Recent Advances in Diagnostic Neuroradiology

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Editor

KATSUTOSHI KITAMURA, M.D.

Department of Neurosurgery,
Neurological Institute, Kyushu University

THOMAS H. NEWTON, M.D.

Department of Radiology,
University of California School of Medicine

Co-editor

YUKICHI YONEMASU, M.D.

Department of Neurosurgery,
Neurological Institute, Kyushu University

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Preface

Microscope is an instrument of mistakes. This is an aphorism for all physicians and surgeons who make diagnosis on the basis of histological findings, and it is the same with X-rays. It is true that X-rays never tell a lie. However, radiological findings are very often puzzling, and they are of great value only when they are correctly interpreted. Neurosurgeons have always desired more and more precise information from radiograms for indication of treatment and planning of operation. Neuroradiological findings in turn require a feed-back from operative findings. Rapid development of neurosurgery and strikingly increasing knowledge of neuroradiology have made the collaboration of both specialties more keenly apparent. To achieve this purpose we have had "Symposium on Recent Advances on Diagnostic Neuroradiology" as one of the meetings affiliated to the Fifth International Congress of Neurological Surgery, Tokyo, October, 1973.

Vertebral angiography has been less utilized until recently. This is mainly because of difficulties in performing techniques and in reading the obtained pictures of complicated vascular anatomy of the posterior fossa. Thanks to continuing development of techniques and increasing knowledge of vascular anatomy, the role of vertebral angiography to be played in the diagnosis of posterior fossa lesions is becoming more and more important. Half of the symposium was thus devoted to a special session on angiography in posterior fossa lesions.

It is the authors' sincere hope that the proceedings of this symposium will contribute to add something new to develop this specialized field—neuroradiology.

Katsutoshi KITAMURA

Contributors

Noboru ARIMIZU, M.D.	Department of Radiology, Chiba University, Chiba, Japan
Peter W. ASCHER, M.D.	Neurosurgical Department of University of Graz, Graz, Austria
Emile BERGER, M.D.	Jean Talon Hospital, Montreal, Canada
Binoy CHAKRAVORTY, M.D.	Medical College, Calcutta, 3 Allenby Road, Calcutta-20, India
Kiyoshi FUJIWARA, M.D.	Department of Neurological Surgery, Kobe University School of Medicine, Kobe, Japan
Yoji GITO, M.D.	Department of Neurosurgery, and Radiology, Akita University School of Medicine, Akita, Japan
Joo-Yong HAHNM, M.D.	University of Iowa, Iowa City, U.S.A.
Kazuo HARA, M.D.	Department of Radiology, Osaka University School of Medicine, Osaka, Japan
Yun P. HUANG, M.D.	Department of Radiology, Mt. Sinai School of Medicine of the City University of New York, New York, U.S.A.
Ryuji KAWAI, M.D.	Department of Radiology, Osaka University School of Medicine, Osaka, Japan
June KIMURA, M.D.	University of Iowa, Iowa, Iowa City, U.S.A.
Takashi KISHIKAWA, M.D.	Department of Neurosurgery, and Radiology, Akita University School of Medicine, Akita, Japan
Katsutoshi KITAMURA, M.D.	Department of Neurosurgery, Neurological Institute, Kyushu University, Fukuoka, Japan
Namio KODAMA, M.D.	Division of Neurosurgery Institute of Brain Disease, Tohoku University School of Medicine, Sendai, Japan
Masayoshi KOWADA, M.D.	Department of Neurosurgery, and Radiology, Akita University School of Medicine, Akita, Japan
Yutaka KURU, M.D.	Department of Radiology, Juntendo University School of Medicine, Tokyo, Japan
Suyong KWAK, M.D.	Department of Neurosurgery, University of Tokyo, Tokyo, Japan
Marina KYRIAZIDOU, M.D.	Jean Talon Hospital, Montreal, Canada
Yutaka MAKI, M.D.	Department of Neurological Surgery, Chiba University, Chiba, Japan *Present address*: Department of Neurological Surgery, Tsukuba University, School of Medicine, Ibaraki, Japan
Satoshi MATSUMOTO, M.D.	Department of Neurological Surgery, Kobe University School of Medicine, Kobe, Japan
Hans K. MEIER	Firma Zeiss, Oberkochen, Austria
Keikichi MIHARA, M.D.	Department of Radiology, Faculty of Medicine, Kyushu University, Fukuoka, Japan
Masanori MITOMO, M.D.	Department of Radiology, Osaka University School of Medicine, Osaka, Japan
Zdeněk MRAČEK, M.D.	Department of Neurosurgery, Charles University, Plzen, Czechoslovakia

