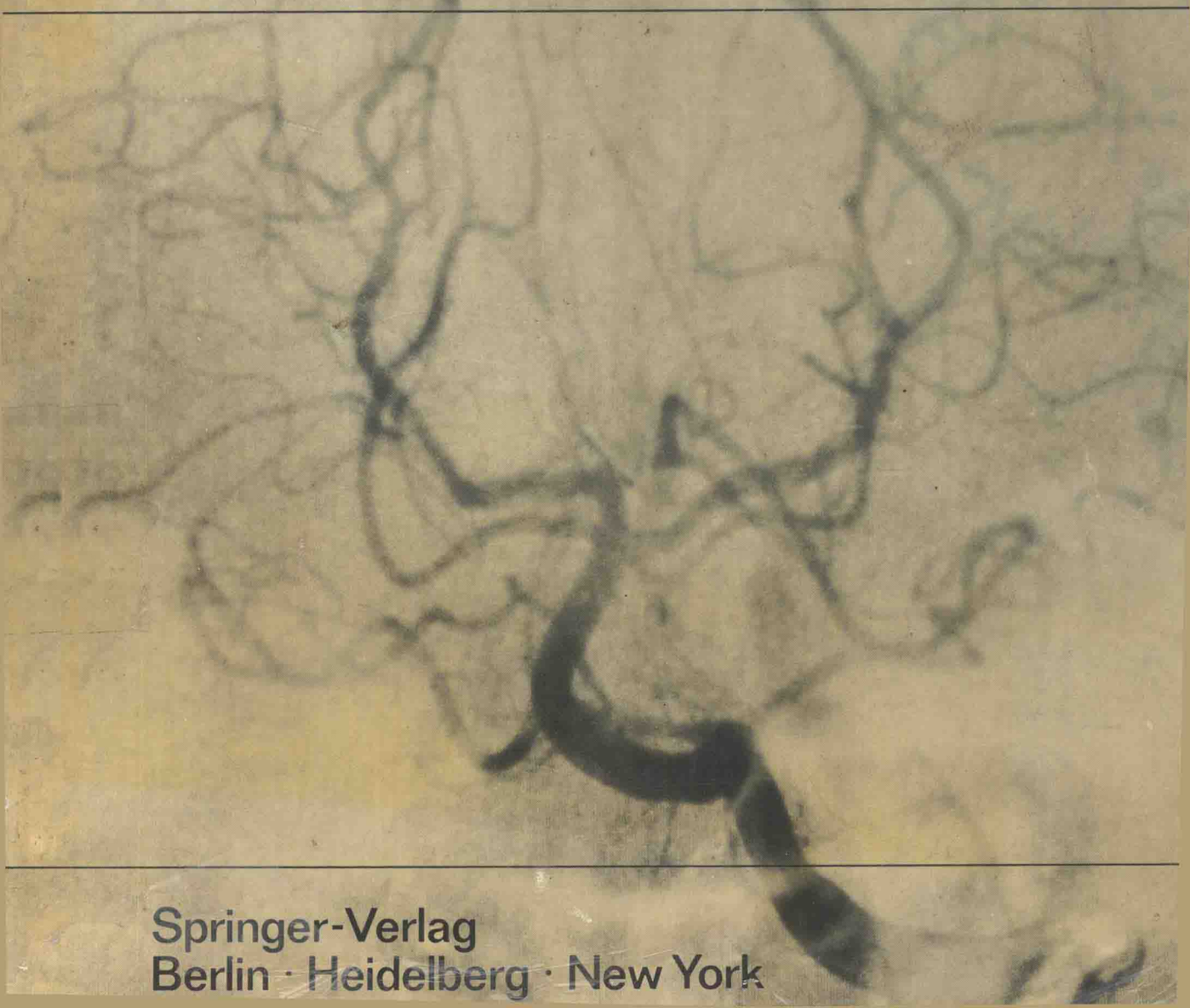
A. Wackenheim · J. P. Braun

Angiography of the Mesencephalon



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Angiography of the Mesencephalon

Normal and Pathological Findings

With 128 Figures

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Preface

In the beginning after Dandy's publication in 1918, ventriculography and pneumencephalography were the main tools in the neuroradiographical examination of brain tumours.
Later on, cerebral angiography after Egaz Moniz in 1927, has been more and more commonly used. Now it appears to be the most important neuroradiological examination in tumours of the great hemispheres.
Up till some years ago, air studies were the predominant examinations in lesions of the brainstem and the contents of the posterior fossa. Gradually angiographic examination for lesions in these regions has been more frequently used.
Nowadays angiographic examination of the mesencephalon proves to be of increasing importance. However, some neuroradiologists feel inhibited. They fear difficulties when reading the angiogram, even if the subtraction method is applied.
Like other workers in the field of neuroradiology and neurosurgery they will be very pleased with the edition of Wackenheim and Braun's monograph.
These authors are already well known because of their excellent air studies in mesencephalic lesions. With this book they provide us with a most valuable and clear guide to the interpretation of normal and pathologic angiograms, including capillarograms, of the mesencephalic regions.

