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Acute subarachnoid haemorrhage: detection of aneurysms of intracranial arteries by computed tomographic angiography

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Background. *We wanted to determine the diagnostic accuracy, sensitivity and specificity of computed tomographic angiography (CTA) of intracranial vessels, and to establish the advantages and disadvantages of CTA compared to digital subtraction angiography (DSA) as the "gold standard" in patients with acute subarachnoid haemorrhage (SAH).*

Patients and methods. *We prospectively studied 52 patients with acute SAH. Confirmation of the haemorrhage by a conventional computed tomography (CT) scan was immediately followed by intracranial CTA. DSA was performed after the CTA examination and so did not influence the interpretation of CTA images. The sensitivity, specificity and diagnostic accuracy of CTA were determined by comparing the results with the data from DSA and with the surgical findings. Cases where the CTA and DSA results did not match were analysed, and the advantages and disadvantages of intracranial CTA were determined.*

Results. *The diagnostic accuracy of CTA was 95%, its sensitivity was 93%, and its specificity was 98%. False-negative results were obtained in three patients who harboured small aneurysms, two in the region of the cavernous sinus and one at the division of pericallosal and callosomarginal arteries. In one patient with a false-positive result, DSA showed an infundibular widening of the posterior communicating artery. In all seven patients who underwent operations on the basis of CTA results, the surgical findings confirmed the presence of aneurysms as well as the intracranial vessel anatomy demonstrated by CTA.*

Conclusions. *Intracranial CTA is a fast and minimally invasive method with a high diagnostic accuracy, sensitivity and specificity, which has an important place in the detection and preoperative evaluation of intracranial aneurysms in patients with acute SAH.*

Key words: subarachnoid haemorrhage - diagnosis; cerebral aneurysm - diagnosis; tomography, x-ray computed; computed tomographic angiography, digital subtraction angiography

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Introduction

Acute subarachnoid haemorrhage (SAH) resulting from a ruptured aneurysm of intracranial arteries carries a poor prognosis, and the mortality in untreated patients may be as high as 45%.[1] The risk of rebleeding, which can be fatal for the patient, is highest in the first 24-48 hours.[2,3] Therefore, prompt exclusion of the ruptured aneurysm from the circulation is essential. Emergency computed tomography (CT) of the head is the first neuroradiological investigation in patients with suspected SAH. A negative CT scan is followed by a lumbar puncture.[4] If SAH is demonstrated, the aneurysm must be visualised by angiography as soon as possible and its features must be defined.

Intraarterial digital subtraction angiography (DSA) (Figure 1) of all four cerebral arteries still represents the "gold standard" for the detection of intracranial aneurysms.[4-7] DSA is an invasive investigation with complications encountered in 1% of patients, while 0.5% develop permanent neurological deficits.[8] Therefore non-invasive magnetic resonance angiography (MRA) and minimally invasive computed tomographic angiography (CTA) have been used increasingly over the past few years.[9,10]

MRA is a non-invasive investigation, providing three-dimensional visualisation of intracranial vessels in various projections without the use of contrast media or ionising radiation (Figure 2).[10,11] Its main disadvantages in patients with acute SAH are the long examination time (up to 30 min) and difficult patient monitoring.[12,13] MRA cannot depict clearly small aneurysms or partially thrombosed aneurysms with a low flow.[12,13] It is contraindicated in patients with ferromagnetic implants.

The spiral technique of CT, in which scanning is performed while the CT table with the

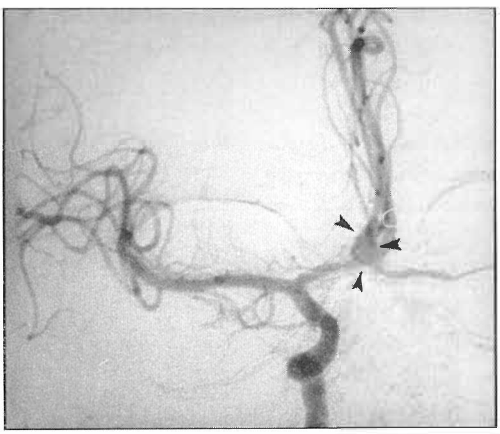

Figure 1a. Lateral digital subtraction angiography view after right internal carotid injection demonstrate an anterior communicating artery aneurysm (arrows).