Nobushige NAKAYAMA, M.D.	Department of Neuroradiology, Neurosurgical Clinic of the University of Mainz, Mainz, Germany
Thomas H. NEWTON, M.D.	Department of Radiology, School of Medicine, University of California, San Francisco, U.S.A.
Tadao NOSE, M.D.	Department of Neurological Surgery, Chiba University, Chiba, Japan
Shige-Hisa OKAWARA, M.D.	University of Iowa, Iowa City, U.S.A. *Present address*: Division of Neurosurgery of Rochester Medical Center, Rochester, New York, USA
Toshio OKUDERA, M.D.	Department of Radiology, Faculty of Medicine, Kyushu University, Fukuoka, Japan *Present address*: Department of Radiology, Research Institute of Brain and Blood Vessels, Akita, Japan
Isamu SAITO, M.D.	Department of Neurosurgery, University of Tokyo, Tokyo, Japan
Keiji SANO, M.D.	Department of Neurosurgery, University of Tokyo, Tokyo, Japan
Kenjiro SHINDO, M.D.	Division of Neurosurgery, Institute of Brain Diseases, Tohoku University School of Medicine, Sendai, Japan
Charas SUWANWELA, M.D.	Department of Radiology, Faculty of Medicine Chulalongkorn University, Bangkok, Thailand
Nitaya SUWANWELA, M.D.	Department of Radiology, Faculty of Medicine Chulalongkorn University, Bangkok, Thailand
Jiro SUZUKI, M.D.	Division of Neurosurgery, Institute of Brain Diseases, Tohoku University School of Medicine, Sendai, Japan
Mutsumasa TAKAHASHI, M.D.	Department of Radiology, Akita University School of Medicine, Akita, Japan
Akira TAKAKU, M.D.	Division of Neurosurgery, Institute of Brain Diseases, Tohoku University School of Medicine, Sendai, Japan
Yoshiharu TAMAKAWA, M.D.	Department of Neurosurgery, and Radiology, Akita University School of Medicine, Akita, Japan
Norihiko TAMAKI, M.D.	Department of Neurological Surgery, Kobe University School of Medicine, Kobe, Japan
Masamichi TOMONAGA, M.D.	Department of Neurosurgery, Neurological Institute, Kyushu University, Fukuoka, Japan *Present address*: Department of Neurosurgery, Fukuoka University School of Medicine, Fukuoka, Japan
Yasuichi UEDA, M.D.	Department of Neurosurgery, University of Tokyo, Tokyo, Japan
Auguste WACKENHEIM, M.D.	Service de Neuroradiologie, Hospices Civils de Strasbourg, Strasbourg, France
Sigurd WENDE, M.D.	Department of Neuroradiology, Neurosurgical Clinic of the University of Mainz, Mainz, Germany
Eizo YABUMOTO, M.D.	Department of Radiology, Chiba University, Chiba, Japan
Hideyuki YAMASHITA, M.D.	Department of Neurological Surgery, Kobe University School of Medicine, Kobe, Japan
Yukichi YONEMASU, M.D.	Department of Neurosurgery, Neurologial Institute, Kyushu University, Fukuoka, Japan

Contents

Introduction

It gives me great pleasure to chair this morning's session. I would like to express the gratitude of all the members participating in this meeting for the efforts of the organizers of this symposium.

The topic for this morning "Angiography of the Posterior Fossa" has assumed a greater importance in recent years. Angiography is now frequently performed as the primary diagnostic method for localizing lesions in the posterior fossa.

The purpose of this meeting is to show some of the diagnostic features of vertebral angiography and discuss what information can be gleaned from these studies.

We plan first to present all this morning's papers. We will have a brief intermission between papers 3 and 4 and then following the completion of all five papers we would like to open the discussion. We would like to have an informal session and I hope that everyone in the audience will join the discussion.

The first paper this morning will be given by Dr. Mutsumasa Takahashi from Akita, Japan. The title is "Angiography of the posterior fossa. The basilar artery and anterior inferior cerebellar artery".