August 6th, 1970 B. G. Ziedses des Plantes

Acknowledgments

This treatise is the result of a paper presented in Cologne in 1968 on tumours of the posterior region of the IIIrd ventricle. Our thanks go to Professor K. Zülch for the confidence he was good enough to have in our work by asking us to handle this subject at that time.
Our thanks are due also to Professor C. Gros, Professor F. Rohmer, Professor D. Phillippidès, Professor E. Woringer and Doctor J. Baumgartner whose wide experience in the pathology of the nervous system was of great help to us.
We address our thanks equally to Dean F. Isch who was good enough to favor the creation of the European Society of Neuroradiology in Colmar by participating actively in the colloquium consecrated to the nervous system of the posterior fossa.
A special acknowledgment goes to Doctor N. Heldt for her highly competent anatomic dissections.
Acknowledgments are in order to Professor Y. Legal who was obliging enough to welcome us at the Institute of Pathological Anatomy in Strasbourg, and to Doctor A. Tänzer of Hamburg who was kind enough to pass on to us certain radiographic documents.
We thank also our technical assistants in Colmar and Strasbourg who handled the work of subtraction and medical photography, and Mrs. L. Braun for her English translation of our text.
Finally our thanks go to two great masters of Neuroradiology, Professor B. Ziedses des Plantes and Doctor James Bull whose support in the founding of the European Society of Neuroradiology makes possible that our monograph appear as the first work published by members of the Society as such. May they find here the expression of our admiration and respect.

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January 17, 1970

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Introduction

The vascularisation of the mesencephalon differs from that of other regions of the brain in that it presents more difficulties, so much so that mesencephalic angiography is not reputed to be sure. We shall see that a wider knowledge of the arteries and veins of this region diminishes considerably these misgivings.

The mesencephalic arteries are relatively thin. Their morphological analysis demands not only well contrasted and sharp radiographs but also complementary procedures to improve the picture's quality and whose application requires a real "laboratory of the radiographic picture". Among the different radiographic methods, Ziedses Des Plantes' subtraction takes the lead. We shall see in this paper that it is absolutely indispensable to the study of the mesencephalic region.

While normal angiographic analysis is relatively easy in lateral views, it is much more difficult in frontal views. Efforts to better the picture produce only mediocre results in frontal views of the normal mesencephalic arteries. Often the superimposition of the superior cerebellar arteries overshadows these views. Under certain pathological conditions the mesencephalic arteries are sufficiently enlarged so as to be clearly distinguishable from the superior cerebellar arteries. However, small avascular tumors present difficulties of interpretation; they appear as negative capillarographic views, that is, as avascular areas (Fig. 83). Vertebral angiographies in a Towne or axial view are of little help. Nevertheless, we shall see that this aspect is of some value in analyzing certain deformations in the peripeduncular loop of the posterior cerebral artery.

Problems in angiography differ basically depending on whether one seeks criteria of normality or whether one wishes to diagnose visible anomalies. Since one turns to ischemic pathology in the search for criteria of normality the results are disappointing. On the other hand, when one is confronted with arterial anomalies, things are much easier. An analysis of shiftings and deformations leads to an accurate topographic diagnosis and sometimes even to an indication as to the cause. We shall not work out any further this idea but shall simply recall to mind those facile aspects provided by spontaneously