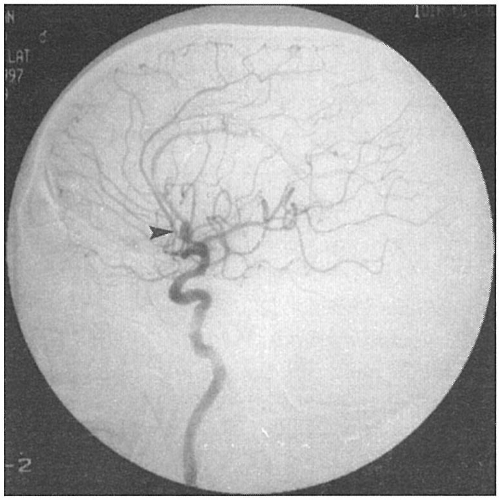

Figure 1b. Anteroposterior digital subtraction angiography view after right internal carotid injection demonstrates an anterior communicating artery aneurysm (arrow).

Figure 2a. Digital subtraction angiogram of left internal carotid artery, lateral view, demonstrates posterior communicating artery aneurysm (arrow).

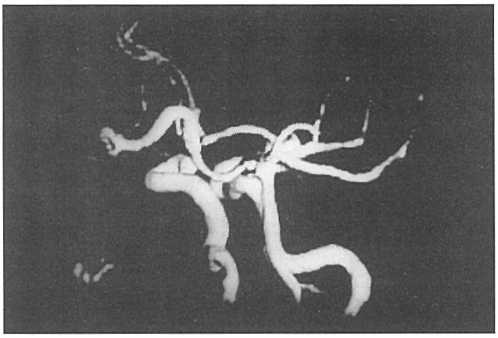

Figure 2b. Three-dimensional magnetic resonance angiographic image, posterolateral view, also clearly demonstrates the same aneurysm (arrows).

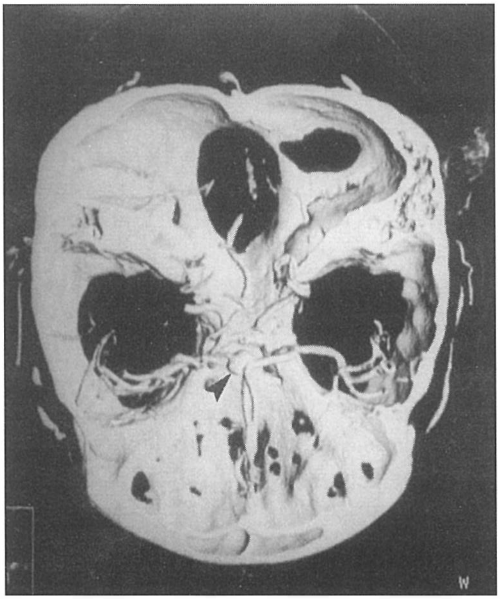

Figure 3a. Three-dimensional computed tomographic angiografic image, superior view, demonstrates a 9-mm-diameter anterior communicating artery aneurysm (arrow).

patient is drawn through the gantry, along with accurate timing of intravenous injections of contrast medium, has made it possible to obtain a three-dimensional display of intracranial arteries also with the use of CT (Figure 3).

The aims of our study were to assess the diagnostic value, advantages and disadvantages of intracranial CTA as compared to DSA

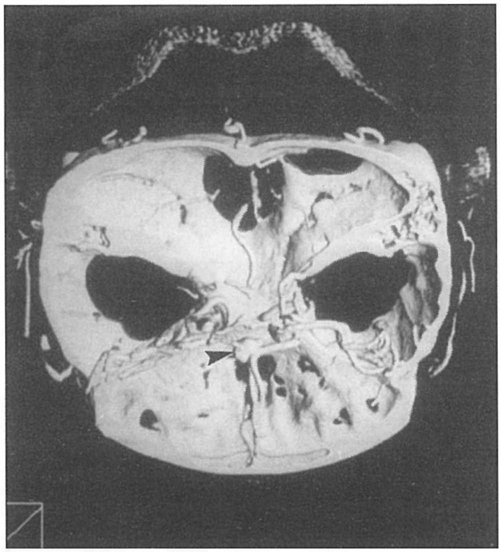

Figure 3b. Three-dimensional computed tomographic angiografic image, posterior view, demonstrates a 9-mm-diameter anterior communicating artery aneurysm (arrow).

in patients with ruptured aneurysms of intracranial arteries, and to define the criteria for proceeding with neurosurgical intervention on the basis of CTA results alone.

