalis (Figs. 35 to 38)

Cisternal walls and lumina (Fig. 38)

The bottom of the cistern is located at the transition of Gyrus rectus and Area subcallosa close to the dorsal posterior border of Chiasma. It is usually the location of A. communicans ant. (Fig. 38) and its aneurysms.

Arteries (Figs. 35 to 38)

- The anatomy of the large arteries is variable. A. communicans ant. may be located distant from the bottom of the cistern. Arteries of the interhemispheric sulcus present variable branching points at A1 and/or A2, especially A. frontobasalis medialis and A. frontopolaris. These may originate close to A. communicans and close to each other, or remote from it or there may be a common trunk (Fig. 35). Such variants and the variable diameter have to be taken into consideration when identifying Heubner's artery during surgery.
- Three types of Rr. perforantes have to be distinguished (Fig. 38):
  - hypothalamic branches, originating from A. communicans ant., A. corporis callosi mediana (Yaşargil's anterior hypothalamic artery), and/or A2
  - branches feeding Chiasma and N. opticus, originating from A1/A2 and from A. communicans ant.
  - inconstant branches feeding basal ganglia, originating from A1/A2. They penetrate the barrier area of Cisterna laminae terminalis and of Cisterna valleculae.

Veins (Figs. 27 and 28)

The veins accompanying A1, A2 and A. communicans ant. are located close to Pia mater. Usually these veins are thin (Duvernoy 1975)

Cranial nerves: None

Cisterna valleculae (Yaşargil's carotid cistern) (Figs. 14, and 39 to 41)

Cisternal walls and luminas (Fig. 14)

Its roof is Substantia perforata ant.
Its base is the dural penetration area of A. carotis int.
Its lumen is filled entirely by A. carotis int. and its bifurcation.
The bifurcation is located close to Substantia perforata ant.
Neighboring cisterns are Cist. fossae lat., Cisterna chiasmatis and Cist. cruralis (segment of Cist. ambiens).
Limen insulae represents the lateral border of the roof of Cisterna valleculae which is identical with the sharp angled lateral end of Substantia perforata anterior. Some perforations are wide. It contains Aa. lenticulostriatae and the lateral terminal branch of Heubner's artery (7 and 4 in Fig. 58). Lateral from Limen insulae perforating arteries are rare (Fig. 41).

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Arteries (Figs. 39 to 41)

- There are three types of arteries:
  - A.carotis int. and the proximal segments of A. communicans post. and of A. chorioidea ant. prior to the penetration of branches through the wall of Cisterna valleculae (Figs. 40 and 45)
  - Rr. perforantes originating from the carotid bifurcation (6 and 7 at Fig. 40). These arteries enter Substantia perforata ant. without penetrating intercisternal walls or barrier areas.
  - Arteries which penetrate intercisternal walls before or after crossing Cisterna valleculae:
    Heubner's artery (Fig. 41)
    A. hypophysialis sup. (6 at Fig. 45)
    bundles of Rr. perforantes feeding the chorioid point (8 at Fig. 40) and bundles which are entering Substantia perforata ant. (9 at Fig.40)

These three types of arteries are located behind the carotid bifurcation and close to the posterior wall of Cisterna valleculae. Sphenoid ridge meningiomas and other space-occupying lesions are predominantly located anterior to the carotid bifurcation. Surgical exposure of the lesions by separation from the carotid bifurcation and from the cerebral surface (Substantia perforata ant.) are less problematic than surgery for aneurysms of the carotid bifurcation which may be hindered by perforating arteries located between the bifurcation and Substantia perforata ant.

Veins (Fig. 43)

Cisterna valleculae contains small veins which run between arachnoid structures close to the Pia mater of Substantia perforata anterior. It connects anterior cerebral veins and the profound sylvian veins to the venous components of the chorioid point. This venous network presents the feeding veins of V. basalis (Rosenthal), as it is illustrated by cast injections of Duvernoy (1975)

Cranial nerve (Fig. 14)

Trigonum olfactorium is located at the anterior barrier area of Cisterna valleculae close to Substantia perforata anterior. Trigonum lies at the posterior end of Sulcus rectus between Gyrus rectus and orbital gyri. Here Cisterna valleculae merges into Yaşargil's olfactory cistern. This cistern is identical to the subarachnoid space of the posterior segment of Sulcus rectus

Cisterna fossae lateralis (Sylvii) (Figs. 14, 16, and 41 to 44)

Cisternal walls and luminas (Figs. 14 and 42)

Insula and its Sulcus inferior and superior represent the bottom of the sylvian fossa. The anterior part of Insula is overlapped by frontal opercular gyri, its posterior part by Gyrus angularis and Gyrus circumflexus. Limen insulae is interposed between Insula and Substantia perforata ant. and the medial border of the Uncus base.
Sulcus inferior insulae is a landmark for the transsylvian approach to Cornu inferius.
Limen insulae is a landmark for amygdalotomy.

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Limen insulae is a landmark for amygdalotomy.

Arteries (Figs. 41, 42 and 44)

The arteries of the sylvian fissure are A. cerebri media and its branches and Rr. temporales of the carotid artery. Rami temporales of A. cerebri media and the main branch of Rr. tempp., A. temporalis posterior, crosses the sylvian cistern and penetrate the fine arachnoid membrane which forms the basal wall of the sylvian cistern. This wall covers Heschl's and other dorsal gyri of the temporal lobe.
Trifurcation of A. cerebri media present two major branches: the distal trunk of A. cerebri media, and the larger A. operculofrontalis (Ring 1969). Fenestrations of the trifurcation are described by Ito (1982). This has to be considered during aneurysma surgery.
Another surgical aspect is the course of the distal trunk of A. cerebri media which may be used as a landmark for localization of Sulcus inferior insulae during the transsylvian approach to Cornu inferius. In childhood, this artery follows Sulcus inferior. In adults, the artery may present loops covering some insular sulci which may be confounded with Sulcus inferior insulae. Surgical incision in this area would endanger basal ganglia, far from Cornu inferius.

Veins (Fig. 43)

Superficial sylvian veins are covered by arachnoid adhesions of the outer arachnoid membranes and by the underlying arachnoid and pial layers. They cannot be loosened without damaging the temporal cortex. Superficial temporal arteries cross the superficial temporal veins penetrating the adhesions of veins to cortex (B in Fig. 16). Transversal veins connect superficial and profound sylvian veins. Profound veins are located close to Pia mater before it penetrates the barrier to Cisterna valleculae and to Cisterna cruralis and before reaching of chorioid point (Fig. 39).

Cranial nerves: None

Cisterna chiasmatis (Figs. 14, 22, 43, and 45 to 48)

Cisternal walls and lumina (Figs. 43, 46 and 47)

Cisterna chiasmatis is the center of the upper basal cisterns. The cisternal barrier area between Cisterna chiasmatis and Cisterna laminae terminalis is located between Chiasma and the outer arachnoid membrane. The barrier between Cisterna chiasmatis and Cisterna valleculae is the lateral margin of N. opticus – Chiasma – Tractus opt. and the medial segment of Cisterna cruralis, as shown in Fig. 14. These areas predominantly consist of arachnoid membranes interrupted by multiple gaps and trabecula, as described by Key and Retzius (1876). The lateral wall separates Cisterna chiasmatis and Cisterna valleculae (carotid cistern). The posterior wall is divided into two segments: One segment which separates Cisterna chiasmatis from Pars profunda of Cisterna interpeduncularis and the other which separates Cisterna chiasmatis from Pars superficialis, as shown in Fig. 22. Only the second part is identical to the well defined Liliequist's membrane and is located below the trabecular structured border of Cisterna chiasmatis and Pars profunda of Cisterna interpeduncularis.
At the cranial base, Cisterna chiasmatis is limited by Dorsum sellae (insertion of Liliequist's membrane), Plica petroclinoidea ant., and by the interoptic sulcus. A fine

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septum in the midline (Key and Retzius, 1876) is found inconstantly or may be interrupted by gaps.

Arteries (Figs. 45 to 47)

The lateral wall of Cisterna valleculae encloses A. communicans post. and A. chorioidea ant., before their branches penetrate this wall and lead to the roof of Cisterna chiasmatis. These branches are predominantly Rr. perforantes. Their target areas are cerebral structures at the roof of Cisterna chiasmatis and neighboring cisterns, especially the barrier areas of Cisterna chiasmatis and Cisterna ambiens (along Tractus opticus and close to Crus cerebri). These arteries are mixed with the anterior group of perforating arteries which originate from the basilar bifurcation. Further fine branches originate from A. carotis int.. After crossing of Cisterna valleculae, Rr. optici and A. hypophysialis sup. perforate the wall between Cisterna valleculae and Cisterna chiasmatis.

Veins (Fig. 43)

A network of fine veins at the roof of Cisterna chiasmatis and adjacent cisterns is connected with deep sylvian veins, V. interpeduncularis, venous components of the choroid point, and with V. basalis (Rosenthal).

Cranial nerves (Figs. 43 and 45 to 47)

The configuration of Cisterna chiasmatis is dependant on variants of Chiasma (prefixed or retropositioned). The position of the Infundibulum and the length of the hypophyseal stalk also depend on the localization and configuration of the chiasma. A prefixed Chiasma is combined with a short and prepositioned hypophyseal stalk. A retropositioned Chiasma is located far dorsal from the coronal level of Dorsum sellae. Combined with this type is a long hypophyseal stalk. According to these variants, the length of N. opticus is variable. Variants of the dural penetration points of N. oculomotorius and N. trochlearis and variants of A. carotis int. are illustrated in Fig. 10. Most variants can be identified by MRI.

Cisterna interpeduncularis (Figs. 21, 22, and 46 to 49)

Cisternal walls and lumina (Fig. 48)

Pars superficialis of Cisterna interpeduncularis (containing the basilar bifurcation) is the target of the transforaminal endoscopic ventriculocisternostomy. Before entering this cistern, the narrow Pars profunda must be penetrated. Pars profunda is interposed between the floor of the third ventricle and the axial segment of the diencephalic portion of Liliequist’s membrane (Figs. 21 and 22). The membrane is connected with Corpora mamillaria a few millimetres posterior of the surgical approach. The border to Cisterna chiasmatis lies anterior. Here trabecula of Pars profunda of Cisterna interpeduncularis are rare. This point is located close to Infundibulum. It is present, if the approach is located rostrally from the usual route. At the usual route, trabecula and anterior Rr. perforantes of the basilar bifurcation may obstruct the surgical approach.

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Veins (Fig. 43)

A network of fine veins at the roof of Cisterna chiasmatis and adjacent cisterns is connected with deep sylvian veins, V. interpeduncularis, venous components of the choroid point, and with V. basalis (Rosenthal).

Cranial nerves (Figs. 43 and 45 to 47)

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Variants of arachnoid adhesions and of vessels, as well as the degree of hydrocephalus may produce variable surgical findings. If the surgical approach is located anterior from the usual route, a second membrane may be present. This membrane is the mesencephalic portion of Liliequist's membrane, anterior from its gap and anterior from the basilar bifurcation*. This is the arachnoid membrane between Pars superficialis of Cisterna interpeduncularis and Cisterna pontis medialis. A narrow variant of the arachnoid gap and a displacement of A. basilaris and its branches should be considered.

Arteries (Figs. 48 and 49)

Large arteries are the basilar bifurcation and its branches. Its numerous perforating branches form posterior and anterior bundles. The posterior bundles consist of Aa. thalamoperforantes at Substantia perforata post. and branches feeding Crus cerebri. These are arteries exclusively located in the lumen of Pars superficialis of Cisterna interpeduncularis. The anterior bundles penetrate the diencephalic membrane of Liliequist. They run nearly parallel between and below Corpora mamillaria. They cross the medial segment of Pars profunda of Cisterna interpeduncularis, penetrate the anterior barrier area of this cistern, close to Tuber cinereum, before running close to the roof of Cisterna chiasmatis (Fig. 48).

Veins (Fig. 43)

The predominant vein is a y-shaped vein, V. interpeduncularis. It begins in Cisterna pontis medialis and connects pontine veins with the feeding veins of V. basalis (Rosenthal) after passing Pars superficialis of Cisterna interpeduncularis, Cisterna cruralis, and Cisterna ambiens. A venous network at the roof of Cisterna interpeduncularis and Cisterna chiasmatis also connects to the feeding veins of V. basalis (Rosenthal).

Cranial nerve (Fig. 48)

The relationship of N. oculomotorius to cisterns is presented in Part I. Surgery at the exit of the nerve at the medial surface of Crus cerebri may be difficult by the overlapping basilar bifurcation. Further variants of the roots of N. oculomotorius to its exit points at the midbrain:

- The roots may originate at the medial anterior segment of Crus cerebri
- The roots may present a compact bundle, or
- The roots may present a long vertical row at their cerebral exit segment before converging to the compact nerve.

The nerve runs underneath A. cerebri post. **lateral** to the connection of A. communicans post. and A. cerebri post. (18 in Fig. 28).

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* Endoscopic intraoperative demonstration by Dr. Nestler and Dr. Preuß, coworkers of Prof. Dr. Böker, Neurochirurgische Universitätsklinik Giessen, to the author

Cisterna ambiens and Cisterna cruralis (Figs. 43 and 48 to 51)

Cisternal walls and luminas (Fig. 48)

Cisterna ambiens, Cisterna valleculae and Cisterna fossae lateralis form an U-shaped configuration surrounding the base of Uncus. The roof of Cisterna ambiens is the flattened Tractus opticus, which is not useful as a surgical landmark during amygdalectomy, in contrast to the medial extension of this cistern, Cisterna cruralis. In this area Tractus opt. is readily identifiable. Resections of Corpus amygdaloides (which is enclosed by Gyrus uncinatus) might jeopardize Aa. perforantes crossing Uncus-Amygdala-base. Furthermore the pyramidal tract, which is located close to this area, surrounded by the flattened Tractus opt. is put at risk.

The topographical orientation during surgery at the ponto-mesencephalic rim is easier. A. cerebelli sup. is a landmark in this area, overlapping A. tecti and A. chorioidea post med. which are surrounded by the mesencephalic portion of Liliequist's membrane medially and basally from Cisterna ambiens/cruralis (a and 8 in Fig. 48).

Arteries (Figs. 49 to 51)

Large arteries of Cisterna ambiens and cruralis are:
- P2-segment of A. cerebri post.
- A. communicans post.
- A. choroidea ant.

Rr. perforantes originate from these large arteries. They perforate the anterior and lateral surface of the midbrain and the inferior surface of Tractus opticus at its medial and lateral rim.

Veins (Figs. 29 and 43)

V. basalis (Rosenthal) is the major vein of Cisterna cruralis and connects with Vv. cerebri ant., deep sylvian veins,V. interpeduncularis and the venous network of Tuber cinereum and adjacent structures.Further it connects to the subependymal veins (inferior tip vein, V. ventricularis inf., plexus vein).
These veins connect the basal vein of Rosenthal to the inner cerebral veins at its originating segment, the choroid point. The choroid point is at the connection point of upper cisternal veins. All these veins are connected with the posterior segment of the inner cerebral veins by the large connection of V. basalis (Rosenthal) to V. magna (Galeni) or Vv. cerebri intt. This system of a venous circle is supplemented by connections to the veins of infratentorial cisterns. The main connections are V. mesencephalica lat. and its connections to Pons, and V. interpeduncularis and its connections to Pons.

Cranial nerves (Figs. 48, 50, and 51)

These are N. oculomotorius and N. trochlearis.
N. oculomotorius transcrosses Cisterna interpeduncularis, Cisterna cruralis and the basal segment of Cisterna chiasmatis. At this transcisternal course it penetrates the common segments of border areas of these cisterns, as it is well known by surgery of supra- and retrosellar speace-occupying lesions.

N. trochlearis is running along the basal area of Cisterna ambiens and Cisterna cruralis, without adhesions to the common border area of cisterns surrounding N. oculomotorius.

During a cadaver head dissection Dr.Kaminsky, Freiburg*, demonstrated to the author an anatomical approach to the cerebellopontine cistern. During this endoscopic approach N. trochlearis was identified along the transcisternal course from Tectum to its dural exit point.

* coworker of Prof. Dr. Zentner, Freiburg

PART III
SYNOPSIS
Figs. 52 to 60

Relationship of cisterns to vessels and relationship of cranial nerves to intra- and extradural structures (Figs. 52 to 60, and Figs. 7, 10, 14, 17, 22 to 24, 29, 31 to 34, 38, 40, 43, and 49)

The topography of the brain and its vessels and cranial nerves is defined using imaging methods. CTs and MRTs with 3D reconstruction may be applied into addition to cadaver brain dissections. Individual exact distance measurements can be taken from the imaging studies nowadays. Even high resolution imaging does not allow the definition of arachnoid structures, fine vessels or fascicles of cranial nerves. Here cadaver brain- and skull-dissections are necessary to acquise the microsurgical and endoscopic techniques, as demonstrated in Freiburg in 2006 by Al Mefty, and by Snyderman et al.

Relationship of cisterns to each other (Figs. 7, 14, 17, and 22 to 24)

The craniobasal relief of the cisterns, as shown in Fig. 7, is not congruent with its cerebrobasal relief (Fig. 14).
Typical overlapping of cisterns may be emphasized:

- Cisterna interpeduncularis overlaps the deep-seated segment of Cisterna chiasmatis posterior. Below this area a bulging of Liliequist's membrane narrows Cisterna chiasmatis in an anterior direction, as shown in Figs. 22 and 23.
- Cisterna pontis medialis overlaps Cisterna pontis lateralis, as shown in Figs. 23 and 24.
- Cisterna interpeduncularis overlaps Cisterna pontis medialis and lateralis. Please compare 7 and 9 in Fig. 7 (superficial relief) to Fig. 23 (deep-seated cisternal compartments).
- The border areas of Cisterna chiasmatis, Cisterna interpeduncularis, and Cisterna ambiens/cruralis, which are penetrated by N. oculomotorius, as shown in Figs. 17 and 24.

Relationship of arteries to surrounding structures (Figs. 52 to 60)

- Large arteries and their perforating branches may be located in only one cistern (carotid bifurcation e.g.). Other arteries may cross two ore more cisterns and penetrate cisternal walls and border areas (A. basilaris between Cisterna pontis medialis and Pars superficialis of Cisterna interpeduncularis, and its perforating branches, e.g.). These types are presented at 6, 8, and 9 in Fig. 40.
- The course of perforating arteries of Circulus arteriosus (Willis) through the cisterns may be very variable (Fig. 56). A high density of perforating arteries is not confined to arteries of Substantia perforata ant. and post. Even the rims between Tractus opticus and Tuber cinereum, the rims between Area subcallosa and Lamina terminalis, the dorsal surface of Chiasma close to Lamina terminalis (area of aneurysms of A. communicans ant.), and the rim between Tractus opt. and Mesencephalon may be highly vascularized (Figs. 38 and 49).

  Usually arteries penetrate cisterns distant from the cerebral surface. Some bundles of perforating arteries may overlap cerebral structures without penetrating them: The roof of Fossa interpeduncularis (superior from Substantia perforata post.), and Tuber cinereum. It is well known from ventriculostomies that the vascularization of the midline area of Tuber cinerum between Infundibulum and Corpora mamillaria is rare. The underlying Pars profunda of Cisterna interpeduncularis contains numerous perforating arteries originating from the bifurcation of A. basilaris.

Relationship of veins to adjacent structures (Figs. 29 and 43)

The following veins connect to the temporomedial choroid point which represents the venous network feeding V. basalis (Rosenthal).

- Deep and superficial Sylvian veins connect V. basalis (Rosenthal) and its feeding veins to superficial cerebral veins: Sinus alae minoris and its connections to Sinus cavernosus.
- This venous system connects to infratentorial veins by the variable V. mesencephalica lat. which is a feeding vein of V. basalis (Rosenthal).
- The anterior connection of V. basalis (Rosenthal) to the inner cerebral veins are the subependymal located veins of Cornu inf. and their subependymal connections before reaching Fissura transversa and Vv. cerebri intt..
- V. mesencephalica lat. and Sinus petrosus sup. connect infratentorial veins to Sin. petrosus inf. and Plexus basilaris (veins of Clivus) to Sinus cavernosus.
- Hippocampal veins cross Cisterna cruralis and connect to Rosenthal's vein.

Most venous connections of the basal cisterns are fine,but nearly constant venous systems. Encephalomalacia following surgical interruptions are rare. Nevertheless, large variants should be taken into consideration preoperatively based on MR-venographic finding.

- Subependymal veins
- Bridging veins of superficial sylvian veins to Ala minor and their connection to Sinus cavernosus, and
- V.petrosa sup. / Sinus petrosus sup. and its connection to pontine veins

Relationship of cranial nerves to adjacent structures (Figs. 10, 17, 24, and 31 to 34)

- N. olfactorius is the only cranial nerve with a segment running along the subdural space, Bulbus olfactorius included. This allows the surgeon to elevate the frontal lobe without shifting and elevating the distal segment of Tractus olfactorius and Bulbus olfactorius from Lamina cribrosa. The intracisternal proximal segment of the nerve may be loosened from the cistern by incision of its arachnoid caves if necessary.
- Vagina ext. n. optici is the dural layer covering Canalis opt. and connecting to the Periosteum of Orbita (= Periorbita). Vagina int. n. optici is the arachnoid envelope of the nerve and its CSF space between Foramen opticum and Bulbus oculi.

Surgical decompression of the nerve may be started by incision of the dural fold at the roof of Foramen opticum*.

- N. oculomotorius crosses Cisterna interpeduncularis and short segments of Cisterna cruralis, Cisterna pontis lateralis, and the barrier area of Cisterna valleculae to Cisterna chiasmatis (Fig. 17). Variants of the dural penetration points of the nerve may

* After an idea of Prof. H. Friedrich, former chairman of Neurochirurgische Abteilung of Asclepios Klinik Hamburg Heidberg

be combined with such of N. trochlearis (Fig. 10). The arachnoid cover of the nerve during its course through the cavernous sinus are similar to the covers of N. trochlearis, N. ophthalmicus and N. abducens (Fig. 32).

- N. trochlearis accompagnies the tentorial edge before penetrating the basal dura between Plica petroclinioidea post. and ant. (Fig. 10). Here N. trochlearis runs below the barrier area of Cisterna cruralis, valleculae, and chiasmatis, after crossing over N. trigeminus (Fig. 24). There are usually no arachnoid adhesions.
- N. trigeminus (Figs. 32 to 34). Its ganglion and main branches are covered by arachnoid sheaths and cisternal CSF spaces. Tumor expansions into the cavernosus area along N. ophthalmicus follow these arachnoid linings. If the arachnoid covers of N. maxillaris are damaged, this might lead to CSF flattage through Sin. sphenoidalis. Surgical approaches to the Cavum Meckeli (Krause / Spiller-Frazier's approach) are difficult because opening of the CSF space of Cisterna trigemini is not possible at the level of Foramen ovale. The subarachnoid space enclosing N. mandibularis is narrow. At Foramen ovale the nerve is surrounded by a thickened dural layer. In earlier times surgeons tried to loosen the dural sheath of Gasserian's ganglion from the temporobasal dura by dissection. Short incision above the Foramen ovale is recommended, as described by Krayenbühl (1968). This temporobasal approach for surgical treatment of tic douloreux was common before Janetta introduced microvascular decompression of the nerve at its exit from the brainstem. There might be some indications for the temporobasal approach for tumors of Cavum Meckeli.

Cranial nerves VI to XII are not related to upper basal cisterns.

ANATOMICAL NEURONAVIGATORY LANDMARKS
OF THE CRANIAL AND CEREBRAL BASE (Figs. 1 to 8)

Fig. 1

Landmarks at the cranial base (black arrows) and landmarks at the inner dural layers close to the basal cisterns (light arrow) are not always congruent, especially at the cavernosus area and adjacent structures

A Area of Curvatura ant. of the carotid siphon. Non-osseous structures added
B Topogram for A (copy of a cadaver skull dissection)

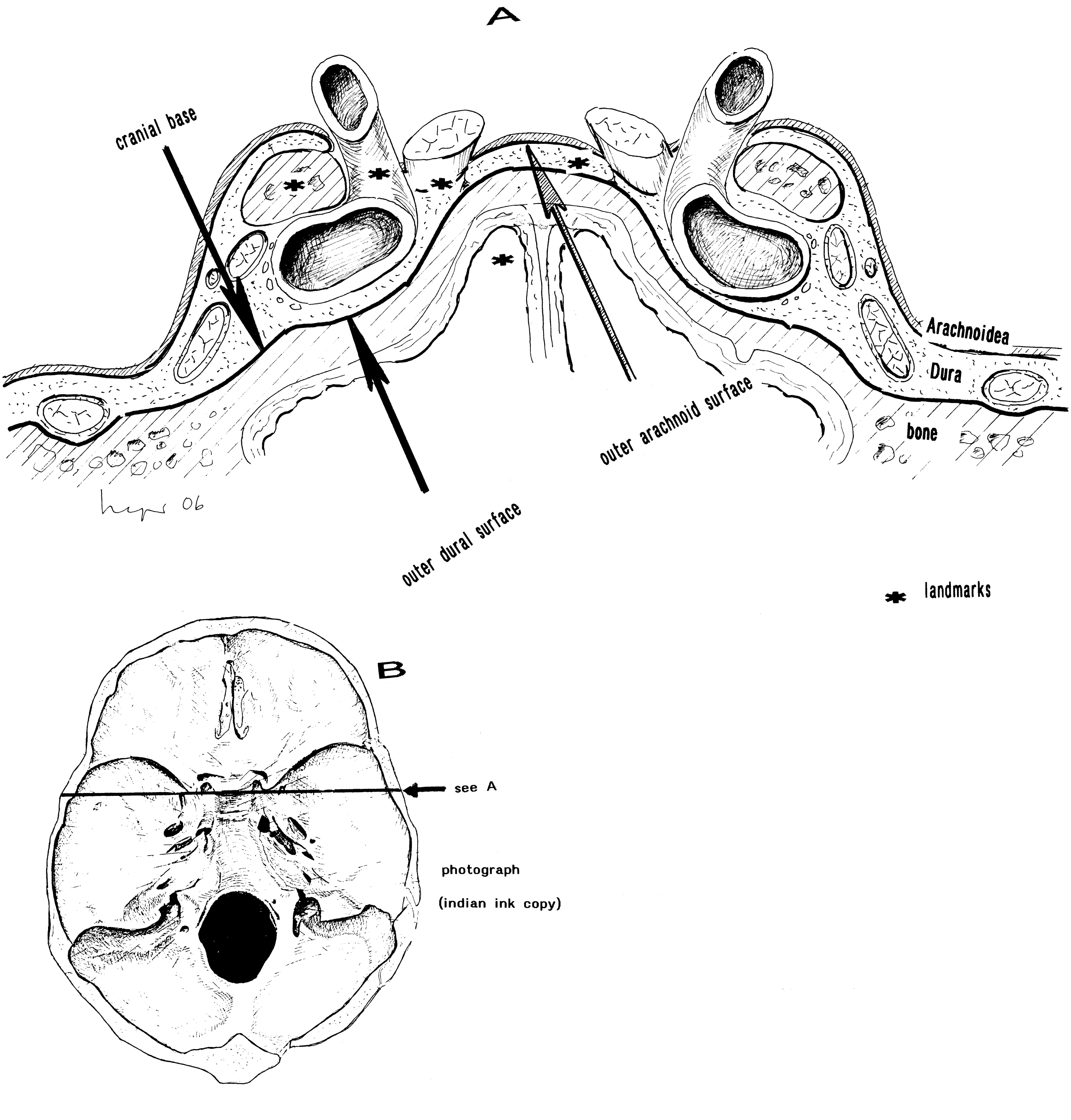
A
cranial base
Arachnoidea
Dura
bone
outer arachnoid surface
outer dural surface
landmarks
B
see A
photograph
(indian ink copy)

Fig. 2

Details of the medial segments of the cranial base which may be used as neuronavigatory landmarks

Abbreviations

1 Crista galli
2 Lamina cribrosa
3 Interoptic line
4 Foramen opticum
5 Processus clinoideus ant.
6 Ala minor
7 Foramen rotundum
8 Sulcus between For. ovale and rotundum
9 Foramen ovale
10 Sulcus a. meningeae mediae
11 Foramen spinosum
12 Foramen lacerum
13 Impressio n. trigemini
14 Sulcus petrosus inf.
15 Sulcus petrosus sup.
16 Sulcus transversus / sigmoideus
17 Sulci underlying Nn. IX to XI
18 Canalis condylaris
19 Canalis n. hypoglossi
20 Sulcus transversus
21 Foramen jugulare, posterior segment
22 Foramen jugulare, anterior segment
23 Porus acusticus int.
24 Apertura int. of Canalis caroticus int.
25 Dorsum sellae
26 Sella
27 Incisura for siphon of A. carotis int.
28 Tuberculum sellae
29 Sulcus chiasmatis
30 Foramen coecum
31 Sulcus sagittalis

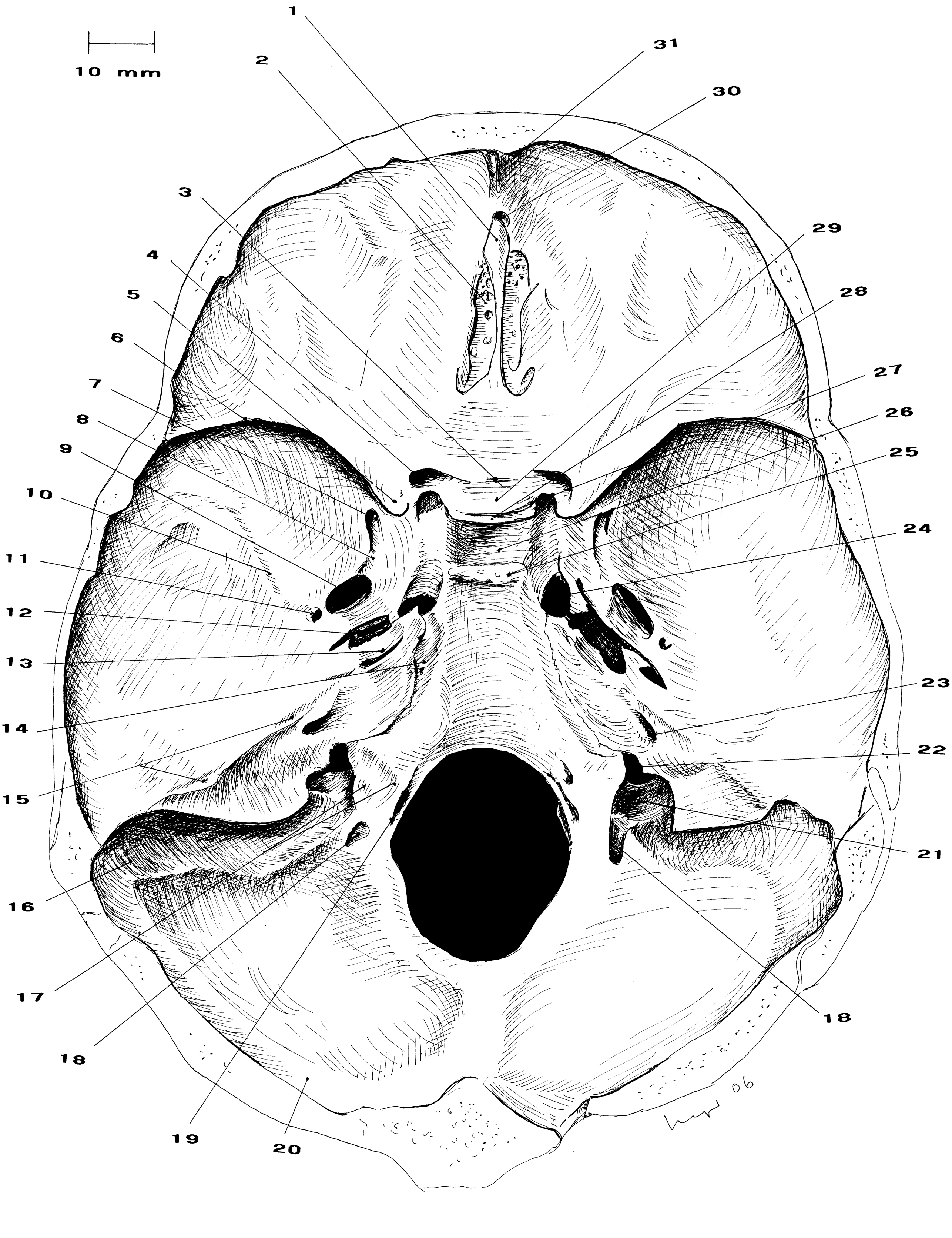
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Fig. 3

Shape of the outer dural surface. Model using a ceramic cast of skull dissection Fig. 2. Indian ink copy taken from a photograph.

Structures of the ceramic relief, which are corresponding to

1 Crista galli
2 Lamina cribrosa
3 Interforaminal sulcus / interoptic sulcus
4 Foramen / Canalis opticus
5 Incisura between Tuberculum sellae and Processus clin.ant. containing A. carotis interna
6 Ala minor
7 Foramen rotundum / N. maxillaris
8 Bony sulcus between For. ovale and rotundum (for N. maxillaris)
9 Foramen ovale – N. mandibularis-Ganglion Gasseri-complex:
10 (see left hemisphere) Sulcus a. meningeae mediae
11 For. spinosum
12 For. lacerum (high variability)
13 Apex ossis petrosi with its Hamulus
14 Sulcus petrosus inferior / Sinus petrosus inf.
15 Sulcus petrosus superior / Sinus petrosus sup.
16 Sulcus transversus and sigmoideus / knee of the sinus
17 Tuberculum jugulare and its fine sulci (inconstant)/fascicles of Nn. IX to XI
18 Canalis condylaris (variable) / Emissarium condylare
19 Canalis n. hypoglossi (right hemisphere: double variant)
20 Sulcus transversus
21 Foramen jugulare / Bulbus sup. v. jugularis internae
22 Foramen jugulare / Nn. IX to XI and Sinus petrosus inf.
23 Porus acust. int. / Nn. VII-VIII
24 Canalis caroticus
25 Dorsum sellae
26 Sella / Hypophysis and its wrappings
27 Anterior area of Uncus
28 Tuberculum sellae
29 Sulcus chiasmatis
30 Foramen coecum, beginning of Sinus sagittalis sup.
31 Sulcus sagittalis / Sinus sagittalis superior

* Fissura orbitalis sup. (in Fig. 2 overlapped by Ala minor)

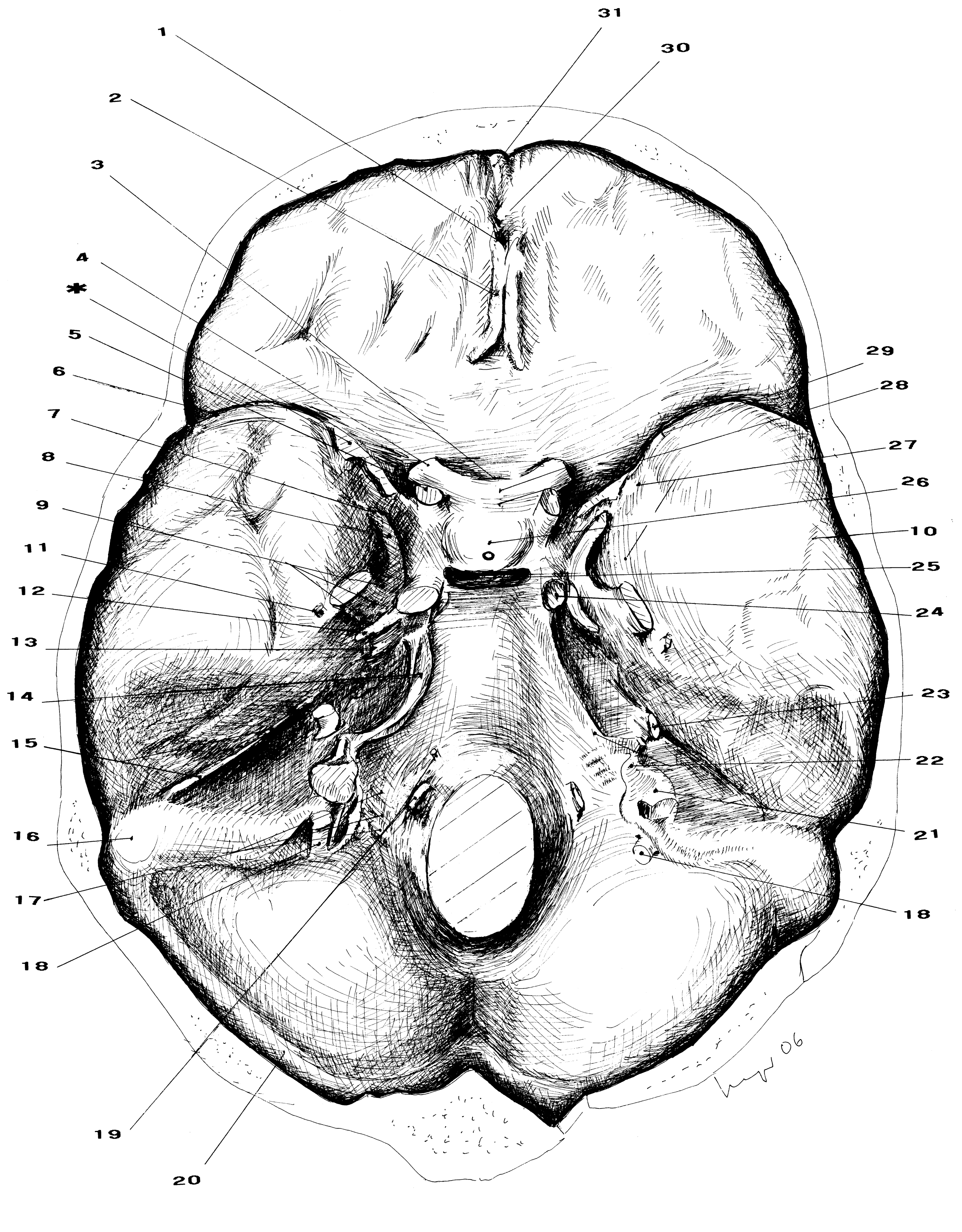
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Fig. 4

Continuation of Fig. 3
Sectional enlargement.