opacified lesions such as congenital vascular malformations, glioblastomas, teratomas, meningiomas and ependymomas.
Another difficulty is of a clinical nature: a mesencephalic syndrome is rarely typical, so much so that the angiographic application can vary from the carotidal to the vertebral field. Carotido-vertebral angiographies do not solve the problem of the mesencephalon. The thinness of mesencephalic arteries demands a high degree of selectivity. The choice between carotidal and vertebral angiography is more difficult in that the carotid furnishes an incomplete view of the posterior cerebral artery since the initial segment remains unseen. Since the medial posterior choroidal artery arises from this segment, it is always necessary to make an angiographic study of the mesencephalon by vertebral means.
The mesencephalon is a virtual crossroads in hydrocephaly, and angiographic diagnosis is of the utmost importance in this syndrome. Therefore, we shall attempt to evaluate mesencephalic angiography along these lines.
The mesencephalic veins are more easily identified than the arteries. They are of a higher calibre and are made up of such invariable elements such as Galen's vein, Rosenthal's basal vein and others, such as the thalamic veins, the lateral and posterior mesencephalic veins, the interpeduncular veins and the anterior pontomesencephalic veins. The method of subtraction permits the realization of excellent pictures whose interpretation is less hazardous than it was.
We shall try to deal with the problems of normal and pathological capillarography. In our opinion, this technique has a future. While we cannot see the capillary vessels of the brain, we can at the present time follow the contrast fluid in these vessels through the spread stain. This procedure is possible only in a department where subtraction is used. Moreover, in the topographic sense, the arterial network complements the venous one. Figs. 2 and 5 demonstrate this well. The veins of the vertebrobasilar system are found in the medial anterosuperior mesencephalic and lateral inferior regions. The arteries, on the other hand, are found in the medial and lateral superior mesencephalon. The topographic dissociation of the mesencephalic arteries and veins can but increase the interest we have in phlebographic study.
The mesencephalon is reputed to be of little neurosurgical interest. Neuroradiological investigation has suffered from this underevaluation. We shall see how this region is suited to certain surgery since extracerebral tumours often react as intra-

cerebral ones from the neurological point of view. An angiographic study permits to differentiate the two forms.

On numerous occasions medial sagittal pneumostratigraphy has furnished us the means with which to diagnose tumours of the mesencephalon. We have been advocating it since 1958 as routine procedure in gas encephalography. Fig. 1 gives examples of pictures taken with this technique. They do not define the nature of the tumour, and in any case the vascularisation of mesencephalic tumours must be studied by means of vertebral angiography. Moreover, capillarography discloses tumoral opacifications which we shall call "positive", while normal capillary stains make it possible to establish the limits of avascular pinealomas by producing "negative" areas. Unfortunately not all cases yield these types of views. In the final analysis the attending physician or surgeon is the sole judge as to the application of this angiographic technique. Mesencephalic angiography, as we shall demonstrate in this paper, deserves a better place than it has.

In the mesencephalon, as elsewhere, special cases may come up which serve to round out and confirm the neuroradiology of this region (Figs. 3 and 4). Our paper does not concentrate on these but rather will try to present as clearly as possible our general experience of three years' standing in this field.

Review of Literature

Works concerned with the mesencephalon are relatively few in number. Reference will be made to those publications we have consulted. We have doubtlessly overlooked some works and we beg the authors here and now to excuse these inevitable omissions.

The *arteries* have been submitted to detailed anatomical and radioanatomical analysis and we shall have little to add to previous descriptions. Our emphasis will be placed on pathological arteriograms.

The *veins* of the mesencephalon have been the object of less detailed study. This is understandable when one considers that the arterial system involves difficulties of interpretation and that the veins present a large anatomical variety as well as differences in time of opacification. There are many papers concerned with the deep phlebogram, but there is a definite lack of works dealing with the mesencephalic veins. We have been led to attempt, therefore, a supplement to current knowledge of the normal and pathologic mesencephalic phlebogram.

A. Papers on the Arteries

Considerable confusion reigns in the nomenclature of the arteries of the mesencephalic area. In our study we shall summarize the principal works concerned with this subject. Furthermore, we can state as of now that the study of approximately 1,000 vertebral angiograms permits us to classify *three groups* of arteries, front to back:

1. The posterior thalamo-perforating arteries (arteriae thalamoperforatae posteriores).
2. The colliculi quadrigemini and corpori geniculati arteries (arteriae colliculi quadrigemini et corpori geniculati).
3. The posterior choroidal arteries (arteriae chorioideae posteriores).

This classification is purely angiographic. Reference to anatomic works reveals a higher degree of complexity in the arterial system of the mesencephalon. This complexity is real and has been substantiated by dissection. In mesencephalic angiography,

only the above-mentioned groups are visible in lateral projections. The identification of these arteries is more difficult in fronto-suboccipital projections. It is almost impossible in axial and half-axial projections in spite of the use, under the best possible conditions, of subtraction. In pathological cases, however, these arteries are visible in frontal projections.

