Perimesencephalic Hemorrhage
Exclusion of Vertebobasilar Aneurysms With CT Angiography

Birgitta K. Velthuis, MD; Gabriël J.E. Rinkel, MD; Lino M.P. Ramos, MD; Theodoor D. Witkamp, MD; Maarten S. van Leeuwen, MD

Background and Purpose—It is important to recognize a perimesencephalic pattern of hemorrhage in patients with subarachnoid hemorrhage (SAH), because in 95% of these patients the cause is nonaneurysmal and the prognosis is excellent. The purpose of this study was to investigate whether CT angiography can accurately exclude vertebrobasilar aneurysms in patients with perimesencephalic patterns of hemorrhage and therefore replace digital subtraction angiography (DSA) in this setting.

Methods—In 40 patients with posterior fossa SAH as shown on unenhanced CT, 2 radiologists independently evaluated unenhanced CT for distinguishing between perimesencephalic and nonperimesencephalic pattern of hemorrhage and assessed CT angiography for detection of aneurysms. All patients subsequently underwent DSA or autopsy.

Results—Observers agreed in 38 of 40 patients (95%) in differentiating perimesencephalic and nonperimesencephalic patterns of hemorrhage on unenhanced CT. On the CT angiograms, both observers detected a vertebrobasilar aneurysm in 16 patients and no aneurysm in 24 patients. These findings were confirmed by DSA or autopsy. No patients with a perimesencephalic pattern of hemorrhage were found to have an aneurysm on either CT angiography or DSA.

Conclusions—Good recognition of a perimesencephalic pattern of hemorrhage is possible on unenhanced CT, and CT angiography accurately excludes and detects vertebrobasilar aneurysms. DSA can be withheld in patients with a perimesencephalic pattern of hemorrhage and negative CT angiography.

Key Words: angiography, digital subtraction □ cerebral aneurysm □ perimesencephalic hemorrhage □ tomography, x-ray computed □ vertebobasilar circulation

In patients with the main focus of subarachnoid hemorrhage (SAH) located in the posterior fossa, a distinction should be made between a perimesencephalic or nonperimesencephalic pattern of hemorrhage. In only 5% of patients with a perimesencephalic pattern of hemorrhage is the cause a vertebrobasilar aneurysm; the remaining 95% have a nonaneurysmal cause, an uneventful clinical course, and invariably good outcome. Current practice requires digital subtraction angiography (DSA) to exclude a vertebrobasilar aneurysm in patients with a perimesencephalic pattern of hemorrhage. The inherent 0.5% risk of permanent neurological deficit, however, is substantial for the 95% of patients who have no aneurysm and an excellent prognosis. If CT angiography is to replace DSA in this group of patients, the accurate selection of patients with perimesencephalic pattern of hemorrhage on unenhanced CT and accurate exclusion of vertebrobasilar aneurysms with CT angiography would be essential requirements. The purpose of this study was to assess whether these requirements could be met in patients with posterior fossa SAH.

Subjects and Methods

Patient Population
Patients for this study were selected from a larger series of 210 patients with nontraumatic SAH who underwent CT angiography at Utrecht University Hospital between October 1994 and October 1997. The study was approved by the institutional review board. When possible, informed consent was obtained from patients or relatives. Implied consent was obtained from the neurologist in the case of comatose patients who were not accompanied by relatives. Inclusion criteria for enrollment were unenhanced CT examination, performed within 3 days of the onset of hemorrhage, demonstrating SAH with the main focus of hemorrhage in the posterior fossa, and either DSA or autopsy as a standard of reference for CT angiographic findings. The criterion used for a posterior fossa hemorrhage was that the main focus of subarachnoid blood was located in 1 or more of the posterior fossa cisterns, namely, the interpeduncular, prepon- tine, premedullary, quadrigeminal, cerebellopontine, and cerebel- lomedullary cisterns. Fifty of the 210 patients had a posterior fossa SAH. Ten of these were excluded: 7 patients who died after CT angiography and had neither DSA nor autopsy, and 3 patients in whom the initial unenhanced CT from which the SAH was diagnosed had been performed >3 days after onset of the SAH. The remaining 40 patients were included in this study (see flow chart in Figure 1). Ages

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ranged from 34 to 84 years (mean, 51 years). CT angiography was performed on the day of the hemorrhage in 15 patients, between days 1 and 3 in 18 patients, and between days 4 and 15 in 7 patients who were referred from other hospitals.