Structures of the ceramic relief, which are corresponding to

1 Lamina cribrosa
2 Planum sphenoidale / Gyrus rectus, Gyri orbitales
3 Interforaminal sulcus / interoptic sulcus
4 Sulcus chiasmatis / Sulcus chiasmatis of embryonic and infantile brains
5 Tuberculum sellae / barrier area of Cisterna lam. terminalis and Cisterna chiasmatis
6 Foramen opt. / N.opt. and A. ophthalmica (usual course)
7 Gap between 5 and 26 / dural penetration of A. carotis int.
8 Fissura orbitalis sup. / transition of Dura and Periorbita, cranial nerves III, IV, VI, VI, V. ophthalmica sup.
9 Sella / wrappings of Hypophysis
10 Medial segment of Fossa cranii media / Uncus and basal cisterns
11 Excavation corresponding to Dorsum sellae
12 Apertura int. of Can. caroticus of the petrous bone / A. carotis int.
13 Ceramic crest corresponding to For. lacerum / A. carot.int., Ganglion Gasseri
14 Continuation of 10 / Gyrus parahippocampalis
15 Facies posterior of the petrous bone/Flocculus, Brach.pontis, Gyrus quadrang.
16 Meatus acusticus int. / Nn. VII and VIII, A. labyrinthi, AICA
17 Sulcus petrosus inf. / Sinus petrosus inf.
18 For. occipitale / its contents
19 For. jugulare / Bulbus sup. v. jugularis internae
20 Foramen jugulare / Nn. IX to XI, and the terminal segment of Sinus petrosus inf.
21 As 15
22 Sulcus petrosus sup. / Sinus petrosus sup.
23 As 13
24 For. ovale / N. mandibularis (V3)
25 For rotundum / N. maxillaris
26 Excavation corresponding to Processus clin. ant.
27 Clivus / Pons and adjacent structures
28 Clivus / Medulla oblongata and adjacent structures

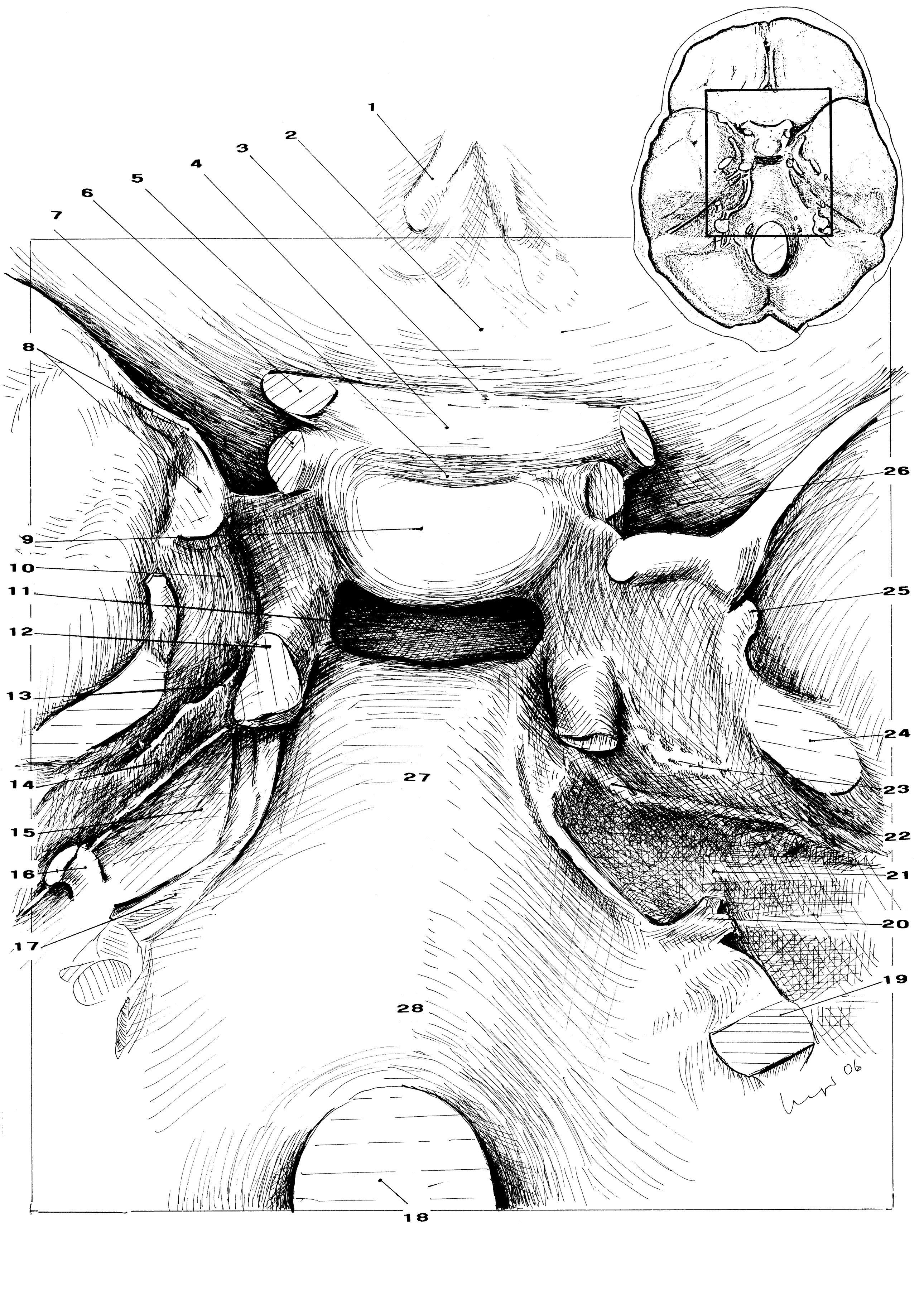
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Fig. 5

Structures which are enclosed by dural outer and inner dural layers
Drawing according to cadaver skull dissections and MRTs. Neuronavigatory landmarks indicated

Abbreviations

1	Foramen coecum
2	Crista galli
3	Bulbus olfactorius
4	Lamina cribrosa
5	Dural branch of A. ethmoidalis post.
(6)	Dural fold
(7)	Anterior wall of Sella below – Tuberculum sellae, variant
(7a)	Posterior wall of Sella below – Dorsum sellae
(8)	Plica petroclinoidalis ant.
9	Tuberculum sellae
10	Foramen rotundum
11	Floor of Sella
12	Bony sulcus for N. maxillaris
(13)	Gap of Diaphragma sellae and hypophyseal stalk
14	Processus clinoideus post.
15	Foramen ovale
16	Hamulus of Apex ossis petrosi
17	A. carotis int. at Apertura int. of the carotid channel
18	Tuberculum jugulare
19	Margin of Canalis caroticus according to 17
20	N. maxillaris according to 12
(21)	Plica petroclinoidalis post
22	Curvatura post of siphon of A. carotis int.
23	N. maxillaris

III to VIII	Cranial nerves (main trunks)
( )	Projections
*	Landmarks

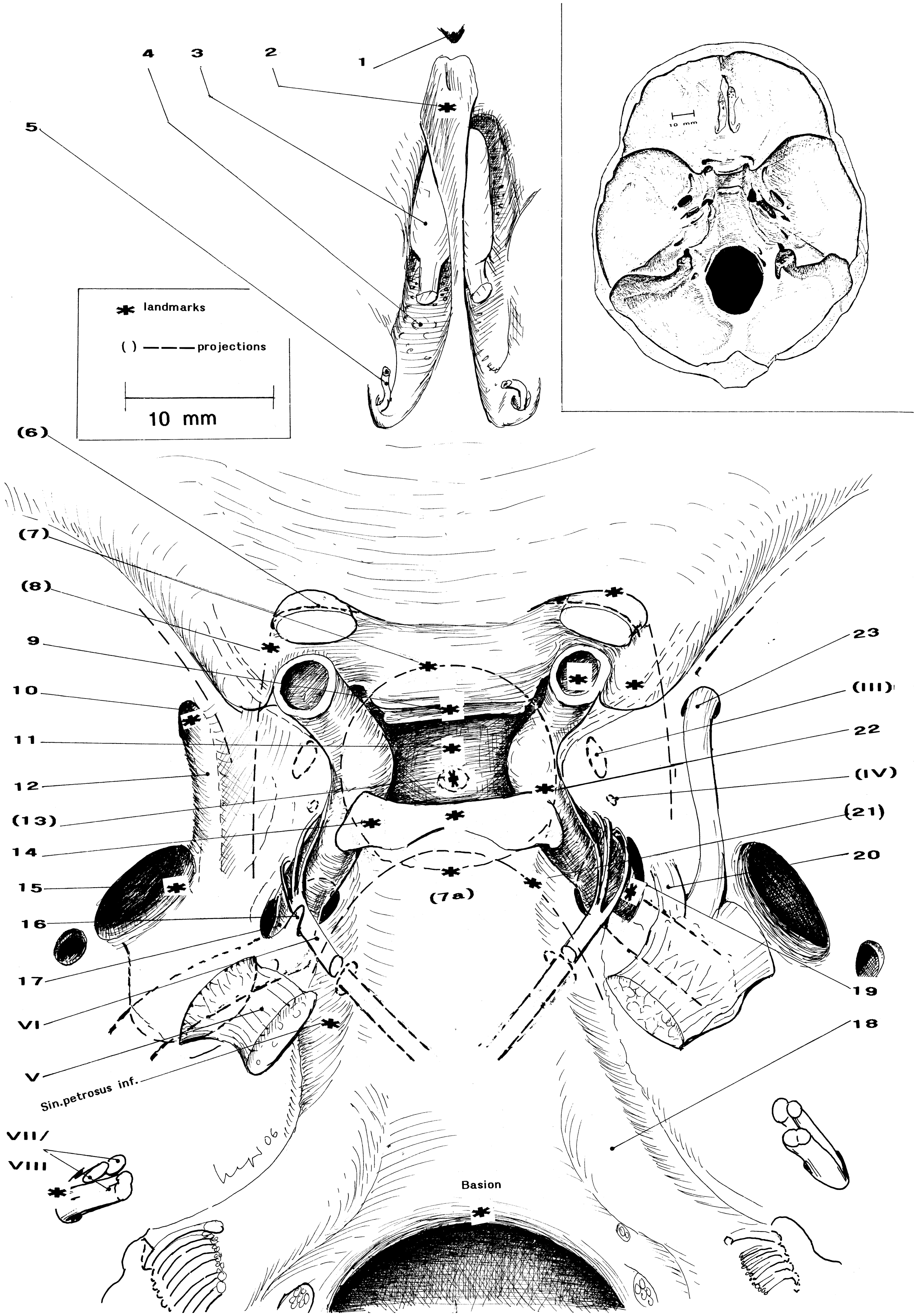

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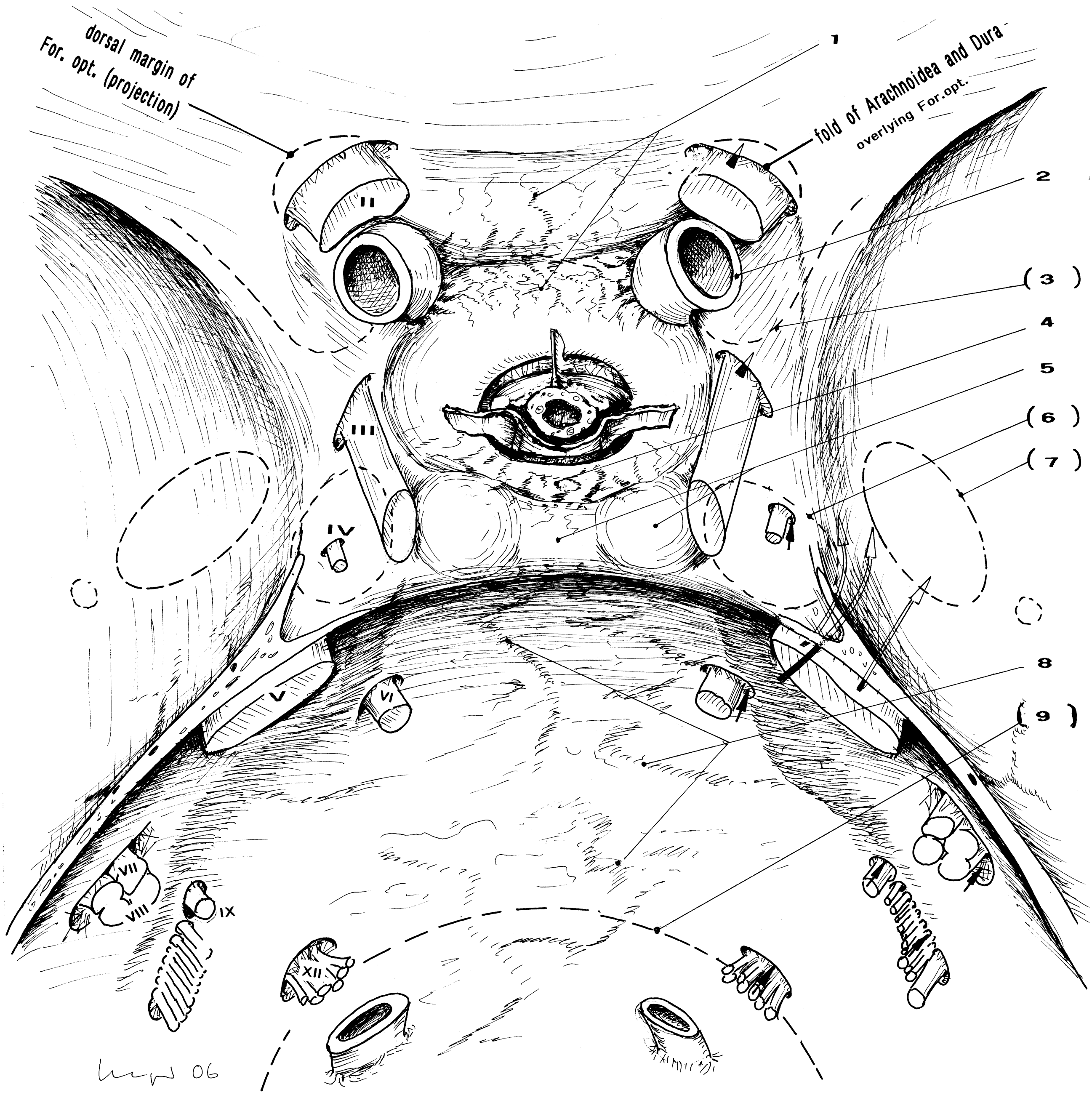
Fig. 6

Surface of the outer arachnoid membrane. Transparent presentation of the inner surface of the Dura

Abbreviations

1	Sinus intercavernosus ant.
2	A. carotis int.
(3)	Processus clinoideus ant. (projection)
4	Sinus intercavernosus post.
5	Reduced vascularization of Dorsum sellae and Processus clinoideus post.
(6)	Apertura int. of Canalis caroticus of the petrous bone (projection)
(7)	For. ovale
8	Plexus (venosus) basilaris
(9)	Foramen magnum

II to XII	Cranial nerves
( )	Projections



dural penetration of cranial nerves

Fig. 7

Surface of the outer arachnoid membrane. Transparent presentation of the walls and barrier areas of cisterns according to Yaşargil (1976). Yaşargil's presentations based on colored cast injections of cadaver brain dissections*

A Relief of basal cisterns. Indian ink copy of Yaşargil's illustration of 1976
B Details added:
- Cisterna olfactoria (1) merges into Cisterna valleculae (carotid cistern) anteriorly. It is identical to the CSF space of Sulcus rectus, containing Tractus olfactorius. In this drawing the cisternal compartments are opened by splitting of the outer Arachnoidea and the fusioned cisternal membranes. Note the subdural course of the distal segment of Tractus olfactorius.
- The outer arachnoid layer and cisternal structures accompany cranial nerves crossing the dural penetration points or channels

Abbreviations

1	Olfactory cistern
2	Cisterna laminae terminalis
3	Cisterna chiasmatis
4	Cisterna valleculae (carotid cistern)
5	Cisterna fossae lat. (Sylvii)
6	Cisterna cruralis (compartiment of Cisterna ambiens)
7	Cisterna interpeduncularis
8	Cisterna ambiens
9	Cisterna pontis
10	Cisterna pontocerebellaris
11	Lateral medullary cistern (Yaşargil), compartment of Cisterna medullaris
I to XI	Cranial nerves

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* Personal demonstration of illustrations by Prof. Yaşargil to author in 1976

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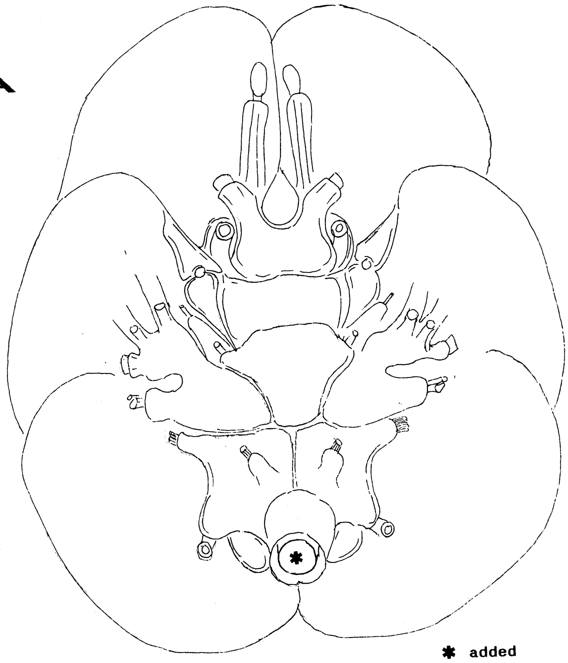
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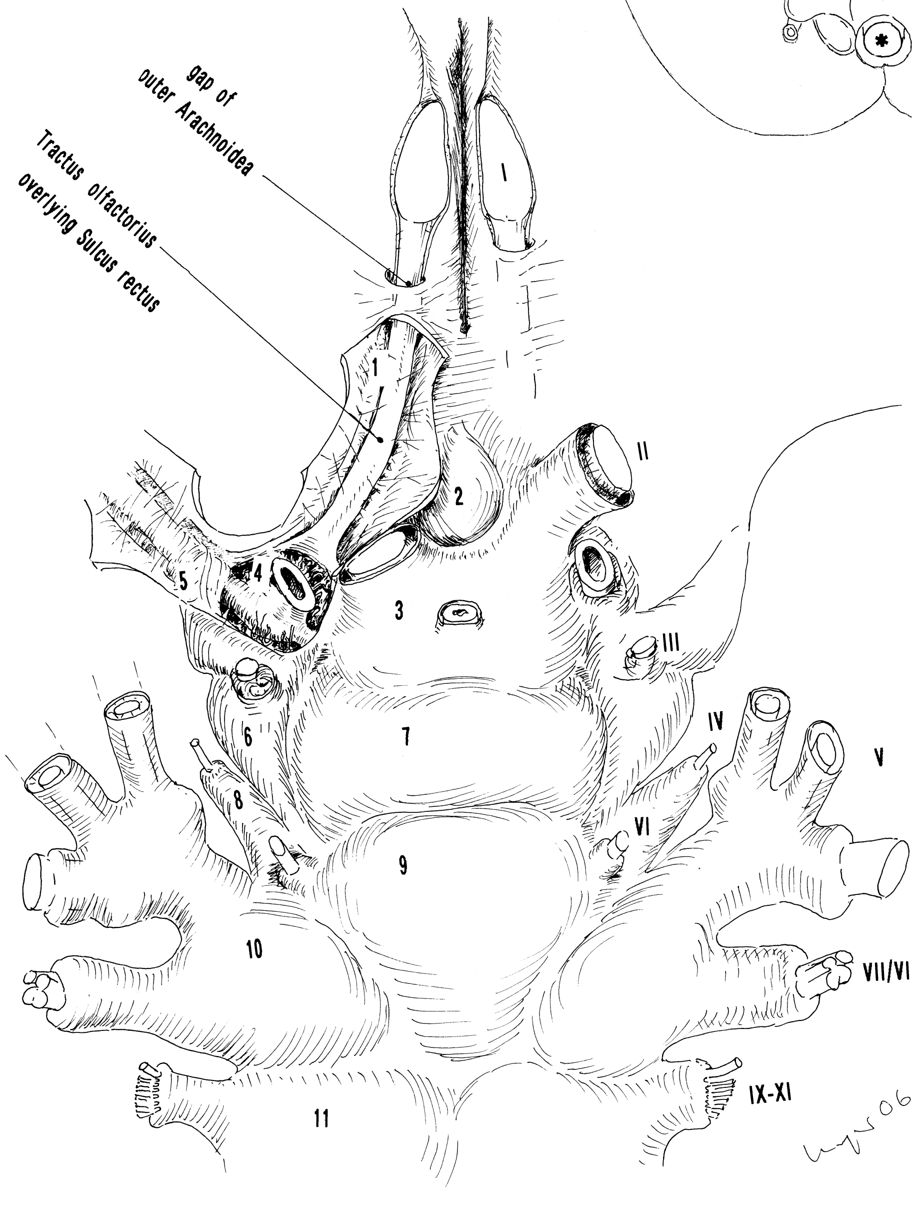
gap of
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Fig. 8

Constant neuronavigatory landmarks at the base of a cadaver skull dissection (male, 65 y, senile atrophia). Non-osseous structures added. Indian ink copy of a photograph.

Abbreviations

1 Tuberculum sellae
2 A. carotis int., level of Tuberculum sellae and Processus clinoideus ant.
3 For. opticum and N. opticus
4 Processus clinoideus ant.
5 Hypophyseal stalk at level of Diaphragma sellae
6 Apertura int. of the carotid channel of the petrous bone
7 Processus clinoideus post.
8 Foramen ovale
9 Dorsum sellae

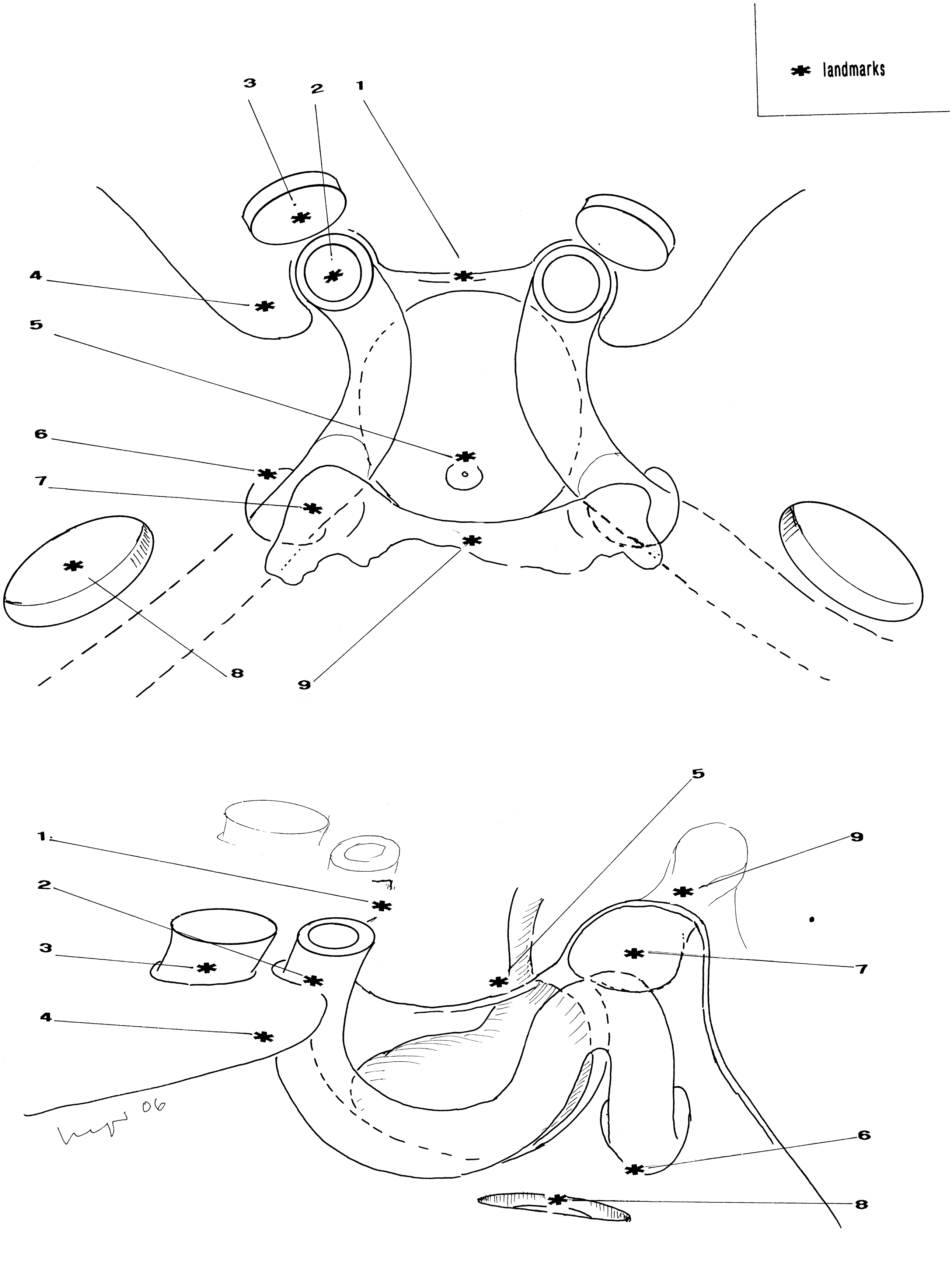
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Fig. 9

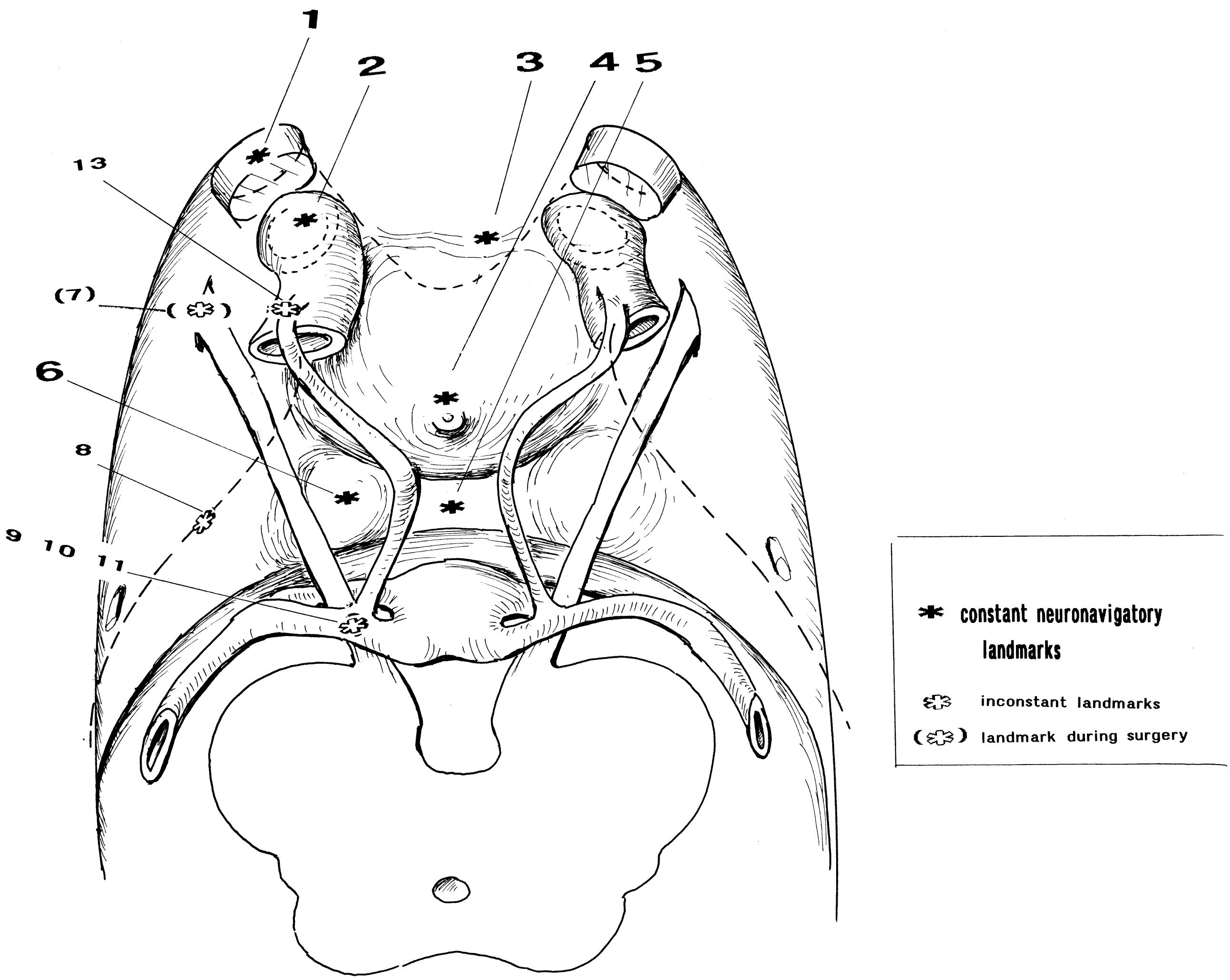
Continuation of Fig. 8.
Inconstant neuronavigatory landmarks added.

Constant landmarks independent on brain shift during surgery

1 N. opticus close to Foramen opticum
2 Dural penetration point of A. carotis int.
3 Tuberculum sellae
4 Hypophyseal stalk close to Diaphragma sellae
5 Dorsum sellae
6 Processus clinoideus post.

Inconstant landmarks dependent on brain shifting during surgery

7 N. oculomotorius close to its dural penetration point can only be identified during surgery, not by neuronavigation (7)
8 Tractus opticus anterior from Crus cerebri (projection)
9 Crossing point of N. oculomotorius and inferior margin of A. cerebri post.
10 Crossing point of N. oculomotorius and superior margin of A. cerebelli sup.
11 Connection of A. communicans post. and A. cerebri post.
12 Origin of A. choroidea ant. from A. carotis int.
13 Origin of A. communicans post. from A. carotis int.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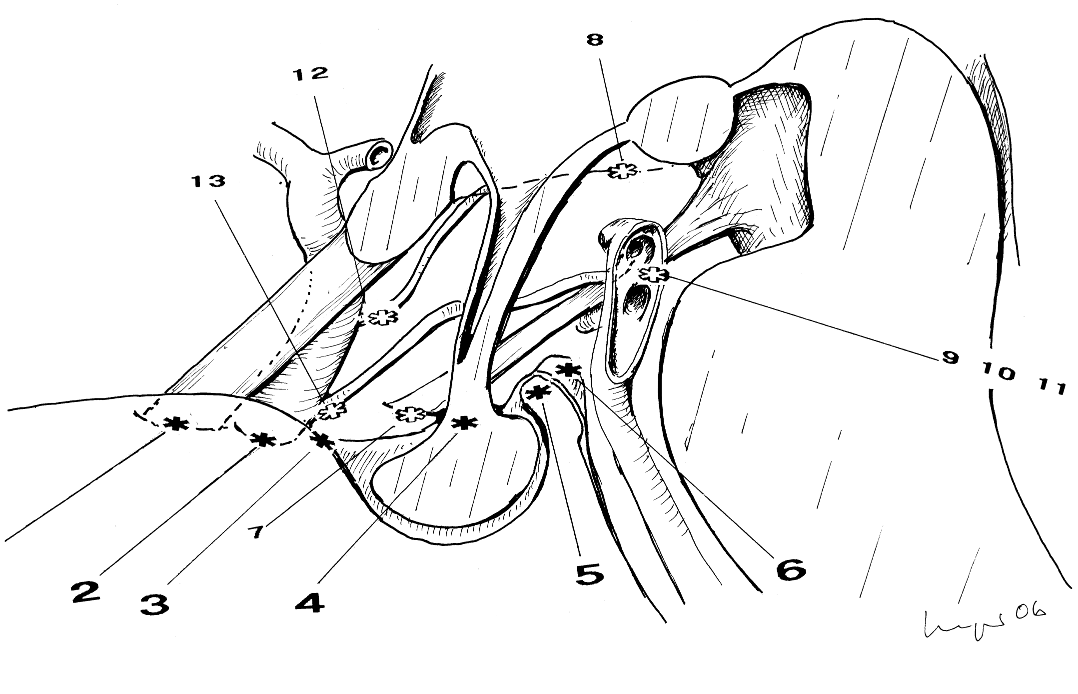
constant neuronavigatory landmarks
inconstant landmarks
landmark during surgery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SURROUNDING STRUCTURES OF BASAL CISTERNS (Figs. 10 to 15)

Fig. 10

Dural penetration points of cranial nerves and of A. carotis int., variants according to Lang (1975)

A Usual findings
B Dural penetration point of N. oculomotorius located posterior to its usual location (arrow)
C Dural penetration point of N. oculomotorius located anterior to its usual position (arrow)
D Dural penetration points of A. carotis int., N. oculomotorius and N. trochlearis located at a posterior direction (arrows)
note the wide distance between A. carotis int.* and N. opticus, and the location of the dural penetration point of N. trochlearis posterior (and not anterior) to Plica petroclinoidea ant.
E Overlapping of N. oculomotorius by Plica petroclinoidea ant.
F Plica petroclinoidea ant. masked by flattening (dotted line)

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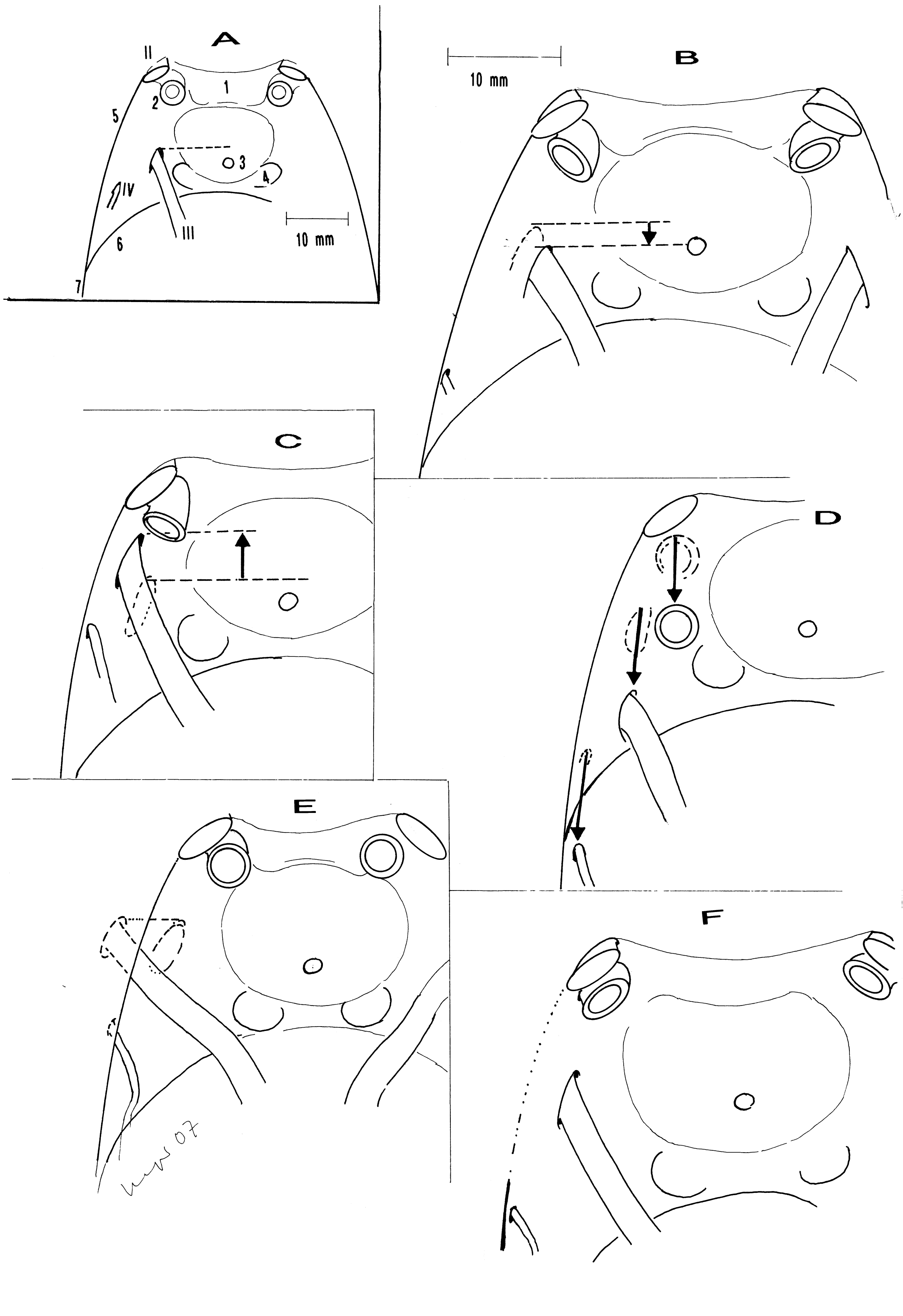
* Usual finding in nonhuman primates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E
F

Fig. 11

Tentorial notch, variants. Surrounding structures presented transparent.
Anatomical sketches according to MRTs

A Usual findings: Diameter of the tentorial notch and Isthmus rhombencephali differs between 0,5 to 2,0cm
B Narrow tentorial notch. Normal dimensions of the midbrain. Narrow Cisterna ambiens (arrows)
C Wide tentorial notch. Wide Cisterna ambiens (arrows)
Note relationship of the tentorial notch and Uncus/Gyrus parahippocampalis in B and C

Abbreviations
1 Plica petroclinoidea ant.
2 Plica petroclinoidea post.
3 Tentorial edge
4 Gyrus parahippocampalis

(III) N. oculomotorius

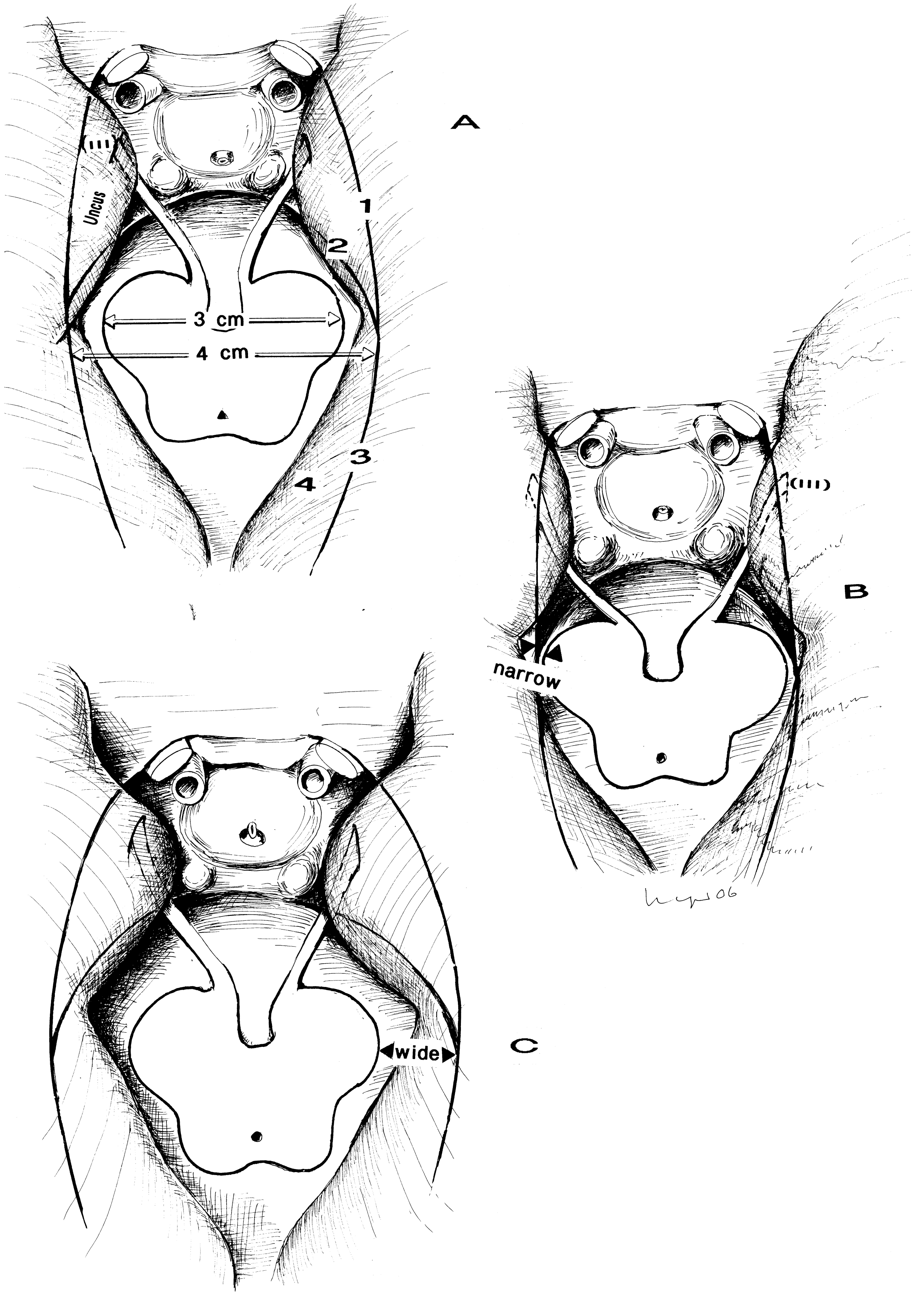

A
(III)
Uncus
1
2
3 cm
4 cm
3
4
B
(III)
narrow
C
wide

Fig. 12

Craniobasal and cerebrobasal areas. Drawing according to a MRT

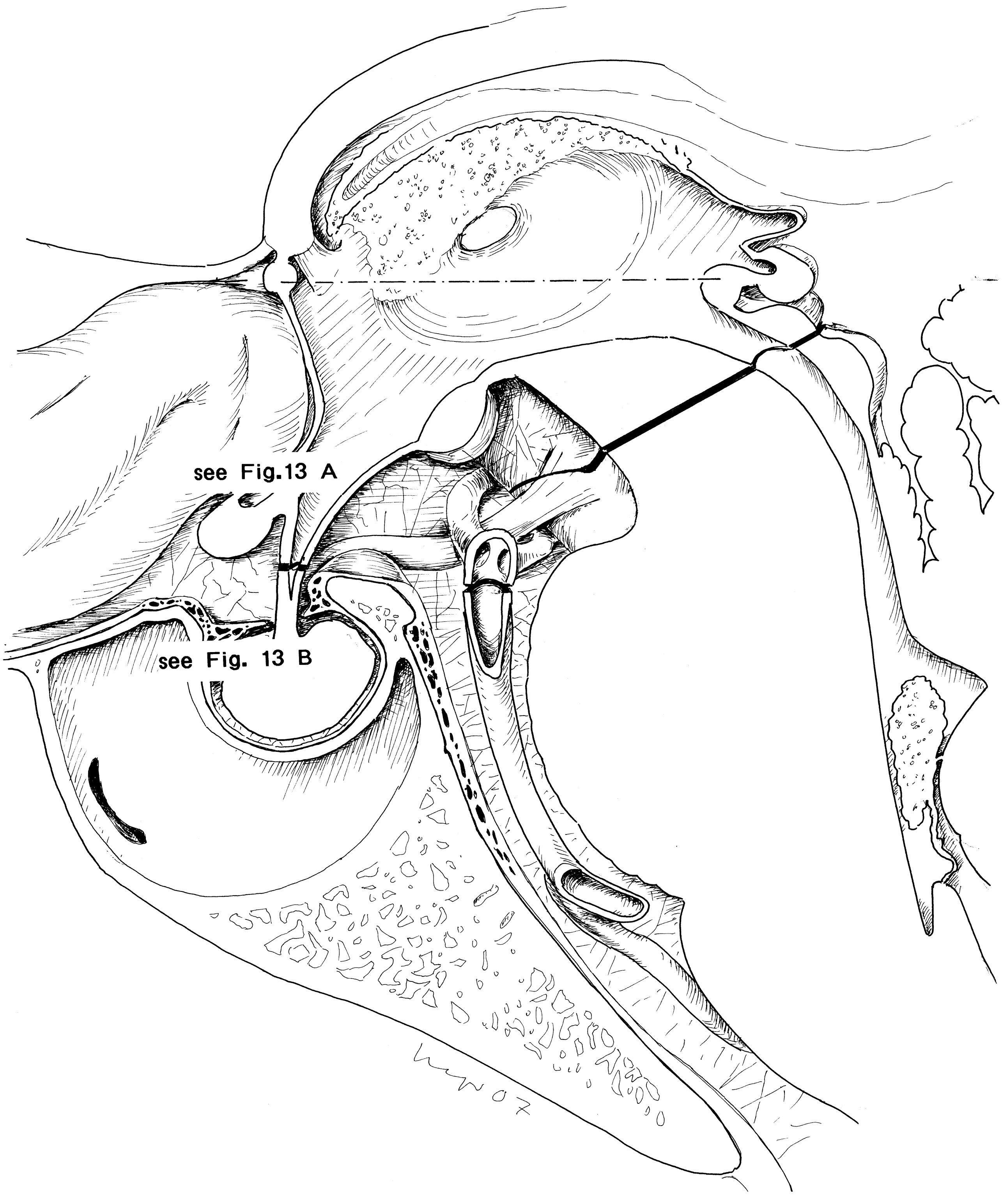

see Fig.13 A
see Fig. 13 B

Fig. 13

Continuation of Fig. 12. Anatomical drawing.
Cerebrobasal –A- and craniobasal –B-structures

