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## Visualisation of intracranial space-occupying lesions by means of transcranial duplex sonography: report on two cases

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**Summary Objective:** A new method for the visualisation of intracranial lesions by means of transcranial duplex sonography is illustrated by two cases. **Methods:** The following methods were used to obtain images of a frontal glioblastoma and a meningioma: transcranial duplex sonography (2 MHz transducer), cerebral computed tomography (cCT), and magnetic resonance imaging (MRI). **Results:** Comparable to cerebral angiography, transcranial duplex sonography revealed displacement of the cerebral blood vessels and thus the presence of space-occupying lesions. **Conclusions:** Transcranial duplex sonography is a non-invasive method for the visualisation of the circle of Willis and its branches and therefore also an indirect indicator of space-occupying lesions within the cranial cavity. As a bedside investigation, it can be used for emergency or routine diagnostic procedures, and repeated as often as necessary for routine follow-up in everyday neurosurgical practice.

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## INTRODUCTION

Before cerebral computed tomography (cCT) became available, it was usual to diagnose intracranial space-occupying lesions using cerebral angiography. Displacement of the blood vessels acted as an indirect indicator of the position and size of the tumour, and the nature of the blood supply.<sup>3–6,8–11</sup>

Transcranial duplex sonography is a non-invasive bedside method which can be repeated as frequently as required. With this method, it is possible to visualise the entire circle of Willis and its branches through the skull, if sound penetration is optimal. By comparing the results of insonation via the right and left temporal windows, conclusions can be drawn on the size of an intracranial lesion and its blood supply, based on the displacement of the blood vessels.

This paper presents the results of examination and follow-up of two patients with different space-occupying lesions using transcranial duplex sonography, and compares the findings with the results of cCT and magnetic resonance imaging (MRI) investigations, and intraoperative findings.

We feel that our results with transcranial duplex sonography show that this method can be of significant benefit in everyday neurosurgical practice.

## CASE REPORTS

Figs. 1A–C show a normal circle of Willis.

Duplex sonographic images were taken using a Logic 500Pro device by General Electrics.

### Case 1

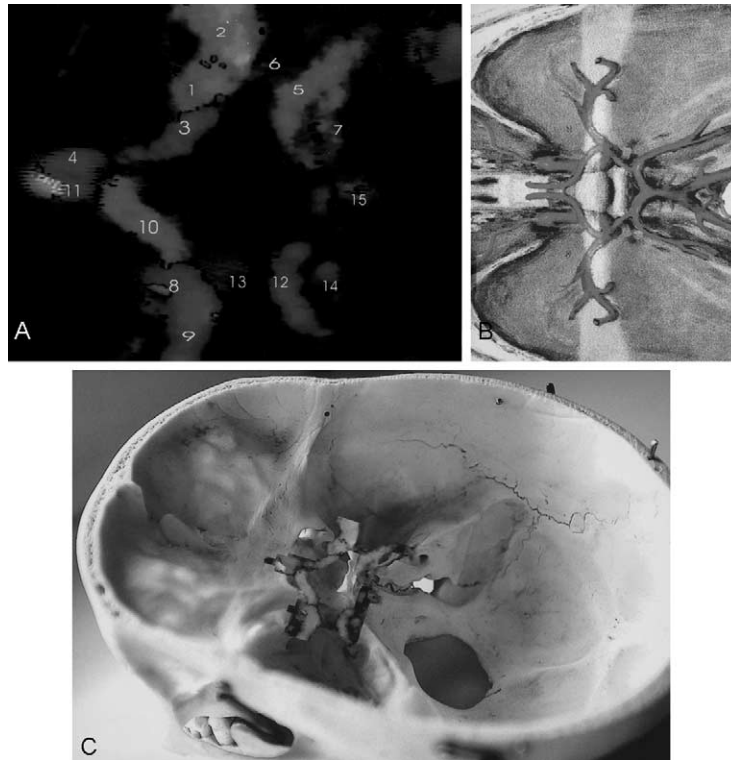
A 50-year-old woman was admitted because of therapy-resistant headache lasting several weeks and increasing insomnia. At cCT (Fig. 2A) and MRI (Figs. 2B and C), a large, inhomogeneous, strongly contrast-enhancing, space-occupying, left frontal lesion in contact with the Sylvian fissure, and pronounced perifocal oedema were found. The physical examination was normal. Transcranial duplex sonography via the left temporal sound window revealed substantial dorsal displacement of the left middle cerebral artery (MCA) and displacement of the left anterior cerebral artery (ACA) to the right beyond the midline (Fig. 2D). Several branches of the peripheral branch of the left MCA were shown to supply the tumour area (Fig. 2D). Arterial Doppler sound was detected in these branches.