CT Angiographic Acquisition and Postprocessing
CT angiography was performed on a spiral CT scanner (Tomoscan SR 7000 or Tomoscan AVE1, Philips Medical Systems) with the gantry angled to the orbitomeatal line, starting just above the posterior arch of the C1 vertebral body. We used 40 1-second rotations with 1.5-mm collimation, 1.5-mm table speed, and 1-mm reconstruction index on the SR 7000 CT scanner, and 60 1-second rotations with 1-mm collimation, 1-mm table speed, and 0.5-mm reconstruction index on the AVE1 CT scanner. Nonionic contrast material (140 mL; 300 mg I/mL iopromide) (Ultravist; Schering) was injected intravenously with a power injector (CT 9000, digital injection system; Liebel Flarsheim) at a rate of 3 mL/s. Initially, we used a fixed 25-second delay before scanning; after May 1997, however, we determined the scan delay time using a 15-mL test bolus injection measured at the level of the foramen magnum, with resulting scan delays ranging from 14 to 30 seconds. Other scanning parameters included a small focus, 140 kV, 125 to 150 mA, and a 16-cm field of view. CT angiographic source images were transferred to an offline computer workstation (Easy Vision, Philips Medical Systems) for viewing and postprocessing.

Maximum-intensity projection images were created with use of an unedited 2-cm thick slab (slab MIP) angled and rotated separately to the carotid and the vertebrobasilar circulations, as previously described (Figure 2).

Unenhanced CT and CT Angiographic Evaluation
The initial unenhanced CT scan and the CT angiographic images were evaluated prospectively by 2 of 3 independent observers (B.K.V, L.M.P.R, and T.D.W.) in a blinded fashion. The initial unenhanced CT scan was evaluated before CT angiography and classified as perimesencephalic or nonperimesencephalic pattern of hemorrhage, according to predefined criteria. The criteria of perimesencephalic pattern of hemorrhage are (1) center of bleeding located immediately anterior to the midbrain; (2) possible extension of blood to the posterior part of the anterior interhemispheric fissure, but not complete filling of the anterior interhemispheric fissure; (3) extension of blood to the basal part of the sylvian fissure is permitted, but not extension to the lateral sylvian fissure, except for minute amounts of blood; (4) sedimentation of small amounts of intraventricular blood is allowed, but not frank intraventricular hemorrhage; and (5) absence of intracerebral hematoma (Figure 3).

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Quality of CT angiographic images was graded as high or suboptimal. The CT angiographic axial source images and slab MIP rotations were viewed in cine loop fashion on the workstation, and the presence of aneurysms was determined with a 5-point scale of confidence: definitely present (1), probably present (2), possibly present (3), probably not present (4), and definitely not present (0). Aneurysms categorized as definitely, probably, or possibly present were considered to be positive findings, and aneurysms categorized as probably not or definitely not present were regarded as negative findings. Aneurysm size was measured on the CT angiographic images on the workstation.

DSA Acquisition and Evaluation
Selective 3- or 4-vessel DSA with frontal, lateral, and oblique projections were performed in 39 of the 40 patients. The vertebrobasilar circulation was visualized by catheterization of both vertebral arteries or 1 vertebral artery with reflux of contrast material into the contralateral posterior inferior cerebellar artery. The CT angiographic findings were used to help the angiographist performing the DSA. A consensus opinion of the DSA images regarding DSA
quality and the presence and location of aneurysms was formed by the angiographist and a neuroradiologist. All DSA examinations were of high quality.