Patients and methods

From the introduction of CTA in November 1997 until February 1999, a total of 174 intracranial CTA examinations were performed at the Institute of Radiology in Ljubljana. The present prospective study included 52 patients (22 males and 30 females, aged between 32 and 81 years, average 51.7 years) in whom conventional CT confirming the presence of SAH was immediately followed by intracranial CTA performed on the same scanner (Figure 4). DSA was carried out subsequently, so that its results did not influence the interpretation of the CTA findings.

The CTA examinations were performed with a Siemens Somatom Plus 4 CT scanner, using the following protocol: slice thickness 1 mm, flow rate of contrast medium 2.5 ml/s, volume of contrast medium 120 ml, field of view 50 mm from the level of the posterior inferior cerebellar arteries to the level of the pericallosal arteries. The intracranial arteries were analysed in axial CT images and in three-dimensional reconstructions produced on a Sienet Magicview 31 VA workstation.

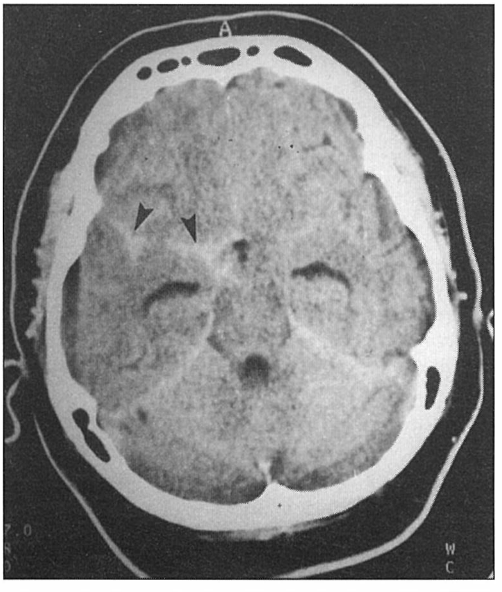

Figure 4a. Patient with subarachnoid haemorrhage from a ruptured aneurysm of the middle cerebral artery. Conventional axial CT shows blood in the basal cisterns and in the right Sylvian fissure (arrows).

In 45 of the 52 patients, a four-vessel DSA study of intracranial arteries was performed on a Philips Integris 2000 system within 12 hours of the CTA examination. In September 1998, the first patient was operated upon on the basis of the CTA results only; afterwards, six further operations were undertaken solely on the basis of CTA.

We evaluated the technical success of CTA and determined the time from the start of the examination until the definitive diagnostic images were produced.

The CTA findings were prospectively compared with the DSA results and for patients undergoing surgical intervention also with the surgical findings. In the seven patients who underwent surgery on the basis of positive CTA findings alone, the CTA result was compared with the neurosurgical result. In this way we were able to estimate the diagnostic value, sensitivity and specificity of intracranial CTA. Patients whose CTA results did not agree with the DSA findings were analysed separately.

We identified the cases where CTA used for the detection and preoperative evaluation of intracranial aneurysms provided sufficient information to allow neurosurgical intervention to be undertaken without DSA.