Insonation via the right temporal sound window showed normal positioning of the right MCA and displacement of the right and left ACA over the midline to the right (Fig. 2E). Intraoperative and histological findings confirmed the diagnosis of a glioblastoma. Dissection showed that the tumour was supplied by the branches of the left MCA. Macroscopically, complete excision was possible. The patient was transferred for postoperative irradiation without neurological deficits.

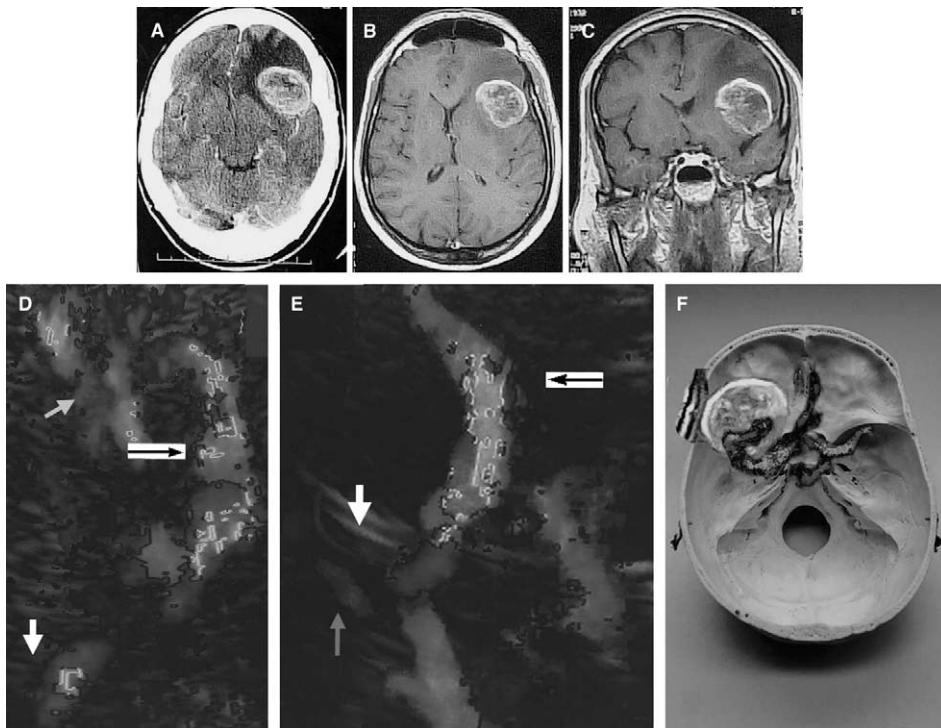
### Case 2

A 69-year-old woman was admitted as an emergency case to the department of cardiology because of syncope. She also had dizziness and visual hallucinations. A large (6 × 4 cm) meningioma at the wing of the right sphenoid bone was noticed at cCT, close to the cranium with displacement of the midline by 1.5 cm. This was confirmed at MRI (Fig. 3A and B). Transcranial duplex sonography was performed before surgery.