Abbreviations

1 N. opticus
2 Outer Arachnoidea
3 N. olfactorius
4 Gyrus rectus
5 Chiasma
6 Tractus opt.
7 Hypophyseal stalk
8 N. oculomot.
9 Infundibulum / Tuber cinereum
10 Corpus mamillare (10) projection
11 Fossa interpeduncularis
12 Crus cerebri
13 Aa. perforantes of Subst. perfor. ant.
14 A. cerebri ant.
15 Bifurcation of A. carotis int.
16 A. carotis int.
17 Uncus
18 Gyri orbitales
19 Gyrus parahippocampalis
20 Tuberculum sellae and Sinus intercavernosus ant.
21 Diaphragma sellae
22 Proc. clin. ant. (projection)
23 Sin. intercavernosus post.
24 Dorsum sellae
25 Bulging of Proc. clin. post.
26 Plica petroclinoidalis post.
27 Plica petroclinoidalis ant.
(27) As 27, projection
28 Dural opening for N. trochlearis
29 Clivus
30 A. cerebelli sup.
31 Bifurcation of A. basilaris
32 A. cerebri post.
33 As 11, Rr. perforantes drawn in

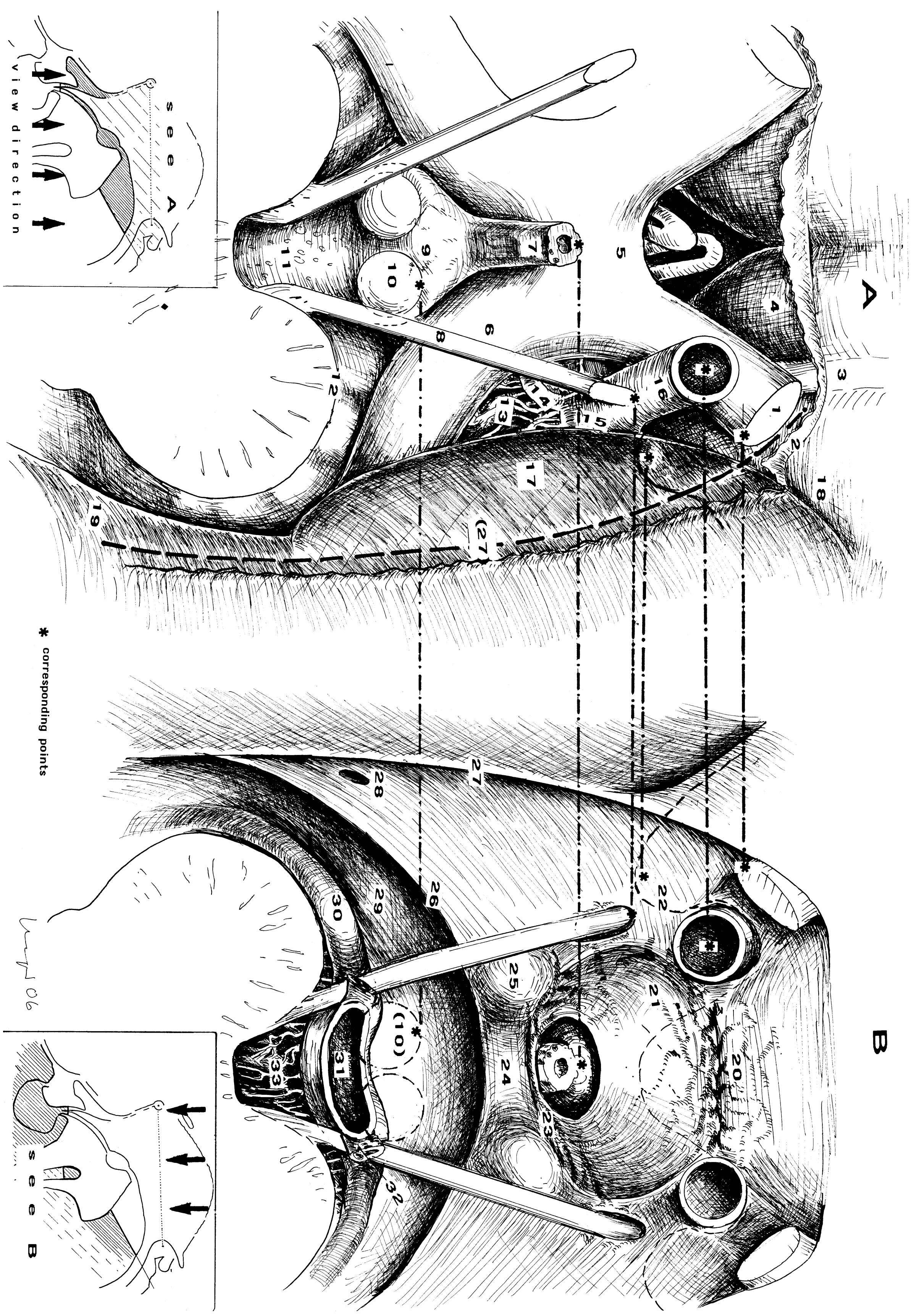
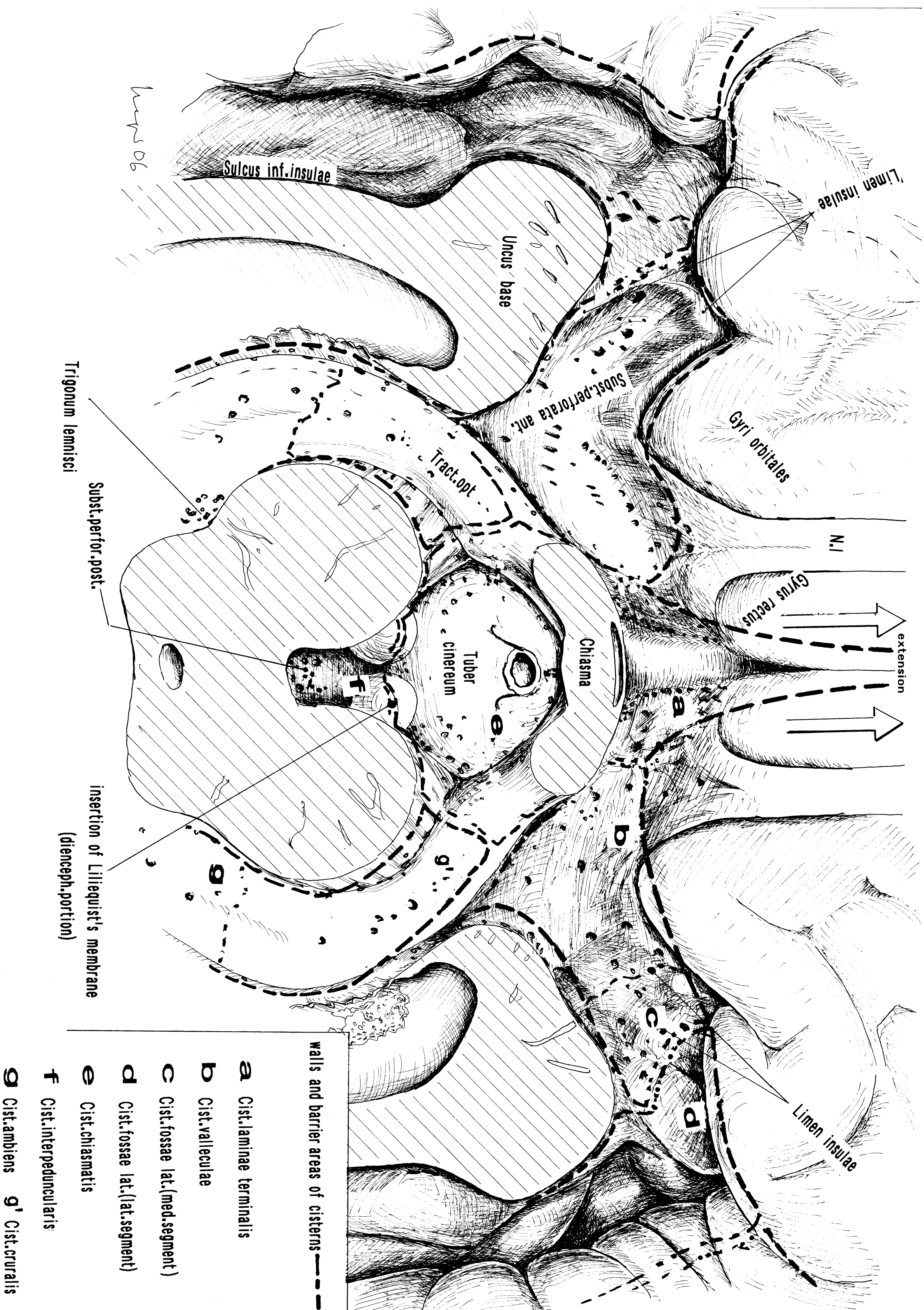

A
B
see A
view direction
see B
* corresponding points

Fig. 14

Roofs of cisterns are not congruent with its basal shapes, as demonstrated in Fig. 7. Cisterns close to the midline (a and f) are smaller than that basal shapes according to the kinking of the brain stem. Penetration points of Rr. perforantes are indicated (Schematic presentations)



Sulcus inf.insulae
Uncus base
Limen insulae
Subst.perforata ant.
Gyri orbitales
Tract.opt
N.I
Gyrus rectus
extension
Chiasma
Tuber cinereum
Trigonum lemnisci
Subst.perfor.post.
insertion of Liliequist's membrane (dienceph.portion)
Limen insulae
a
b
c
d
e
f
g
g'
walls and barrier areas of cisterns
a Cist.laminae terminalis
b Cist.valleculae
c Cist.fossae lat.(med.segment)
d Cist.fossae lat.(lat.segment)
e Cist.chiasmatis
f Cist.interpeduncularis
g Cist.ambiens g' Cist.cruralis

Fig. 15

Addendum for Fig. 14
Cadaver brain dissection distorted for presentation of deep-seated structures by a reduction of the natural brain kinking

A Topogram for B
Black arrows: combination of perspectives as shown in B
Dotted lines: before distortion

B Distortion
Areas in the depth:
- **1** Lamina terminalis close to the 3rd ventricle
- **2** Substantia perforata anterior, close to the basal ganglia
- **3** Substantia perforata posterior, close to Tegmentum mesencephali, posterior to Crura cerebri

Note high density of penetration points of Rr. perforantes, originating from Circulus arteriosus (Willisi)

FIG. 15

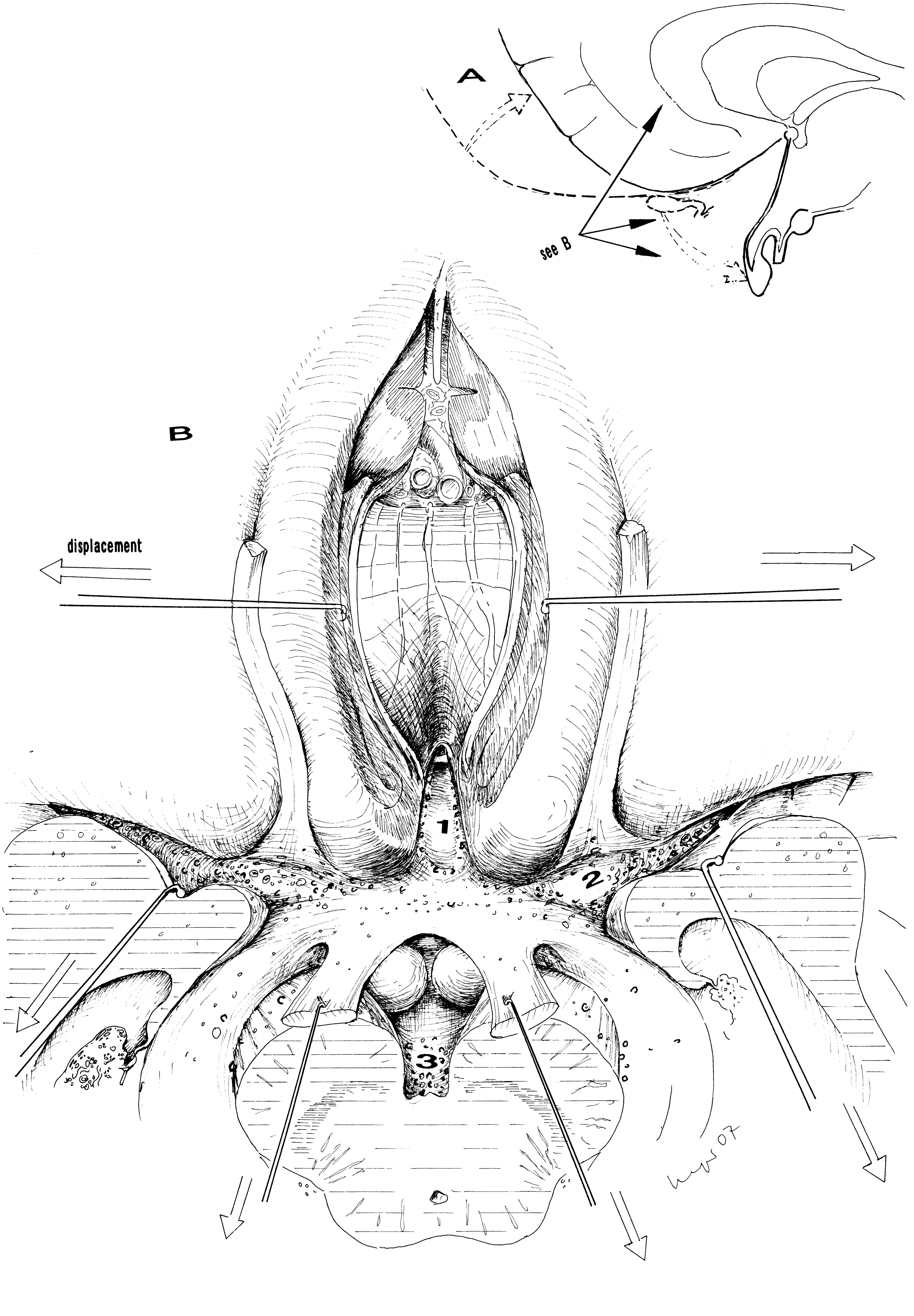


Fig. 16

Architecture of the basal cisterns
General aspects of arachnoid membranes (layers) and trabeculae, and bundles of trabeculae.

A A cranial nerve crosses a gap of the outer arachnoid layer and of the Dura before entering a bony canal or foramen of the skull base. The nerve is surrounded by an arachnoid sheath containing CSF. This sheath is the extension of a basal cistern (Cisterna chiasmatis, N. opticus, and Foramen opticum, e.g.)

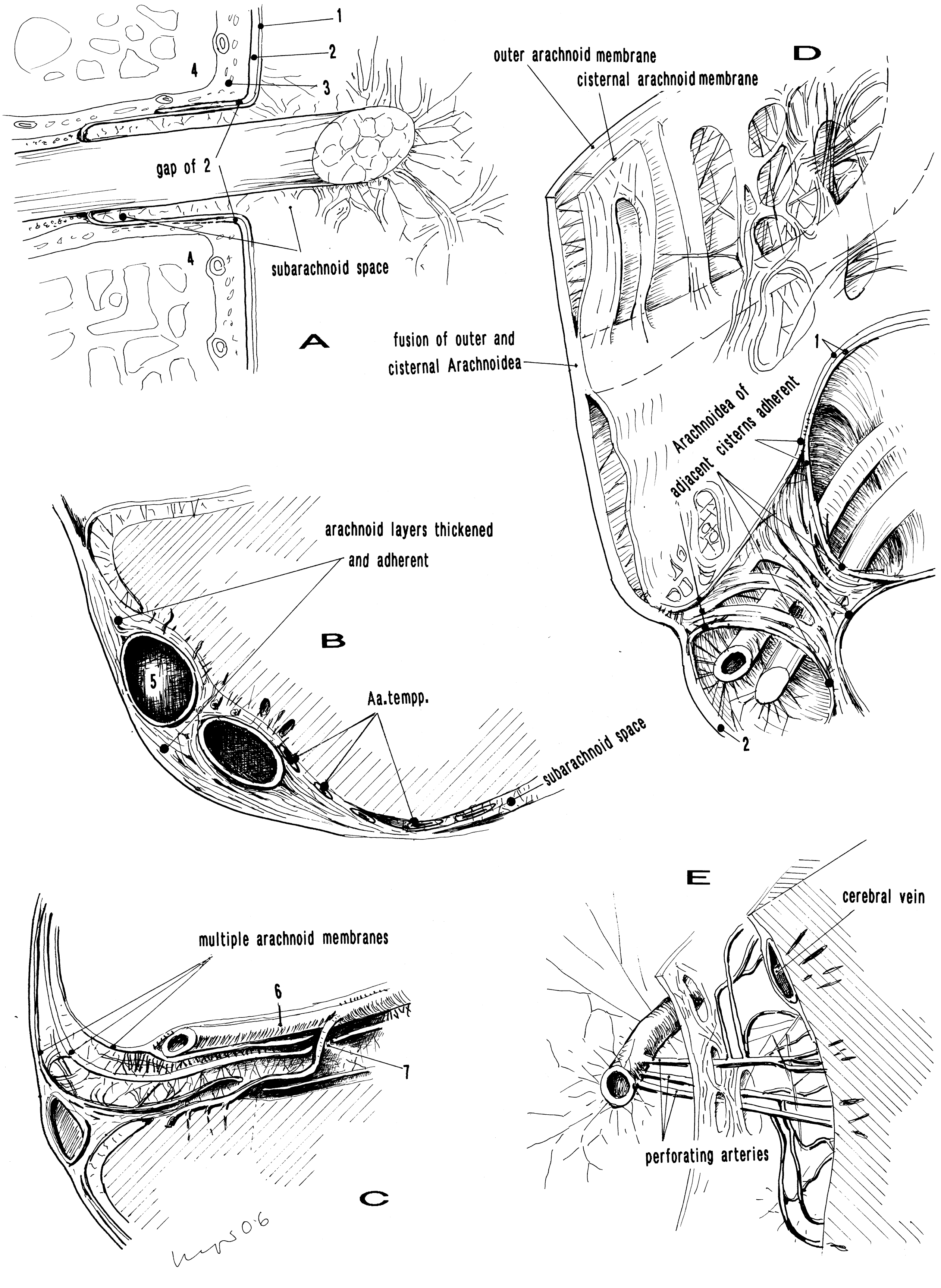
B Adhesions of all arachnoid layers with a cerebral vein (superficial sylvian vein, e.g., bridging veins along Sinus sagittalis sup., e.g.)

C Intracisternal arachnoid membranes covering vessels (A. cerebri media and its main branches -6- and temporal branches -7-, e.g.)

D Adhesions of the outer and cisternal arachnoid layers.
In this drawing arachnoid fibers perform a tunnel covering arteries (sylvian fossa, e.g.) or cranial nerves (N. trigeminus between Cisterna pontocerebellaris and Cisterna pontis lat., e.g.)

E Vessels (or cranial nerves) crossing gaps of intracisternal or intercisternal arachnoid membranes (between Cisterna chiasmatis and Cisterna interpeduncularis, e.g.)

Abbreviations
1 Cisternal arachnoid membranes
2 Outer arachnoid membrane (enclosing brain, spinal cord and its nerves)
3 Dura mater
4 Bony foramen or channel of the cranial base
5 Vein
6 Artery (ies)
7 Branch(es) crossing arachnoid membranes


1
2
3
4
gap of 2
subarachnoid space
4
A
outer arachnoid membrane
cisternal arachnoid membrane
D
fusion of outer and cisternal Arachnoidea
1
Arachnoidea of adjacent cisterns adherent
2
arachnoid layers thickened and adherent
B
5
Aa.tempp.
subarachnoid space
E
cerebral vein
multiple arachnoid membranes
6
7
perforating arteries
C

TOPOGRAPHY OF BASAL CISTERNS (Figs. 17 to 24)

Fig. 17

Basal cisterns according to Key and Retzius, Liliequist, Yaşargil, and 5 cadaver brain dissections of the author. For Liliequist's membrane see Fig. 21

Abbreviations

1	One of the variable arachnoid tunnels covering A. cerebri media and its main branches
2	Diencephalic portion of Liliequist's membrane
2 a	Insertion of 2 at Corpora mamillaria
3	Margin of the gap of the mesencephalic portion of Liliequist's membrane
3 a	Insertion of the mesencephalic portion of Liliequist's membrane at the pontomesencephalic rim
4	Inferior wall of Cisterna pontocerebellaris
5	Superior wall of Cisterna medullaris lateralis

III to XII	Cranial nerves
Arrows:	Arachnoid tunnels

Note:	4 and 5 are separated from each other

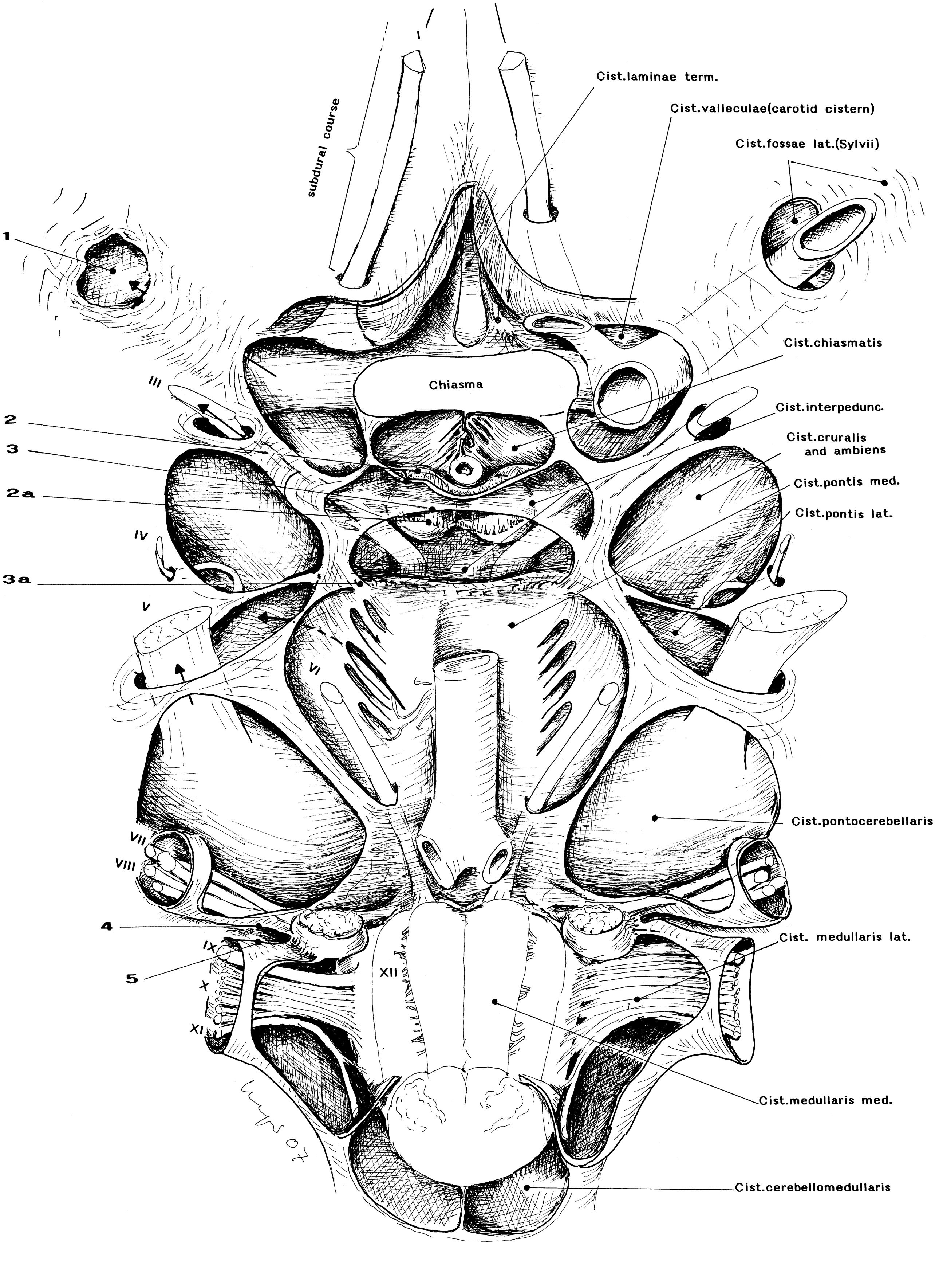

Cist.laminae term.
Cist.valleculae(carotid cistern)
Cist.fossae lat.(Sylvii)
subdural course
1
Chiasma
Cist.chiasmatis
III
2
3
2a
Cist.interpedunc.
Cist.cruralis and ambiens
Cist.pontis med.
Cist.pontis lat.
IV
3a
V
VI
Cist.pontocerebellaris
VII
VIII
4
IX
5
X
XI
XII
Cist. medullaris lat.
Cist.medullaris med.
Cist.cerebellomedullaris

Fig. 18

Continuation of Fig. 17
Surrounding structures of the basal cisterns

Abbreviations

1	Lateral wall of Cisterna laminae terminalis
2	Substantia perforata ant. (= roof of Cisterna valleculae)
3	Arachnoid tunnel containing a segment of A. cerebri media
4	Liliequist's membrane, diencephalic portion
5	Liliequist's membrane, mesencephalic portion
6	Arachnoid tunnel between Cisterna pontis lateralis and Cist. pontocerebellaris containing N. trigeminus
7	Tunnel between Cist. pontis medialis and Cisterna medullaris medialis, containing N. abducens
8	Arachnoid wall of Cist. pontocerebellaris
9	Arachnoid wall of Cist. medullaris lateralis
10	Bochdalek's plexus
11	Tunnel between Cisterna interpeduncularis and Cisterna ambiens, containing N. oculomotorius
12	Chiasma
13	Sagittal septum of Cisterna chiasmatis
I, III, V to XII	Cranial nerves
*	Outer and cisternal arachnoid layers containing cranial nerves at their dural exit areas

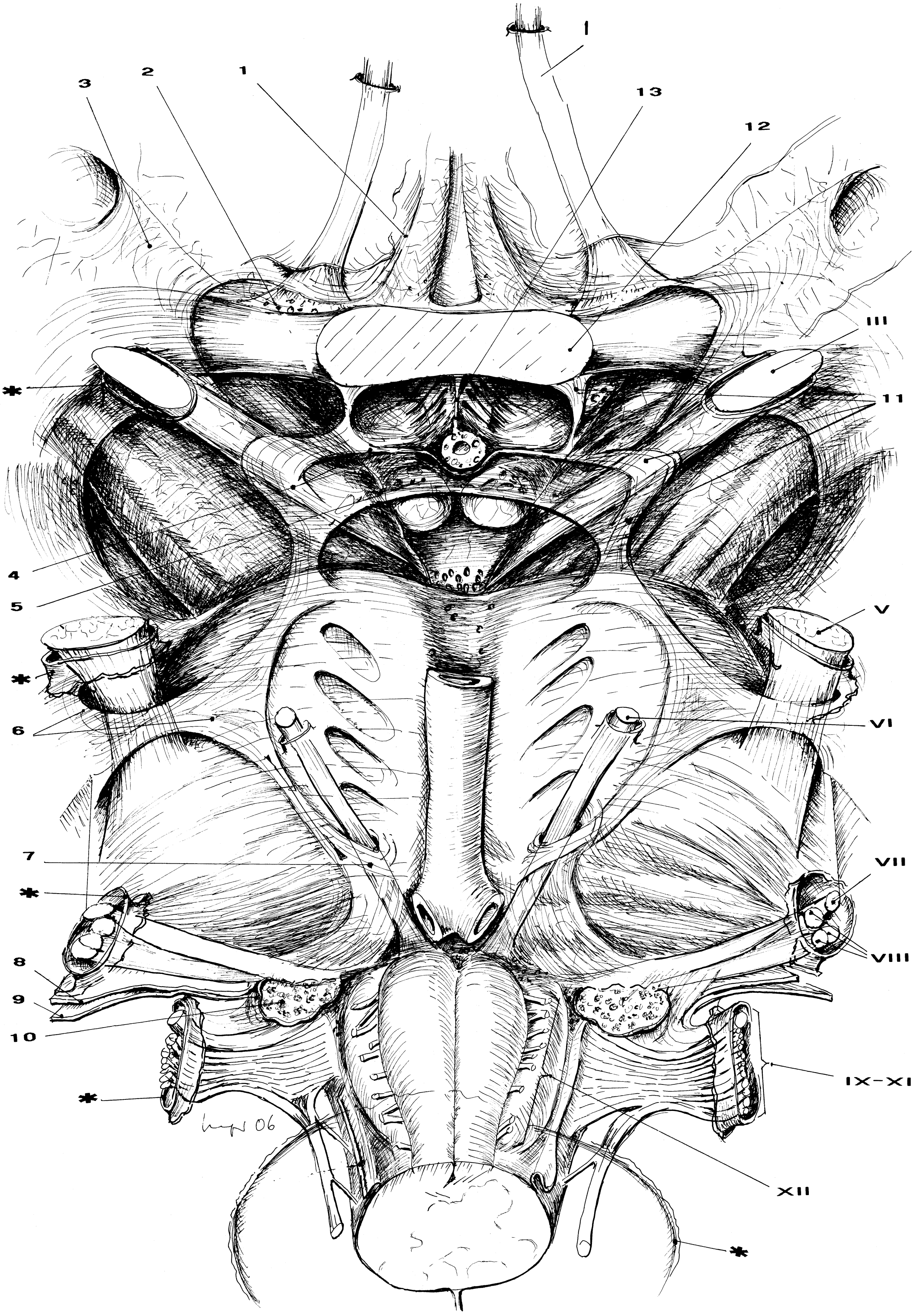

I
3
2
1
13
12
III
*
11
4
5
V
*
6
VI
7
VII
*
VIII
8
9
10
IX-XI
*
XII
*

Fig. 19

Life-like presentation of basal cisterns, created by Key and Retzius (1875).
Lithography of N. O. Björkman and Th. Lundberg, Stockholm.

Outer arachnoid membranes have narrow gaps for penetrations of vessels and cranial nerves. Walls and barrier areas of cisterns have multiple fenestrations.

Abbreviations

1	Outer arachnoid membrane of Cisterna laminae terminalis
2	A. carotis int.
3	Hypophyseal stalk
4	Wall between Cisterna pontis med. and lat.
5	As 4, everted
6	Outer arachnoid membrane of Cisterna pontis lat.
7	Outer arachnoid membrane of Cisterna chiasmatis preserverd
8	Mesencephalic portion of Liliequist's membrane = roof of 9
(8 a)	Gap of Liliequist's membrane, mesencephalic portion, between Cist. pontis med. and Cist. interped.
9	Base of Cisterna pontis medialis
10	Cisterna pontis lat.
11	Outer arachnoid membrane of Cisterna cruralis and ambiens
12	Ground of Cisterna pontocerebellaris
13	Bochdalek's plexus
14	Cisterna medullaris lat.
15	Cisterna medullaris med.
16	Flap after incision of the wall between 12 and 14 clapped in a cranial direction
17	As 16, clapped in a caudal direction
II, III, V to XII	Cranial nerves

Note: Shifting of the arachnoid flaps at 16 and 17 was done for presentation of cranial nerves VII and VIII, and cranial nerves IX to XI, which were masked by the thickened arachnoid flaps and by Bochdalek's plexus.

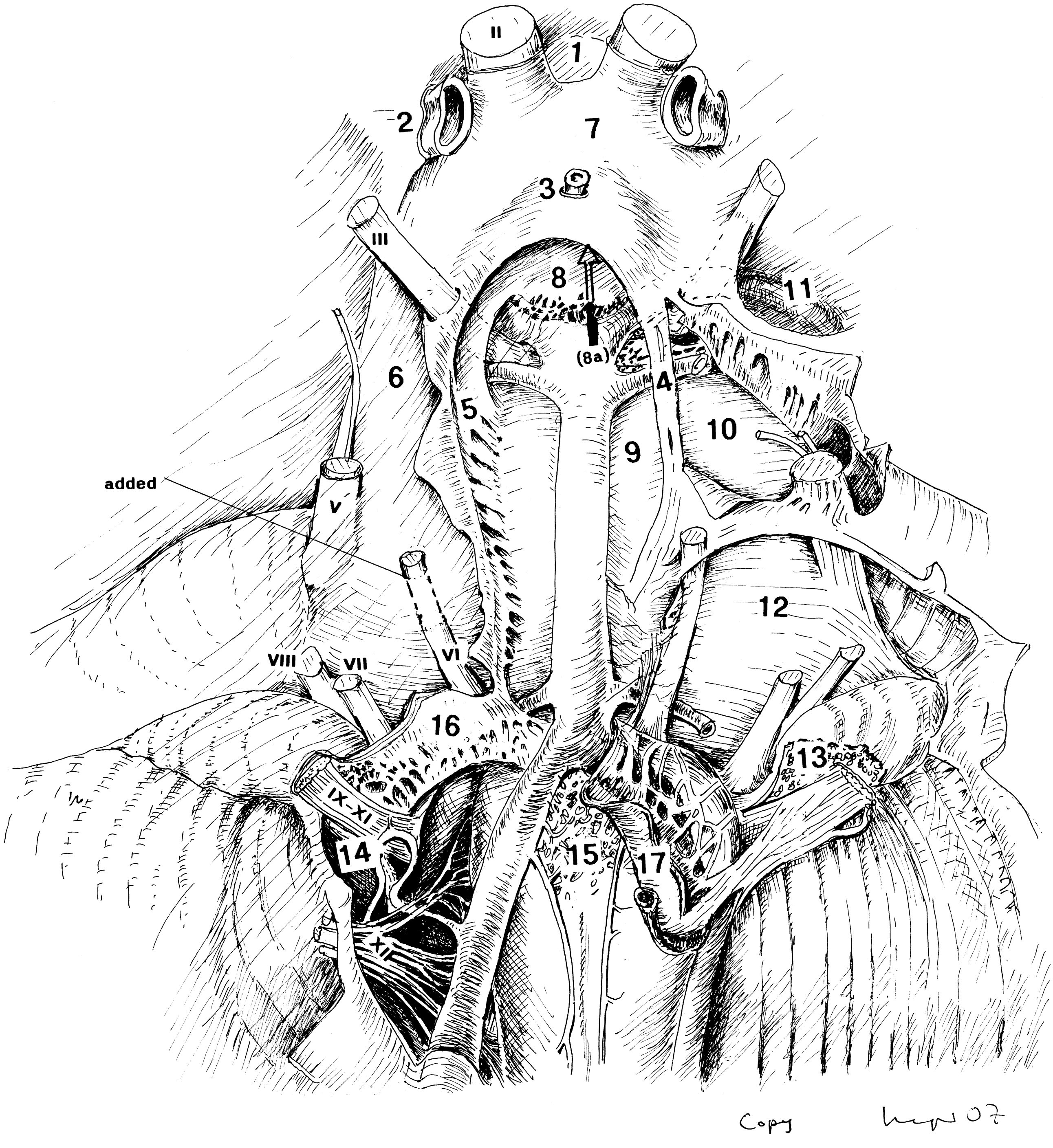

II
1
2
7
3
III
8
11
(8a)
4
6
5
10
9
added
V
12
VI
VIII
VII
16
13
IX-XI
14
15
17
XII
Copy

Fig. 20

Continuation of Fig. 19
Supratentorial cisterns. Basal and dorsal compartments of Cisterna chiasmatis.

Right hemisphere: Basal wall of Cisterna chiasmatis between N. II and III.
Left hemisphere: Dorsal wall of Cisterna chiasmatis between N. II and the posterior arachnoid wall of Cisterna chiasmatis (see 17).

A	Overview
B	As A, sectional enlargement

Abbreviations

1	Carotid bifurcation
2	Arachnoid tunnel and A. cerebri media
3	Outer arachnoid layer
4	Arachnoid tunnels for main branches of A. cerebri media
5	Tractus olfactorius
6	Bed of Bulbus olfactorius
7	Outer arachnoid layer close to Falx
8	Gap of outer arachnoid layer for N. I
9	Gyrus rectus
10	Cisterna laminae terminalis
11	Outer arachnoid layer, flap
12	Basal outer and cisternal arachnoid membranes, leftsided, flap everted
13	Median septum of Cisterna chiasmatis
14	Roof of Cisterna chiasmatis
15	Wall between Cisterna valleculae and Cist. chiasmatis
16	Hypophyseal stalk
17	Liliequists's membrane
18	A. chorioidea ant.
19	Wall between Cist. pontis med. and Cisterna cruralis
20	Roof of Cist. interpeduncularis
21	Mesencephalic portion of Liliequist's membrane
22	A. cerebri post.
23	A. communicans post.
24	A. cerebri ant.
25	A. cerebri media
26	Temp. bridging vein
27	Outer and cisternal arachnoid layers fusioned (note gaps)
28	Outer arachnoid layer enclosing Cist. laminae terminalis

I to III	Cranial nerves
*	Cist. pontis med.
**	Cist. pontis lat.
***	Cist. cruralis

FIG. 20

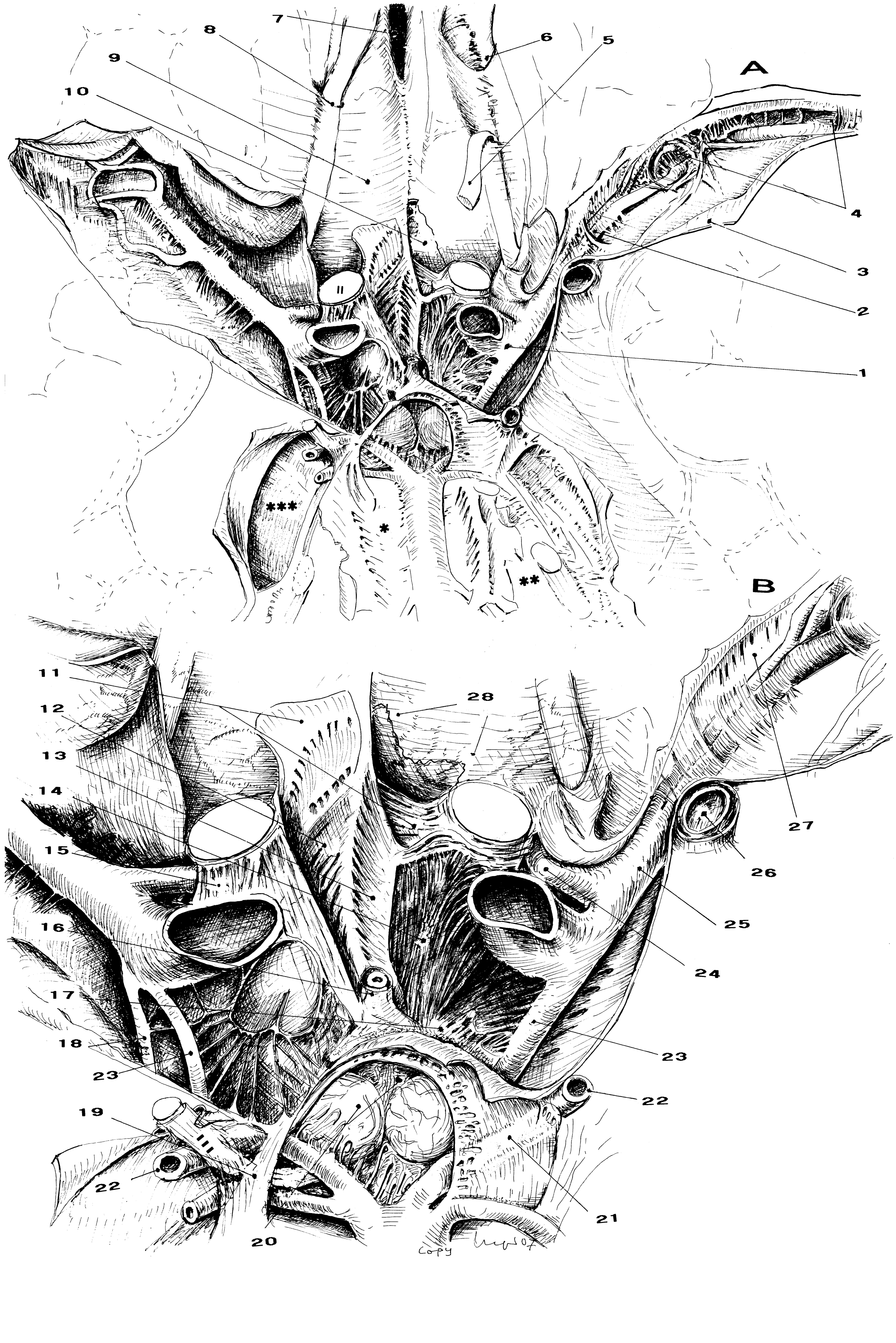

A
B
1
2
3
4
5
6
7
8
9
10
II
III
*
**
***
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

Fig. 21

Liliequist's membrane is divided in 3 parts:

- Common part inserting at the outer arachnoid layer of Dorsum sellae
- Diencephalic part connecting the common part to the pial layer of Corpora mamillaria and adjacent lateral structures
- Mesencephalic part connecting the common part to pial and arachnoid structures of the pontomesencephalic rim.

For endoscopic aspects of ventriculocisternostomy see Part II, chapters 4 and 5.

