Acute basilar artery thrombosis: a pictorial review and appraisal of outcome prediction using cross-sectional imaging

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Learning objectives

Acute basilar artery (BA) thrombosis is an uncommon but potentially fatal condition that if presenting to hospital may well be referred for imaging. It is vital that cases are diagnosed promptly, as immediate recognition may lead to early thrombolytic treatment that may improve functional outcome or survival. We reviewed the imaging features associated with a series of clinically proven cases and we also review the evidence pertaining to the use of cross-sectional imaging in the prediction of clinical outcome.

Background

Partial or complete basilar artery occlusion may result from a variety of insults including embolism, in-situ thrombus on an atherosclerotic plaque or, vessel dissection. This may result in ischaemia or infarction in the brainstem, cerebellum, thalami or occipital cortex. The condition presents with a variety of clinical signs and symptoms. Most patients suffer prodromal symptoms in the preceeding two weeks including headache, vertigo or both (1). In the acute presentation, altered levels of consiousness, dysarthria, paresis, hemi or tetraplegia, ataxia, cranial nerve deficits and supranuclear occulomotor disturbances are the commonest presenting signs (1).

Traditionally, basilar artery occlusion has been associated with a high mortality and morbidity. In one large series of 80 conventionally treated patients, 80% had a poor outcome, with a case fatality of 40% and the presence of a severe residual deficit in more than 65% of survivors (2). More recently there has been an emphasis on acute therapeutic recanalisation to reestablish perfuson, although there is controversy as to the best mode of treatment, whether it be intravenous thrombolysis or intra-arterial thrombolysis/mechanical clot disruption (3, 4).

The potential benefit of vessel recanalisation lacks data from randomised controled trails but several case series suggest a reduction in mortality and improved functional outcomes following thrombolytic treatment (5). Recognition of imaging features
associated with this condition are therefore vital to allow early diagnosis and institution of thrombolysis or prompt transfer to a Neuroradiology centre for intra-arterial therapy. Furthermore, prediction of outcome based on imaging findings is a potentially useful tool in patient management, the aim being to select only those patients who will respond to treatment before subjecting them to intervention.

**Imaging findings OR Procedure details**

**Clinical presentation and imaging of cohort**

Over the last six years, we identified twelve patients (age range 54-84 years, mean 68.5 years) who were referred for imaging and whose final clinico-radiological diagnosis was that of basilar artery thrombosis. Five patients presented with coma. The remaining seven patients had hemiplegia, of which two had alternating symptoms, three had vertiginous symptoms and two suffered cranial nerve deficits. All patients underwent unenhanced CT scanning within 24 hours of onset of symptoms, with two patients undergoing CT angiography and four patients having further MR imaging including diffusion weighted studies and magnetic resonance angiography. We discuss the imaging features associated with each modality with reference to patients from our series and further discuss research into the use of cross-sectional imaging in the prediction of patient outcome.

**Unenhanced CT**
A hyperdense basilar artery sign, presumed to represent acute thrombus or clot within the basilar artery is seen in approximately 50-70% of patients with basilar artery thrombosis (see figure 1 on page 9) and is the first identifiable abnormality on unenhanced CT (5, 6). This shows similarity to the dense middle cerebral artery sign and should be considered when the Hounsfield units exceed approximately 40 (7) and through comparison with other unaffected intracranial vessels. Often it is the only abnormality on the scan (6).

A recent study using CT angiography for verification suggested that a hyperdense basilar artery had a 71% sensitivity, 98% specificity, 94% accuracy, 83% positive predictive value, and 95% negative predictive value for basilar artery occlusion (8). Of our series, six patients showed an hyperdense basilar artery on initial CT. Five of these patients died within 2 days supporting the notion that this is a poor prognostic sign (8). However, it should be highlighted that caution must be exercised in applying this sign, as normal basilar arteries may appear slightly dense in older patients, likely due to the presence of mural calcium. Smaller hyperdensities representing acute thrombus in more distal vessels may also occur (6).