H. Rouvière's Works (1940)

In his work on human anatomy, Rouvière distinguishes the following arteries:

—*the arteries of the cerebral peduncles* which arise from the basilar artery and from the posterior cerebral arteries. They extend as far as the peri-aqueducal grey matter. These arteries correspond to our "group of posterior thalamo-perforating arteries".

—*the anterior and middle arteries of the colliculi quadrigemini* arise from the posterior cerebral artery and vascularise the posterior quadrigeminal bodies. These arteries are included in the second group, the "colliculi quadrigemini and corpori geniculati arteries".

—*the posterior arteries of the colliculi quadrigemini*, according to Rouvière, arise from the superior cerebellar arteries in order to vascularise the posterior segment of the posterior quadrigeminal bodies, the superior cerebellar peduncles and the antero-superior wall of the IVth ventricle. We have never seen a picture corresponding to such arteries.

P. Namin's Works (1955)

Namin distinguishes:
the peduncular arteries
the optic arteries
the posterior choroidal arteries
the quadrigeminal arteries

1. Peduncular Arteries

Internal Arteries: these small arteries arise from the extremity of the basilar trunk. They also issue from the first segment of the posterior cerebral artery and from the posterior communicating artery. They are terminal and irrigate the tegmentum, the lemniscus medialis, the nucleus ruber, the superior cerebellar peduncle, and the nuclei of the IIIrd and IVth cranial nerves.

External Arteries: they have the same origins as the internal branches but can also originate from the superior cerebellar

artery and the anterior choroidal artery. They irrigate the external part of the tegmentum.

2. Optic Arteries

These are branches of the posterior cerebral artery. We believe that they may also arise from the posterior choroidal arteries. Since their angiographic individualization seems problematical, we shall not take these arteries into account. Namin describes the inferior optic arteries which supply the lateral wall of the IIIrd ventricle and the internal side of the thalamus. He also describes the posterior and internal optic arteries which supply the postero-internal side of the thalamus. Finally, he reports the presence of the posterior and external optic arteries relegated to the postero-external side of the thalamus.

3. The Posterior Choroidal Arteries

a) Posterior and Lateral Choroidal Artery

This artery arises from the posterior cerebral artery behind the peduncle and divides into two branches:
an external branch intended for the superior part of the choroidal plexus of the lateral ventricle.
an internal branch for the tela chorioidea of the IIIrd ventricle.

b) Posterior Middle Choroidal Artery

One branch supplies the pineal gland while the other two are terminal arteries:
—an internal one for the tela chorioidea,
—an external one for the choroidal plexus of the lateral ventricle.

4. Arteries of the Corpori Quadrigemini

Namin describes three arteries which issue from the posterior cerebral artery: one for the anterior quadrigeminal bodies, another for the posterior corpus and a third artery for the intercorporeal area.

The Works of Columella (1956)

The author lays stress on the semeiology of the posterior cerebral artery which permits to localise pineal tumours and such extra-cerebral tumours in this area as meningiomas of the free edge of the tentorium. The internal occipital artery is lifted by meningiomas and lowered by pinealomas. We wish to render hommage to Columella who undertook the study of these types of tumours well before us.

The Works of Lazorthes and his Coworkers (1956—1961)

In their study concerned with cerebral vascularisation, the authors enumerate the central cortical branches of the posterior cerebral artery.

The central or meso-diencephalic branches are divided into four groups. These arteries originate in the proximal segment of the posterior cerebral artery (precommunicating segment). In 1968 Professor Lazorthes confirmed the data reported hereinafter.

1. The Interpeduncular Arteries

(Foix and Hillemand's retromammillary pedicle) Lazorthes and his coworkers describe:

—*an anterior or diencephalic group*, situated in front of and at the level of the mammillary tubercles. It includes arteries which supply the hypothalamus and the ventral nuclei of the thalamus.

—*a posterior or mesencephalic group*, situated behind the mammillary tubercles. This group is found in the interpeduncular cistern and vascularises the cerebral peduncle, the nucleus ruber, the locus niger, the sub-thalamic area and the superior cerebellar peduncle.

2. The Quadrigeminal Arteries

These arise from the posterior cerebral artery ahead of the posterior communicating artery (precommunicating segment.) Two branches may be distinguished, one for the anterior quadrigeminal body, and the other for the posterior one.

3. The Posterior Choroidal Arteries

—Lazorthes holds that the posterior choroidal arteries may have an isolated origin or issue from a common trunk.