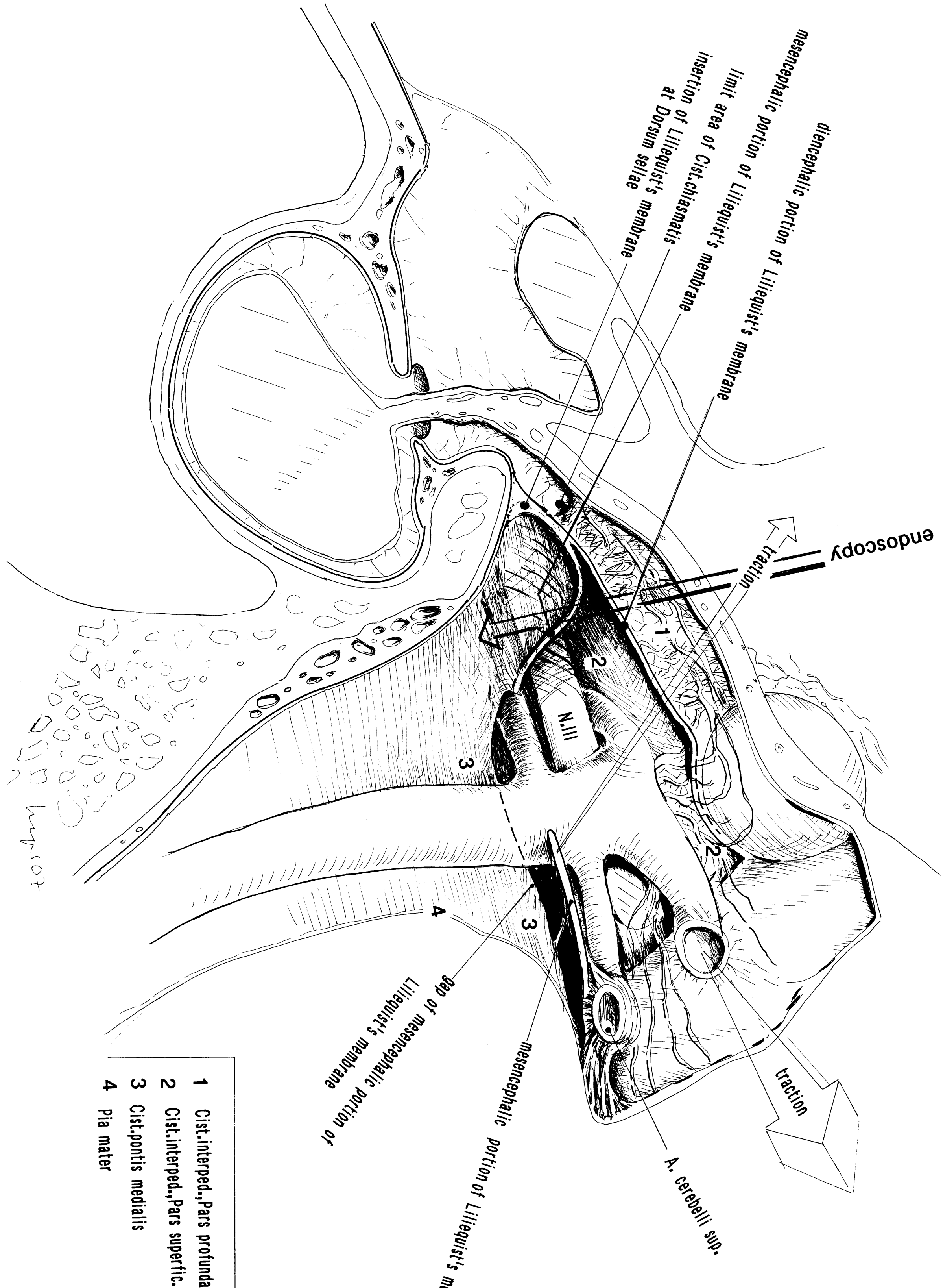
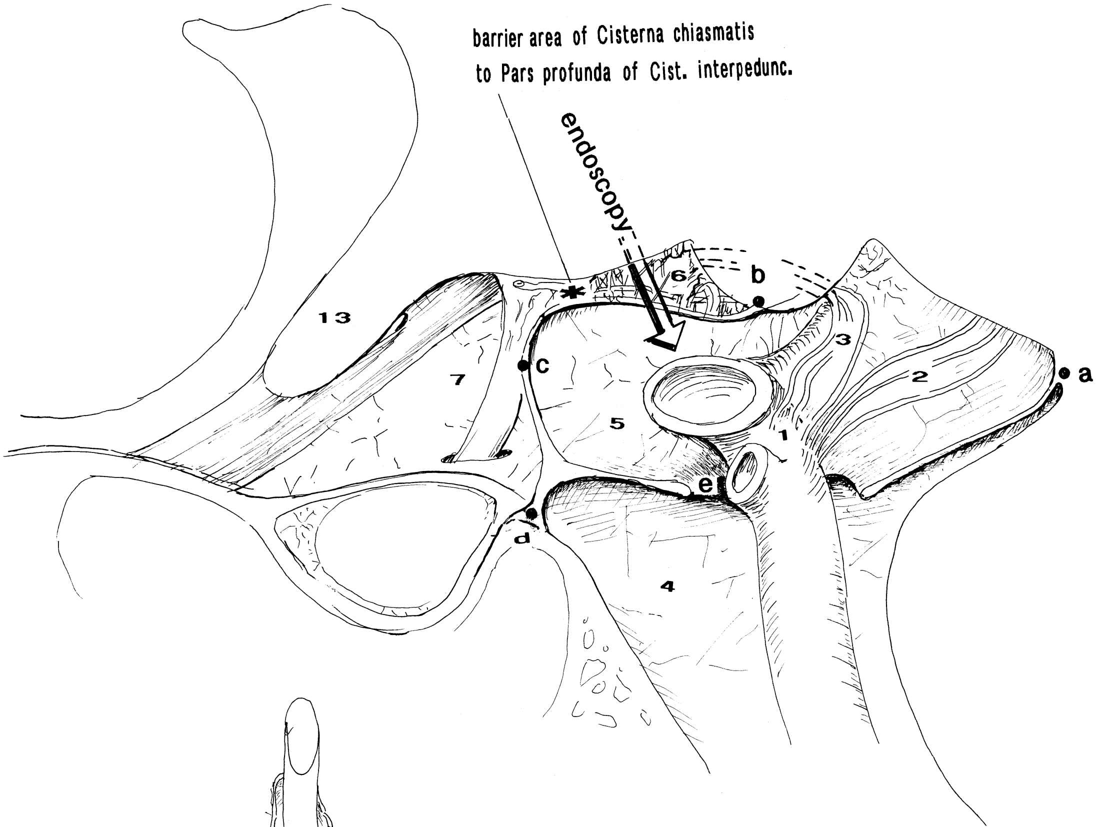

diencephalic portion of Liliequist's membrane
mesencephalic portion of Liliequist's membrane
limit area of Cist.chiasmatis
insertion of Liliequist's membrane
at Dorsum sellae
endoscopy
traction
N.III
1
2
2
3
3
4
gap of mesencephalic portion of
Liliequist's membrane
mesencephalic portion of Liliequist's membrane
A. cerebelli sup.
traction
1 Cist.interped.,Pars profunda
2 Cist.interped.,Pars superfic.
3 Cist.pontis medialis
4 Pia mater

Fig. 22

Liliequist's membrane and its relationship to surrounding cisterns and its arteries. Parasagittal and basal perspectives.
Walls and border areas of the roof of cisterns included. Dotted lines:
Projection of Liliequist's membrane.

Liliequist's membrane
a Insertion of the mesencephalic segment of Liliequist's membrane at the pontomesencephalic rim
b Insertion of the diencephalic portion of Liliequist's membrane ot Corpora mamillaria
c Bulging of this segment against Cisterna chiasmatis. Comparison of the parasagittal and basal view direction
d Insertion of Liliequist's membrane at Dorsum sellae
e Gap of the mesencephalic segment. It connects Cisterna pontis to Pars superficialis of Cisterna interpeduncularis

Projections of the basal presentation may be compared to the parasagittal presentation.
Cisterns and their contents and surrounding structures
1 Bifurcation of A. basilaris
2 Posterior bundle of perforating arteries, penetrating Subst. perforata post.
3 Anterior bundle of perforating arteries, crossing Cisterna interpeduncularis, Pars superficialis -5-, penetrating Liliequist's membrane –-b-, crossing Cisterna interpeduncularis, Pars profunda -6- and Cisterna chiasmatis -7-
4 Cisterna pontis medialis
5 Cisterna interpeduncularis, Pars superficialis
6 Cisterna interpeduncularis, Pars profunda
7 Cisterna chiasmatis
8 Cisterna cruralis
9 Cisterna ambiens
10 Cisterna valleculae (carotid cistern)
11 Cisterna fossae lat. (Sylvii)
12 Tip of Cornu inf.
13 Chiasma


barrier area of Cisterna chiasmatis
to Pars profunda of Cist. interpedunc.
endoscopy
*
6
b
13
c
7
5
3
2
a
1
e
d
4

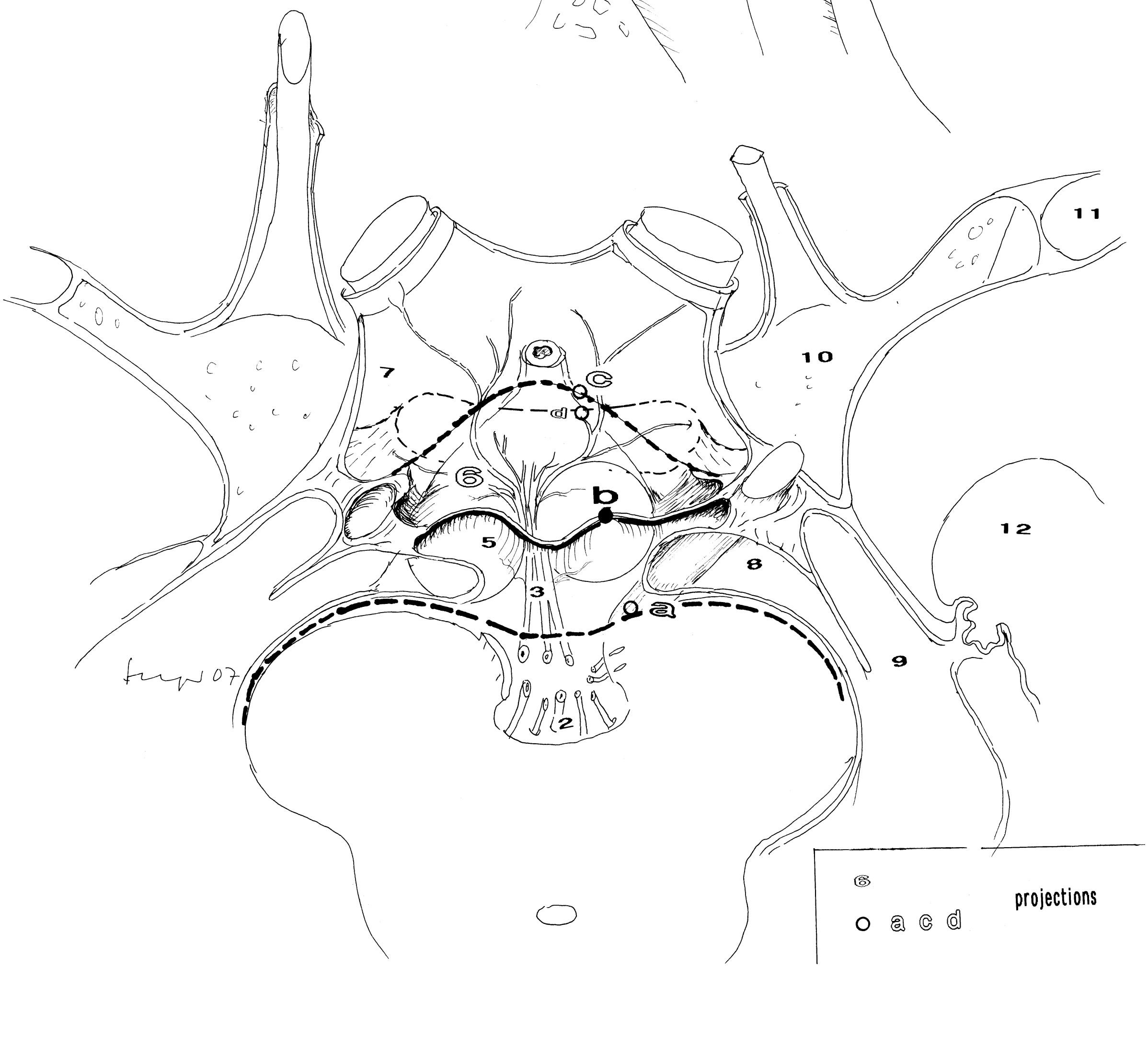

11
10
7
c
d
6
b
12
5
8
3
a
9
2
projections
o a c d

Fig. 23

Overlapping of Cisterna pontis lateralis by Cisterna pontis medialis.
Note the wide extension of Cisterna pontis lateralis in a medial basal direction. This segment of the cistern is overlapped by Cist. pontis medialis

A As Fig. 18, sectional enlargement
B Coronal transsectional plane taken from A

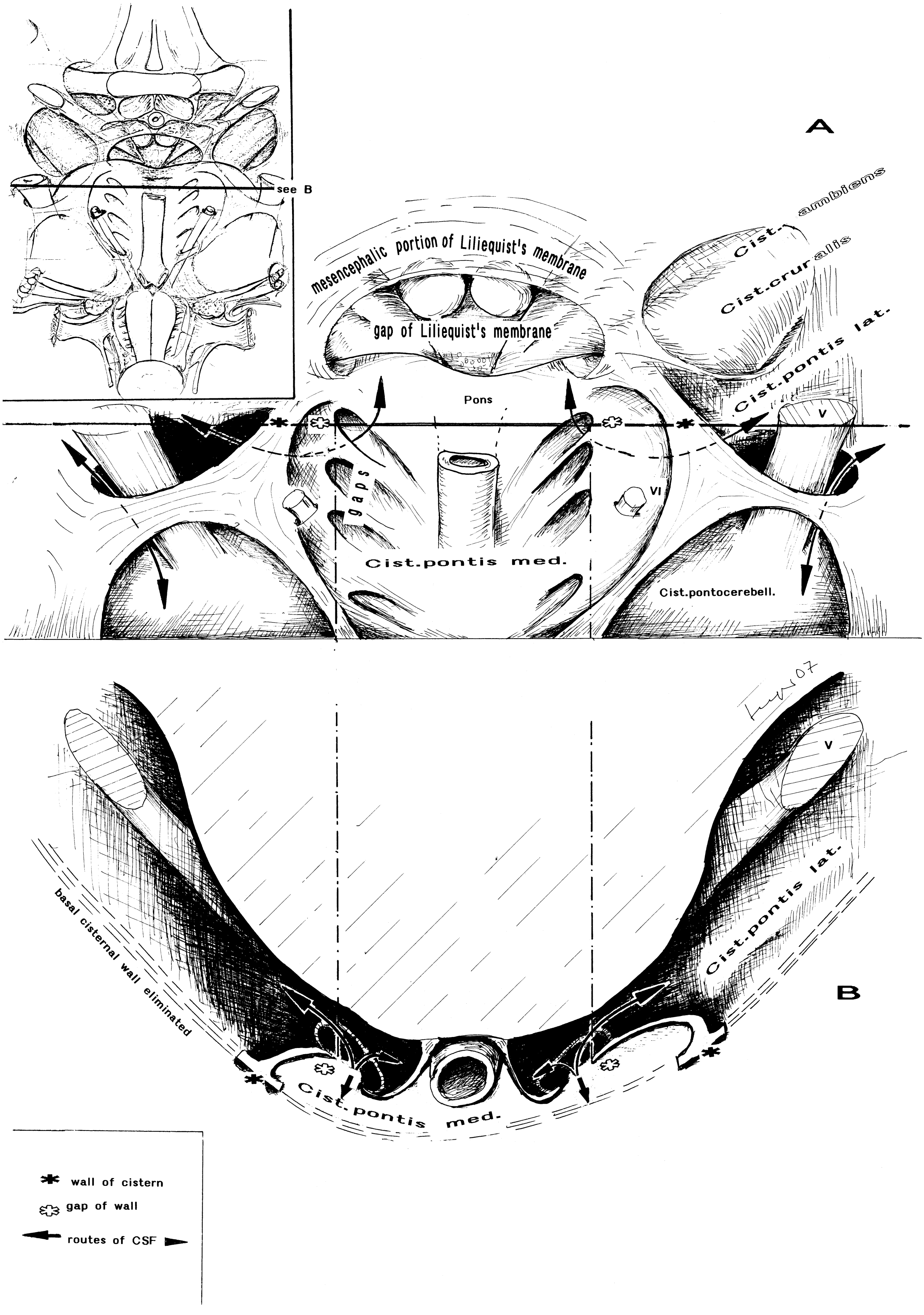

see B
A
Cist. ambiens
Cist. cruralis
Cist. pontis lat.
mesencephalic portion of Liliequist's membrane
gap of Liliequist's membrane
Pons
V
VI
gaps
Cist. pontis med.
Cist. pontocerebell.
V
basal cisternal wall eliminated
Cist. pontis lat.
B
Cist. pontis med.
wall of cistern
gap of wall
routes of CSF

Fig. 24

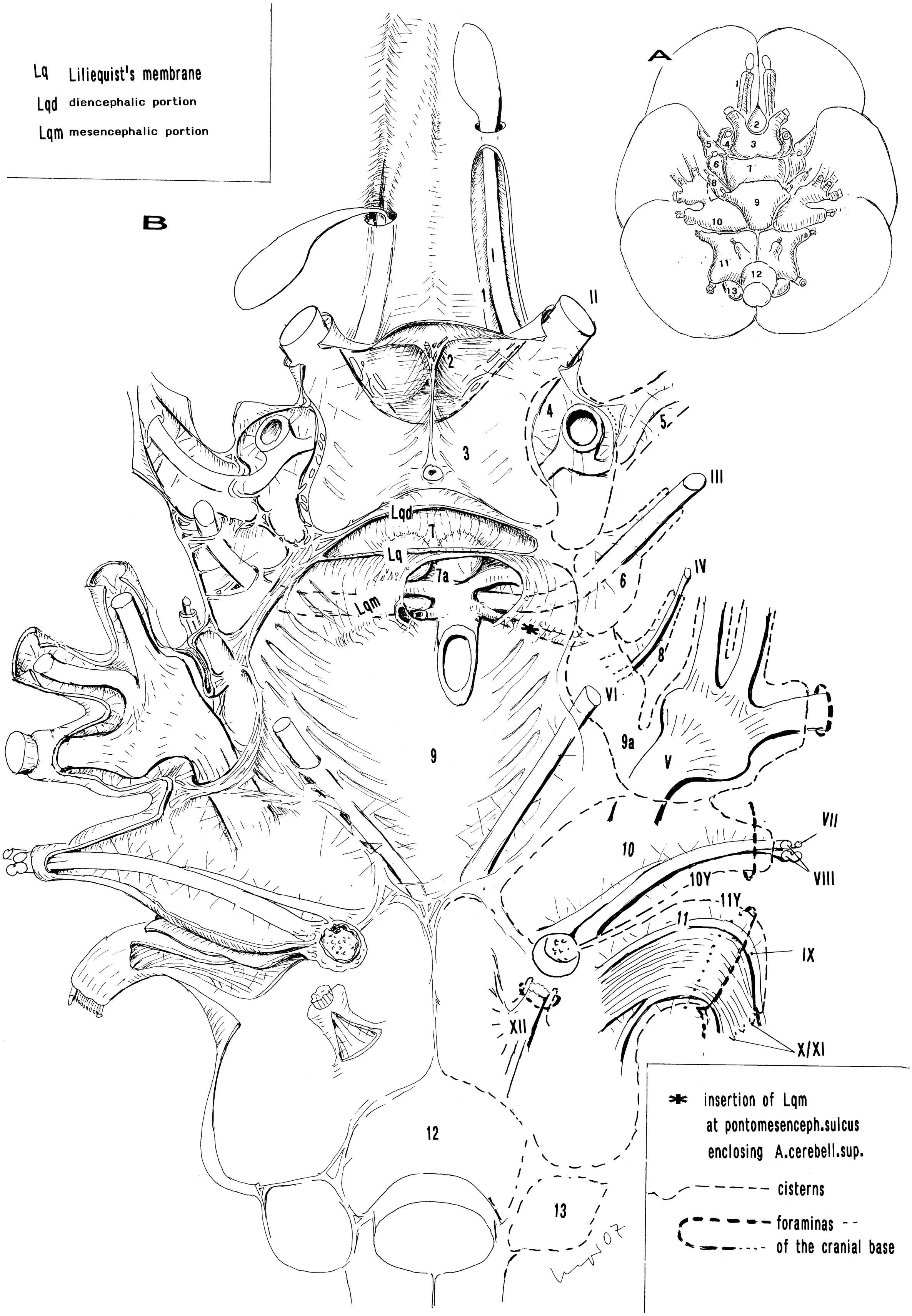
Summary

A Relief of the outer surface of cisterns, according to Fig. 7A.

B Outer basal membranes and cisternal walls opened. In the depth Cisterna interpeduncularis is smaller than at the basal surface in A.
Cisterna pontis medialis overlaps Cisterna pontis lateralis.
Note the overlapping of Cisterna pontis medialis by Cisterna interpeduncularis in A.

Abbreviations

1	Yaşargil's olfactory cistern (continuation of Cisterna valleculae)
2	Cisterna laminae terminalis
3	Cisterna chiasmatis
4	Yaşargil's carotid cistern (Cisterna valleculae)
5	Cisterna fossae lat. (Sylvii)
6	Cisterna cruralis (part of Cisterna ambiens)
7	Cisterna interpeduncularis, Pars superficialis
7a	Cisterna interpeduncularis, Pars profunda
8	Cisterna ambiens
9	Key and Retzius' Cisterna pontis medialis (modern terminus: Pars. med. of Cist. pontis)
9a	Key and Retzius' Cisterna pontis lat. (modern terminus: Pars lat. of Cist. pontis)
10	Cisterna pontocerebellaris ("cerebello-pontine cistern")
10Y	Yaşargil's wall of Cisterna pontocerebellaris
11	Yaşargil's lateral medullary cistern (lateral portion of Cist. medull.)
11Y	Yaşargil's wall of the lateral cerebellomedullary cistern
12	Cisterna medullaris medialis
13	Cisterna medullaris lateralis
Lq	Liliequist's membrane
Lqd	Its diencephalic portion
Lqm	Its mesencephalic portion
I to XII	Cranial nerves


Lq Liliequist's membrane
Lqd diencephalic portion
Lqm mesencephalic portion
B
A
I
II
III
IV
V
VI
VII
VIII
IX
X/XI
XII
1
2
3
4
5
6
7
7a
8
9
9a
10
10Y
11
11Y
12
13
Lqd
Lq
Lqm
insertion of Lqm
at pontomesenceph.sulcus
enclosing A.cerebell.sup.
cisterns
foraminas
of the cranial base

CONTENTS OF THE BASAL CISTERNS (Figs. 25 and 26)

Fig. 25

Overview
Left-sided contents of the basal cisterns, seen from a contralateral direction (A) and right-sided contents, seen from a ipsilateral direction (B)
For topogram see (C).

Abbreviations

1 N. opticus
2 Chiasma
3 A. cerebri ant.
4 Corpus mamillare
5 Fossa interpeduncularis
6 A. cerebri post.
7 A. cerebelli sup.
8 A. basilaris
9 N. oculomotorius
10 Hypophysis
11 Hypophyseal stalk
12 A. chorioidea ant.
13 A. communicans post.
14 A. carotis int. (left)
15 A. carotis int. (right)
16 Chiasma
17 Tractus opt./Chiasma
18 A. cerebri ant.
19 As 20, lateral margin
20 Tractus opt., medial margin
21 A. cerebri post.
22 A. cerebelli sup.
23 A. basilaris
24 Uncus
25 N. oculomotorius
26 A. communicans post.
27 A. chorioidea ant.

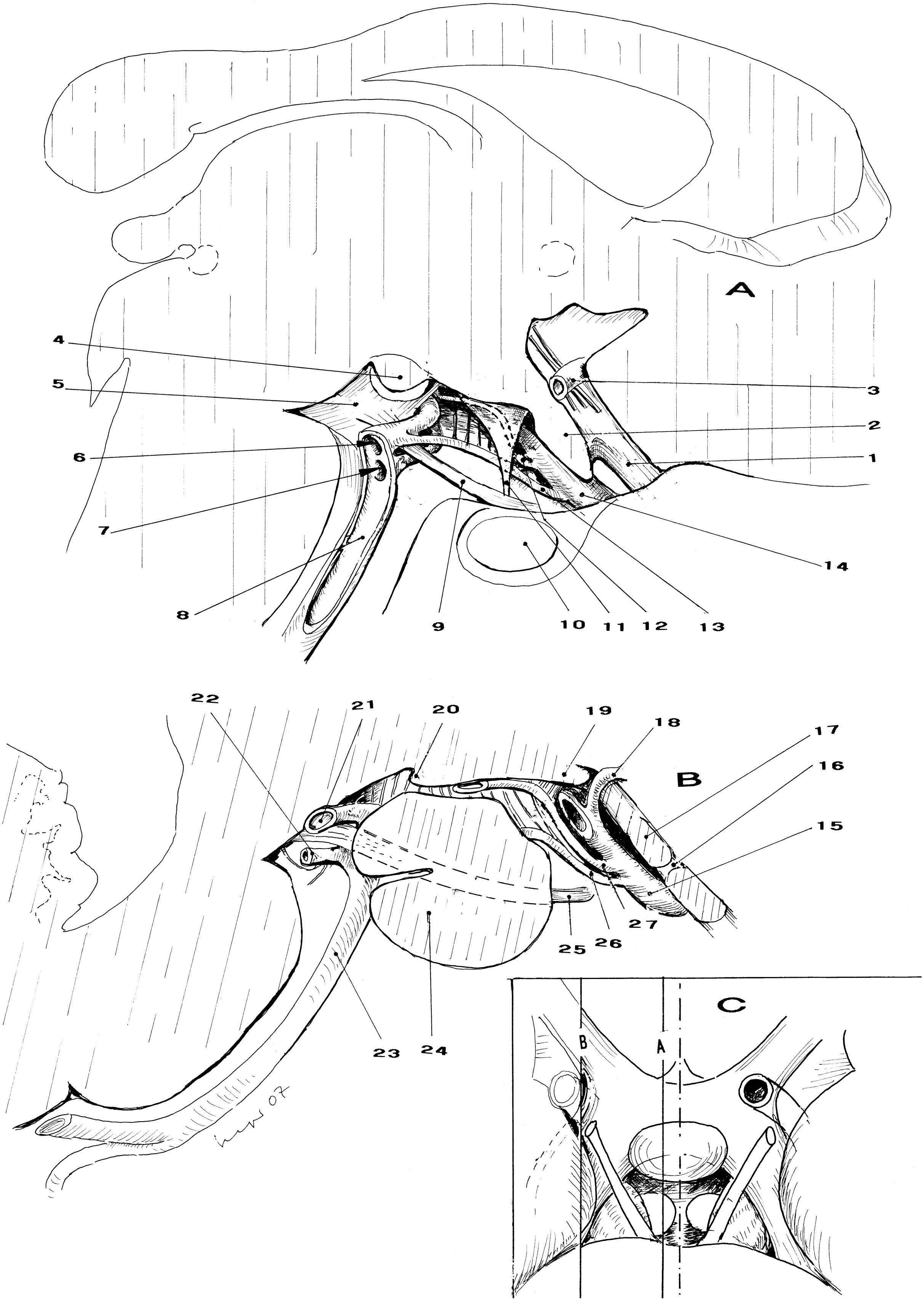

A
1
2
3
4
5
6
7
8
9
10
11
12
13
14
B
15
16
17
18
19
20
21
22
23
24
25
26
27
C
A
B

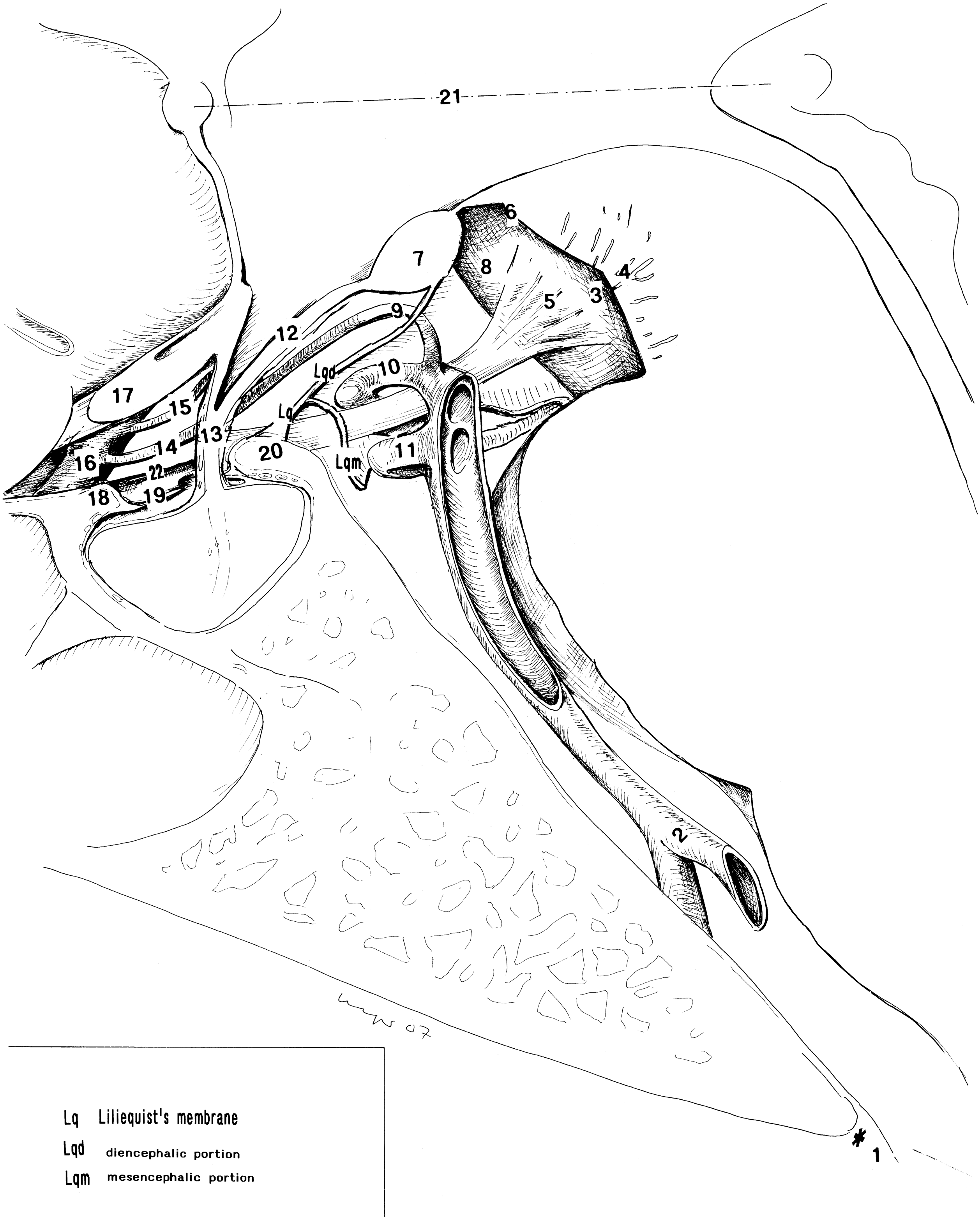
Fig. 26

Similar to Fig. 25A, right hemisphere, sectional enlargement

Abbreviations

1	Basion (anthropological landmark)
2	Junction of Aa. vertebrales
3	Substantia perforata post.
4	Aa. thalamoperforantes
5	Filia radicularia of N. oculomotorius
6	Roof of Fossa interpeduncularis
7	Corpus mamillare
8	Crus cerebri
9	A. communicans post.
10	A. cerebri post.
11	A. cerebelli sup.
12	Tuber cinereum
13	Hypophyseal stalk
14	As 9
15	A. chorioidea ant.
16	A. carotis int.
17	Chiasma
18	Tuberculum sellae
19	Diaphragma sellae
20	Dorsum sellae
21	Intercommissural line
22	Plica petroclinoidea ant.
Lq	Liliequist's membrane
Lqd	Its diencephalic portion
Lqm	Its mesencedphalic portion

FIG. 26



Lq Liliequist's membrane

Lqd diencephalic portion

Lqm mesencephalic portion

ADDENDUM. VESSELS OF THE MEDIAL BASAL CEREBRAL AREAS
(Figs. 27 to 30)

Fig. 27

Arteries are overlapping veins

A Vessels of the left temporal lobe, transected and loosened from the cadaver brain dissection B. View from a dorsal direction.

B Vessels of the left cerebral base after removal of the temporal lobe. View from a basal direction.

For nomenclature see Fig. 28


A
B

Fig. 28

Nomenclature for Fig. 27

1 V. basalis Rosenthal (as 34)
2 A. thalamogeniculata
3 A. operculofrontalis
4 V. ventricularis inf.
5 Plexus vein
6 Gyrus uncinatus (as 44)
7 Fenestration of A. cerebri media
8 Tip vein of Cornu inf.
9 Corpus amygdaloides (as 42)
10 Lateral margin of Tract. opt.
11 Deep sylvian vein(s)
12 V. interpeduncularis
13 Rr. perforantes of carotid bifurcation
14 Area of Limen insulae
15 A. cerebri media, proximal trunk
16 Carotid bifurcation
17 A. communicans post.
18 A. chorioidea ant.
19 A. cerebri ant. (A1)
20 Corpus mamillare
21 Branch of A. recurrens (Heubneri)
22 Infundibulum and Tuber cinereum
23 Chiasma
24 A. recurrens (Heubneri)
25 A. cerebri ant. (A2)
26 A. communicans ant. fenestrated
27 N.I penetrating outer arachnoid membrane
28 Tractus olfactorius
29 Artery of Bulbus olfactorius and its dural branch (common finding)
30 Bulbus olfactorius
31 Aquaeductus
32 Colliculus inf.
33 Rr. thalamoperforantes in Fossa interpeduncularis
34 V. basalis (Rosenthal) (as 1)
35 Taenia chorioidea
36 Taenia fornicis
37 Corpus geniculatum mediale
38 V. mesencephalica lat.
39 A. cerebri media, distal trunk
40 A. (Aa.) chorioidea(ae) lat. (latt.)
41 Uncus branch(es) of A. carotis int. and/or A. chorioidea ant.
42 Corpus amygdaloides (as 9)
43 Rr. temporales of A. carotis int. and/or A. cereberi media
44 Gyrus uncinatus (as 6)
45 Bridging veins
46 Outer arachnoid membrane (projection)
47 Superficial sylvian veins
48 Deep sylvian veins
49 Rr. temporales (as 43)
50 Connections of superficial and deep sylvian veins
51 Tip of Cornu inf. (ground)
52 Uncus
53 Pes hippocampi
54 Fimbria fornicis
55 Corpus hippocampi
56 Rr. temporales of A. cerebri posterior
57 A. hippocampi
58 Gyrus dentatus
59 A. cerebri posterior

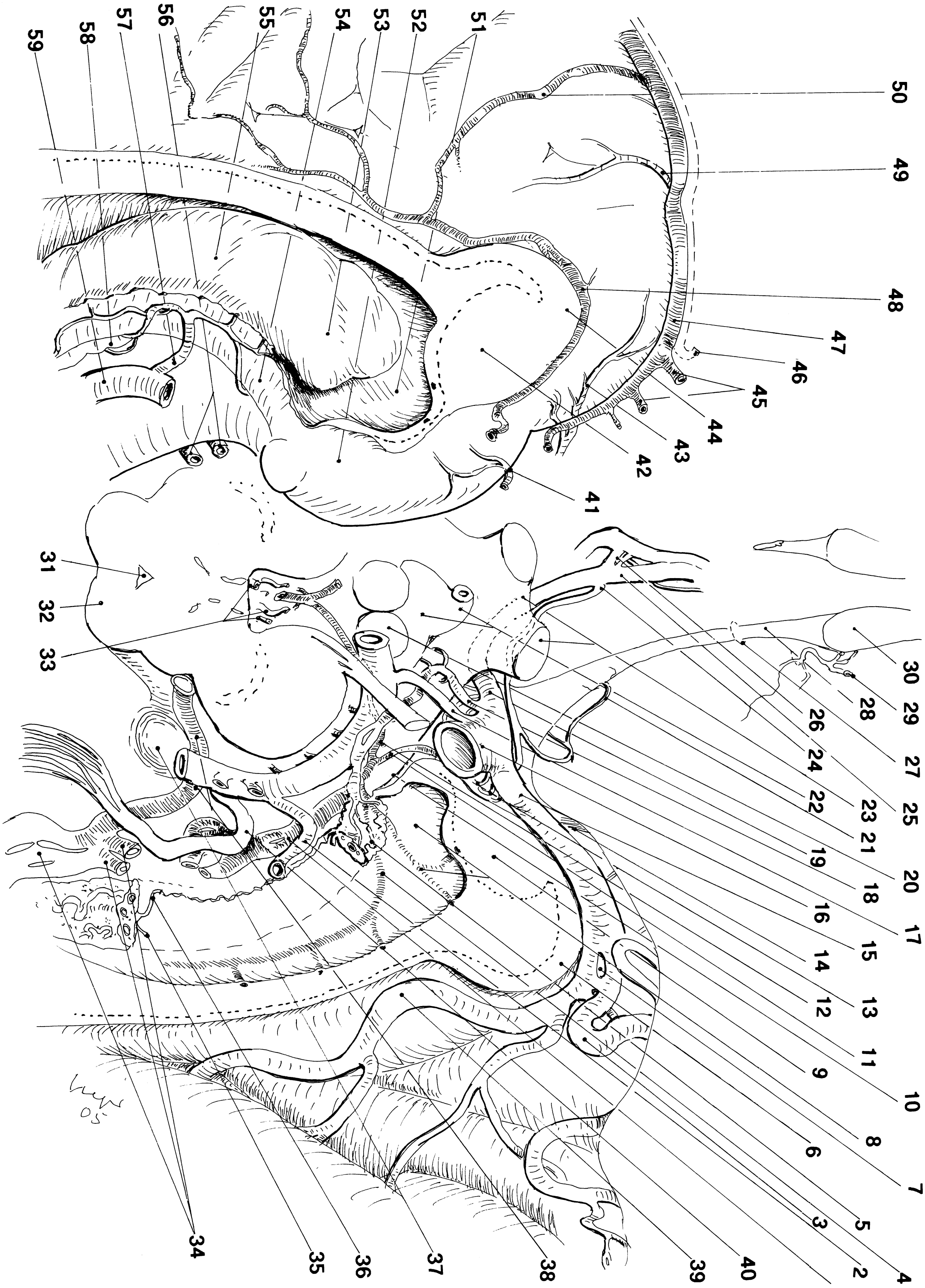

1
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Fig. 29

Cerebral veins after removal of arteries

Abbreviations

1 V. mesencephalica lat.
2 Plexus vein (as 5)
3 V. basalis (Rosenthal)
4 V. ventricularis inferior
5 Plexus vein (as 2)
6 Rr. transversi of V. ventricularis inf.
7 A. cerebri media, distal trunk
8 Connections of deep and superficial sylvian veins
9 Deep sylvian veins
10 Vein crossing the sylvian fossa, connecting to the Uncus base and the frontal lobe (common finding)
11 Frontobasal veins
12 Bridging vein (connected with Sinus alae minoris and/or V. sphenobasalis)
13 Superficial sylvian vein(s)
14 V. hippocampi
15 Uncus vein
16 V. interpeduncularis
17 V. cerebri ant.
18 Venous plexus of the choroid point between the tip of Cornu inf. and Cisterna ambiens = originating veins of V. basalis Rosenthal (connections of 2, 4, 9, 17 and 19)
19 Hippocampal veins
20 Inferior tip vein

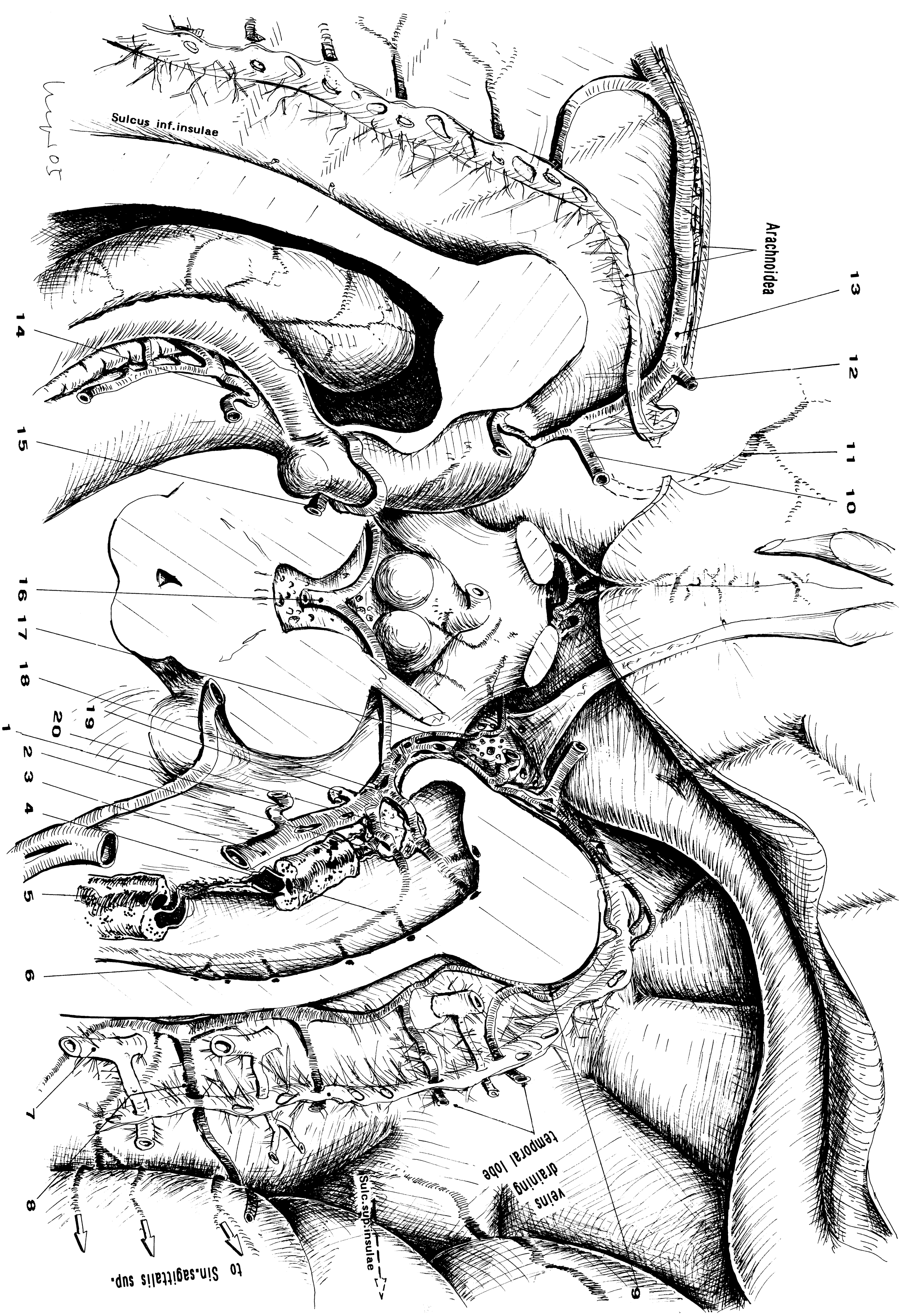
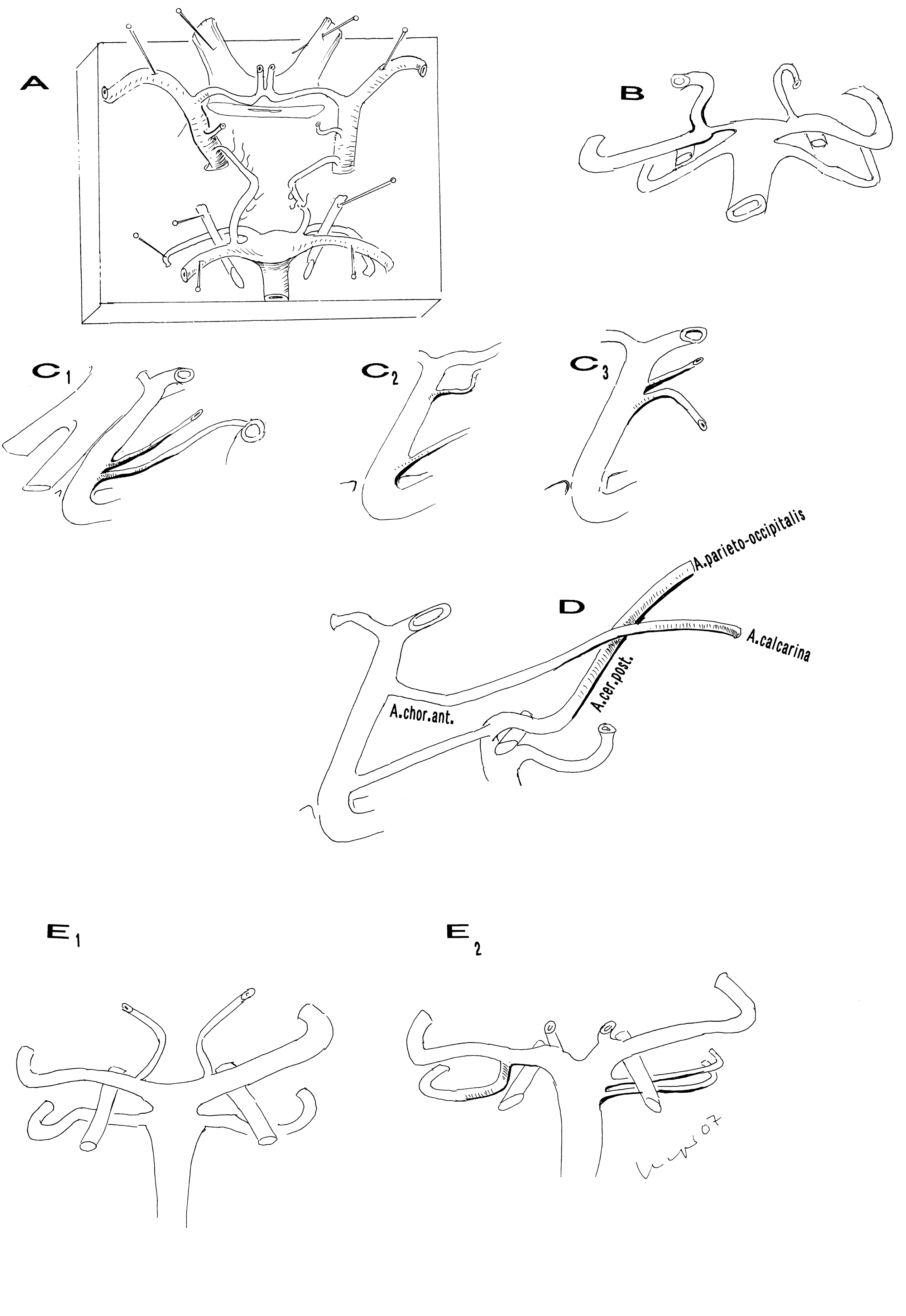

Sulcus inf.insulae
Arachnoidea
13
12
11
10
14
15
16
17
18
19
20
1
2
3
4
5
6
7
8
9
veins
draining
temporal lobe
Sulc.sup.insulae
to Sin.sagittalis sup.