Thomas H. NEWTON

Angiography of the Posterior Fossa: The Basilar Artery and Anterior Inferior Cerebellar Artery

MUTSUMASA TAKAHASHI, M.D.

Department of Radiology, Akita University School of Medicine, Akita, Japan

The neuroradiologic diagnosis of posterior fossa lesions has been based upon roentgenograms of the skull that include tomograms, pneumoencephalograms, vertebral angiograms, and cisternograms with opaque contrast media and ventriculograms. Until recently, vertebral angiography was considered less important in the diagnosis of posterior fossa lesions. With development of the safe catheter technique for vertebral angiography and increased knowledge of the vascular anatomy of the posterior fossa, however, vertebral angiography in the evaluation of posterior fossa lesions has been emphasized. The procedure has replaced that of air study to a certain extent in the diagnosis of posterior fossa tumors, especially when intracranial pressure is increased.

Despite the recent widespread use of vertebral angiography, only little attention has been directed to the basilar and anterior inferior cerebellar artery. We have reviewed 1,000 vertebral angiograms accomplished by the transfemoral catheter technique and evaluated the significance of these vessels in lesions of the posterior fossa,

BASILAR ARTERY

Anterior and lateral displacement of the basilar artery has served as an indication of an expanding lesion of the posterior fossa. Anterior displacement has been considered a direct effect of tumor and increased intracranial pressure in the posterior fossa. Because of the wide variations in the course of the basilar artery, this displacement is of little significance, however. Lateral displacement, in particular, has been considered as unreliable in the diagnosis of posterior fossa lesions [13, 19].

The pontine branches of the basilar artery are infrequently opacified, but they may provide valuable information [9].

Although these statements have proved true in our experience, careful interpretation and measurements frequently provide valuable information in the diagnosis of supratentorial and infratentorial expanding lesions when considered with other arteriographic and venographic features.

In this section, the significance of the basilar artery and its pontine branches is evaluated in the diagnosis of tumoral and vascular lesions.

Vascular Anatomy

Basilar artery

The basilar artery is formed by the junction of the two vertebral arteries between the clivus and the brain stem at about the level of the pontomedullary sulcus. The level of the junction varies considerably. It courses upward near the midline along the anterior surface of the pons. The artery lies within the prepontine cistern behind the clivus and is covered by the arachnoid. It ends by dividing into the two posterior cerebral arteries just after passing between the two oculomotor nerves. The terminal portion of this artery lies within the interpeduncular cistern surrounded by the cerebral peduncles. This portion may bend posteriorly to a variable degree.

The course of this artery is frequently curved or tortuous and is usually deviated from the midline. The straight basilar artery is found only in 25 per cent [1]. Especially in the older age group is the basilar artery dislocated from the midline and appears as a S-shaped curve.

When one vertebral artery is hypoplastic, the first convexity of the basilar artery is usually toward the ipsilateral side and then the artery swings back, with the second convexity toward the contralateral side.

The level of the bifurcation into the two posterior cerebral arteries is usually close to the midline within the interpeduncular cistern, and above the level of the top of the dorsum sellae. The posterior cerebral artery may be supplied by the internal carotid artery via the posterior communicating artery, when the proximal portion of one or both of the posterior cerebral arteries is hypoplastic.

Branches of the basilar artery

The basilar artery gives off many branches: the internal auditory, the anterior inferior and superior cerebellar arteries and the pontine branches.

The pontine branches of the basilar artery consist of several small vessels that originate from the basilar artery. They supply the midbrain and the adjoining part of the pons. They may be grouped as median branches and transverse branches [15, 35]. The median branches are numerous small arterial branches that arise from the posterior part of the basilar artery and soon enter the pons at its median shallow groove. These branches arise at various angles from the basilar artery. The transverse branches arise from the lateral and posterolateral aspect of the basilar artery and circumvent the anterior and lateral borders of the brain stem [9, 15]. Along their courses, they send out small branches that penetrate the pons.

Variations

Since the basilar artery is formed by the union of paired primitive longitudinal arteries, various anomalies may appear because of arrested development. These anomalies include septum formation, fenestration, and duplication of the basilar artery.

The lumen of the basilar artery may be divided by a complete septum [1, 5]. With this anomaly a depression usually develops on the dorsal or ventral surface of the basilar artery, at the site of the septum. Partial duplication or fenestration of the basilar artery may be present. Wollschlaeger et al. [45] reported that the latter condition was observed in 5.26 per cent of 291 dissected brains. Adachi [1] described this fenestration in 4 of 84 brains, its site being at any segment of the basilar artery. Busch [7] noted only 13 instances of this anomaly in 1,000 necropsies. Fenestration is usually located in the lower half of the basilar artery.