Reference Standards
Because no standard of reference was available for the discrimination between a nonperimesencephalic and a perimesencephalic pattern of hemorrhage, we used a third experienced observer (G.J.E.R.) to assess the unenhanced CT scans in which the 2 observers disagreed on the pattern of hemorrhage. These unenhanced CT scans were read in the same blinded fashion and according to the same predefined criteria of perimesencephalic pattern of hemorrhage. The 2 concordant readings were then used in the results (Figure 1).

The standard of reference for presence or absence of aneurysms was DSA performed in 39 of the 40 patients and autopsy in 1 patient who died before undergoing DSA. A vertebrobasilar aneurysm was demonstrated in 16 of the 40 patients and no aneurysm in 24 patients. No additional aneurysms, either definitely or possibly present, were detected on DSA.

Three groups emerged in the 40 patients with predominantly posterior fossa SAH (Figure 1): 15 patients with a perimesencephalic pattern hemorrhage and no aneurysm on DSA; 16 patients with a nonperimesencephalic pattern of hemorrhage caused by a ruptured vertebrobasilar aneurysm as seen on DSA or autopsy; and 9 patients with a nonperimesencephalic pattern of hemorrhage and no aneurysm on DSA.

Data Analysis
Interobserver agreement between the 2 observers who prospectively evaluated the data for discrimination of nonperimesencephalic and perimesencephalic patterns of blood on the unenhanced CT was

Figure 2. CT angiography postprocessing using maximum intensity projection with 2-cm slabs (slab MIP). A, Frontal view of CT angiographic slab MIP angled to vertebrobasilar circulation in a patient with nonaneurysmal perimesencephalic hemorrhage. Superior cerebellar arteries (arrows) and right anterior inferior cerebellar artery (open arrow) are visible on this view. Slab rotation is required to obtain oblique views of (B) the right vertebral artery and right posterior inferior cerebellar artery (PICA) (arrowhead) and (C) the left vertebral artery and PICA (curved arrow) without overprojection of adjacent bone (short arrow).

Figure 3. Unenhanced CT of a patient with perimesencephalic pattern of hemorrhage (A and B). The center of bleeding is located immediately anterior to the midbrain (arrow). According to the criteria of perimesencephalic pattern of hemorrhage, extension of blood to the posterior part of the anterior interhemispheric fissure (open arrow) and to the basal part of the sylvian fissure (arrowhead) is permitted, and sedimentation of small amounts of intraventricular blood (curved arrow) is allowed.
measured by $\kappa$ statistics. The level of agreement was regarded as poor if $\kappa$ was between 0.41 and 0.60, good between 0.61 and 0.80, and excellent between 0.81 and 1.0. Sensitivity and specificity were calculated for detection and exclusion of aneurysms with CT angiography.

**Results**

**Unenhanced CT Scan Evaluation**

There was interobserver agreement between the 2 prospective observers in discriminating nonperimesencephalic from perimesencephalic SAH in 38 of the 40 patients (95%), with a $\kappa$ value of 0.89 (95% CI, 0.75 to 1.00). The 2 observers disagreed on 2 unenhanced CT scans. After assessment by the third observer, it was determined that 1 pattern of hemorrhage was perimesencephalic (Figure 4) and 1 nonperimesencephalic (Figure 5).

**CT Angiographic Detection of Verteobasilar Aneurysms**

The quality of CT angiography was high in 30 patients and suboptimal in 10. Four of the suboptimal CT angiograms were repeated, and these were included in the prospective evaluation. Suboptimal CT angiograms in 4 patients with vertebrobasilar aneurysms were not repeated because of poor clinical condition in 3 patients and because 1 patient died before undergoing DSA or repeat CT angiography and autopsy was performed. Two patients with perimesencephalic pattern of hemorrhage and no aneurysm on suboptimal though adequate CT angiography underwent early DSA instead of repeat CT angiography.