Fig. 30

Some variants of Circulus arteriosus (Willisi)

A Usual anatomical findings
B Common variant of A. communicans post. (here right side)
C1 to **C3** Variants of the origins of A. communicans post. and A. chorioidea ant. from A. carotis int. (common findings)
D Rare findings (Seeger 1978 p 245)
E1 For comparison with E2
E2 Common variants of A. cerebelli sup.


A
B
C1
C2
C3
D
A.parieto-occipitalis
A.calcarina
A.cer.post.
A.chor.ant.
E1
E2

EXTRADURAL EXTENSIONS OF CISTERNS (Figs. 31 to 34)

Fig. 31

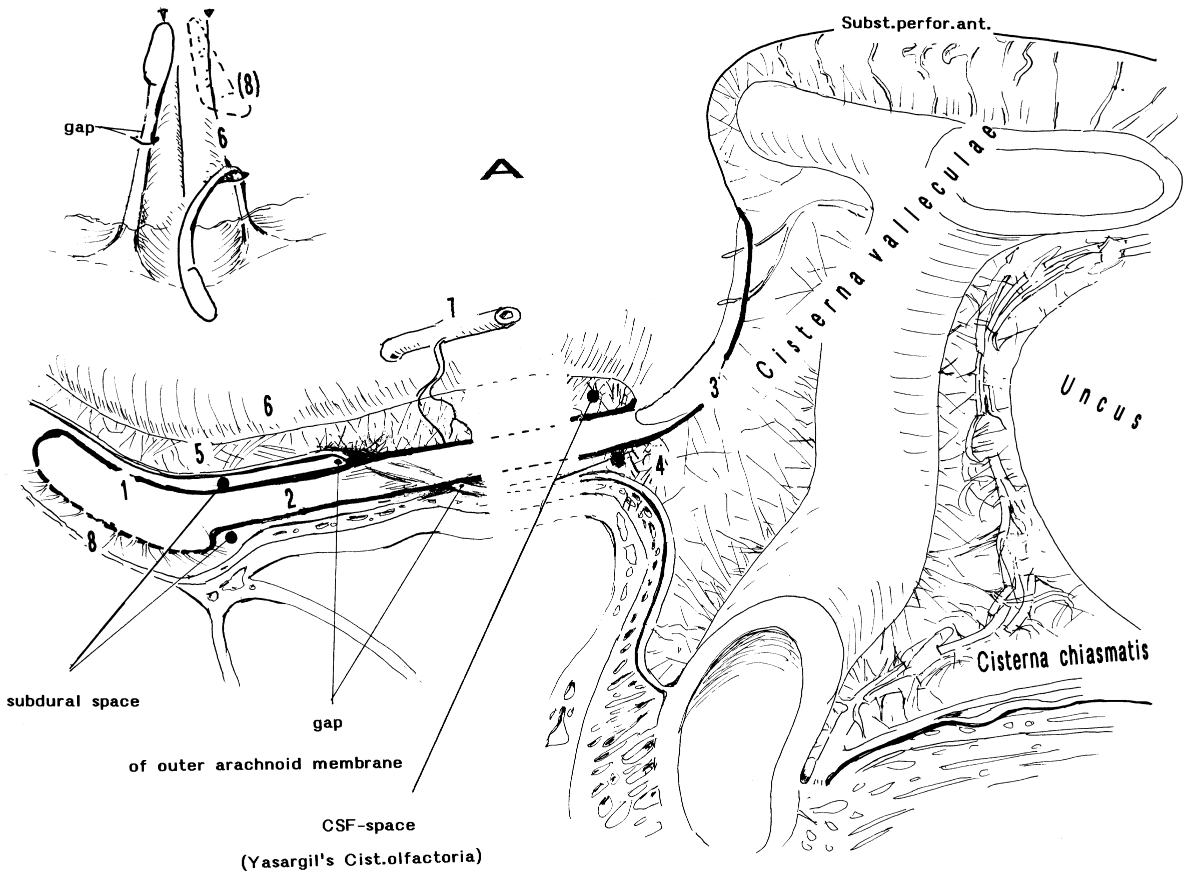
Extensions of cisterns along N. olfactorius and N. opticus

A Trigonum olfactorium is located at the anterior superior wall of Cisterna valleculae (carotid cistern) (3). Fine arteries of sulcus are feeding Tractus olfactorius (7), before Tractus olfactorius enters the gap of the outer arachnoid membrane and before it is running along the subdural space. The length of the subdural segment of Tractus olfactorius ist variable and asymmetric.

Abbreviations for A
1 Bulbus olfactorius
2 Tractus olfactorius
3 Trigonum olfactorium
4 Transitional area of Cisterna valleculae and Cisterna olfactoria
5 Continuation of Sulcus rectus, anterior to its olfactory compartment
6 Wall of Gyrus rectus
7 Medial frontobasal artery (A. frontopolaris, e.g.) and branches
8 Lamina cribrosa (projection)
(8) As 8 (projection)

B Cisterna chiasmatis continues along N. opticus until Bulbus opticus is reached. Around N. opt. this area is highly vascularized (Aa. ciliares post., 10)

Abbreviations for B
1 Chiasma
2 N. opticus and A. centralis retinae
3 Retina
4 Dural fold: transitional area of Dura and Vagina externa n. optici
5 For. opt.
6 Bony roof of Can. opt.
7 Periorbita
8 Anulus tendineus (Zinii)
9 Orbita
10 Aa. ciliares postt.


A
Subst.perfor.ant.
gap
(8)
6
1
6
5
1
2
8
3
4
Cisterna valleculae
Uncus
Cisterna chiasmatis
subdural space
gap
of outer arachnoid membrane
CSF-space
(Yasargil's Cist.olfactoria)

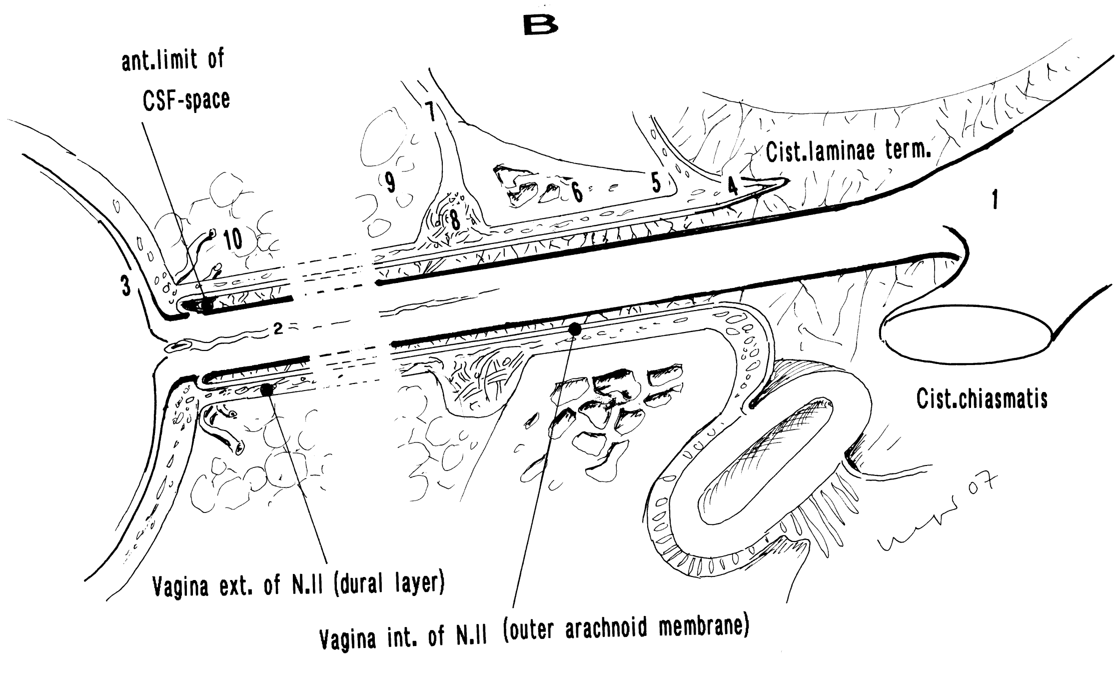
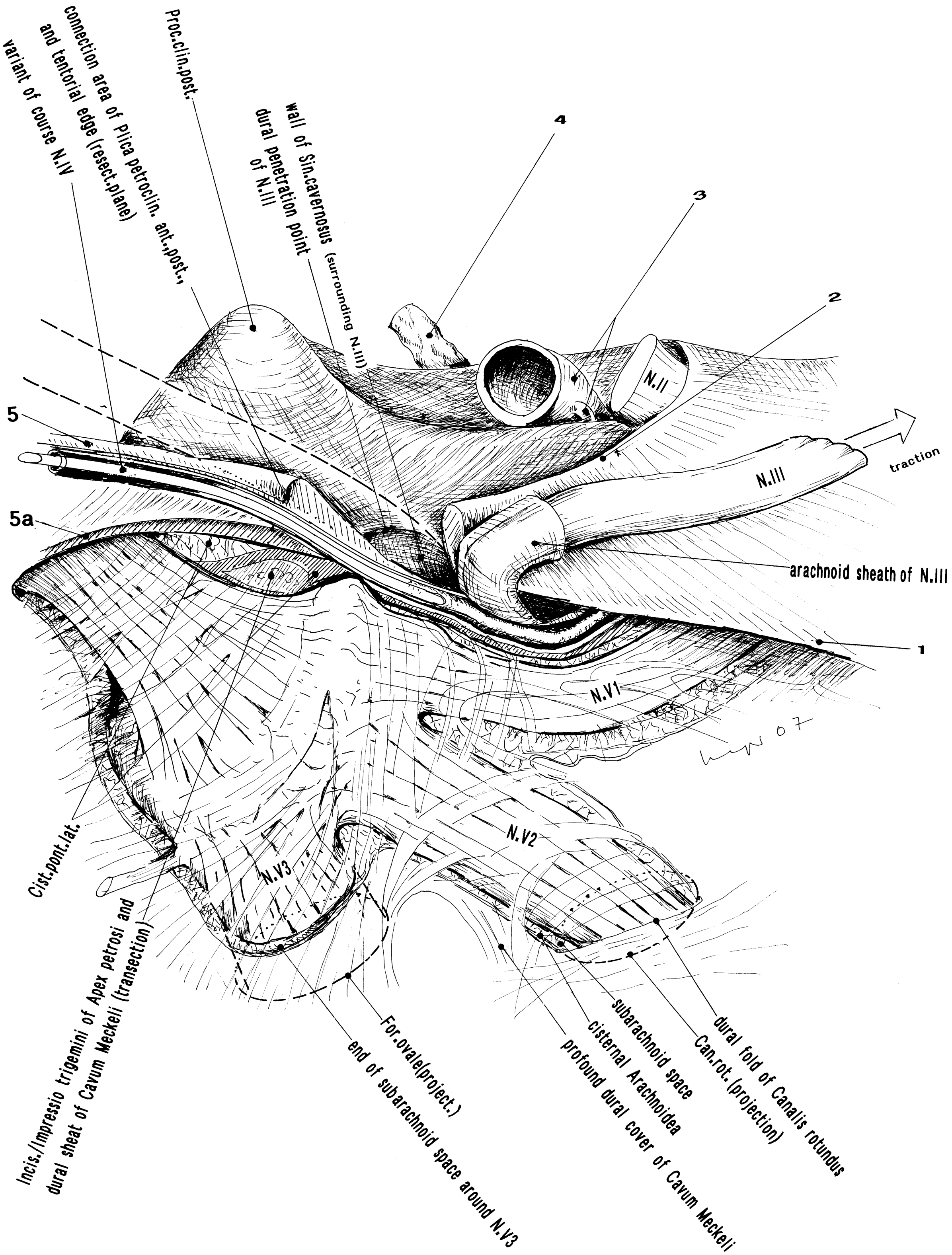

B
ant.limit of
CSF-space
7
9
8
6
5
4
Cist.laminae term.
1
10
3
2
Cist.chiasmatis
Vagina ext. of N.II (dural layer)
Vagina int. of N.II (outer arachnoid membrane)

Fig. 32

Extensions of cisterns along N. oculomotorius, N. trochlearis and N. trigeminus

– N. oculomotorius and N. trochlearis
  These nerves penetrate the basal Dura medial to Plica petroclinoidea ant.. Its CSF-containing arachnoid covers extend into the cavernosus area, similar to N. trochlearis. Usually the dural exit point of N. trochlearis is located anterior to Plica petroclinoidea post. Fig. 32 shows a variant. Here the intracavernous segment of the nerve begins posterior to Plica petroclinoidea post. (as shown in Fig. 9 D). Usually the distal segment transcrosses Cisterna ambiens dorsal from N. trigeminus. Between both nerves the arachnoid walls of Cisterna pontis lat. (containing N. V) and Cisterna ambiens (containing N. IV) all are interposed. The density of arachnoid trabecula and/or membranes is variable.
– N. trigeminus
  After crossing Cisterna pontis, the nerve penetrates a wide dural gap. Cisterna trigeminalis of Meckel's diverticle is an extension of Cisterna pontis lateralis. It continues along N. VI, V2 and V3.

Abbreviations
1 Dural cover of Ala minor
2 Plica petroclinoidea ant.
3 A. carotis int. and A. ophthalmica
4 Hypophyseal stalk
5 Tentorial edge
5a Tentorium



according to Lang (1979), p 80

modified

Fig. 33

Addendum to Fig. 32 (anatomical sketch)

A N. V_1 and V_2 spread out. Transdural extension of cranial nerves and their CSF containing covers are drawn in. N. trigeminus and its main branches presented after resection of the covering dural layers. Distal segments of Nn. V_1 and V_2 are even surrounded by CSF-spaces. CSF-space around N. V_3 ends before Foramen ovale is reached.

B View from above. Normal position of Nn. V_1 and V_2 without spreading

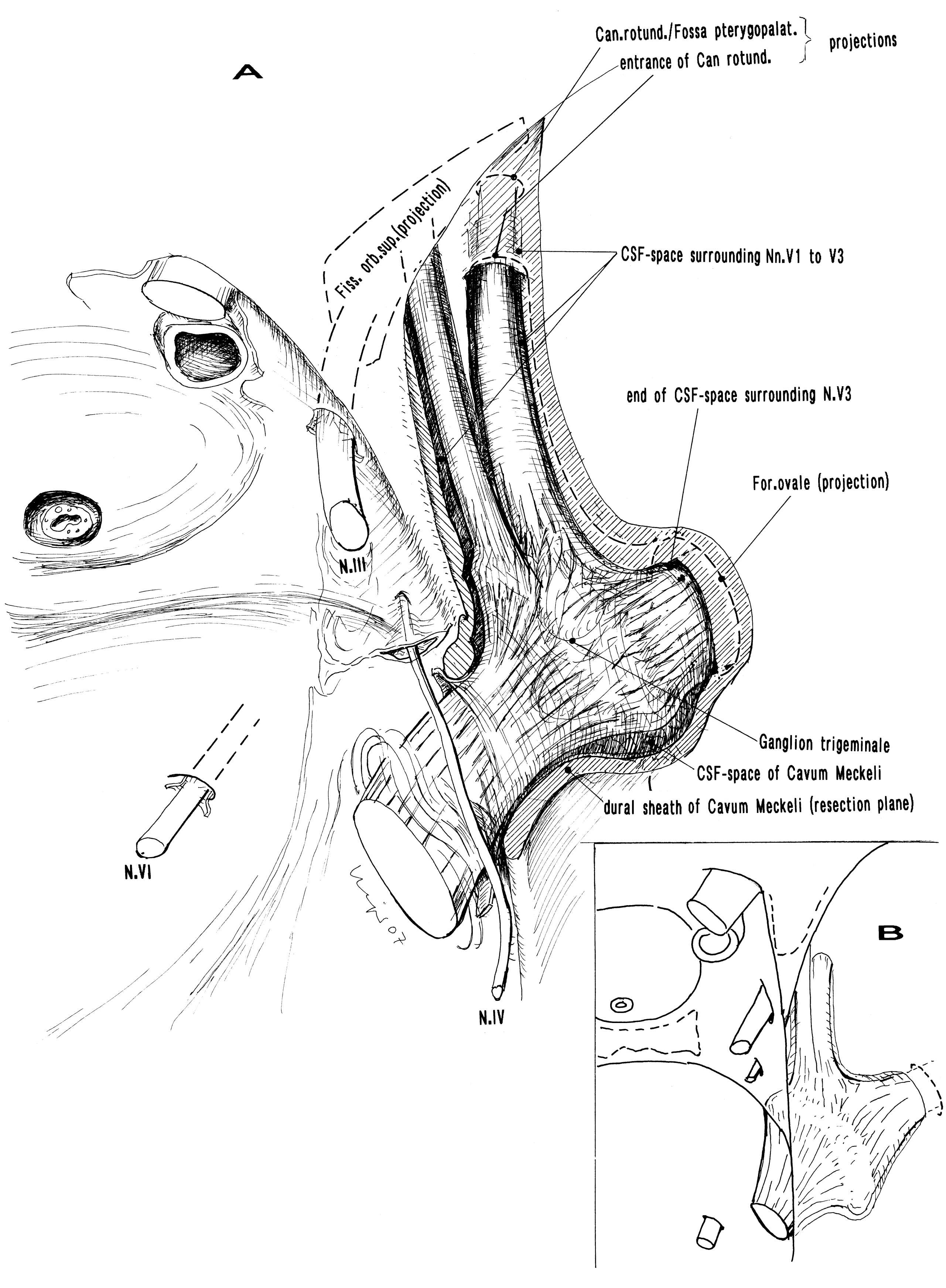
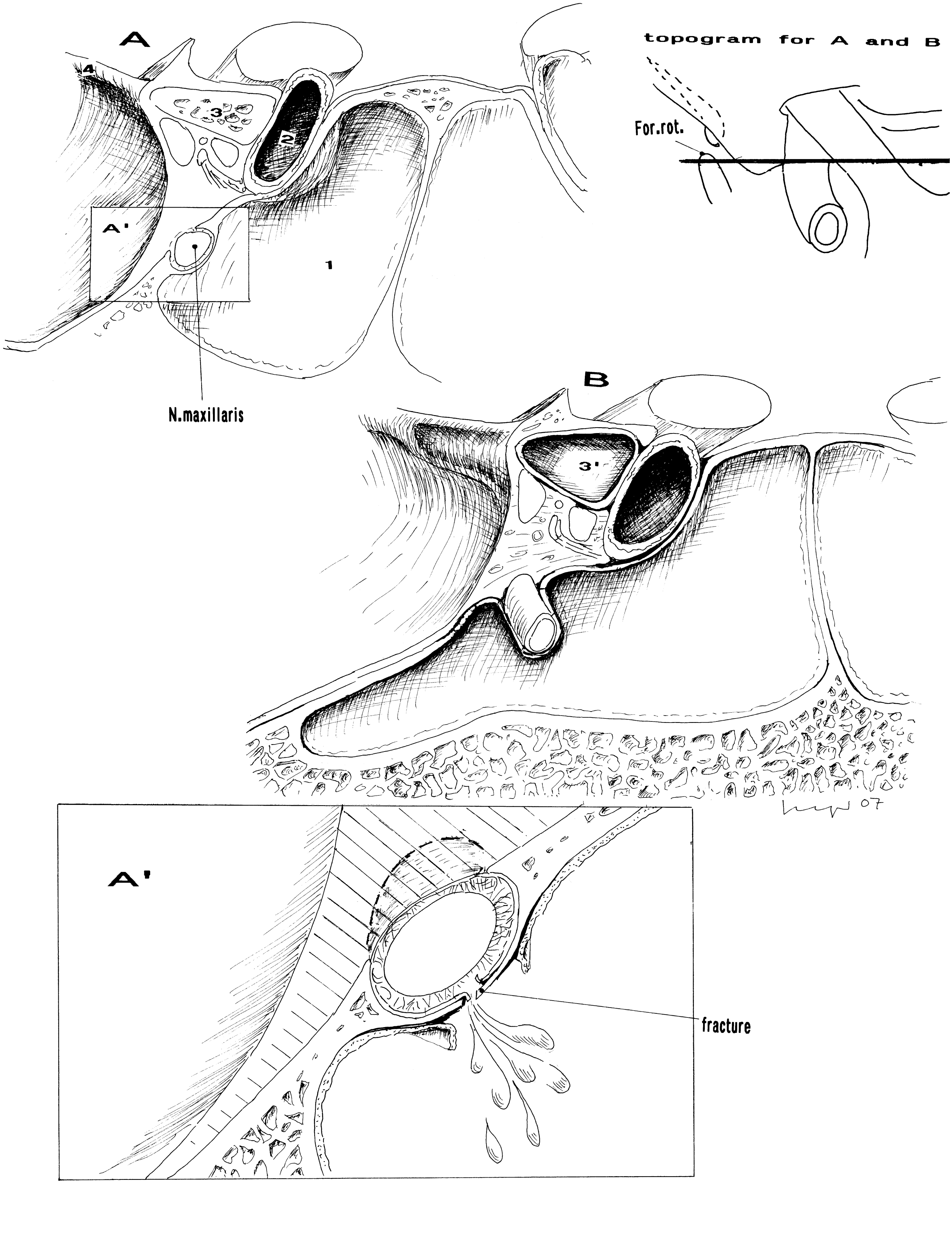

A
Can.rotund./Fossa pterygopalat.
entrance of Can rotund.
projections
Fiss. orb.sup.(projection)
CSF-space surrounding Nn.V1 to V3
end of CSF-space surrounding N.V3
For.ovale (projection)
N.III
Ganglion trigeminale
CSF-space of Cavum Meckeli
dural sheath of Cavum Meckeli (resection plane)
N.VI
N.IV
B

Fig. 34

Continuation of the cistern of Cavum trigeminale (Meckeli) along N. maxillaris. Danger for CSF leak after trauma to the wall of Sinus sphenoidalis (Seeger, 2000).

A Usual topographical anatomy
A' Traumatic CSF leak
B Enlarged Sinus sphenoidalis. Bulging of N. maxillaris and its covers against the lumen of the sinus.
Increased danger for traumatic CSF leak (Seeger 2000)

Abbreviations
1 Sinus sphenoidalis
2 bending (siphon) of A. carotis int.
3 Processus clinoideus ant.
3' Pneumosinus of 3


A
4
3
2
A'
1
N.maxillaris
topogram for A and B
For.rot.
B
3'
A'
fracture

CISTERNA LAMINAE TERMINALIS.
ARTERIES AND RAMI PERFORANTES (Figs. 35 to 38)

Fig. 35

Arteries of Cisterna laminae terminalis and Area subcallosa, and of the basal medial segment of the frontal lobe

A Common findings (Lang, 1995, p 107)
B Common trunk of A. frontobasalis medialis and A. frontopolaris (Nieuwenhuys et al 1991, p 35)
C Common trunk of A. frontopolaris and A. callosomarginalis (Staubesand and Ferner 1973, p 95)
D Similar to B (Lang, 1995, p 107)
E T-shaped bifurcation of A. frontobasalis medialis (Lang 1995, p 109)
F Rightsided common trunk of A. frontobasalis medialis and A. frontopolaris. The olfactory branch originates from A1, not from Heubner's artery. This is a rare variant (Stephens and Stilwell, 1969, p 59)
G Common trunk of A. frontobasalis medialis and A. frontopolaris with a T-shaped bifurcation (Lang, 1995, p 109)

Abbreviations
1 A. cerebri anterior
2 A. frontobasalis medialis
3 A. frontopolaris
4 A. callosomarginalis
5 A. recurrens (Heubneri). Synonym: A. centralis longa
5' As 5, double
6 Branches of 5 for Trigonum olfactorium and Tractus opticus
6' As 6, originating from A2, not from 5

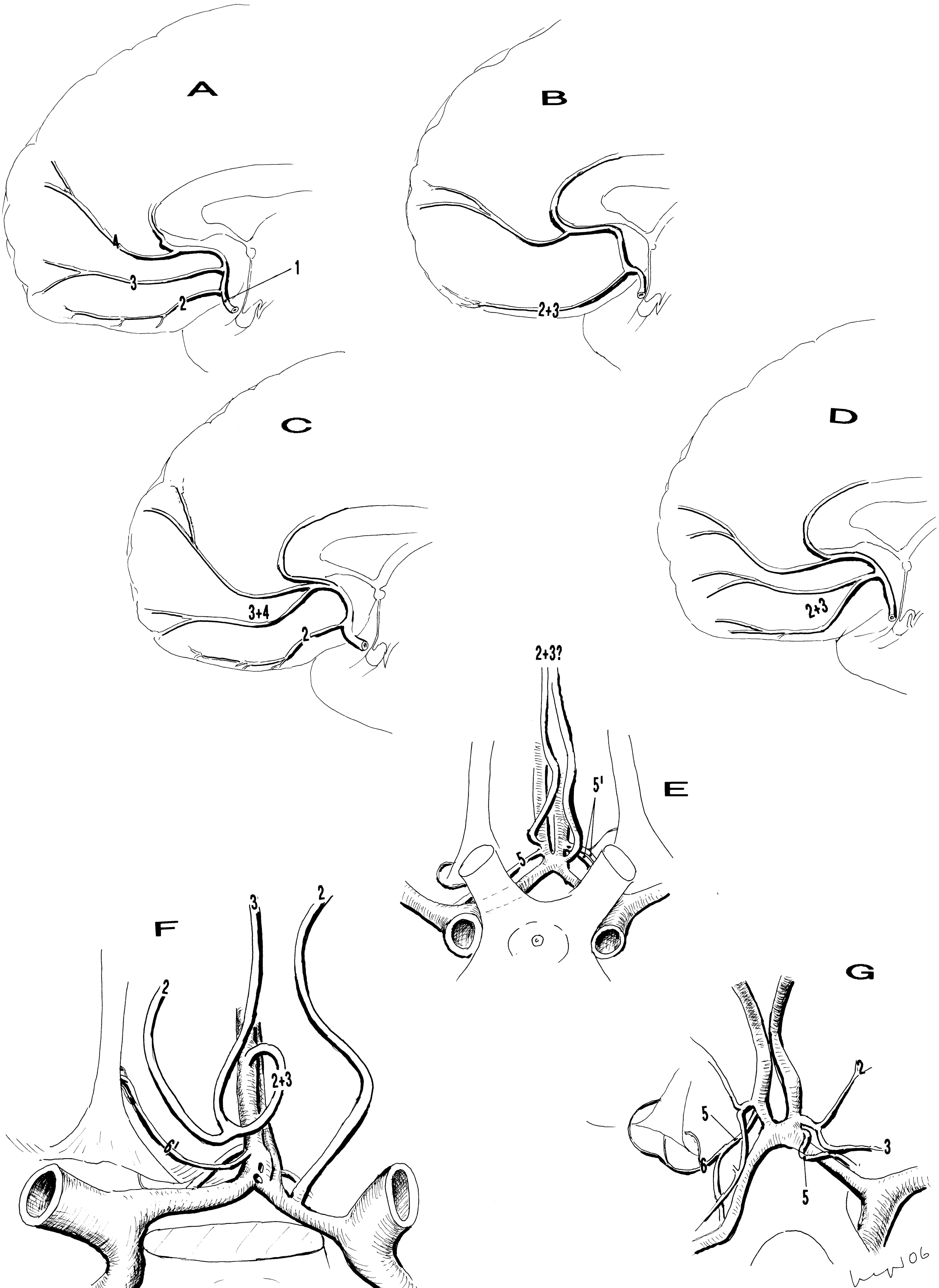

A
4
3
1
2
B
2+3
C
3+4
2
D
2+3
2+3?
5'
E
5
F
3
2
2
2+3
G
2
5
3
6
5

Fig. 36

A. cerebri ant. (A1-segment) and A. communicans ant., variants according to Perlmutter and Rhoton (1976) and to von Mitterwallner (1955)

A Common fenestration of A. communicans ant. Schematical presentation of the barrier areas of the cisterns
- *a* Cisterna laminae terminalis
- *b* Cisterna valleculae
- *c* Cisterna chiasmatis

B to **D** Additional types of fenestrations

E to **G** Fenestrations of A. cerebri ant. (A1-segment), rare

H Hypoplasia of A. cerebri ant. (A) combined with hyperplasia of Heubner's artery

I Combination of different rare variants. Only the course of olfactory branches of the left hemisphere is regular as usual

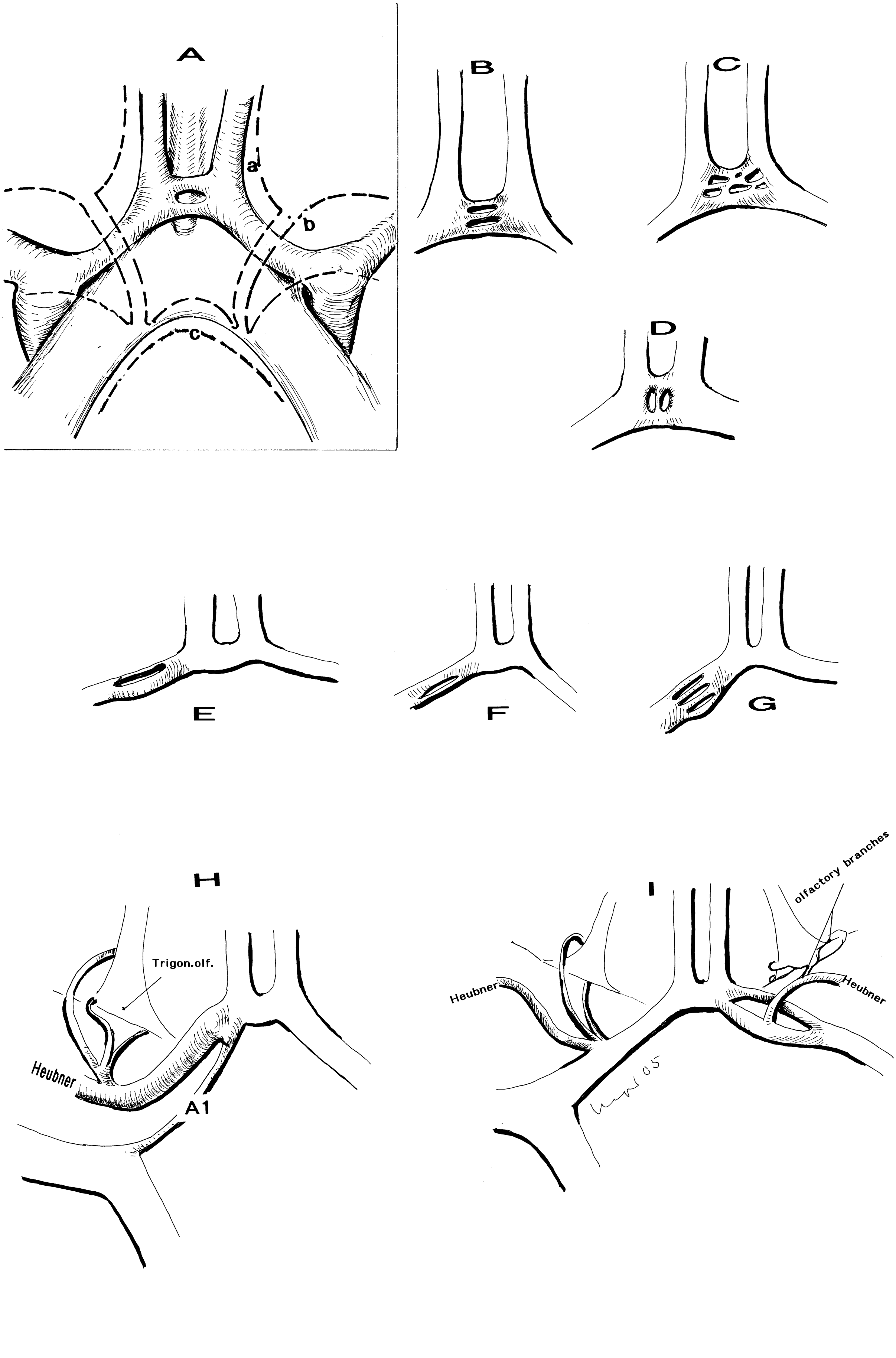
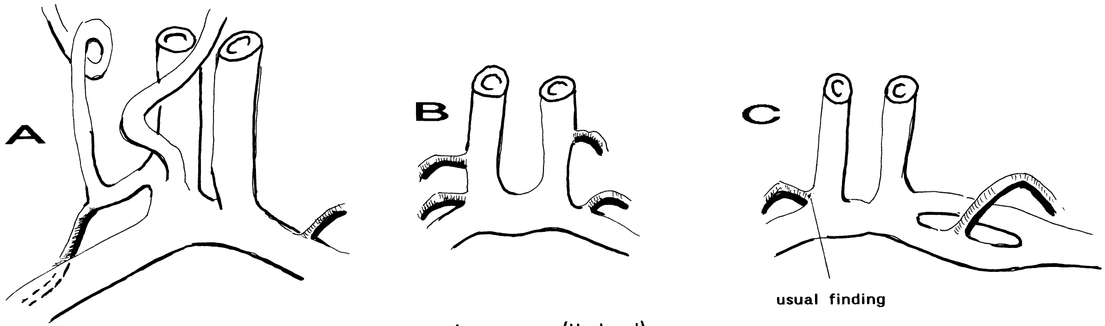

A
a
b
c
B
C
D
E
F
G
H
Trigon.olf.
Heubner
A1
I
olfactory branches
Heubner
Heubner

Fig. 37

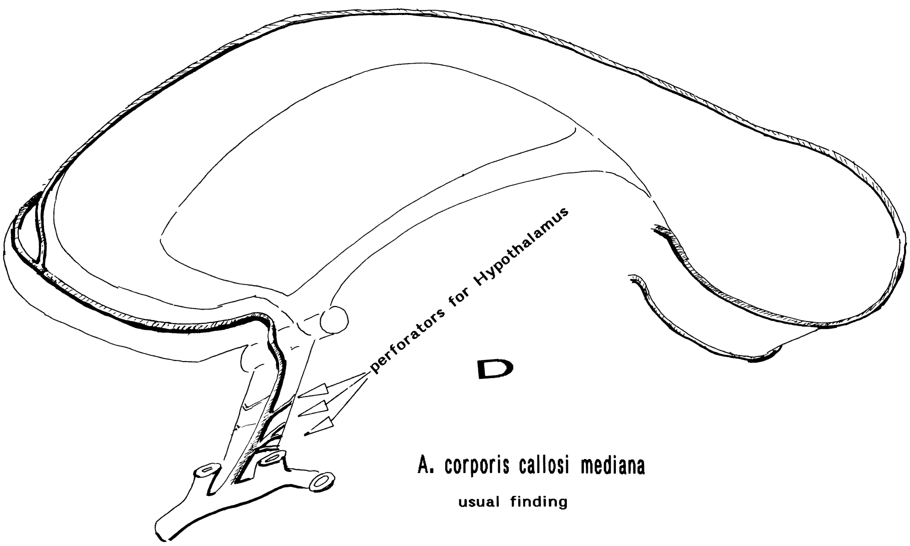
Addendum to Fig. 36

A to **C** Variants of A. recurrens (Heubneri).
According to Kribbs and Kleihues (1971), slightly modified.

D to **G** Usual presentation of A. corporis callosi mediana (D), and variants, according to Kleiss (1941/42), von Mitterwallner (1955), Stephens and Stilwell (1969), Mc Cormick (1969), modified.
This artery may be described as “single A2” (E), or as a “treble A2” (F) in the literature.
A. corporis callosi mediana is a phylogenetic remnant. In mammalian brains with a dominant Allocortex (limbic cortex) and only an early stage of Neocortex there, A. corporis callosi mediana and its both branches are the main arteries of the forebrain. In humans, It is a fine artery but important during surgery. Yaşargil stated in 1984 that the fine proximal branches of A. corporis callosi mediana are perforating branches feeding Hypothalamus. Its interruption, especially during aneurysm surgery, may be followed by neurological and neuropsychological deficits. If A. corporis callosi mediana is large (see E to F), it may be a substitute of one or both hypoplastic A2-segments of A. cerebri ant.