Duplication of the basilar artery with union at the distal and proximal ends of the basilar artery has been reported [38]. Complete doubling of the basilar artery has also been described [1, 18]. With this anomaly each vertebral artery supplies the ipsilateral basilar artery on each side.

Radiographic Technique

The basilar artery appears less distorted in the lateral projection. Its proximal end, however, cannot be seen because of overlapping of both vertebral arteries. Towne and axial projections shorten the length of the basilar artery considserably and are not suitable for its evaluation. The anteroposterior projection usually shows the true length of the artery. For this projection, the central roentgen beam tilted 5 degrees caudad to the canthomeatal line has proved most desirable in our experience.

Radiographic Anatomy

Basilar artery

In the lateral projection the terminal segments of the vertebral arteries approach the clivus from behind and form the basilar artery, which proceeds upward against the clivus. The course of the basilar artery in the lateral view is straight or is shown to arch slightly anteriorly. The distal bifurcation of the basilar artery varies in position and is situated behind and slightly above the top of the dorsum sellae. The terminal segment of this artery may indent the floor of the third ventricle [14].

In the frontal projection the basilar artery may be straight or curved to one side. Such tortuosity is common in older persons. In younger subjects, the artery is approximately in the midline. The bifurcation in the frontal film is near the midline in all age groups.

Pontine branches

Transverse branches of the pontine arteries course laterally along the anterior surface of the pons and are seen to project tangentially in the lateral projection. These branches are demonstrated as irregular lines 2 to 3 mm posterior to the basilar artery. They

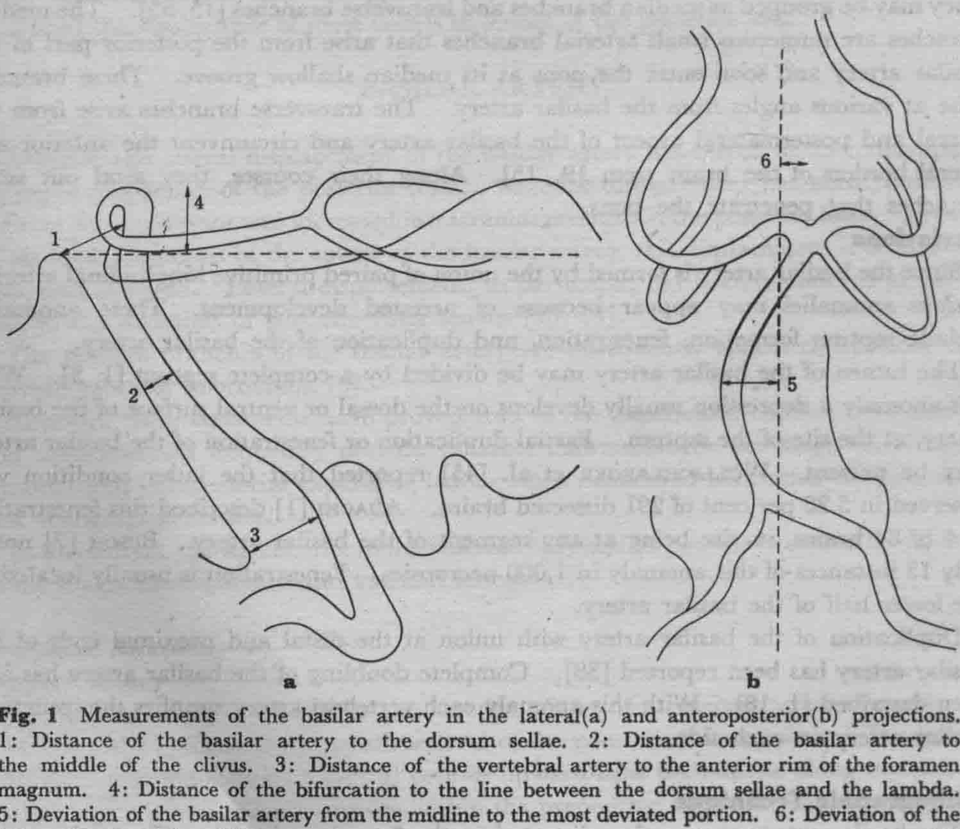

Fig. 1 Measurements of the basilar artery in the lateral(a) and anteroposterior(b) projections. 1: Distance of the basilar artery to the dorsum sellae. 2: Distance of the basilar artery to the middle of the clivus. 3: Distance of the vertebral artery to the anterior rim of the foramen magnum. 4: Distance of the bifurcation to the line between the dorsum sellae and the lambda. 5: Deviation of the basilar artery from the midline to the most deviated portion. 6: Deviation of the bifurcation from the midline.