Unenhanced CT has a low sensitivity for early parenchymal ischemia and usually has the disadvantage of significant artifacts caused by the bony structures surrounding the brainstem and cerebellum. Subtle abnormalities that may prompt the diagnosis include loss of grey-white matter differentiation in the occipital lobes that may occur after approximately 6 hours (see figure 2 on page 9). However, following a more protracted delay of approximately 48 hours, plain CT will clearly show low density and or tissue swelling representing cerebellar, brainstem, thalamic or occipital infarction (see figure 3 on page 10).

**CT angiography**

We have found CT angiography a useful method for rapid diagnosis of basilar artery occlusion in the acute setting, especially in severely ill patients. CT angiography showed either poor flow and incomplete occlusion (figure 4 on page 10) or occlusive thrombus in the basilar artery (figure 5 on page 11 and 6 on page 12) and prompted intervention in one of our patients. In one series, CT angiography detected basilar thrombus in 18 of 19 patients with suspected basilar thrombus scanned in the acute setting (9). It provides reliable information on vessel patency, on the exact site and extent of occlusion, and to some extent on collateral pathways (that on digital subtraction angiography have been shown to have an important impact on prognosis) (9, 10). Indeed, some authors advocate reliance on CT angiography results in decisions concerning treatment planning in clinically suspected basilar artery occlusion (9). Technically, calcification within the basilar artery is a limitation of the technique, with differentiation...
of a large region of focal calcification and any possible contrast enhancement in CT angiography being potentially challenging but windowing tools are useful. Three-dimensional image reconstruction aids demonstration of vascular anatomy to the clinician (see figure 6 on page 12).

**Magnetic Resonance Imaging**

We used magnetic resonance imaging when the diagnosis was not clear or in cases where the patient was not critically ill, as there are obvious benefits in terms of scan time for the use of CT angiography. Using conventional axial T2 and sagittal T1-weighted images, basilar thrombus can be detected as early as 90 minutes following the onset of symptoms (6). Loss of flow void phenomena on axial T2-weighed images show relative hyperdensity within the basilar artery (figure 7 on page 12). However, this may not be seen in cases of incomplete occlusion (6). Sagittal T1-weighted images detect thrombus through development of intermediate signal intensity within the basilar artery (figure 8 on page 13) (6), thought to represent deoxyhemoglobin within fresh intraluminal thrombus.

However, these abnormalities are not of reliable diagnostic value, and therefore magnetic resonance angiography is usually advocated to confirm the diagnosis (figure 9). Through comparison to digital subtraction angiography, Rother et al (11) demonstrated that the sensitivity of time-of-flight gradient echo MR angiography for correctly diagnosing distal vertebral and basilar artery pathologies was 97%, whereas the specificity was 98.9%. The straight course of vessels in the vertebrobasilar system lends to this technique and signal loss caused by turbulence blood flow in curved arterial segments is a minor problem.

Potential difficulties of MR angiography of the vertebro-basilar arteries lie in the proper evaluation of absent or low blood flow signal. The flow signal in MRA is highly dependent on the flow velocity. For example, a weak flow signal of the distal vertebral artery can be the result of a proximal stenosis or hypoplasia. Use of gadolinium has been advocated in these circumstances (11).

MR imaging is superior to CT in the depiction of infarction, notably with the use of diffusion-weighted imaging, so allowing early detection of such pathology (see figure 10 on page 15).

**Clinical outcome prediction using cross-sectional imaging**
Factors including the presence of vessel collateralisation, distal thrombus site and length of occlusion seen on digital subtraction angiography have been shown to help predict outcome in these patients (10, 12). However, a number of groups have aimed to find an association between cross-sectional imaging signs and prognosis in an attempt to develop the ability to predict outcome and therefore guide whether to treat or withhold thrombolysis or intraarterial therapy in a given patient.

The hyperdense basilar artery sign:

The results of research linking the presence of this sign and patient outcome is not conclusive. In a series of 95 patients presenting with posterior circulatory symptoms, Goldmakher et al (8) found that the presence of a hyperdense basilar artery (seen in 12 patients) showed significant correlations with both poor short-term outcome, measured by discharge National Institute of Health Stroke Scale (NIHSS) scores and poor long-term outcome measured by 6-month modified Rankin score. Most of these patients were scanned outwith a 3 hour window and, confoundingly, some received thrombolysis, whereas some did not.