A. recurrens (Heubneri)



A. corporis callosi mediana

usual finding

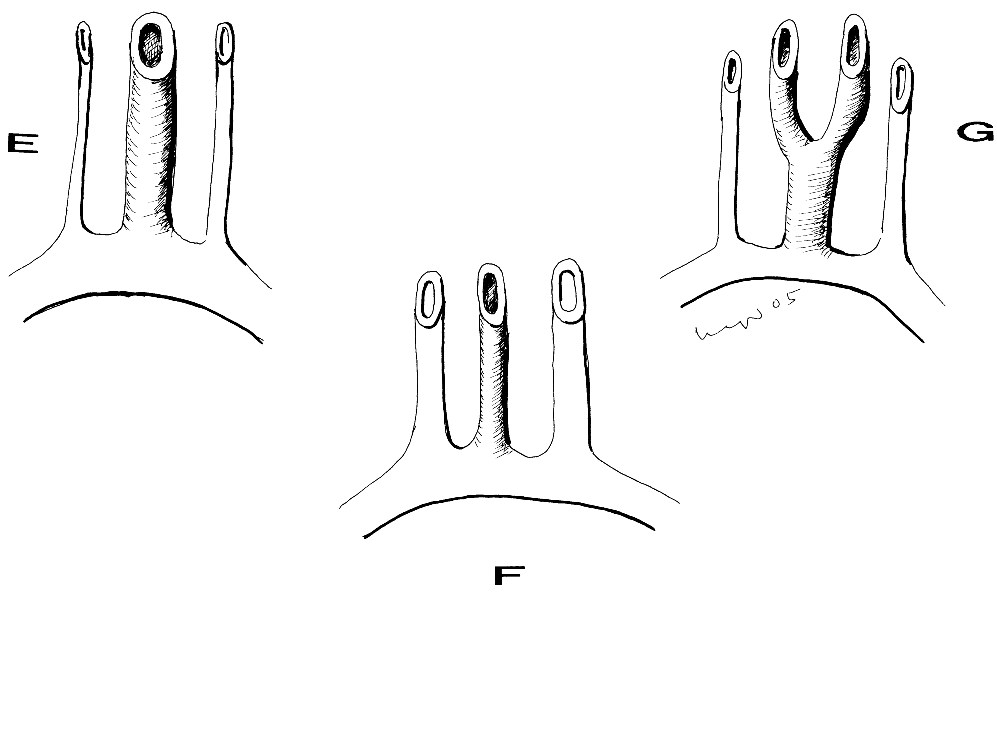


Fig. 38

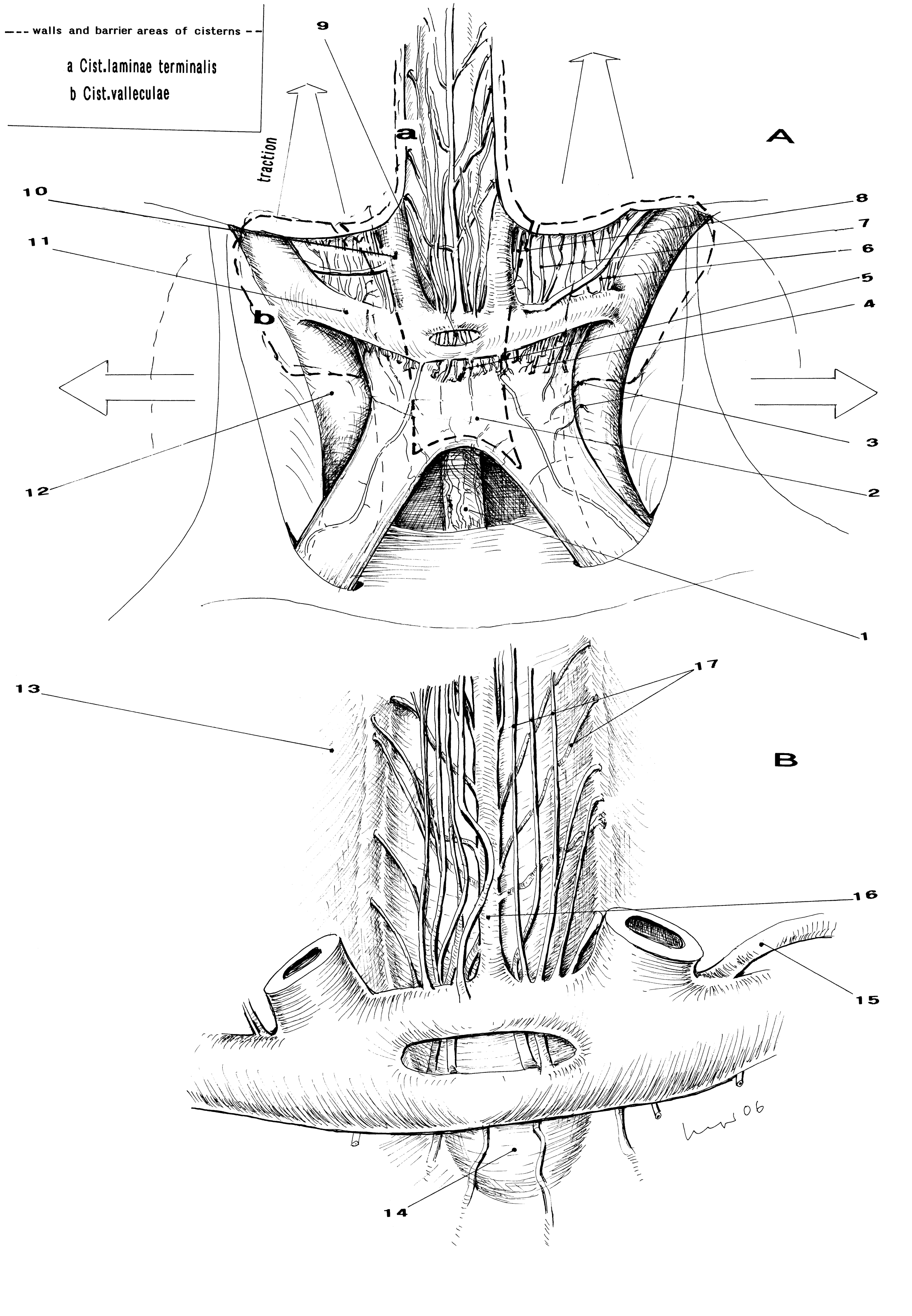
Rami perforantes of the area of Cisterna laminae terminalis and adjacent structures according to Lang (1995, p 107)

A Overview
B Arteries covering Lamina terminalis and feeding Hypothalamus, basal ganglia and Chiasma.

Abbreviations

1 Hypophyseal stalk
2 Chiasma
3 Rami carotici feeding Chiasma and N. opticus
4 Rami perforantes of the A1-segment of A. cerebri ant. feeding Chiasma and N. opt.
5 Rami perforantes of the fenestrated A. communicans ant. feeding Chiasma and Nn. optici
6 Rami perforantes of the A1-segment of A. cerebri ant. penetrating Substantia perforata ant.
7 Rami perforantes of the carotid bifurcation penetrating Subst.perforata ant.
8 Rami perforantes of the A1- and A2-segment of A. cerebri ant. penetrating Substantia perforata ant. and the transitional area between Subst. perforata ant., Area subcallosa, and Lamina terminalis immediately posterior from Gyrus rectus (overlapped by Area subcallosa of the frontal lobe)
9 Fenestration of A. communicans ant.
10 A2-segment of A. cerebri ant. and distal type of the origin of A. recurrens (Heubneri)
11 A1-segment of A. cerebri ant.
12 A. carotis int.
13 Area subcallosa of the frontal lobe close to Lamina terminalis
14 Lamina terminalis
15 A. recurrens (Heubneri)
16 A. corporis callosi mediana
17 Rami perforantes of A. communicans ant. and of A. corporis callosi mediana penetrating Area subcallosa immediately lateral from Lamina terminalis and feeding Hypothalamus.

Arrows: Shifting of Area subcallosa of the frontal lobe and of Uncus by traction.


--- walls and barrier areas of cisterns ---
a Cist.laminae terminalis
b Cist.valleculae
traction
a
b
A
B
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

CISTERNA VALLECULAE (CAROTID CISTERN).
ARTERIES AND RAMI PERFORANTES (Fig. 39 to 41)

Fig. 39

Rami perforantes of the area of Substantia perforata ant. and adjacent structures. Schematical presentation.

Cisterna valleculae is an CSF-space containing A. carotis int. and its branches and other vascular connections:
– Medial limit of Cisterna valleculae: Chiasma and Tractus opticus
– Lateral limit: Uncus and Limen insulae
– Anterior limit: Gyri orbitales and Trigonum olfactorium
– Basal area: Transitional zone to Cisterna ambiens
– Roof: Substantia perforata ant. (Basal limit of basal ganglia)

Abbreviations
1 Tractus opticus
2 Chiasma
3 Substantia perforata ant.
4 Lamina terminalis
5 Medial group of perforating arteries feeding Chiasma, N. opticus, and the basal segment of Hypothalamus
6 Dorsomedial branches of 5, feeding the anterior area of Hypothalamus
7 Trigonum olfactorium
8 Middle group of perforators feeding basal ganglia and Capsula int.
9 Gyri orbitales
10 Insula, medial segment
11 Lateral group of perforating arteries (Aa. lenticulostriatae) feeding basal ganglia and Capsula int.
12 Limen insulae
13 Uncus base (transsected)
14 Plexus chorioideus
15 A. chorioidea ant.
16 Branch of 15 feeding Crus cerebri
17 Rr. perforantes of 18 feeding Tractus opt., basal ganglia, and Capsula int.
18 A. communicans post.
19 Rr. perforantes of Substantia perforata post.

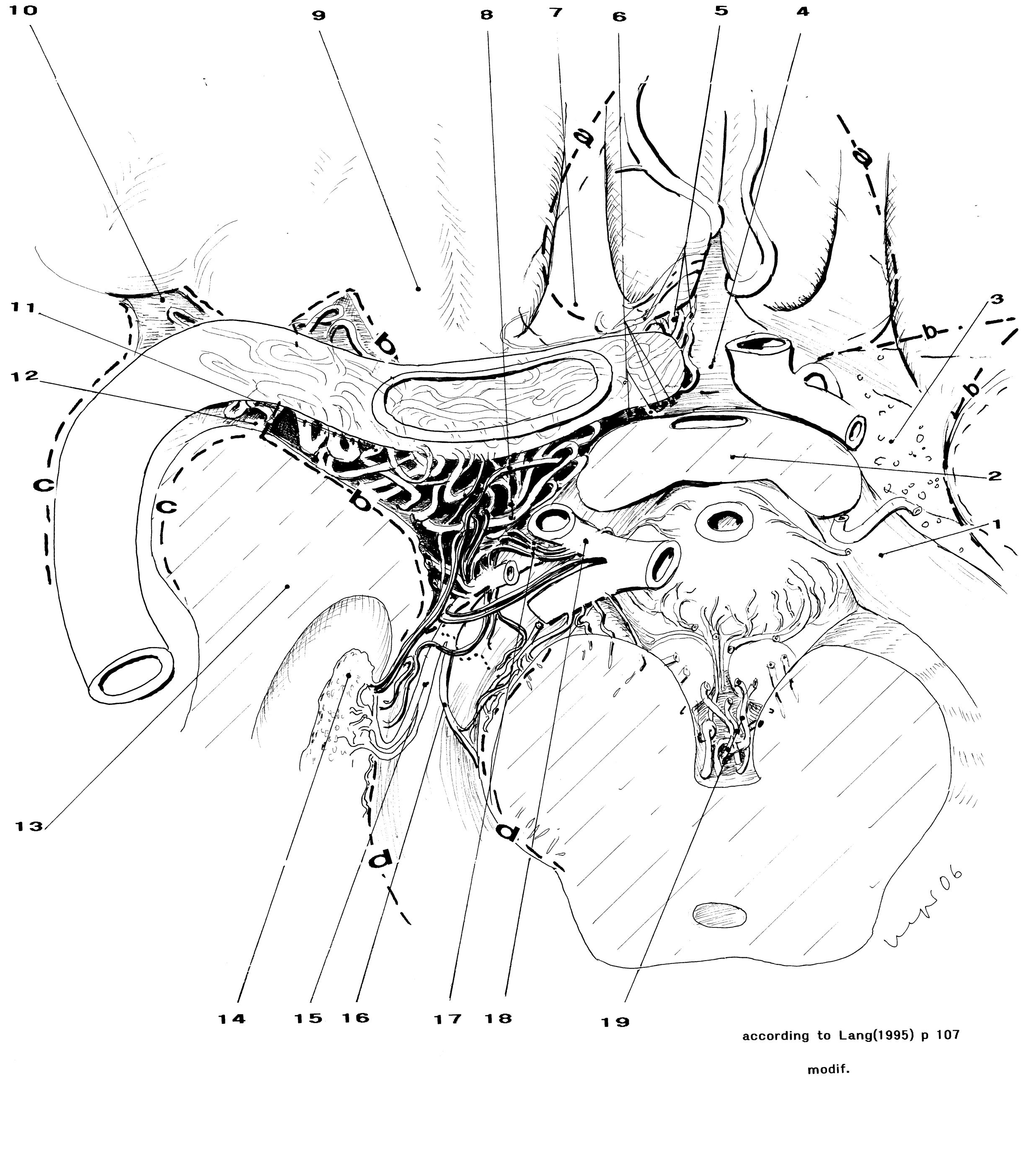
— — — walls and barrier areas of cisterns — — —

a Cist.laminae terminalis

b Cist. valleculae

c Cist.fossae lat.(Sylvii)

d Cist.ambiens



according to Lang(1995) p 107

modif.

Fig. 40

Continuation of Fig. 39. Sectional enlargement.
Barrier areas of the cistern are not compatible with vascular territories, especially not for Rami perforantes. But number and target areas are more variable during their transcisternal course than inside the brain parenchyma
(Stephens and Stilwell 1960, p 113)

Abbreviations
1 Rr. perforantes feeding Crus cerebri and penetrating Substantia perforata post.
2 Rr. perforantes feeding Crus cerebri
3 Rr. perforantes penetrating Tractus opt.
4 Rr. perforantes penetrating Substantia perforata ant.
5 Rr. perforantes penetrating the transitional area of Substantia perforata ant. and the base of Sulcus longitudinalis close to Lamina terminalis
6 Numerous Rr. perforantes penetrating Subst. perforata ant.
7 Aa.lenticulostriatae and other Rr. perforantes penetrating the lateral segment of Subst. perforata ant.
8 Long bundle of Rr. perforantes (common variant) feeding Plexus chorioideus of Cornu inferius
9 Common Rr. perforantes feeding Substantia perforata ant.
10 Rami temporales for Uncus
11 Rr. perforantes penetrating the inferior surface of Tractus opt.
12 Rr. perforantes penetrating the medial area and the medial rim of Tractus opt.
13 Terminal branches of A. chorioidea ant. feeding Plexus chorioideus of Cornu inferius

Ramifications of large cerebral arteris
Rami of *A. carotis int.* see abbreviations 6
Rami of *A. cerebri media* see abbreviations 7
Rami of *A. cerebri ant.* see abbreviations 5
Rami of *A. communicans post.* see abbreviations 3, 4
Rami of *A. chorioidea ant.* see abbreviations 9, 10, 11, 12, 13
Rami of *A. cerebri post.* see abbreviations 1, 2

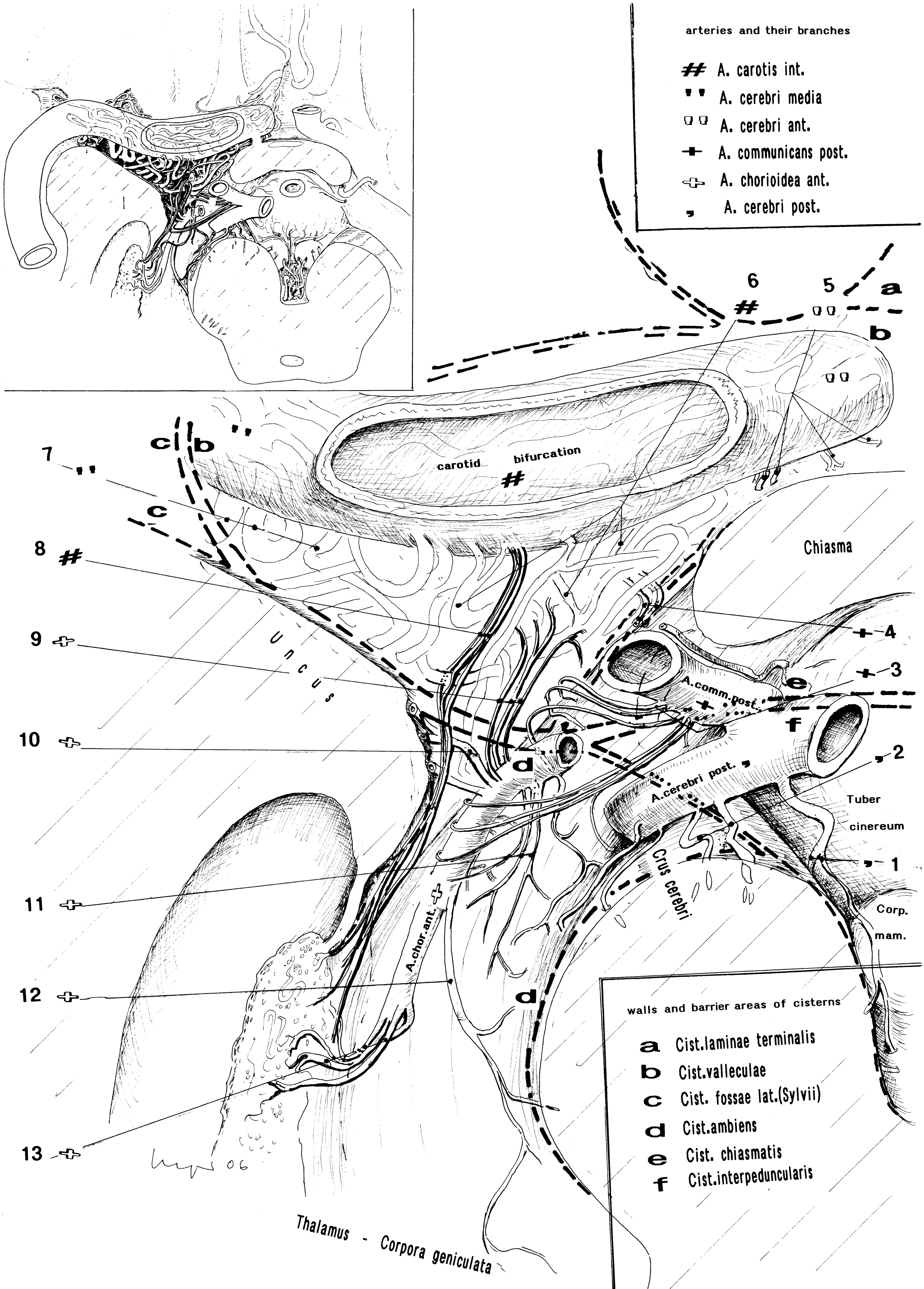
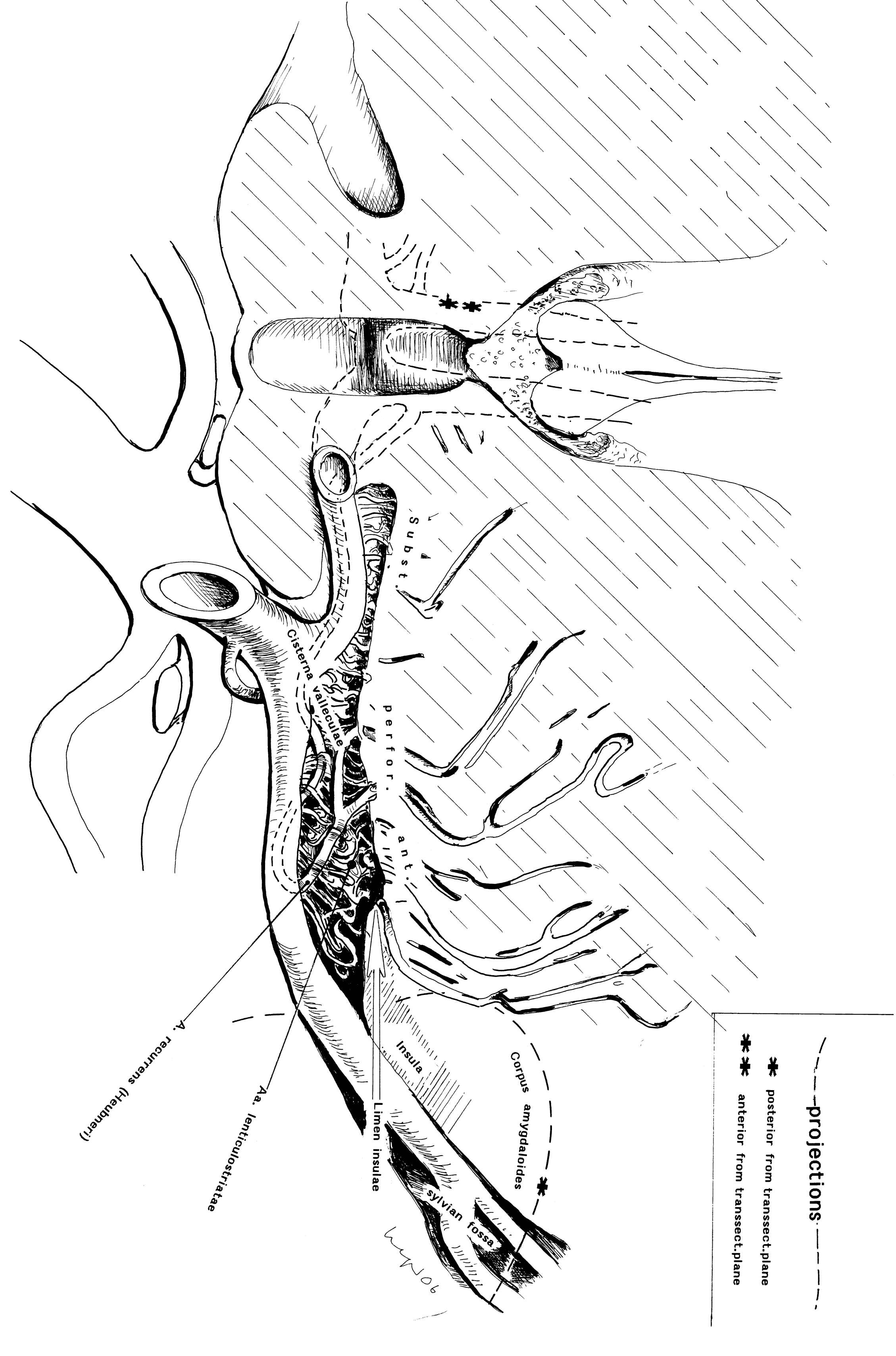

arteries and their branches
A. carotis int.
A. cerebri media
A. cerebri ant.
A. communicans post.
A. chorioidea ant.
A. cerebri post.
6
5
a
b
carotid bifurcation
Chiasma
7
c
b
c
8
9
Uncus
10
11
12
13
4
3
2
1
e
A.comm.post.
f
d
A.cerebri post.
Tuber
cinereum
Crus cerebri
A.chor.ant.
Corp.
mam.
d
walls and barrier areas of cisterns
a Cist.laminae terminalis
b Cist.valleculae
c Cist. fossae lat.(Sylvii)
d Cist.ambiens
e Cist. chiasmatis
f Cist.interpeduncularis
Thalamus - Corpora geniculata

Fig. 41

Aa. perforantes feeding basal ganglia and Capsula int.

These vessels originate from the carotid bifurcation and the main trunk of A. cerebri media. They are located in Cisterna valleculae, not in the sylvian fossa. The barrier area of these cisterns is limen insulae close to Aa. lenticulostriatae.
The roof of Cisterna valleculae is concave in the depth.
The base of Cisterna fossae lat. (Sylvii) is protruding close to the middle basal segment of Insula.


Subst. perfor. ant.
Cisterna valleculae
A. recurrens (Heubneri)
Aa. lenticulostriatae
Insula
Limen insulae
Corpus amygdaloides
sylvian fossa
projections
* posterior from transsect.plane
** anterior from transsect.plane

CISTERNA FOSSAE LATERALIS (SYLVII).
ARTERIES AND VEINS (Figs. 42 to 44)

Fig. 42

Arachnoidea and course of A. cerebri media. Surgical aspects.

A Arachnoid density (T: tunnels) and relationship of Sulcus inferior insulae to Cornu inferius (arrow)

B Course of A. cerebri media running along Sulcus inferior insulae (dotted lines) obstructing the transsylvian surgical approach to Cornu inferius. After surgical interruption of one or two fine insular branches, mobilization of the artery in a dorsal direction can be done.
Incision of Sulcus inferior insulae for opening of Cornu inferius is now possible (arrow).

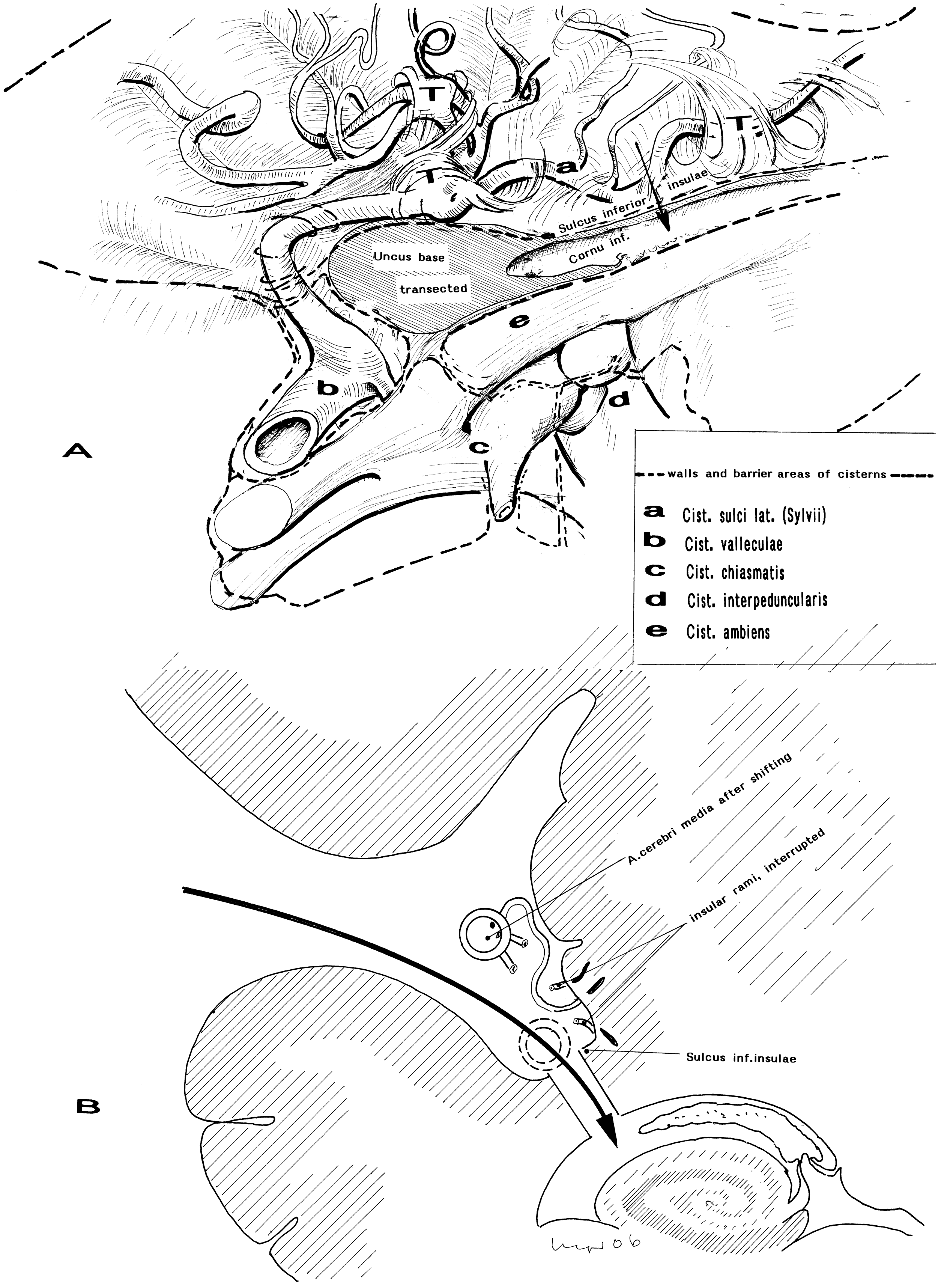
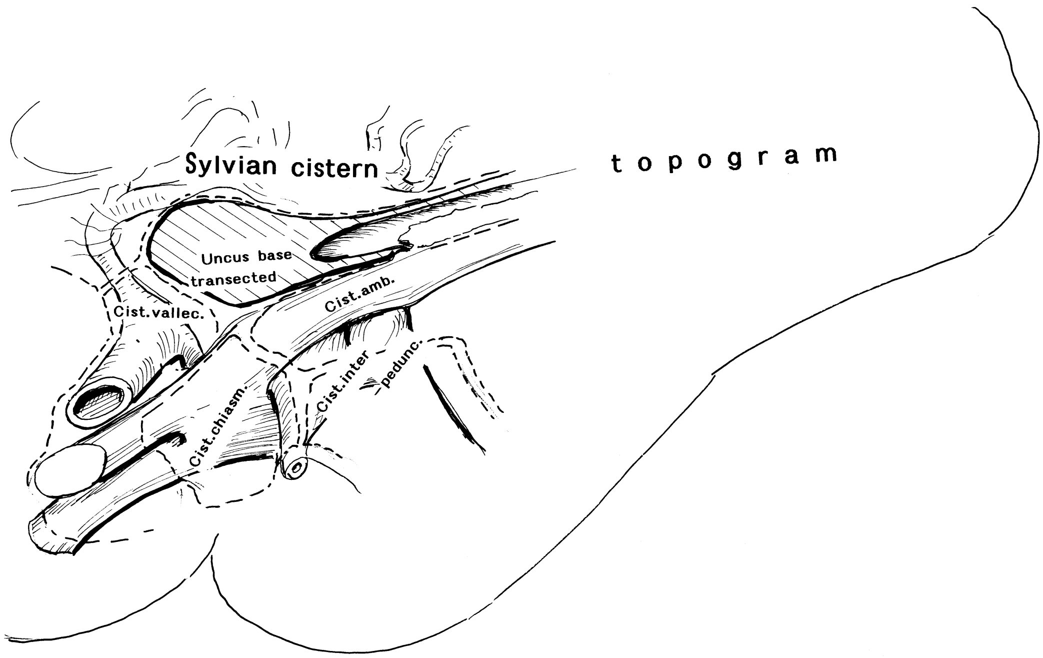

A
T
T
T
a
Sulcus inferior insulae
Cornu inf.
Uncus base
transected
e
b
c
d
walls and barrier areas of cisterns
a Cist. sulci lat. (Sylvii)
b Cist. valleculae
c Cist. chiasmatis
d Cist. interpeduncularis
e Cist. ambiens
B
A.cerebri media after shifting
insular rami, interrupted
Sulcus inf.insulae

Fig. 43

Transcisternal draining veins in the depth of the cisterns

Abbreviations

1 Vein of Plexus chorioideus
2 Rami transversi of 3
3 V. ventricularis inf.
4 Inferior tip vein
5 Connecting veins of the superficial and profound sylvian vein(s)
6 Profound sylvian vein or multiple fine veins
7 V. cerebri anterior
8 V. interpeduncularis
9 Venous network


Sylvian cistern
topogram
Uncus base
transected
Cist.vallec.
Cist.amb.
Cist.chiasm.
Cist.inter
pedunc.

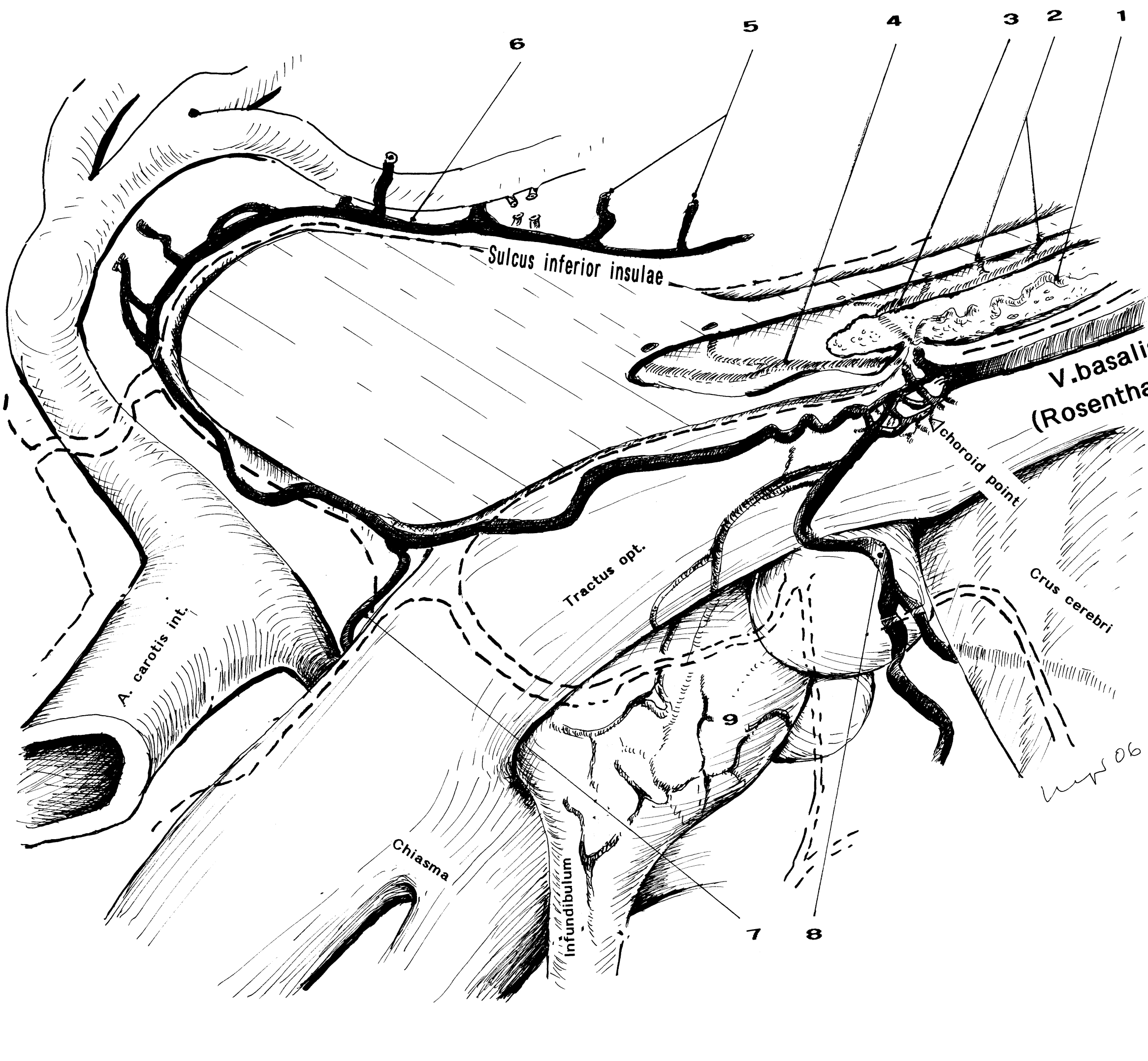
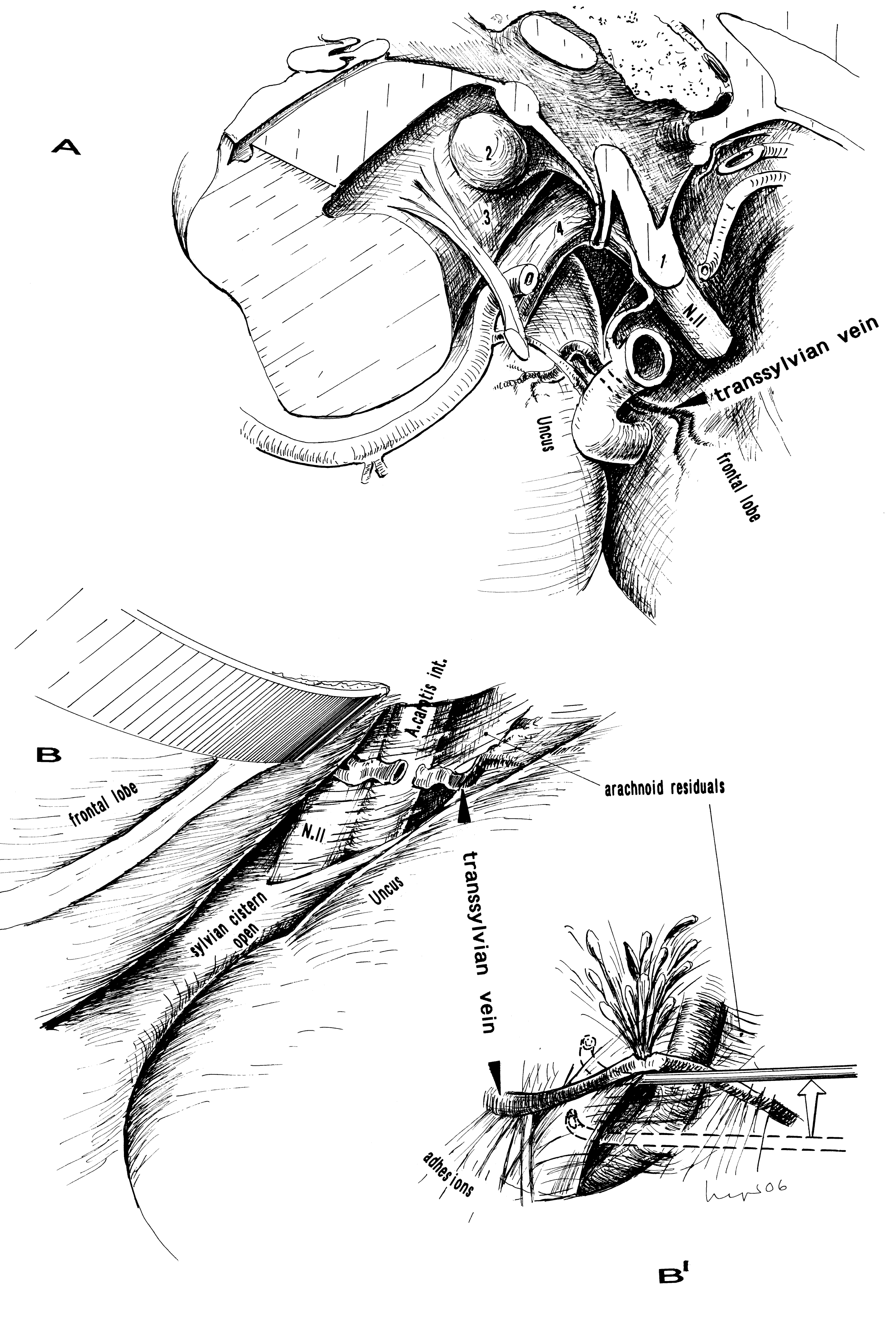

6
5
4
3
2
1
Sulcus inferior insulae
V.basalis
(Rosenthal)
choroid point
Tractus opt.
Crus cerebri
A. carotis int.
9
Chiasma
Infundibulum
7
8

Fig. 44

Addendum to Fig. 43
Transsylvian vein located lateral to A. carotis int. and N. opticus

This typical vein connects Uncus to the frontobasal cortex. Its interruption at pterional surgical approaches is usually unproblematic. During transnasal endoscopic approaches the vein is covered by A. carotis int. and by N. opticus. Brain shift may result in damage to this vein with consecutive occult bleeding.

A View from a medial basal direction. Anatomical model according to a transnasal endoscopic approach
B View from a frontotemporal direction. Anatomical model according to a transnasal endoscopic approach.
B' Vein damaged


A
2
3
4
1
N.II
transsylvian vein
Uncus
frontal lobe
B
A.carotis int.
arachnoid residuals
frontal lobe
N.II
transsylvian vein
Uncus
sylvian cistern open
adhesions
B'

CISTERNA CHIASMATIS. ARTERIES AND RAMI PERFORANTES. ANATOMICAL MODELS. (Fig. 45 to 47)

Fig. 45

Walls of Cisterna chiasmatis and adjacent cisterns.
Relationship to arteries.