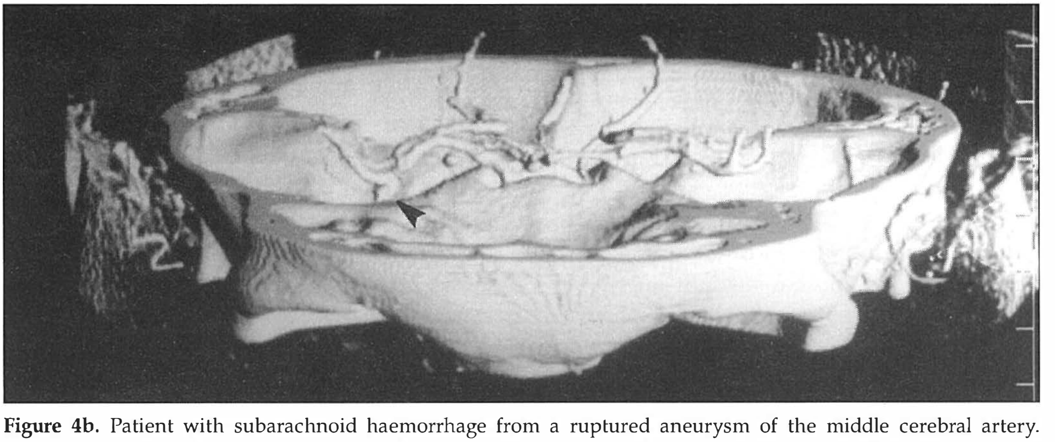

Figure 4b. Patient with subarachnoid haemorrhage from a ruptured aneurysm of the middle cerebral artery. Intracranial CTA performed immediately after conventional CT clearly demonstrates the small aneurysm of the middle cerebral artery (arrow).

Results

Of the 52 CTA studies, 50 (96%) were technically successful. In two studies the image quality was poor because the patients were restless, and so the examination had to be repeated.

The time from the start of the examination until the final elaboration of diagnostic films ranged from 35 to 60 min.

One or more aneurysms were present in 42 of the 52 patients studied. In all seven patients who underwent neurosurgical operations solely on the basis of positive CTA results, the presence and position of the aneurysm as seen on CTA was confirmed at surgery. The results for the remaining 45 patients, in whom the CTA examinations were followed by DSA, are presented in Table1.

Table 1. Number of patients with acute SAH and number of aneurysms detected in these patients with CTA and/or DSA

	Positive DSA	Negative DSA
Positive CTA	32 patients 35 aneurysms	1 patient 1 aneurysm
Negative CTA	3 patients 3 aneurysms	9 patients

Both investigations were positive in 32 patients, in whom a total of 35 aneurysms were detected. One patient had two aneurysms and another had three. For all the aneurysms visualised by CTA and DSA, the presence and position of the lesions were confirmed at neurosurgical operation.

In 10 patients the cause of the acute SAH was not found and so an operation was not undertaken.

In three patients, DSA detected an aneurysm that was not visible on CTA (false-negative results of CTA). In one patient, a small aneurysm measuring 2 mm was located at the bifurcation of the callosomarginal and

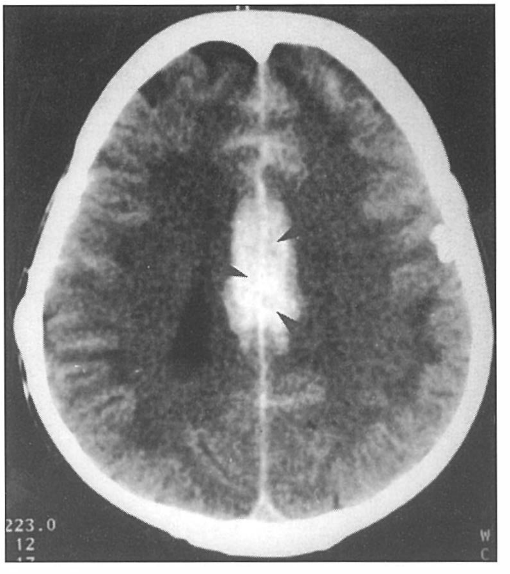

Figure 5a. Conventional CT shows blood in subarachnoid spaces and in the interhemisferic fissure (arrows).

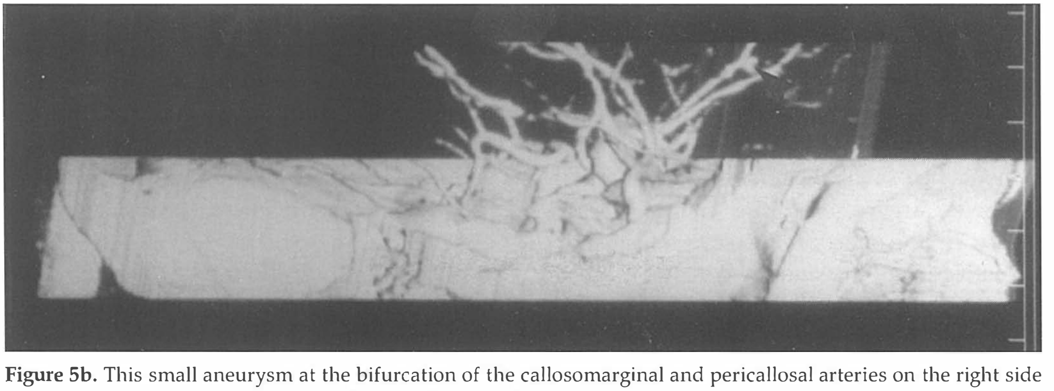

Figure 5b. This small aneurysm at the bifurcation of the callosomarginal and pericallosal arteries on the right side was missed on CTA images because of its small size and unusual position (arrow).