usually indicate the anterior border of the pons [9]. At the same time, the origin of the pontine branches may be demonstrated as an increased linear density superimposed upon the course of the basilar artery.

In the frontal projection the pontine branches may be seen as small arterial branches between the superior cerebellar artery and the anterior inferior cerebellar artery. Pontine branches are usually so small that differentiation from the branches of the cerebellar arteries is frequently difficult.

GABRIELSEN and AMUNDSEN [9] reported that the incidence of visualization of the pontine branches of the basilar artery is 87% in the lateral projection and 41% in the anteroposterior projection when selective vertebral angiograms are tabulated. In our experience, th ; incidence is slightly lower.

Variations and anomalies

To assess the anatomic variations of the basilar artery, measurements were obtained on 100 normal vertebral angiograms in patients more than 15 years of age and in 20 normal children less than 15 years of age. True lateral and straight anteroposterior roentgenograms were reviewed for the measurement (Fig. 1a & b; Table 1).

The size of the basilar artery varies and may be small when both posterior cerebral arteries are supplied by the posterior communicating arteries.

The junction of both vertebral arteries may be high or low, with a short or long basilar artery. Fenestration of the basilar artery is demonstrated in the straight anteroposterior projection to good advantage (Fig. 2). Duplication of the basilar artery is infrequent.

Fig. 2 Fenestration of the basilar artery. A window formation or fenestration is seen in the proximal third of the basilar artery. The anterior inferior cerebellar artery originates from the fenestration on both sides.

Table 1 Normal measurements for the vertebrobasilar arterial system

Lateral projection	Adults	Children
1. basilar artery—top of the dorsum sellae	6.8 ± 2.1	4.1 ± 1.5
2. basilar artery—middle of the clivus	3.1 ± 0.9	3.0 ± 1.6
3. vertebral artery—anterior foramen magnum	5.9 ± 3.0	6.6 ± 2.5
4. bifurcation—line between the top of dorsum sellae and the lambda	3.9 ± 3.6	3.3 ± 3.0
Anteroposterior projection		
5. midline—most deviated portion of the basilar artery	0.5 ± 4.1	0.9 ± 2.0
6. midline—bifurcation of the basilar artery	0.1 ± 2.3	0.5 ± 2.0

Expanding Lesions

Extra-axial tumors of the posterior fossa

These tumors include masses that originate from the clivus and the cerebellopontine angle and extracranial tumors that invade the posterior fossa. Other extracerebellar tumors are tentorial and convexity meningiomas. Extra-axial tumors usually displace the basilar artery posteriorly and laterally and the pontine branches are displaced backward.

Clivus tumors Frequent clivus lesions are chordoma, meningioma, abscess, and epidermoid. Meningeal cyst and metastatic tumor may also be seen.

Tumors of the clivus usually displace the basilar artery posteriorly (Fig. 3a & b). When the tumor is situated lateral to the midline, the basilar artery is displaced opposite of the affected side and posteriorly. With a small tumor the basilar artery may be straight or anteriorly concave.

A meningioma of the clivus may receive its blood supply from the meningohypophyseal arteries of the internal carotid artery and the meningeal arteries of the vertebral arteries.

Tumors in the cerebellopontine angle Tumors in this area include acoustic neurinoma, neurinoma of the gasserian ganglion, meningioma, metastatic tumor, abscess, and epidermoid (Fig. 4a & b). Extracranial or supratentorial tumors may involve the cerebellopontine angle.

The basilar artery may be displaced to the contralateral side by a large cerebellopontine angle tumor. In our series of 30 acoustic neurinomas [39], a definite lateral displacement of the basilar artery was seen only in 7 tumors which were all larger than 5 cm in their greatest diameter. The basilar artery may also be displaced backward when a tumor extends anterior to the pons. Only 2 of 30 acoustic neurinomas displaced this artery backward.