A Perspective according to microsurgical pterional approaches
B Perspective according to transnasal endoscopic approaches

Abbreviations
1 A. communicans post.
2 A. chorioidea ant.
3 Branches to the temporal lobe
4 Dural branch (Yaşargil)
5 Branches to N. opt. and Chiasma
6 A. hypophysialis sup.
7 Branches to Chiasma and Hypothalamus

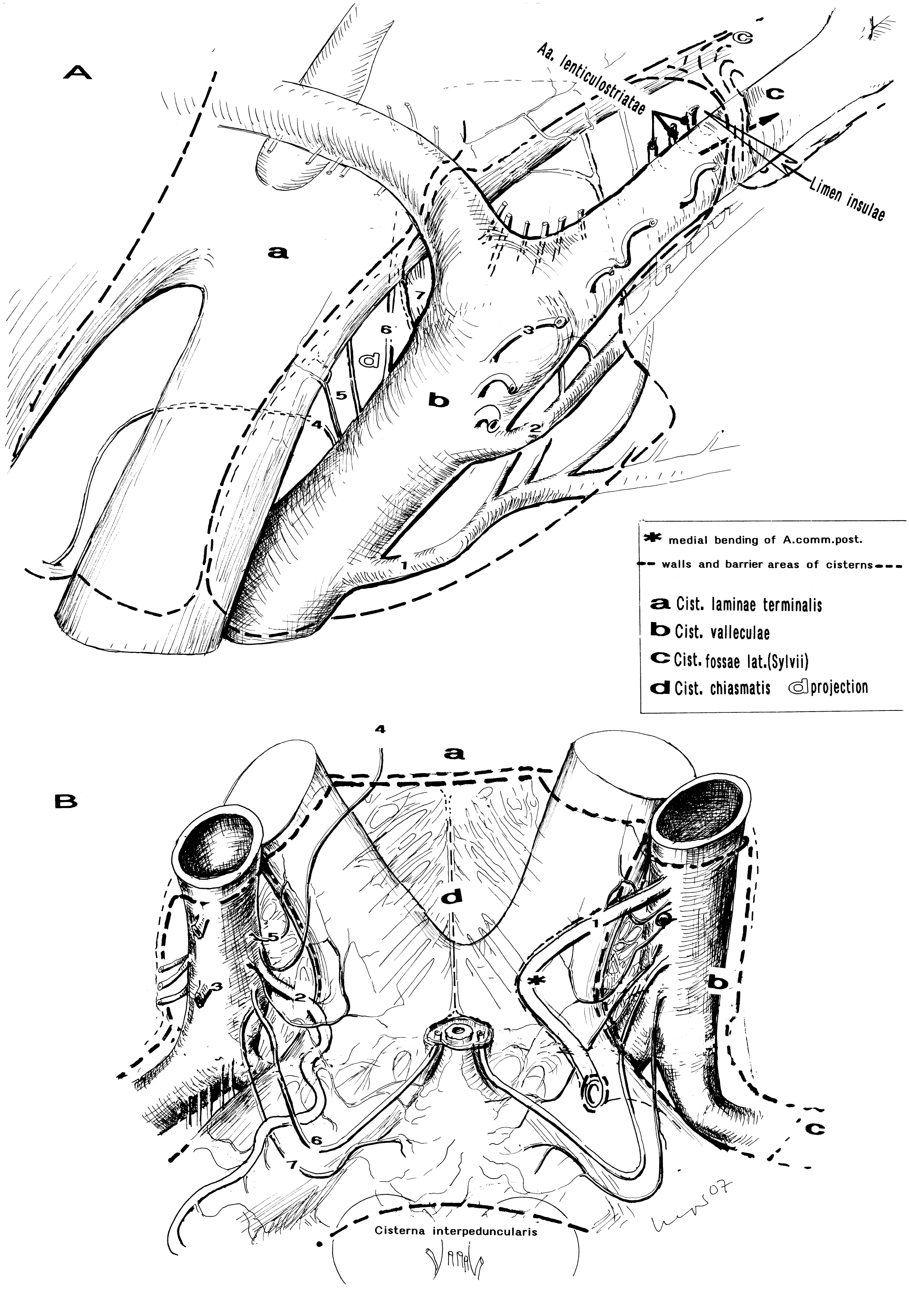

A
a
b
c
d
1
2
3
4
5
6
7
Aa. lenticulostriatae
Limen insulae
* medial bending of A.comm.post.
walls and barrier areas of cisterns
a Cist. laminae terminalis
b Cist. valleculae
c Cist. fossae lat.(Sylvii)
d Cist. chiasmatis
d projection
B
Cisterna interpeduncularis

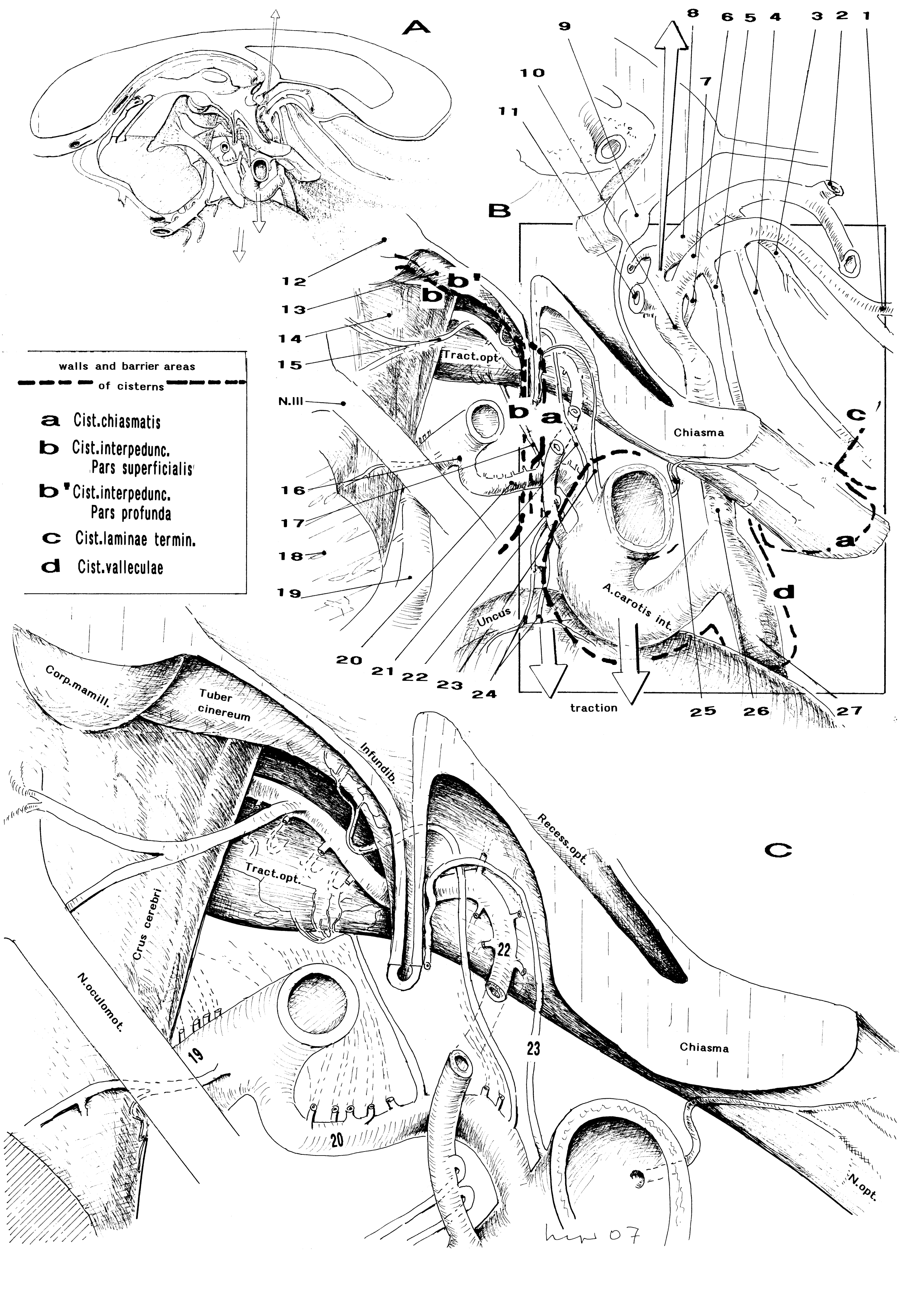
Fig. 46

Arteries of Cisterna chiasmatis and adjacent cisterns stretched for understanding shifted arteries during surgery (arrows)

A Overview
B Details
C Sectional enlargement of B

Abbreviations
1 A. callosomarginalis
2 Branch of A2
3 As 2, crossing midline for feeding the contralateral hemisphere
4 A. frontopolaris
5 A. frontobasalis medialis
6 A. recurrens (Heubneri)
7 A2 left
8 A2 right
9 Commissura ant.
10 A1 left
11 A1 right (transsected)
12 Corpus mamillare
13 Tuber cinereum
14 Crus cerebri
15 Branches of A. chorioidea ant. feeding Crus cerebri
16 Connection point of A. cerebri post. and A. communicans post.
17 Branches of A. communicans post. feeding Tractus opt., basal ganglia and Capsula int.
18 Crus cerebri, transectional plane
19 A. cerebri post.
20 A. communicans post.
21 Similar to 17
22 A. chorioidea ant., interrupted
23 A. hypophysialis sup.
24 Branches of A. chorioidea ant. feeding Uncus
25 Branches of A. carotis int. feeding Chiasma and N. opticus
26 A. cerebri ant. (A1)
27 A. cerebri media

III N. oculomotorius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17
18
19
20
21
22
23
24
25
26
27
b'
b
Tract.opt.
N.III
a
Chiasma
c
a
d
Uncus
A.carotis int.
traction
walls and barrier areas of cisterns
a Cist.chiasmatis
b Cist.interpedunc. Pars superficialis
b' Cist.interpedunc. Pars profunda
c Cist.laminae termin.
d Cist.valleculae
Corp.mamill.
Tuber cinereum
Infundib.
Recess.opt.
Tract.opt.
Crus cerebri
N.oculomot.
22
23
19
20
Chiasma
N.opt.

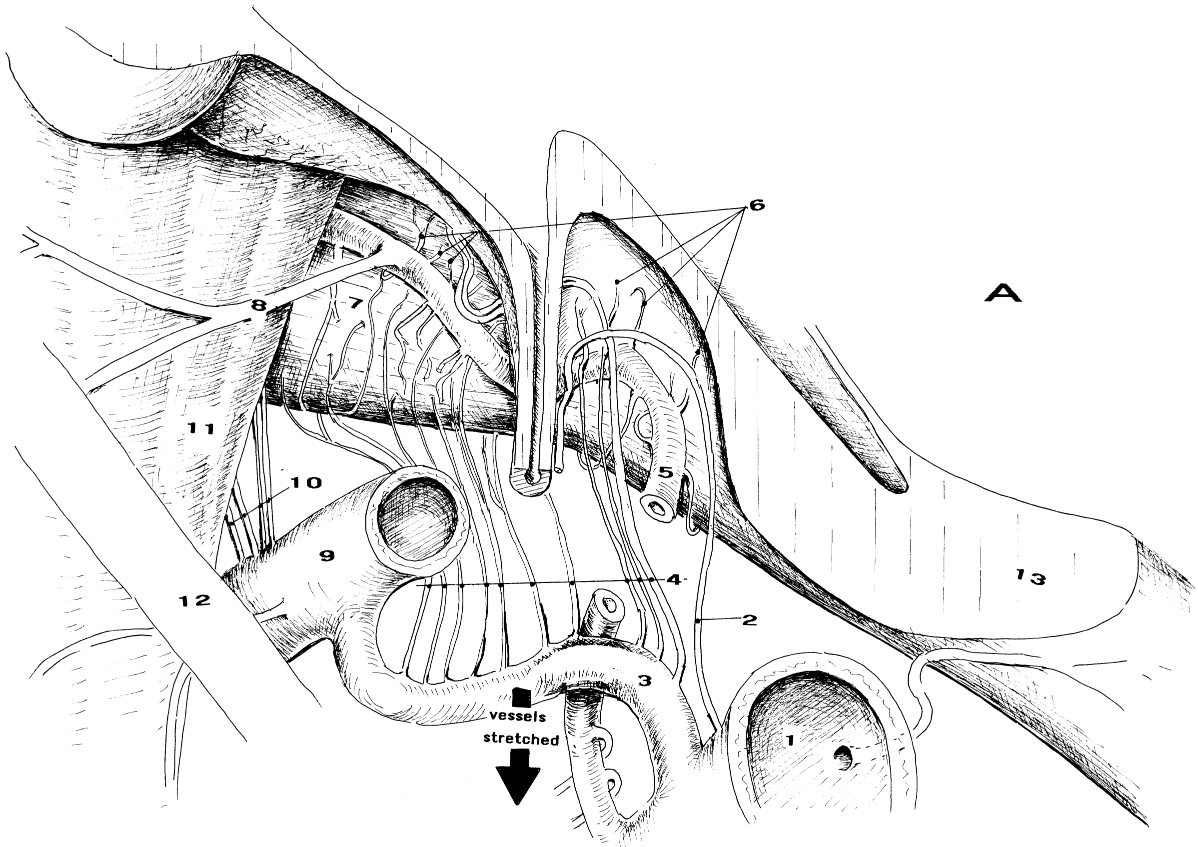
Fig. 47

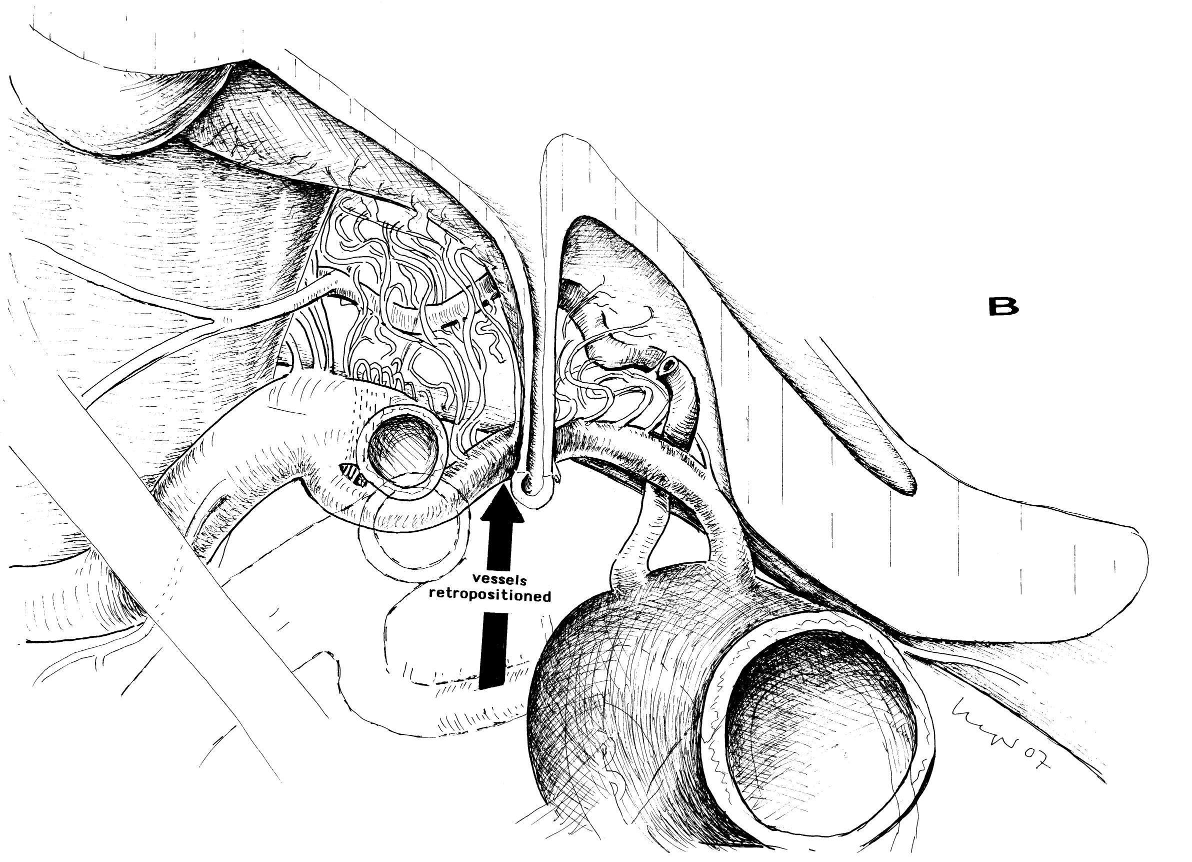
Addendum to Fig. 46

A Arteries stretched
B Arteries repositioned into their normal position

Abbreviations

1 A. carotis int.
2 A. hypophysialis sup.
3 A. communicans post.
4 Rr. perforantes of 4, penetrating (and feeding) Tractus opt.
5 A. chorioidea ant.
6 Rr. perforantes of 5, penetrating (and feeding) Tractus opt.
7 Tractus opt.
8 Branch(es) of A. chorioidea ant., feeding Crus cerebri
9 A. cerebri post.
10 Rr. perforantes of 9, feeding Crus cerebri and penetrating Substantia perforata post., penetrating (and feeding) Tractus opt.
11 Crus cerebri
12 N. oculomotorius
13 Chiasma


A
1
2
3
4
5
6
7
8
9
10
11
12
13
vessels
stretched


B
vessels
retropositioned

CISTERNA INTERPEDUNCULARIS, ADJACENT CISTERNS, VESSELS AND CRANIAL NERVES (Figs. 48 and 49)

Fig. 48

Middle area of the upper cisterns: Cisterna interpeduncularis and its transversal wall (Liliequist's membrane). Note high density of intercisternal walls enclosing N. oculomotorius

Abbreviations

a	Cisterna laminae terminalis
b	Cisterna valleculae
c	Cisterna fossae lat. (Sylvii)
d	Cisterna chiasmatis
e	Pars superficialis of Cisterna interpeduncularis
f	Cisterna cruralis
g	Cisterna ambiens

1	Insertion of the diencephalic portion of Liliequist's membrane
2	Bulging of Liliequist's membrane overlapped by Cisterna chiasmatis
3	Insertion of the mesencephalic portion of Liliequist's membrane at the pontomesencephalic rim
4	Trabecula enclosing N. oculomotorius
5	Posterior group of arteries originating from the basilar bifurcation
6	Anterior group of arteries originating from the basilar bifurcation
7	Chorioid point
8	V. basalis Rosenthal
9	V. mesencephalica lat.

I to IV	Cranial nerves

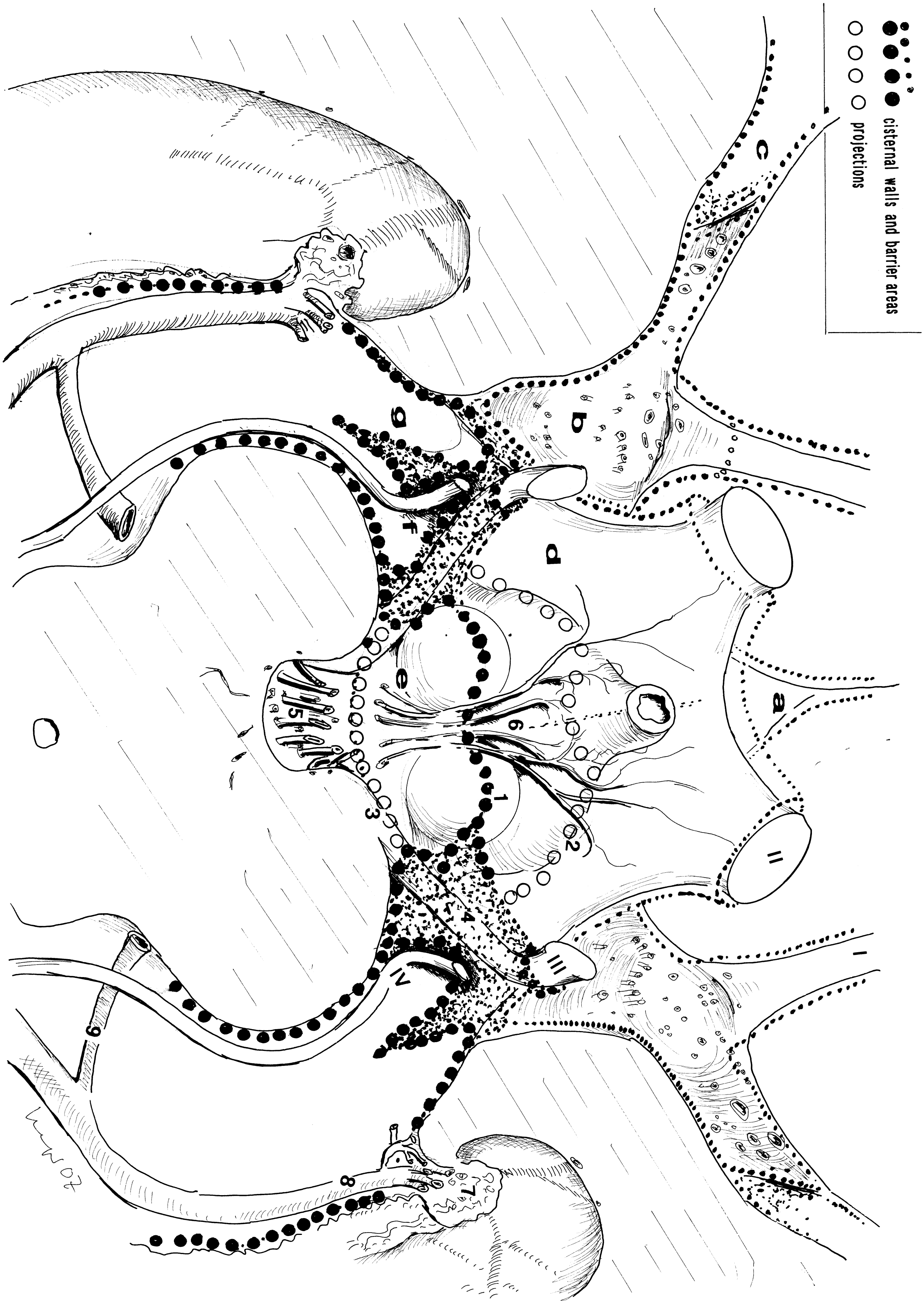

cisternal walls and barrier areas
projections

Fig. 49

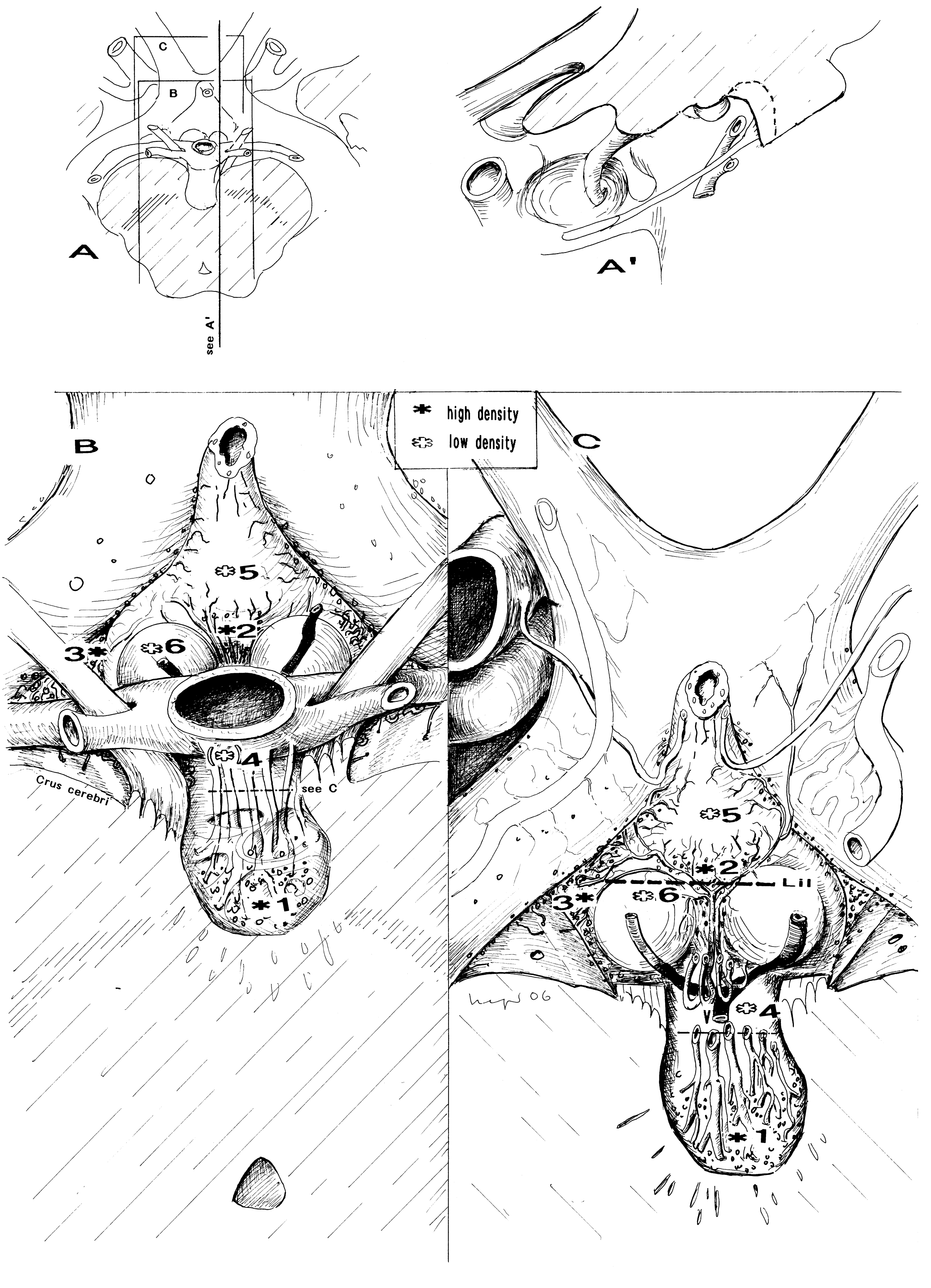
Addendum for Fig. 48
Density of penetration points of Rami perforantes at the cerebral base.

A and **A'** Topograms, sketches
B Bifurcation of A. basilaris added
C Bifuraction of A. basilaris omitted

High density of penetration points
– 1 Substantia perforata post.
– 2 Tuber cinereum close to Corpora mamillaria
– 3 A rim between the medical margin of Tractus opt. and Crus cerebri, Corpora mamillaria and Tuber cinereum

Low density of penetration points
– 4 Roof of Fossa interpeduncularis between Corpora mamillaria and Substantia perforata post.
– 5 A circular area of Tuber cinereum surrounding Infundibulum
– 6 Corpora mamillaria, basal surface

Note V. interpeduncularis –v-
and Liliequist's diencephalic membrane – Lil-


A
A'
C
B
see A'
B
C
high density
low density
5
2
3
6
(4)
4
see C
Crus cerebri
1
5
2
Lil
3
6
V
4
1

CISTERNA AMBIENS. GROUND OF THE CISTERN AND ADJACENT AREAS (Figs. 50 and 51)

Fig. 50

Arteries and cranial nerves

A Wide and variable distribution of feeding arteries according to a cadaver brain injection of Stephens and Stilwell, 1969, nomenclature supplementary. Indian ink copy by the author.

B As A. Panorama. Walls and barrier areas of Cisterna ambiens marked in (dotted lines)

Abbreviations

1 Rr. temporales of A. cerebri post.
2 Bundle of Aa. chorioideae posteriores
3 Terminal branch of A. choroidea ant.
4 Branches of A. choroidea ant. penetrating Tractus opt., feeding midbrain and Pons
5 Rr. temporales of A. cerebri media
6 A. cerebri media
7 Rr. temporales of A. carotis int.
8 Rr. perforantes of A. communicans post. penetrating Tractus opt. and feeding Hypothalamus and basal ganglia
9 Rr. optici of A. carotis int.
10 A. hypophysialis sup.
11 A. commun. post., hyperplastic variant
12 Rr. perforantes of A. carotis int. penetrating Substantia perforata ant.
13 A. cerebri post., hypoplasia of P1-segment
14 A. chorioidea post. medialis and A. tecti
15 Collateral branch
16 R. ad pontem of A. cerebelli sup.
17 Branch of A. cerebelli sup. feeding midbrain
18 Branch of A. cerebri post. feeding midbrain
19 Branch of A. choroidea ant. feeding midbrain

II to IV Cranial nerves

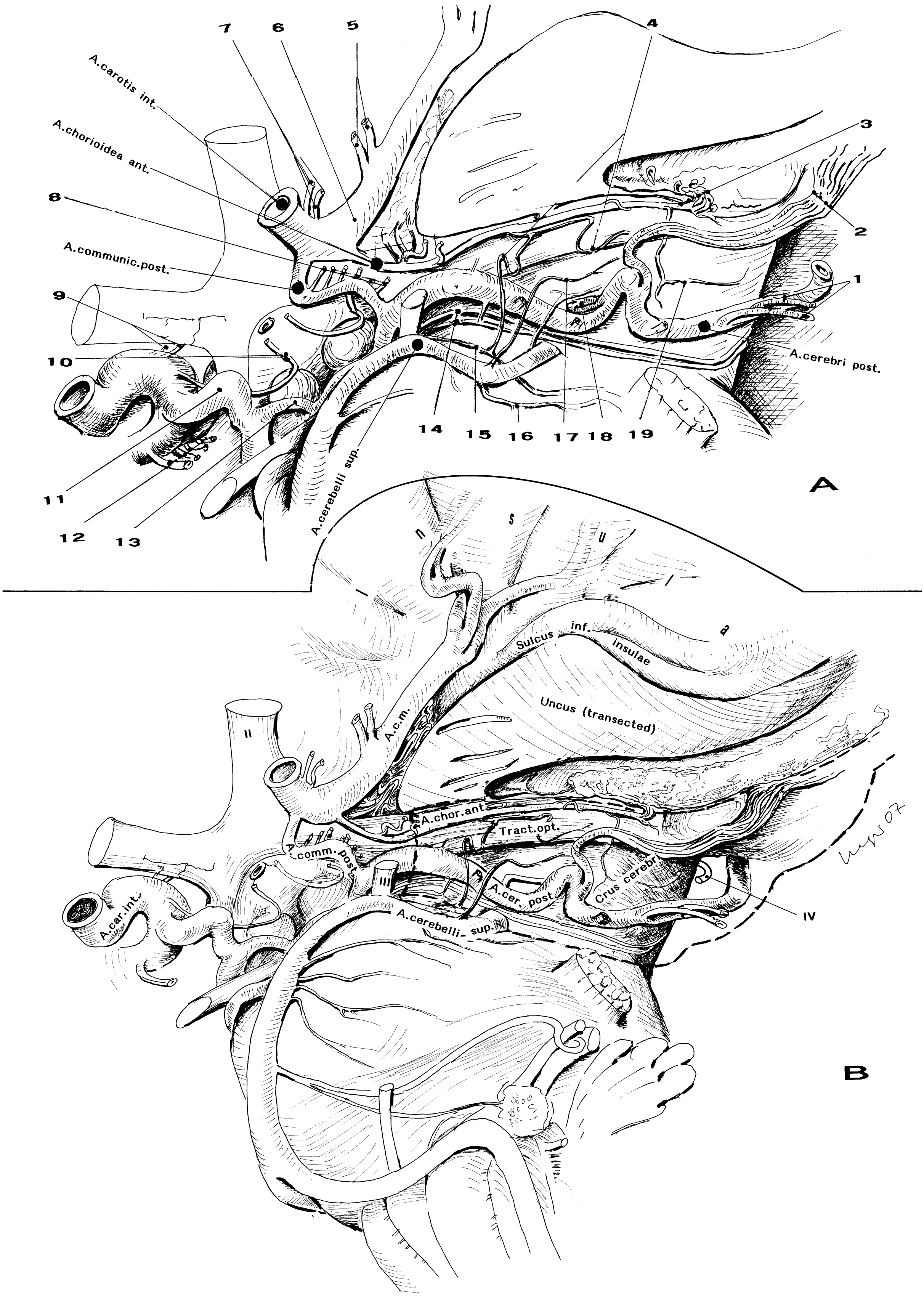

7
6
5
4
3
2
1
A.carotis int.
A.chorioidea ant.
8
A.communic.post.
9
10
11
12
13
A.cerebelli sup.
14
15
16
17
18
19
A.cerebri post.
A
n
s
u
a
Sulcus inf. insulae
Uncus (transected)
A.c.m.
II
A.chor.ant.
Tract.opt.
A.comm.post.
III
A.cer. post.
Crus cerebri
IV
A.car.int.
A.cerebelli sup.
B

Fig. 51

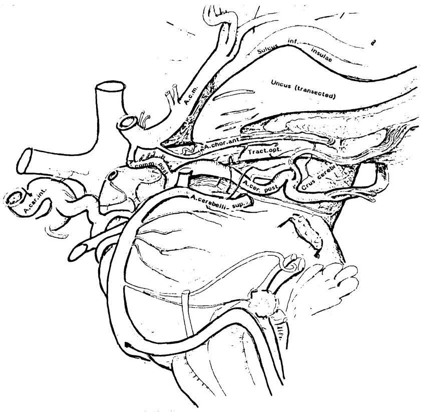
Continuation of Fig. 50, sectional enlargement
The same cerebral areas are fed by a mixture of perforating branches from arteries of variable origin

Uncus-Amygdala-area
– Rr. perforantes originating from A. carotis int., A. chor. ant. and A. cerebri media
– Rr. perfor. originating from A. communicans post.
Basal ganglia
– Rr. perforantes of Heubner's artery, carotid bifurcation, A. cerebri media
– Rr. perforantes originating from the basilar bifurcation
Crus cerebri
– Rr. perforantes originating from A. chorioidea ant. and A. communicans post.
– Rr. perforantes originating from the basilar bifurcation and A. cerebelli sup.

Abbreviations

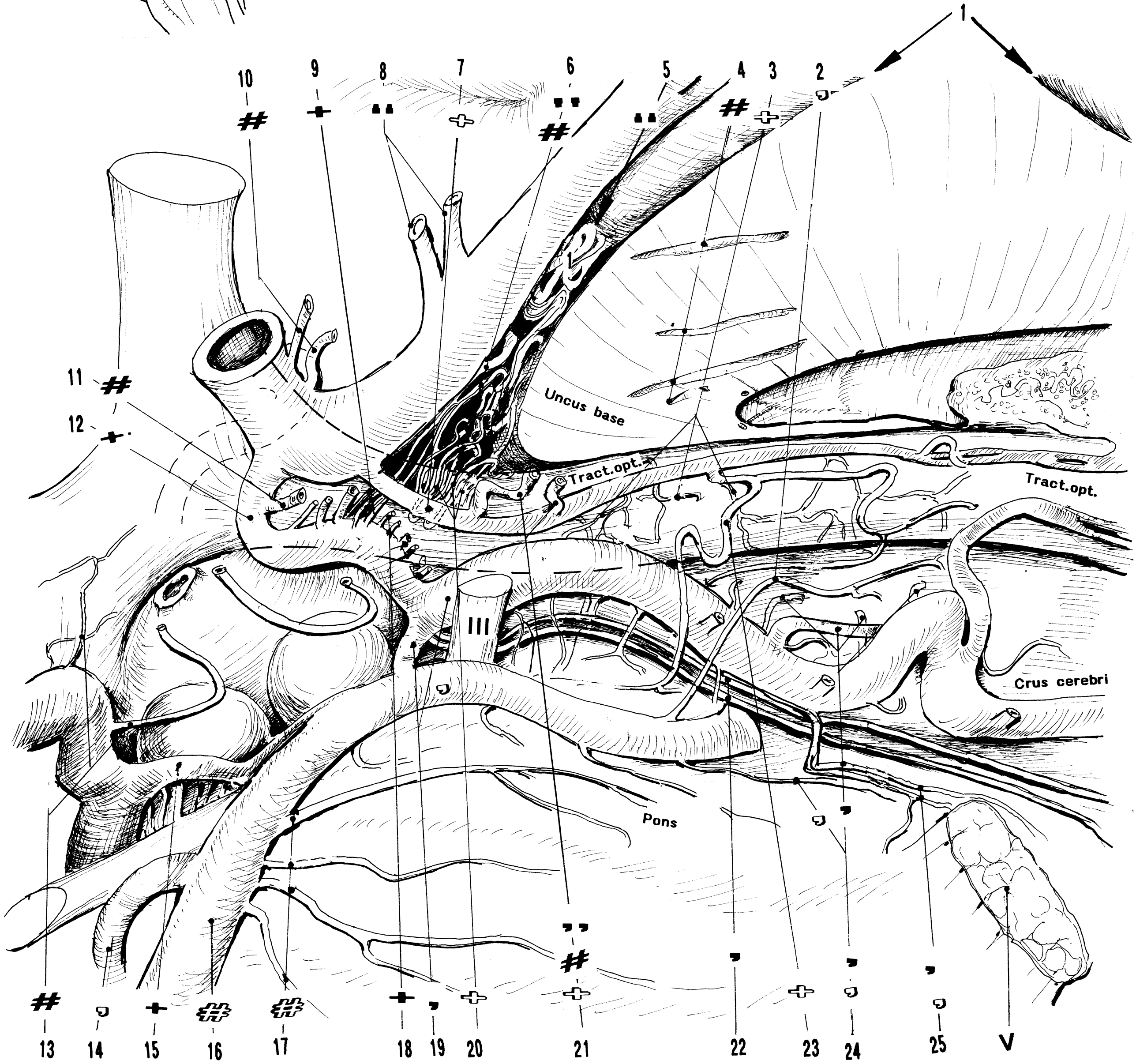
1	Sulcus inf. insulae
2	R. perforans of A. cerebelli sup.
3	Rr. perforantes of A. chor. ant.
4	Rr. perforantes / basal ganglia
5	Limen insulae
6	Rr. perforantes of A. carotis int. and ACM
7	A. chor. ant.
8	Rr. tempp. of Uncus and/or ACM and A. car. int.
9	Rr. perfor. of A. comm. post.
10	Rr. tempp. of A. chor.post.
11	Anterior hypothalamic artery
12	A. comm. post.
13	R. (Rr.) opt. and A. hypophysialis sup.
14	A. cerebelli sup.
15	As 12, contralateral
16	A. basilaris
17	Rr. ad pontem
18	Rr. perforantes of A. comm. post.
19	A. cerebri post.
20	Rr. perfor. of A. chor. ant.
21	Rr. tempp. of A. chor. post.
22	A. chor. post. med. and A. tecti
23	Branch of A. chor. ant. feeding midbrain
24	Branches of A. cerebri post. and A. cerebelli sup. feeding Pons
25	As 24

III and V Cranial nerves (N IV omitted)



feeding arteries

- # A.carotis int.
- + A. communicans post.
- ▪▪ A.cerebri media
- , A.cerebri post.
- A.basilaris
- ✚ A. chorioidea ant.
- A. cerebelli sup.



SYNOPSIS (Fig. 52 to 60)

Fig. 52

Arteries, Overview

Abbreviations

1 A. corporis callosi mediana
2 ***A. cerebri ant. /***
A. communicans ant.
3 Hypothalamic branch of ***2***
4 Heubner's artery, branch of ***2***
5 Branch of ***2***, feeding
Subst. perfor. ant.
6 Branches of ***2***, feeding Chiasma
7 Branches of ***2***, feeding Chiasma
8 ***A. chorioidea ant.***
9 Branches feeding Chiasma and N.II
10 Branch of ***8***, penetrating
Subst. perfor. ant
11 Branch of 4, penetrating
Subst. perfor. ant.
12 Branch of ***8***, penetrating Tract. opt.
13 Rr. tempp. of ***8*** feeding Uncus
14 As 12
15 Terminal branches of ***8***
16 Branch of ***8***, as 12
17 As 12
18 As 12
19 Branch of ***8***, feeding Crus cerebri
20 Branch of ***26***, feeding Crus cerebri
21 Branch of ***23***, feeding Crus cerebri
22 Branch of ***26***, feeding
Corpus mamillare
23 ***A. cerebelli sup.***
24 Branch of ***26***, feeding
Crus cerebri
25 Branch of ***26***, penetrating
Subst. perfor. ant.
26 ***A. basilaris***
27 Branch of ***28***, feeding
Crus cerebri
28 ***A. cerebri post.***
29 Branch of ***38***, penetrating
Tract. opt.
30 Branch of ***38***, penetrating
Tract. opt.
31 Branch of ***8***, penetrating
Tract. opt.
32 As 30
33 Branch of ***33***, penetrating
Subst. perfor. ant.
34 As 33
35 Branch of ***8***, penetrating
Subst. perfor. ant.
36 Branch of ***40***, penetrating
Subst. perfor. ant.
37 A. (Aa.) lenticulostriata(ae)
38 ***A. communicans post.***
39 ***A. carotis int.***
40 ***A. cerebri media***
41 Branch of ***39***, feeding N. II
42 A. hypophysialis sup.