In an earlier series of 40 patients with basilar occlusion confirmed by arteriography in which outcomes were measured in a similar way but all patients received thrombolytic therapy, a hyperdense basilar artery sign (seen in 26 patients) on the admission CT scan and early CT signs of ischaemia, were not predictive of the clinical outcome (5). Interestingly, however, the presence of a hyperdense basilar artery sign on CT was associated with a greater likelihood of recanalisation using thrombolytic therapy. This has been attributed to the correlation between clot density and acuity, which would presumably correlate with a positive outcome.

The posterior circulation Acute Stroke Prognosis Early CT Score (pc-ASPECTS):

Puetz et al (13) aimed to quantify early ischemic changes seen on T Angiography Source Images (CTASI) to predict functional outcome (using a modified Rankin score) in patients with basilar artery occlusion. They developed a novel CT scoring system, the posterior circulation Acute Stroke Prognosis Early CT Score (pc-ASPECTS). Pc-ASPECTS score allocates the posterior circulation 10 points. One point each is subtracted for hypoattenuation on CTASI in left or right thalamus, cerebellum, or posterior cerebral artery territory, respectively, and 2 points each are subtracted for hypoattenuation on CTASI in any part of the midbrain or pons. A pc-ASPECTS score of 10 indicates absence of visible posterior circulation ischemia; a score of 0 indicates hypoattenuation in all pc-ASPECTS territories.
Of 46 patients with basilar artery occlusion, 52% (12/23) with CTASI pc-ASPECTS score #8 but only 4% (1/23) with a score #8 had favorable functional outcome. This difference was consistent in 21 patients with angiographic recanalisation. In contrast, patients with a CTASI pc-ASPECTS score #8 were less likely to die. The authors conclude that the CTASI pc-ASPECTS score can identify basilar artery thrombosis patients who will have a poor clinical outcome despite recanalisation. In a further study, the same group have demonstrated that the extent of hypoattenuation on initial CTASIs predicts the final infarct extent (based on the pc-ASPECTS score) in patients with basilar artery occlusion (14). However, it should be stressed that the nature of the hypoattenuation on these images may vary with time from symptom onset and cannot distinguish between reversible ischaemia or infarction.

The brain stem DWI lesion score:

Semiquantitative scales have also been constructed using findings from diffusion weighted MR imaging. Acute global diffusion-weighted MR lesion volume does not correlate with the baseline NIHSS score in several studies of vertebrobasilar ischemic stroke (15, 16). Indeed relatively small lesions in the posterior circulation can have devastating effects. Therefore, score systems based on arterial segmentation rather than a global volume assessment have been developed.

Recently, Cho et al (17) used a scale to evaluate the extent of the brain stem diffusion weighted imaging (DWI) lesion on pretreatment MR scans according to the affected arterial territories of the medulla, pons, and midbrain. The number of arterial territories with abnormal DWI was assessed at each brain stem level: 0-8 in the medulla, 0-6 in the pons, and 0-8 in the midbrain. The total number of involved arterial territories defined the "brain stem DWI lesion score", comprising scores between 0 and 22. Therefore, a score of 0 indicates absence of visible posterior circulation ischemia; a score of 22 indicates DWI restriction in the entire brainstem. Of the 29 patients included, the authors found that the DWI score was able to predict clinical outcome (modified Rankin score) despite recanalisation being achieved in 76% of patients. The authors concluded that this scoring system may be able to identify patients most likely to benefit from treatment. Extensive brain stem damage may indicate poor prognosis regardless of recanalisation success or failure. Conversely, they suggest that patients with limited DWI lesions might benefit from late reperfusion therapy.