Nasopharyngeal tumors Nasopharyngeal carcinoma and malignant lymphoma may extend into the posterior fossa. The basilar artery is displaced posteriorly and laterally, depending on the extent of the tumor (Fig. 5).

Other extra-axial tumors Tentorial and cerebellar hemispheric tumors, mostly meningiomas, may displace the basilar artery to the opposite side. Glomus jugulare tumor may extend into the posterior fossa and displace the basilar artery laterally.

Large saccular aneurysms of the basilar artery may displace the basilar artery in the posterior or lateral direction (Fig. 6a & b).

Large carotid aneurysms may displace the basilar artery posteriorly [36].

Intra-axial tumors of the posterior fossa

These tumors include pontine, cerebellar, and fourth ventricle tumors. They usually a

b

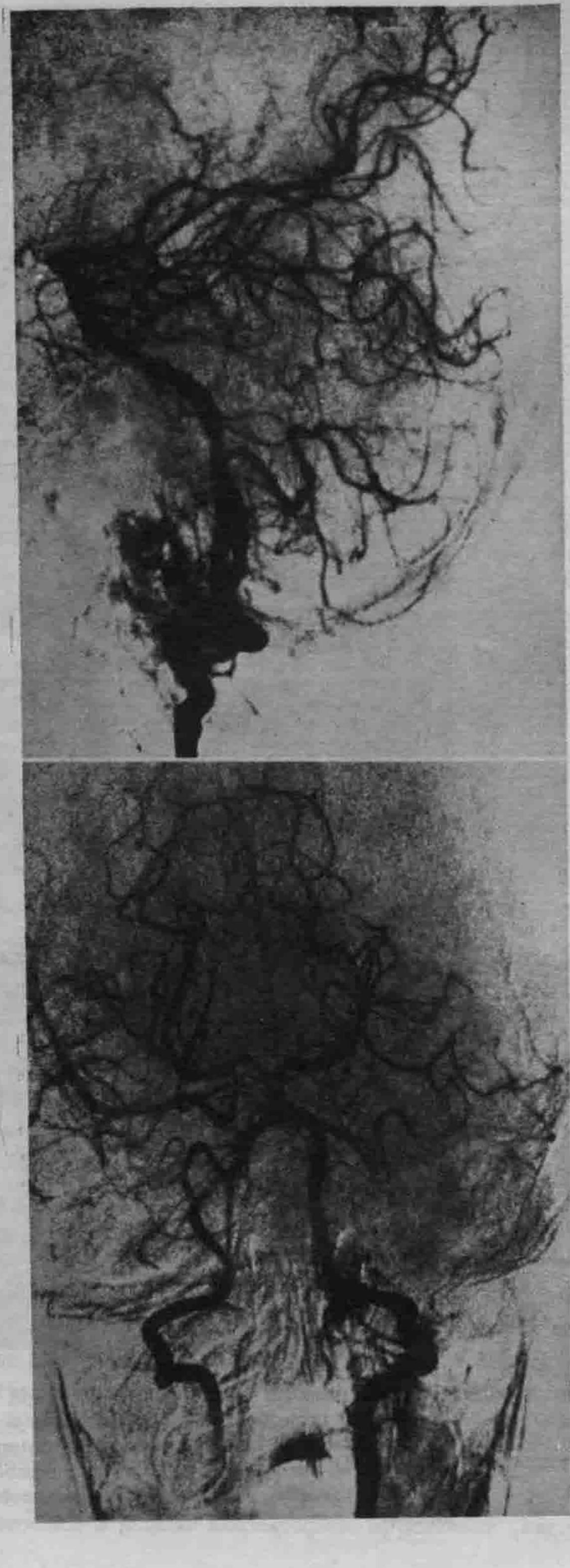

Fig. 3 Malignant tumor in the lower portion of the clivus. **a.** Lateral projection. The proximal basilar artery and the distal vertebral arteries are displaced posteriorly. Tumor vessels over the lower portion of the clivus are irregular. **b.** The basilar artery appears shortened with elongated distal vertebral arteries. Tumor vessels are supplied by abnormal arterial branches from the left vertebral artery. A fenestration is noted in the distal right vertebral artery.