Both observers detected all 16 vertebrobasilar aneurysms on CT angiography, and all were classified as being definitely present. There were 9 basilar top aneurysms, 4 posterior inferior cerebellar artery, 2 superior cerebellar artery, and 1 vertebral artery aneurysm. Three aneurysms measured <5 mm, 9 were 5 to 10 mm, 2 were 11 to 15 mm, and 2 measured 16 to 20 mm. Neither observer detected an aneurysm in the 24 patients without aneurysms on DSA. The sensitivity of detecting vertebrobasilar aneurysms on CT angiography was 100% (95% CI 0.79 to 1.00) and the specificity was 100% (95% CI 0.86 to 1.00) for both
observers. The predictive value of a negative CT angiography for a negative DSA was 1.00 (95% CI 0.86 to 1.00) for both observers.

DSA was repeated in 6 of the 9 patients with nonperimesencephalic pattern of hemorrhage and no aneurysm on CT angiography or initial DSA. All repeated DSA examinations were completely normal. Of the remaining 3 patients, 2 underwent repeat CT angiography (with normal results) instead of repeat DSA: I died before undergoing repeat DSA or CT angiography, and no autopsy was performed.

In the 10 excluded patients with posterior fossa SAH, the findings of both observers on CT angiography were in agreement. In the 7 patients who died without undergoing DSA or autopsy, a posterior fossa aneurysm classified as definitely present was found on CT angiography. In the 3 other patients the initial unenhanced CT was made 3 days after onset of the SAH, and these patients were therefore excluded.

**Discussion**

In SAH located predominantly in the posterior fossa, the prognosis of patients with nonaneurysmal perimesencephalic hemorrhage is excellent, in contrast to that of patients with a ruptured aneurysm or patients with nonperimesencephalic SAH and negative angiography. Patients with nonaneurysmal perimesencephalic hemorrhage should preferably not be exposed to the risk associated with DSA. CT angiography may provide a safe, noninvasive, and swift alternative to DSA in these patients.

Accurate recognition of a perimesencephalic pattern of hemorrhage on unenhanced CT scan is of paramount importance: the chance of finding an aneurysm is very high in patients with a nonperimesencephalic pattern of hemorrhage, compared with 5% in patients with a perimesencephalic pattern of hemorrhage. In our study, the interobserver agreement between prospective observers for recognizing a perimesencephalic pattern of hemorrhage on unenhanced CT was excellent, with a $\kappa$ value of 0.89. This is in accordance with the findings of Rinkel et al, who reported a $\kappa$ of 0.87 for interobserver agreement on perimesencephalic pattern of hemorrhage in 37 patients with a posterior circulation hemorrhage, and with those of Kallmes et al, who reported an interobserver agreement $\kappa$ of 0.93 in a study distinguishing perimesencephalic from nonperimesencephalic patterns of hemorrhage in 169 patients with ruptured vertebrobasilar aneurysms. These data show that experienced radiologists can accurately discriminate between perimesencephalic and nonperimesencephalic patterns of hemorrhage.

Early CT within 3 days is necessary for reliable assessment of the pattern of hemorrhage. A considerable amount of hemorrhage may disappear in the first few days, and in >90% of patients with nonaneurysmal perimesencephalic hemorrhage no SAH is visible on CT performed 1 week after the hemorrhage. Also, redistribution and resorption of blood can change the pattern of hemorrhage after a few days, so that SAH from a ruptured vertebrobasilar aneurysm may resemble a perimesencephalic pattern of hemorrhage (Figure 6).

If CT angiography is to replace DSA after unenhanced CT demonstrating a perimesencephalic pattern of hemorrhage, a high negative predictive value is required. Detection and exclusion of vertebrobasilar aneurysms with CT angiography was highly accurate in the present study, with a sensitivity and specificity of 100%. All vertebrobasilar aneurysms that could theoretically have caused a perimesencephalic pattern of hemorrhage were detected, and the negative predictive value of CT angiography to exclude vertebrobasilar aneurysms was 1.00. Specificity was also high (89% to 100%) in other studies on the detection of all intracerebral aneurysms with CT angiography.