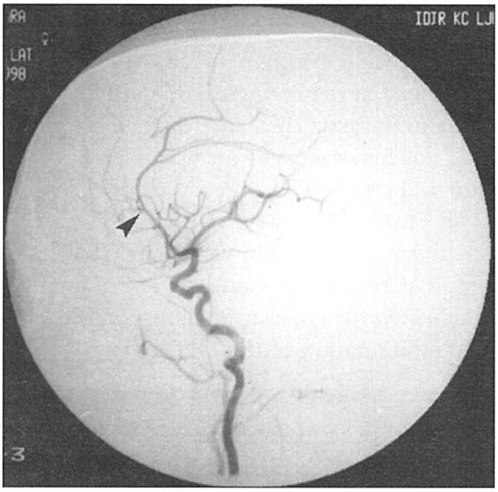

Figure 5c. DSA image, lateral projection, demonstrates this small aneurysm (arrow).

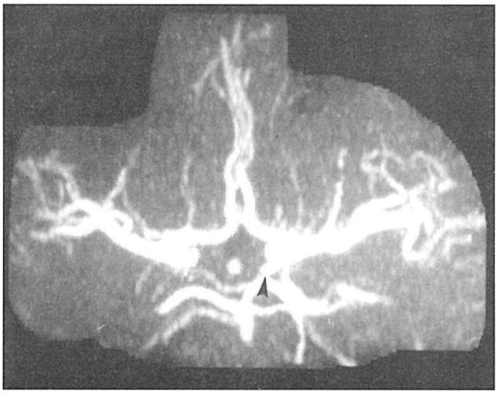

Figure 6a. On CTA images an infundibular widening of the posterior communicating artery (arrow) was misinterpreted as an aneurysm.

pericallosal arteries on the right side. The lesion was seen on CTA but could not be identified as an aneurysm because of its small size and position (Figure 5). Two other patients had small aneurysms, 3 and 4 mm in diameter, arising from the internal carotid artery in the area of the cavernous sinus; opacification of the sinus by contrast medium obscured the boundary between the sinus and the aneurysm. In one patient, an infundibular widening of the posterior communicating artery was erroreously interpret-

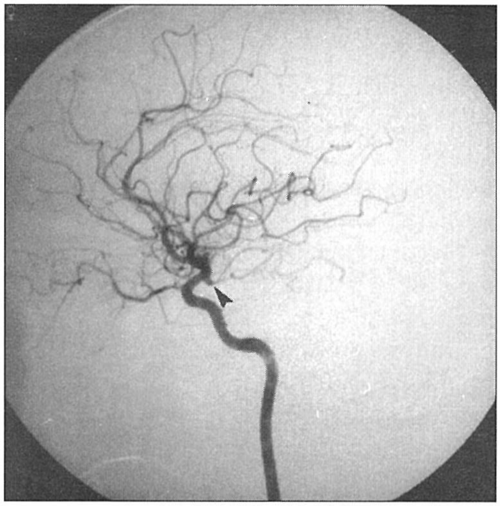

Figure 6b. DSA clarified the situation (arrow), and an operation was not undertaken.

ed as an aneurysm (a false-positive result of CTA); DSA clarified the situation, and an operation was not undertaken (Figure 6).

Comparison of the results of CTA with those of DSA and surgery showed that CTA in our patients had a sensitivity of 93%, a specificity of 98%, and a diagnostic accuracy of 95%.

Discussion

Intracranial CTA is the most recent neuroradiological angiographic examination method. Several authors have evaluated the diagnostic accuracy, sensitivity and specificity of intracranial CTA as compared to DSA[4-7,9] and recently also to neurosurgical findings.[16,17] Most of these studies have shown CTA to be highly accurate, sensitive and specific. This is confirmed also by our present results.