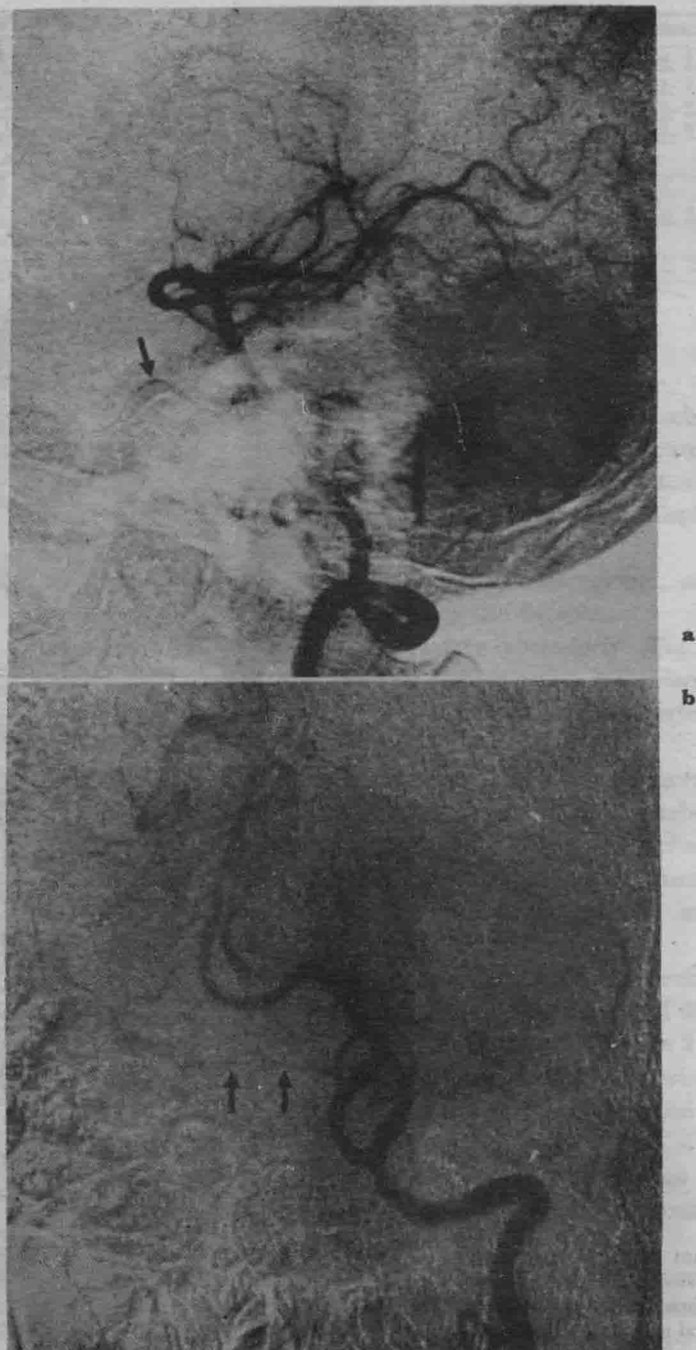

Fig. 4 Acoustic neurinoma in the right cerebellopontine angle. **a.** Lateral projection. The basilar artery is displaced backward by the tumor, extending into the prepontine cistern. The dorsum sellae is indicated by an arrow. **b.** Towne projection. The basilar artery is shifted to the left. The anterior inferior cerebellar artery is straightened (arrows).

Fig. 5 Nasopharyngeal carcinoma extending into the posterior fossa. The basilar artery is displaced backward. The angle of the caudal loop of the posterior inferior cerebellar artery is decreased, suggesting a posterior displacement of the medulla. The arrow indicates the dorsum sellae.

elevate the intracranial pressure in the posterior fossa. Therefore, the basilar artery is displaced anteriorly, partly as a result of increased intracranial pressure and partly as a direct effect of the tumor.

Pontine tumors Large pontine tumors usually displace the basilar artery anteriorly. Lateral displacement of the basilar artery is rare. Such a displacement is usually seen in a short segment of the basilar artery. In some instances, pontine tumors may wrap around the basilar artery and displace this artery posteriorly whereas other vessels, such as anterior pontomesencephalic veins and pontine branches of the basilar artery are pushed forward. This displacement is called paradoxical and has been observed only in exophytic pontine tumors (Fig. 7a & b).

The pontine branches may be stretched and displaced anteriorly in the presence of pontine tumors (Fig. 8a & b).

Hemorrhage into the pons may produce a similar angiographic appearance (Fig. 9a & b).