Use of these systems remains experimental. To the authors' knowledge, there has been no published evidence regarding the use of these scoring systems in clinical practice and there has not yet been a comparison of techniques. Furthermore, owing to the relative rarity of the condition, many of the studies are performed with small numbers.
Perhaps the speed of CT lends itself to the acute setting with the ability to produce rapid information when time is at a premium. However, diffusion-weighted MR imaging may be able to detect smaller lesions earlier and more accurately differentiate ischaemia or infarct patterns and therefore outcome.
**Fig. 1:** Axial CT showing a hyperdense basilar artery as an isolated abnormality in a 54 year-old man presenting with collapse.
**Fig. 2:** Axial unenhanced CT: Initial scan showing subtle low density and loss of grey-white differentiation in the right occipital lobe (left). A scan performed 24 hours later (right) shows a more marked area of low density at this site representing infarction.

**Fig. 3:** A 60 year-old gentleman presented with collapse. Initial axial unenhanced CT (left) showing a hyperdense basilar artery but no evidence of cerebral ischaemia. 48 hours following symptom onset there is widespread infarction throughout the occipital lobes, brainstem and cerebellum (right).
Fig. 4: A 75 year old man presented with fluctuating left sided weakness. Initial CT scan was normal. Repeat unenhanced CT (left) showed scattered small areas of infarction in the cerebellum. CT angiography (right) demonstrated a partial occlusion in the basilar artery.
Fig. 5: A 54 year-old male presented with collapse. Unenhanced CT images (top left, arrow) demonstrated a hyperdense basilar artery. Axial and sagittal CT angiographic images demonstrated occlusion of the basilar artery (top right and bottom, arrows).

Fig. 6: 54 year-old patient presenting with collapse. Three dimensional reconstruction CT angiogram showing occluded basilar artery.
**Fig. 7:** 78 year-old presenting with vertigo and facial weakness. Axial T2-weighted spin echo image showing loss of flow void within the basilar artery (arrow).
Fig. 8: 73 year-old male presenting with episodic vertigo and right hemianopia. T1-weighted sagittal MR image showing intermediate signal in the basilar artery (arrow).
Fig. 9: 58 year-old male with dysphasia and alternating arm weakness. Axial 2D and 3d MIP time-of-flight MR angiographic images showing basilar artery occlusion.
**Fig. 10:** 78 year-old female presented with vertigo, nausea and vomiting. Axial CT (top, left) shows no abnormality. Axial T2-weighted spin echo image (top, right) shows loss of flow void in the basilar artery indicative of thrombus and a small area of signal intensity in the right cerebellum. Diffusion weighted (bottom, left) and ADC map (bottom, right) show hyperintensity and low signal respectively in keeping with a small infarct.
Conclusion

Several important early imaging signs are indicative of acute basilar artery thrombosis on both unenhanced CT and conventional MRI. Computed tomographic signs include a hyperdense basilar artery that has high specificity, accuracy, positive and negative predictive value. Unenhanced CT is insensitive for detection of acute ischaemia or early infarction. Early magnetic resonance features include loss of flow void, seen as increased signal intensity within the basilar artery on T2-weighted images and identification of acute thrombus, seen as intermediate signal on T1-weighted images. MR sequences are more sensitive for detection of acute ischaemia or infarction and this can be detected early using this modality, ideally with diffusion-weighted imaging. Both CT and MR angiography are sensitive for detection of acute thrombus, seen as a filling defect or occlusion. These are the non-invasive imaging modalities of choice to confirm diagnosis, with perhaps the speed of CT angiography lending the use of this modality most readily to the acute setting.

Several methods of predicting outcome based on imaging signs have recently been published. Evidence regarding the prognostic significance of the hyperdense basilar artery sign is conflicting. However, several studies have shown correlation between clinical outcome and scores based on the number and location of either areas of low density seen on CT angiographic source images or areas of signal intensity on diffusion-weighted images. These systems are based on arterial segmentation rather than a global volume assessment that has failed to show correlation with outcome. Both CT and MR methods show potential in prediction of outcome and therefore the ability to target only those patients who will benefit from attempts at recanalisation. Data regarding the use of these systems in clinical practice to guide treatment are needed.
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References