CTA has the following advantages over DSA:

1. It is a minimally invasive examination because contrast material is injected through an intravenous cannula.
2. It can be performed on the same scanner as conventional CT directly after the demonstra-

tion of SAH by a conventional CT scan. Therefore it gives results more rapidly than DSA, for which the patient must be transported to the apparatus and the team, which is constantly on call, must be assembled.
3. In a CTA study, three-dimensional reconstructions can be examined in any projection, but with DSA, the number of projections is limited.
4. CTA is able to define more accurately the relationship of the aneurysm to skeletal structures, and depict a thrombus within the aneurysm or calcifications within its wall, which is important in preoperative evaluation (Figure 7).

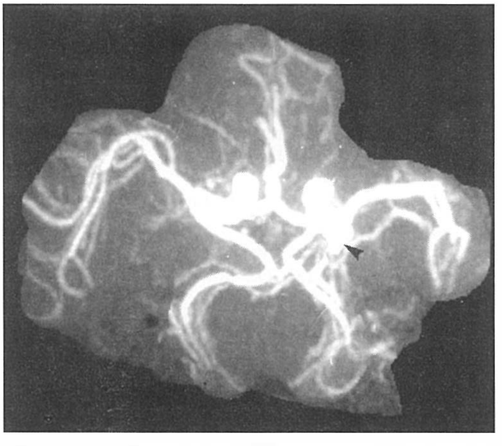

Figure 7a. Inferior view CT angiogram (maximum intensity projection) demonstrates left posterior communicating artery aneurysm and calcifications within the neck of this aneurysm (arrow).

Compared to DSA, CTA also has several disadvantages, which must be considered:
1. Because of lower image resolution, CTA carries a higher probability of false-negative results for small aneurysms measuring less than 3 mm.
2. CTA has a lower diagnostic accuracy in areas where the intracranial arteries border on skeletal structures or the cavernous sinus.
3. CTA requires a greater volume of contrast medium than DSA.
4. CTA is capable of displaying large intracranial arteries but is unable to depict clearly small peripheral arteries; therefore a negative CTA examination must be followed by DSA.

Since the two examinations are in most cases complementary, their combination often provides more data than would be obtained with each of them separately.

When CTA depicts clearly an aneurysm that appears to be the source of haemorrhage, considering the distribution of blood in the subarachnoid spaces, and when the intracranial vessels are distinctly visible from the level of the origin of the posterior inferior cerebellar artery to the level of pericallosal arteries, neurosurgical intervention can be undertaken on the basis of the CTA findings alone. Intracranial CTA has a high diagnostic accuracy, sensitivity and specificity. It can play an important part in the management of patients with acute SAH because the results are acquired rapidly and in a minimally invasive way.

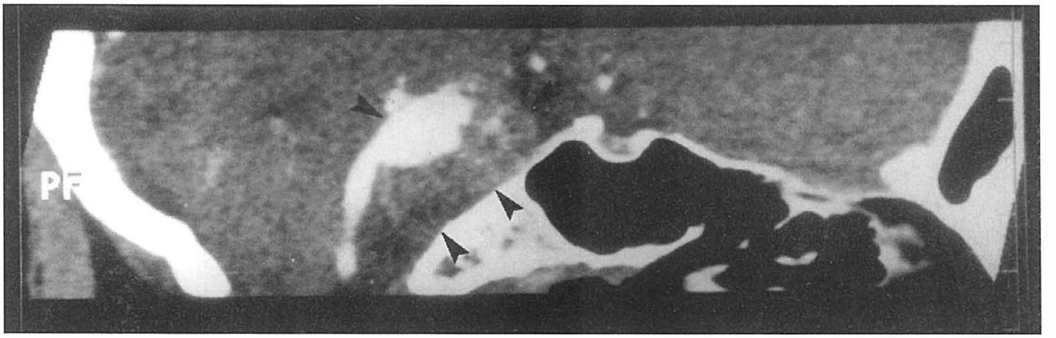

Figure 7b. Multiplanar reconstruction (MPR) in sagital plane in another patient demonstrate a giant, partially thrombosed basilar artery aneurysm (arrows).

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