In the present study, none of the 15 patients with a perimesencephalic pattern of hemorrhage on the initial unen-
hanced CT scan had a vertebrobasilar aneurysm. Neither Goergen et al\textsuperscript{22} nor Pinto et al\textsuperscript{23} found a vertebrobasilar aneurysm in 9 patients with a perimesencephalic pattern of hemorrhage. van Gijn et al\textsuperscript{4} reported a basilar aneurysm in 1 of 14 patients with perimesencephalic patterns of hemorrhage (7%), Rinkel et al\textsuperscript{1} in 1 of 23 patients (4%), and Kitahara et al\textsuperscript{24} in 1 of 11 patients (9%). Combining these studies, the overall chance of finding a vertebrobasilar aneurysm in a patient with a perimesencephalic pattern of hemorrhage is 4.6% (95% CI, 0.01 to 0.13). A perimesencephalic pattern of hemorrhage has also been described with aneurysms at vertebrobasilar sites other than the basilar top: a distal posterior cerebral artery (P2 segment) aneurysm,\textsuperscript{25} a vertebrobasilar junction aneurysm,\textsuperscript{25} and a superior cerebellar artery aneurysm.\textsuperscript{12} Pinto et al\textsuperscript{23} also reported a perimesencephalic pattern of hemorrhage in 1 posterior communicating artery aneurysm; no other studies describe anterior circulation aneurysms with a perimesencephalic pattern of hemorrhage. In the series from which the patients for this study were selected, none of the patients with an anterior circulation aneurysm, including 26 ruptured posterior communicating artery aneurysms, had a perimesencephalic pattern of hemorrhage.

Given the 5% chance of an aneurysm being present in patients with a perimesencephalic pattern of hemorrhage and the test characteristics of CT angiography, the chance of harboring an aneurysm after a negative CT angiography with a perimesencephalic pattern of hemorrhage is much smaller than the risk of a conventional angiography with catheterization of the vertebral arteries.

Nine patients with posterior fossa hemorrhage but with no aneurysm on CT angiography and DSA did not fulfill the strict criteria of a perimesencephalic pattern of hemorrhage. All 9 patients had the initial unenhanced CT scan within 24 hours of the onset of symptoms, enabling us to make an accurate assessment of the distribution of the SAH and the amount of intraventricular blood. These patients underwent repeat examination at a later date, but no aneurysms were found. Some of these patients might have had a true nonaneurysmal cause of the SAH, as in the patients with perimesencephalic patterns of hemorrhage.
encephalic hemorrhage. However, because the chance of a vertebrobasilar aneurysm is much higher in these patients, we still advise DSA in this specific group of patients if CT angiography is negative. Although promising results have been reported with MRI, unenhanced CT is still the reference standard for identification and distribution of SAH. The advantages of CT angiography over MR angiography as a noninvasive technique are that it can immediately follow the initial CT and can be performed in nearly all patients in the acute phase of SAH, because the scanning time is only up to 60 seconds. MR angiography can be used in a selected group of patients in the acute phase of SAH with 80% to 90% sensitivity and 100% specificity. It is, however, not suitable for all patients with SAH, because many are restless or in poor clinical condition during the acute phase. Also, there is always an additional planning delay compared with the initial CT and CT angiography.

In conclusion, in patients with an SAH located predominantly in the posterior fossa, reliable discrimination between a perimesencephalic and nonperimesencephalic pattern of hemorrhage is possible on unenhanced CT. Subsequent CT angiography can accurately detect and exclude vertebrobasilar aneurysms. Our study demonstrates that in patients with a perimesencephalic pattern of hemorrhage and a negative CT angiography, DSA can be withheld, provided that (1) the initial unenhanced CT is made within 3 days of the onset of the SAH, (2) the strict criteria of perimesencephalic pattern of hemorrhage are adhered to, and (3) there is a high-quality negative CT angiography. We still recommend DSA for patients with a nonperimesencephalic type SAH and negative CT angiography.

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References
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