—*The main or medial posterior choroidal artery* passes around the cerebral peduncle spreading six or seven branches which vascularise the anterior quadrigeminal tubercles as well. The first two segments are concave forward, the second of which runs along the lateral margin of the pineal gland parallel to the great vein of Galen and ending in several branches in the tela chorioidea and in the superior choroidal plexus.

—*The accessory or lateral posterior choroidal artery* runs along the supero-internal margin of the thalamus, vascularises the internal part of the body of the nucleus caudatus and anastomises with the anterior choroidal artery.

4. Lazorthes' Posterior and Lateral Thalamic Arteries

(Foix and Hillemand's thalamo-geniculate pedicle or Duret's infero-external optic artery).

These arteries penetrate into the internal part of the external geniculate body and vascularise the postero-lateral part of the thalamus, the posterior part of the internal capsule and the external part of Wernicke's area.

Given our angiographic data, we believe that the aforementioned systematization can be found, in part, in arteriograms along the following lines:

—*arteriae thalamo-perforatae posteriores*. These correspond to Lazorthes' posterior interpeduncular arteries and to Foix and Hillemand's peduncular arteries.

—*arteriae colliculi quadrigemini et corpori geniculati*. These correspond to Lazorthes' quadrigeminal arteries, to his posterior and lateral thalamic arteries, to Foix and Hillemand's thalamo-geniculate pedicle or to Duret's infero-external optic artery.

—*arteriae chorioideae posteriores*. Everyone agrees with this designation. The size of these arteries is important enough to permit us to recognize them rather clearly in angiograms.

F. O. Löfgren's Works (1958)

Löfgren's study ranks among the most important works. It concerns solely the diagnosis of pineal tumours, to the exclusion of other tumours of the mesencephalic area. We wish to remind our readers that it was Radner's method that was first used in vertebral angiography. This author was a forerunner in this field. At present the retrograde angiographic method is generally employed via the brachial, axillary and femoral arteries.

Löfgren shows very schematically the anatomy of the posterior choroidal arteries. As we shall see later, his diagram will be criticized by Galloway. According to Löfgren:

The *medial posterior choroidal artery* supplies the choroidal plexus of the IIIrd ventricle. It issues from the cerebral artery and runs along the lateral margin of the pineal gland towards the tela chorioidea of the IIIrd ventricle following the course of the internal cerebral vein.

The *lateral posterior choroidal artery* also issues from the posterior cerebral artery and runs parallel with it in a short course before going around the thalamus and ending in the choroidal plexus of the lateral ventricle. This artery is designated as "main branch"

by Löfgren who worked out measurements from 100 lateral vertebral angiograms. These measurements are still valid today.

Löfgren's first guidemark is established by the distance between the extremity of the basal trunk and the most posterior point of the artery. This distance is plotted on a straight line which runs parallel to the direction of the posterior cerebral artery. Normally this distance measures 30 to 45 mm.

Löfgren's second guidemark is taken from the largest distance which separates the extremity of the basilar artery from the lateral posterior choroidal artery. This distance measures, as does the first one, about 30 to 45 mm, with an average of 35 to 40 mm.

Löfgren's third guidemark is based on the distance between the extremity of the basilar artery and the extremity of the lateral posterior choroidal artery. It measures 25 to 40 mm. Because of the variability in terminal filling of these small arteries, we feel that this third point is of lesser importance.

We shall see that Löfgren's measurements are of real general interest. They serve in teaching, in settling differences of opinion or in dispelling doubt. Aware of the relative value of these measurements, we have drawn up a slightly modified diagram to be used in iconography. Such a diagram has the advantage of helping the radiologist to commit to memory the area of normal lateral projection of the posterior choroidal arteries.

In cases of tumours in the pineal region, Löfgren indicates a symmetrical displacement upwards and backwards of the posterior choroidal arteries effecting an unwinding curve. These modifications were found in 10 out of 21 cases of pineal tumours. Löfgren further indicates that in 3 of these 10 cases the displacement was solely upwards of the posterolateral choroidal artery. There was no displacement backwards.

Löfgren recalls that hydrocephaly can cause rigidity of the posterior cerebral artery. He points out that posterior thalamic tumours can cause the same arterial deformation as pineal tumours, but that these deformations are asymmetrical or unilateral (3 cases out of 6). In three other cases of posterior thalamic tumours, the author observed an opposite displacement of the posterior choroidal arteries, that is frontwards and downwards. However, the only picture he gives is not convincing. As to the frontal image of these arteries, Löfgren does not deal with the question, insisting upon the difficulties of identification. He does point out, however, that the lateral expansion of a pineal tumour is found in one case by a medial