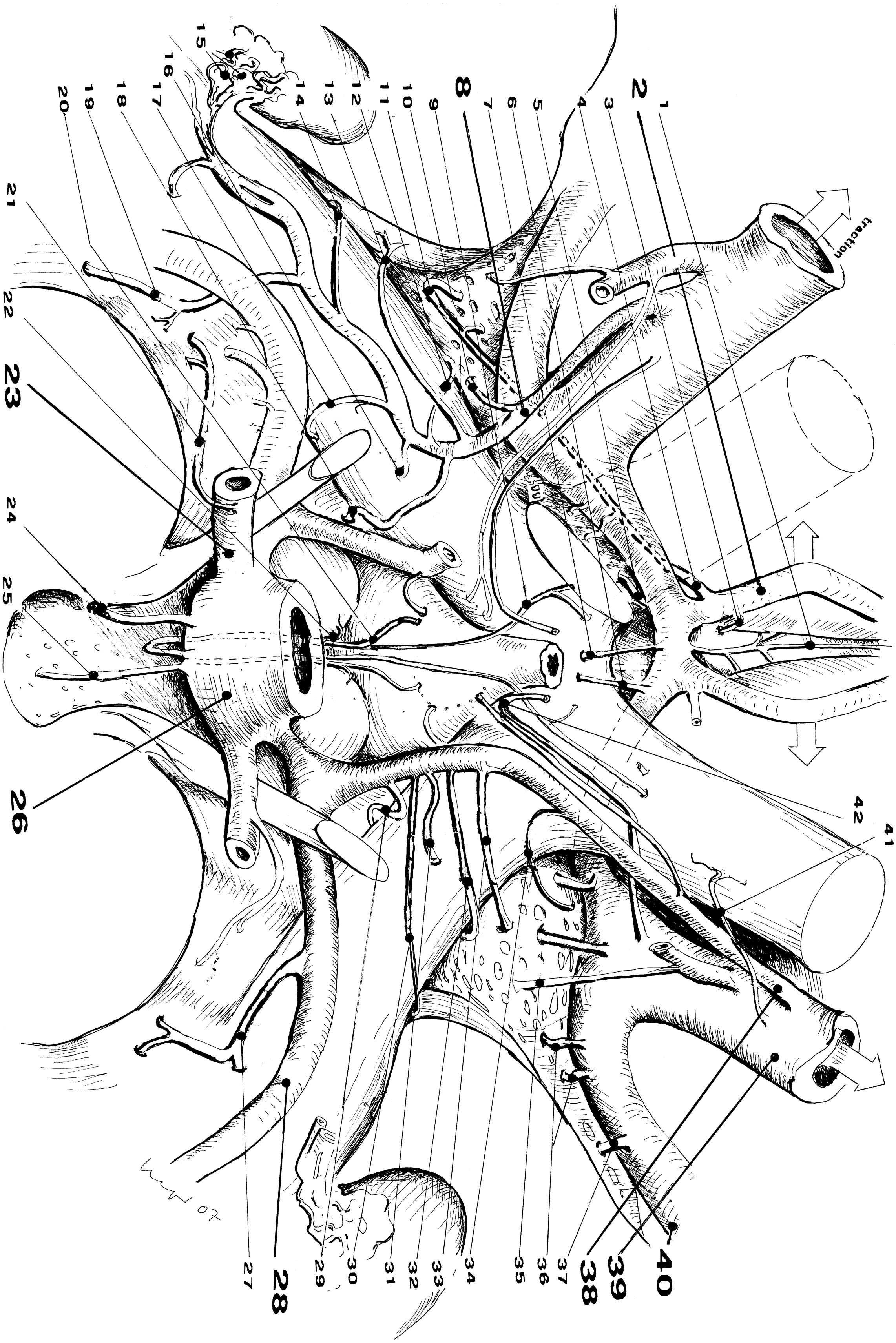

traction
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Fig. 53

Continuation of Fig. 52. Sectional enlargement.
Abbreviations as in Fig. 52

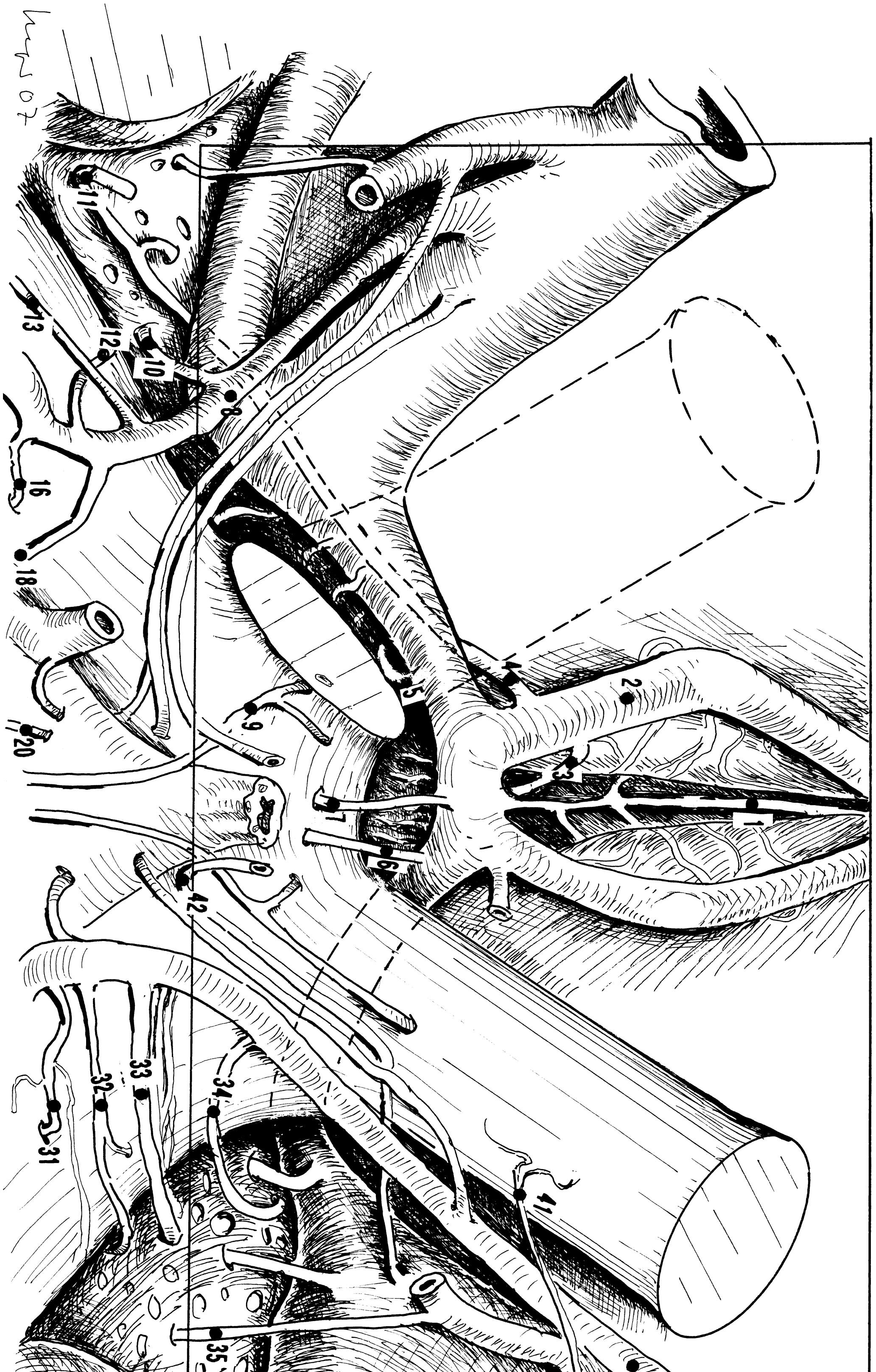
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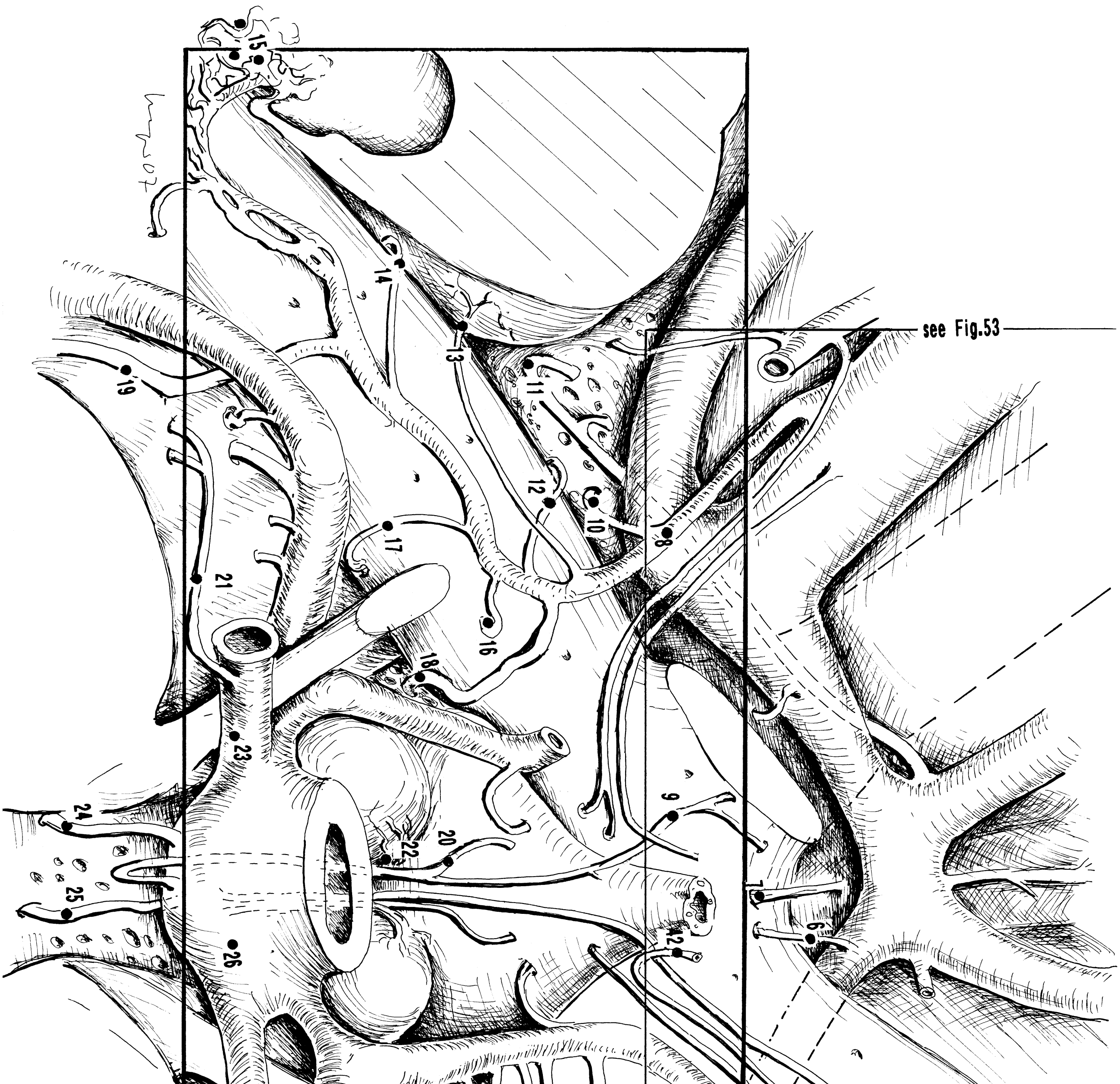
Fig. 54

Continuation of Figs. 52 and 53.
Abbreviations as in Fig. 52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see Fig.53
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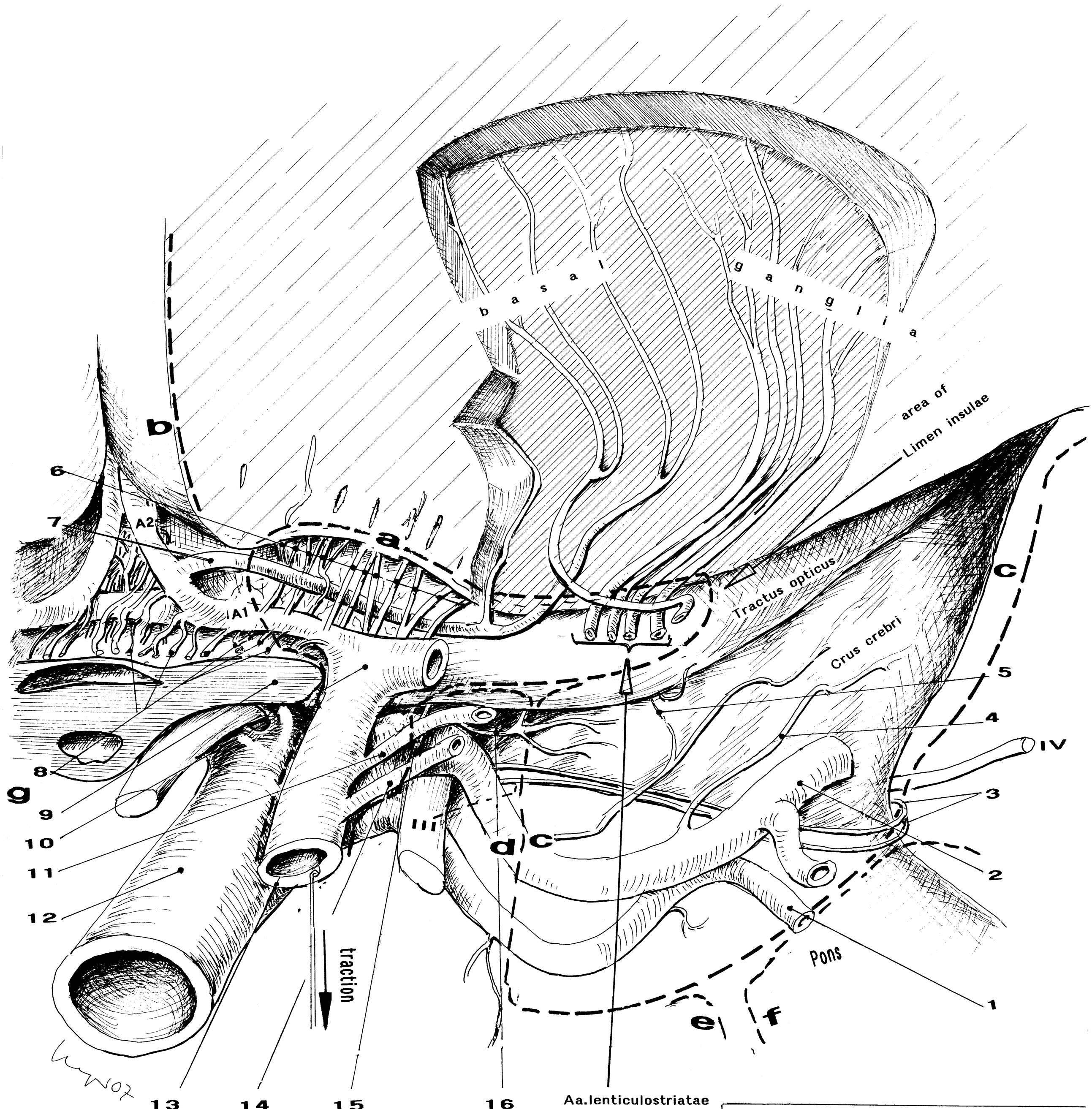
Fig. 55

Continuation of Figs. 52 to 54

Abbreviations

1	A. cerebelli sup.
2	A. cerebri post.
3	A. chorioidea post. med. and A. tecti
4	Branch of A. cerebri post. feeding Crus cerebri
5	Branch of A. cerebri post. penetrating Tractus opt., medial margin
6	Rr. perforantes of A. carotis int., A. cerebri ant. and A. cerebri media penetrating Substantia perforata ant.
7	A. recurrens (Heubneri)
8	Rr. perforantes of A. cerebri ant. and A. communicans ant., feeding Chiasma
9	Beginning of Tractus opt.
10	Carotid bifurcation
11	A. chorioidea ant.
12	Bifurcation of A. basilaris
13	A. carotis int.
14	A. communicans post.
15	Anterior hypothalamic branch of A. communicans ant.
16	Branch of A. chorioidea ant. feeding Crus cerebri and penetrating Tractus opt.

III and IV Cranial nerves



- - • walls and barrier areas of cisterns - - -

a Cist. valleculae

b Cist. laminae terminalis

c Cist.ambiens

d Cist. interpeduncularis

e Cist.pontis medialis

f Cist.pontis lat.

g Cist.chiasmatis

Fig. 56

High variability of the origins of Rr. perforantes and their target areas

Abbreviations

1 Substantia perforata ant.
2 Lamina terminalis
3 Tuber cinereum
4 Trigonum lemnisci

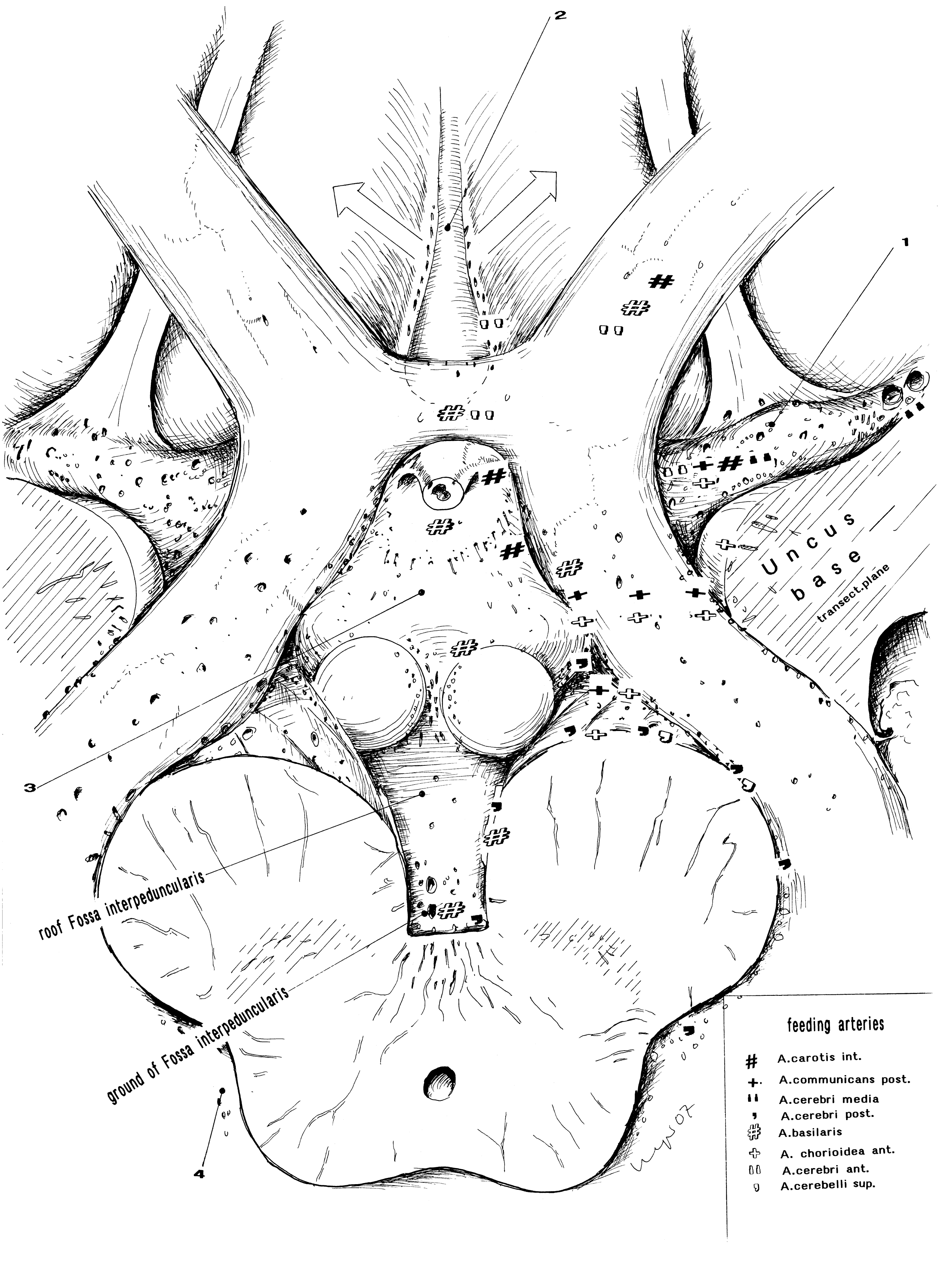
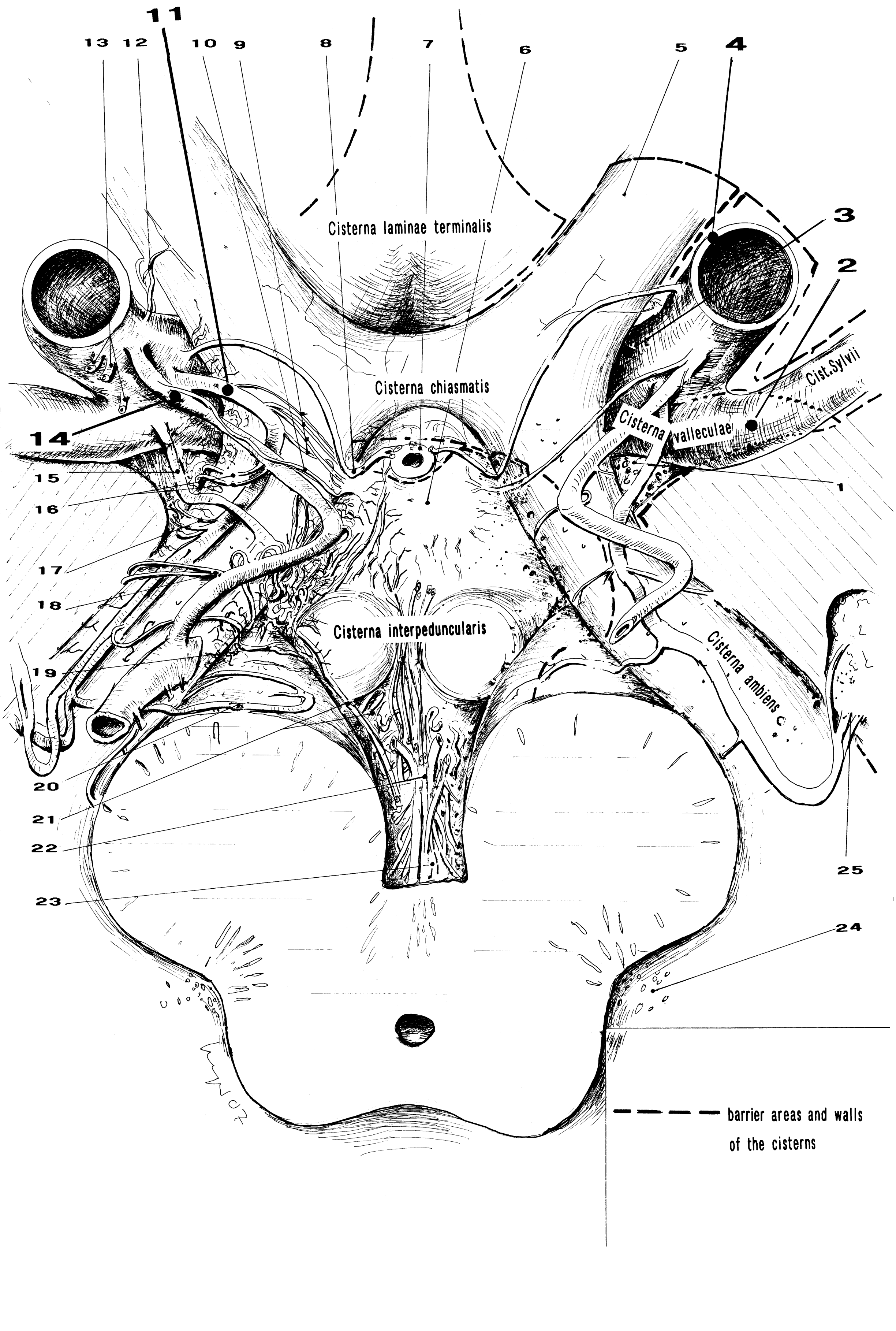

2
1
Uncus
base
transect.plane
3
roof Fossa interpeduncularis
ground of Fossa interpeduncularis
4
feeding arteries
A.carotis int.
+ A.communicans post.
A.cerebri media
A.cerebri post.
A.basilaris
A. chorioidea ant.
A.cerebri ant.
A.cerebelli sup.

Fig. 57

Continuation of Fig. 56. Samples of arteries and their Rami perforantes. The course of Rr. perforantes may be nearly vertical (at Subst. perforata ant. and post., e.g.).
Other Rr. perforantes may enter the cerebral surface at an approximately tangential course (some arteries of the midbrain, e.g.)

Abbreviations

1 Substantia perforata ant.
2 ***A. cerebri media***
3 ***A. cerebri ant.***
4 ***A. carotis int.***
5 N. opticus
6 Tuber cinereum
7 Infundibulum
8 A. hypophysialis sup.
9 Bundle from **11** penetrating Tractus opt. medial limit area
10 Yaşargil's hypothalamic artery and/or further perforating arteries
11 ***A. chorioidea ant.***
12 Bundles from 4 feeding N. opticus
13 Temporal branches from 4 feeding the temporal pole and Uncus
14 ***A. communicans post.***
15 Branch of carotid bifurcation or neighboring arteries penetrating Tractus opticus (large variant)
16 Less or multiple fine perforating rami from **14** penetrating Tractus op., lateral limit area, and Substantia perforata ant.
17 Less or multiple fine perforating rami from **11** penetrating Tractus opt., lateral limit area, and Substantia perforata ant.
18 Less or multiple fine perforating rami from **14** penetrating Tractus op., lateral limit area, and Corpus amygdaloides (here transectional plane)
19 Branch of 11 feeding Crus cerebri (small variant). Fine rami are penetrating Tractus opt.
20 Branch of **14** feeding Crus cerebri
21 Multiple fine perforating rami from **A. cerbri post. and/or A. basilaris**, antero-lateral group feeding Hypothalamus, Corpora mamillaria, Tractus opt. and Capsula int.
22 As 21, antero-medial group
23 Aa. thalmoperforantes penetrating Substantia perforata post.
24 Fine perforating rami of **A. cerebri post.** feeding midbrain
25 Chorioid point of **11**


11
13
12
10
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6
5
4
3
2
Cisterna laminae terminalis
Cisterna chiasmatis
Cist.Sylvii
Cisterna
valleculae
1
14
15
16
17
18
19
20
21
22
23
24
25
Cisterna interpeduncularis
Cisterna ambiens
barrier areas and walls
of the cisterns

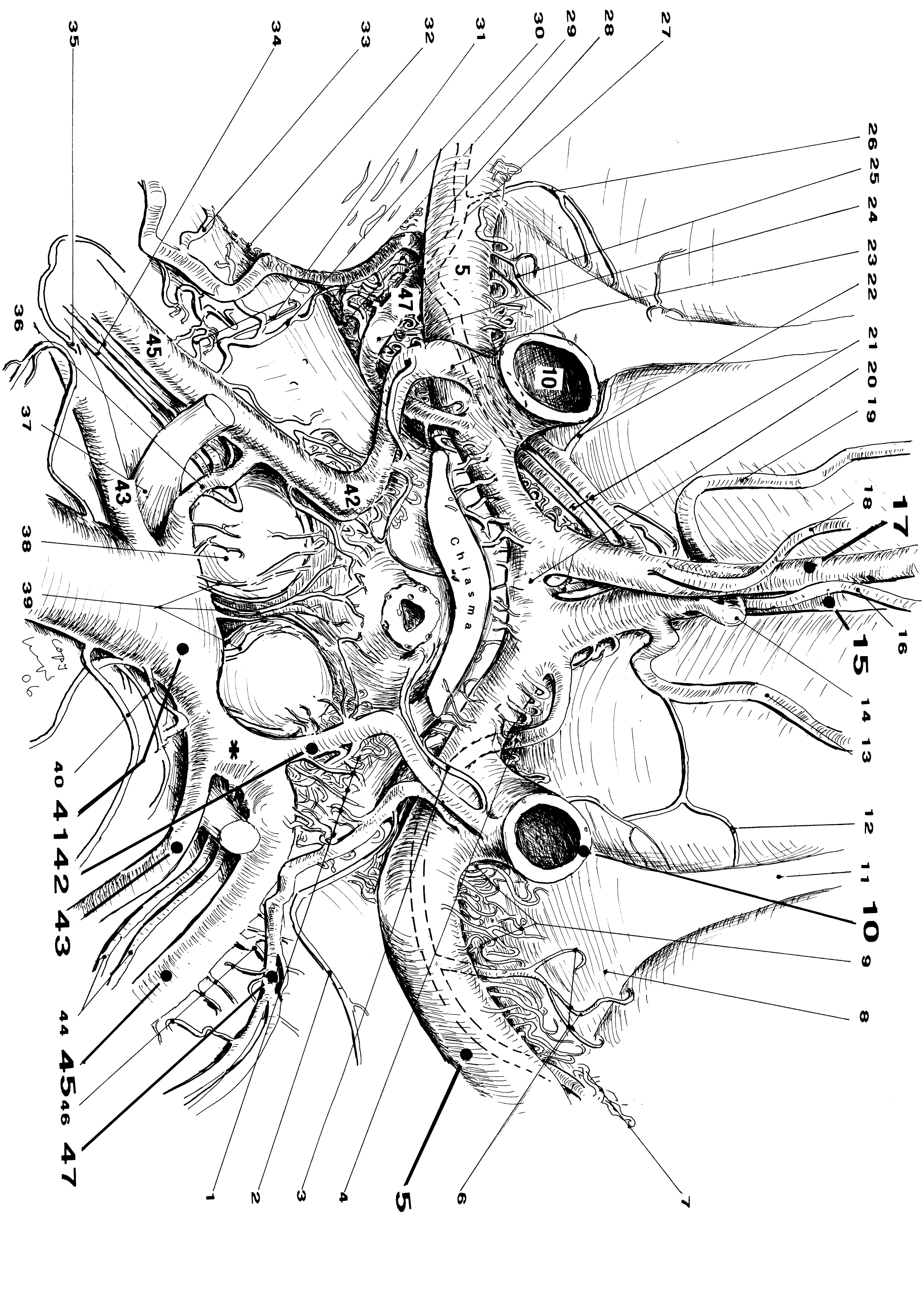
Fig. 58

Cadaver brain injection, according to Stephens and Stilwell (1969, p 27) Indian ink copy.

Abbreviations

1 Rr. perforantes penetrating Tract. opt.
2 Branch of ***4***
3 Ant. hypothal. ramus of ***42*** (Yaşargil)
4 A. recurrens (Heubneri)
5 ***A. cerebri media***
6 Rami of Heubner's artery
7 Aa. lenticulostriatae
8 Trigonum olfactorium
9 Rr. perforantes of 5 and 10
10 ***A. carotis int.***
11 Tractus olfactorius
12 Branches of A. frontobasalis medialis
13 A. frontobasalis medialis
14 Contralat. origin of A. frontobas. med.
15 ***A. cerebri ant.***
16 A. frontopolaris
17 ***As 15, contralateral***
18 As 16
19 As 14
20 A. communic. ant. and A. corp. call. mediana
21 As 4, double variant
22 Branch of A. recurrens (Heubneri)
23 Hyperplasia of ***42***
24 Prox. segment of ***47***
25 Branches of **5** feeding Trigonum olfact.
26 Branches of Heubner's artery
27 Large branch of ***47*** penetrating Subst. perforata ant.
28 Branches of **10** penetrating Subst. perforata ant.
29 Rami of ***47*** penetrating Subst. perforata ant. and the lat. margin of Tractus opt.
30 Ramus of ***42*** penetrating Subst. perforata and the lat. margin of Tractus opt.
31 As 30
32 Rr. perforantes between Tract. opt. and Uncus base
33 As 32, large branch of ***47***
34 A. chor. ant. med. and A. tecti
35 Branch of **43** feeding Crus cerbri
36 P1 of ***45***, hypoplasia
37 N. oculomotorius
38 Corpus mamillare
39 Rr. perforantes of ***41*** (ant. group)
40 Rami ad pontem of ***41***
41 ***A. basilaris***
42 ***A. communicans post.***
43 ***A. cerebelli sup.***
44 As 34
45 ***A. cerebri post.***
46 Rr. perforantes of **45** feeding Crus cerebri
47 **A. chorioidea ant.**

* ***Common trunk of A.commun.post. -42-, A. cerebri post. -45-, and A. cerebelli sup. -43-*** (variant)


Chiasma
1
2
3
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6
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Fig. 59

Continuation of Fig. 58. Nomenclature as Fig. 58

A Variants as in Fig. 58

B Usual findings, schematical presentation
Note: (34) presents a shift of arteries into a dorsal direction, no variants
This is a common finding in age and well known in Neurosurgery and in Ophthalmology (Janetta 1967, 1970, 1971, 1974, 1975, 1976, 1977*)

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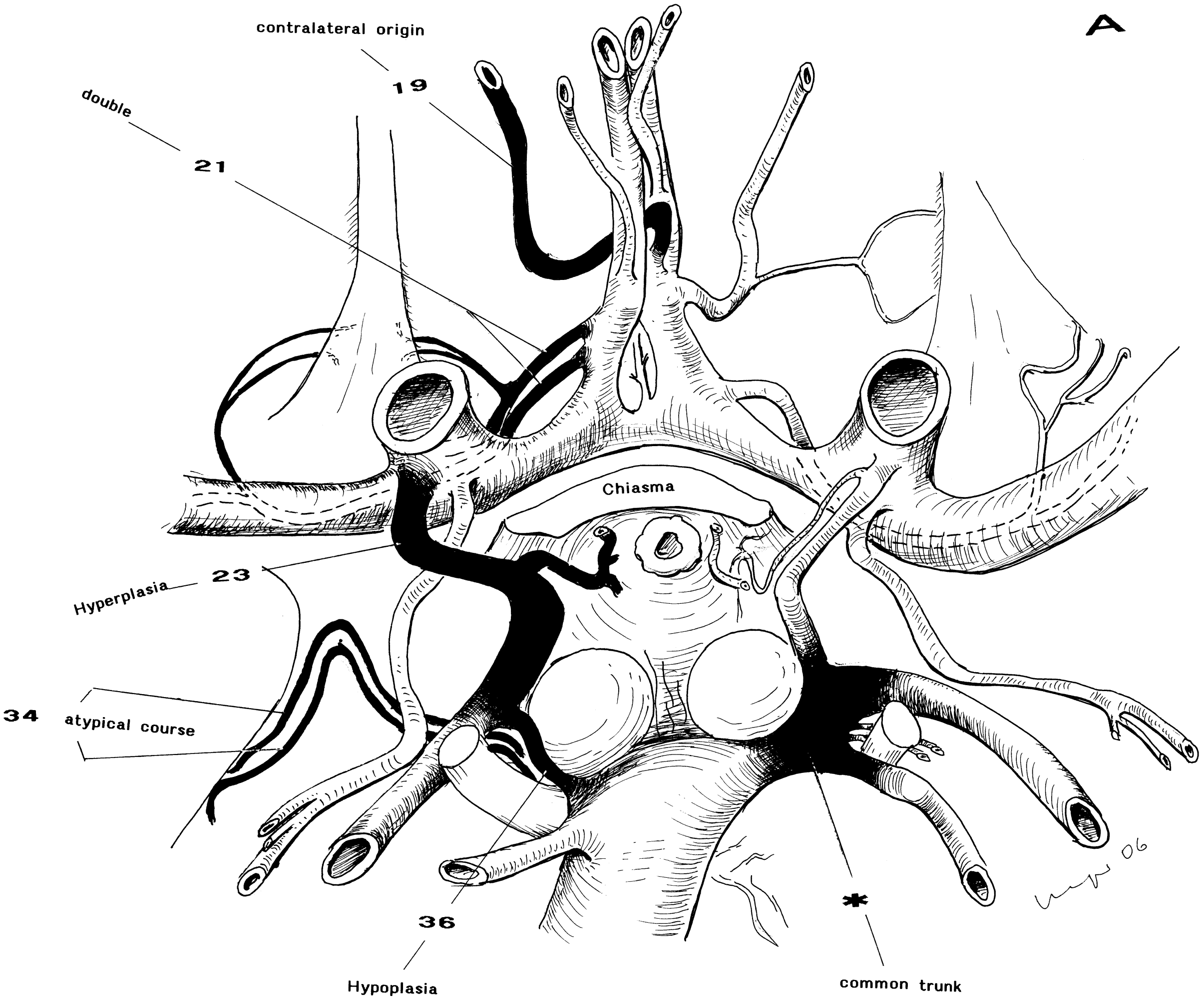
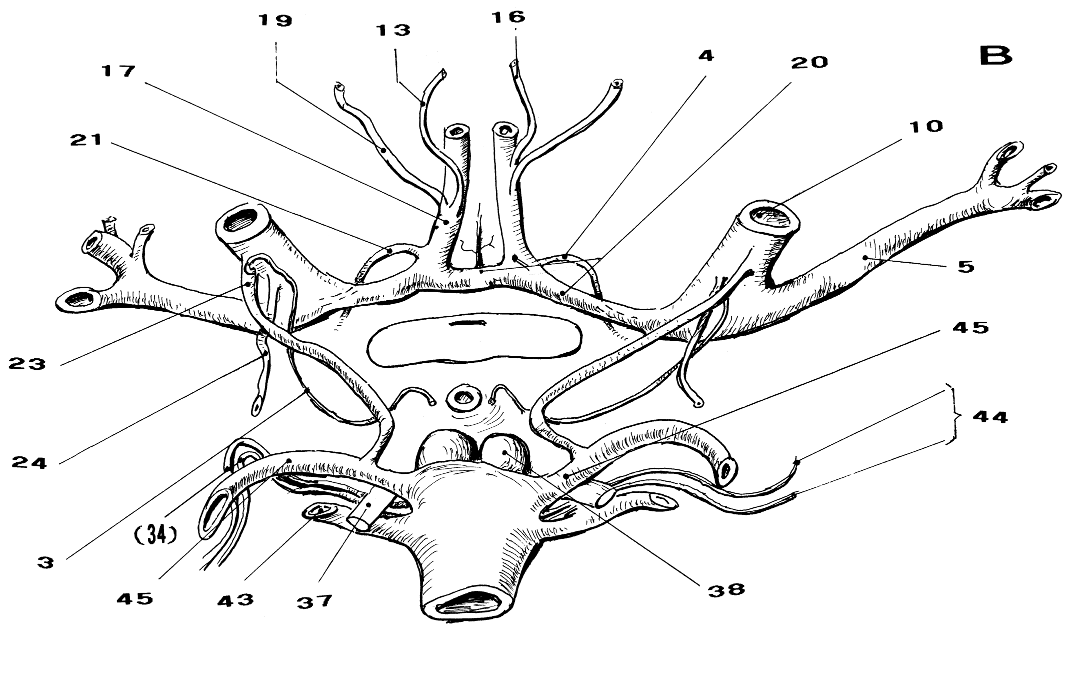
* See Seeger (1980/II) p 719


A
contralateral origin
19
double
21
Chiasma
Hyperplasia
23
34
atypical course
36
Hypoplasia
*
common trunk


B
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16
17
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20
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10
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23
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24
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(34)
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Fig. 60

Cadaver brain injections and presentation of arachnoid structures according to Lang (1975)*

A Outer arachnoid membrane and underlying lateral cisternal membranes fenestrated.
Contents of the cisterns masked by arachnoid trabeculas and membranes. Arrows are indicating surgical routes

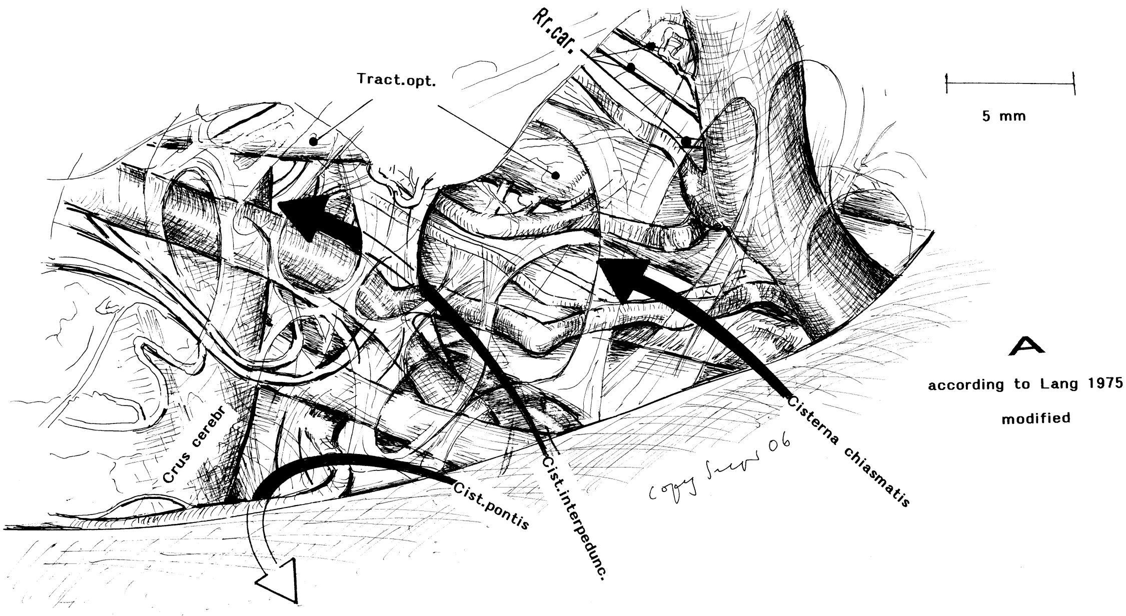
B Magnified copy of A. Arachnoid structures omitted.
Constant neuronavigatory landmarks:
1 N. opticus close to For. opt.
2 A. carotis int. close to Plica petroclinoidea ant.
3 Hypophyseal stalk close to Diaphragma sellae
4 Processus clinoideus post.

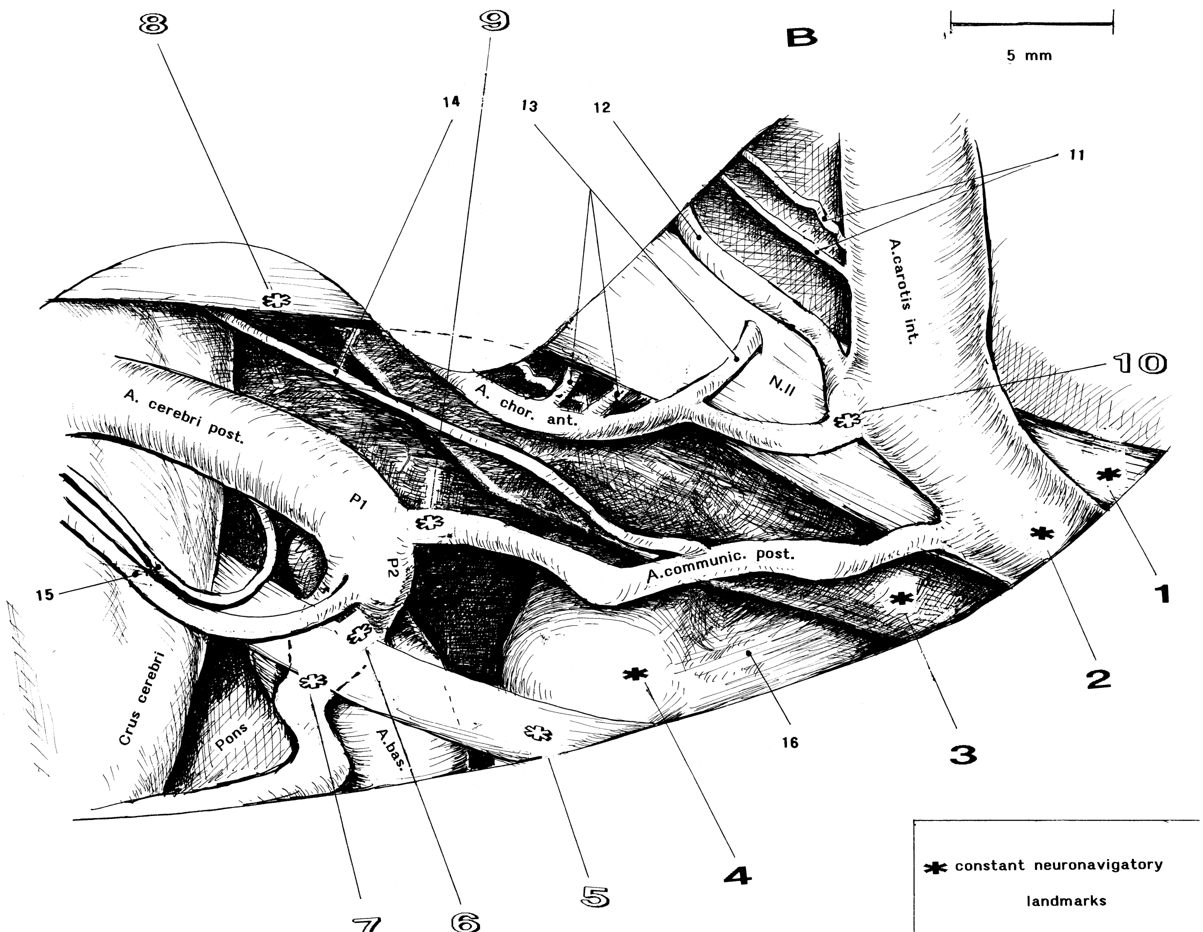
Inconstant neuronavigatory landmarks: These typical anatomical structures can be used for orientation,
even if intraoperative neuronavigation is not available.

5 N. oculomotorius
6 As 5, relationship to bifurcation of A. basilaris
7 A. cerebelli sup. / N. oculomotorius
8 Tractus opt.
9 A. communicans post.

Further abbreviations
10 Hypothalamic branches and/or A. hypophysialis sup. of A. carotis int.
11 Atypical large variant of 10
12 Atypical large branches of A. chorioidea ant. feeding N. II and Hypothalamus
13 R. perforans of A. communicans post. penetrating the medial margin of Tractus opt.
14 R. perforans feeding crus cerebri
15 A. chorioidea post. medialis and A. tecti
16 Diaphragma sellae enclosing Sinus intercavernosus post.

* Here: Indian ink copy





✱ constant neuronavigatory landmarks

✽ inconstant landmarks

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