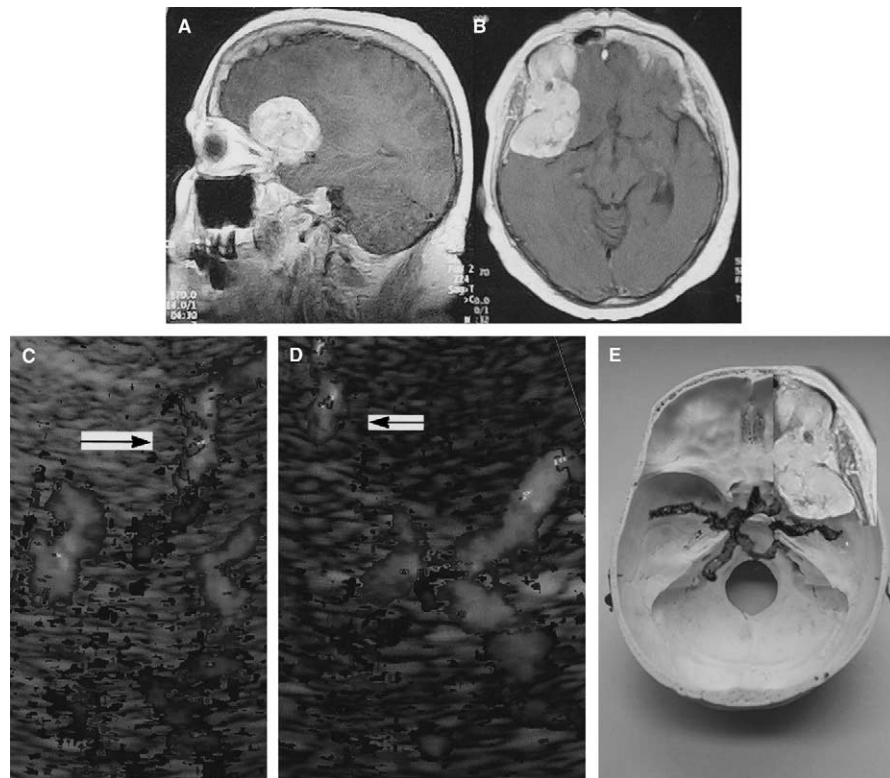
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**Fig. 1** (A) Duplex sonography of a normal circle of Willis. The Doppler signals from the retrograde (away from the duplex applicator) blood flow were colour-coded blue and those from the anterograde (to the duplex applicator) blood flow were colour-coded red. Right: 1 internal carotid artery, 2 middle cerebral artery, 3 anterior cerebral artery A1, 4 anterior cerebral artery A2, 5 posterior cerebral artery, 6 posterior communicating artery, 7 superior cerebellar artery, Left: 8 internal carotid artery, 9 middle cerebral artery, 10 anterior cerebral artery 1A, 11 anterior cerebral artery A2, 12 posterior cerebral artery, 13 posterior communicating artery, 14 superior cerebellar artery, 15 basilar artery. (B) Schematic view of the circle of Willis with demonstration of the direction of insonation. (C) Image fusion of duplex sonographic findings of a normal circle of Willis and a skull.



**Fig. 2** (A) Cerebral CT in case 1 with contrast application shows a left frontal tumor with perifocal oedema and a shift of the midline structures. (B and C) The T1-MRI-findings in case 1 demonstrate a large, inhomogeneous, strongly contrast-enhancing, space-occupying, left frontal lesion in contact with the Sylvian fissure and a pronounced perifocal oedema. (D) The transcranial duplex sonography via the left temporal sound window revealed a dorsally displaced left MCA (←) and displacement of the left ACA to the right beyond the midline (white arrow). Several branches of the peripheral branch of the left MCA were shown to supply the tumor area (yellow arrow). (E) Insonation via the right temporal sound window showed normal positioning of the right MCA (←) and displacement of the right (white arrow) and left ACA (green arrow) over the midline to the right. (F) Image fusion (duplex sonographic findings, results of MRI-study, skull) in patient 1 showing a glioblastoma in relation with the displaced MCA and ACA.



**Fig. 3** (A and B) The MRI in case 2 demonstrates a meningioma on the lateral wing of the right sphenoid bone. (C) The duplex sonography with insonation via the right temporal sound window showed a dorsolaterally displaced right MCA (→). (D) The left MCA was shown to be normal via the left temporal sound window (←). (E) Image fusion (duplex sonographic findings, results of MRI-study, skull) in patient 2 showing a meningioma at the lateral wing of the right sphenoid bone in relation with the displaced MCA.

With relatively poor ultrasound penetration because of a thick cranium, insonation via the right temporal sound window showed that the right MCA (Fig. 3C) was displaced dorsolaterally. It was briefly possible to visualise the right ACA which was displaced to the opposite side. The left MCA was shown to be normal via the left temporal sound window (Fig. 3D). No Doppler signals were measurable in the region of the tumour and no blood vessels could be detected.

At surgery, a meningioma of the wing of the sphenoid bone was found, supplied mainly by the branches of the middle meningeal artery. The tumour was completely removed and the patient was discharged without neurological deficits.

## DISCUSSION

Transcranial duplex sonography is an easy method of visualising the circle of Willis and offers a new alternative to angiography for the visualisation of intracranial space-occupying lesions. It is a dynamic, direction-coded procedure which can also provide three-dimensional images. Therefore it gives the surgeon more and better quality information on the site and blood supply of a lesion pre- and post-surgery.

Video recordings of the transcranial duplex investigation mean that the findings can easily be reviewed. They are also easily transportable for training or interdisciplinary discussions.

Other significant benefits of this system are that it is a non-invasive bedside method which can be repeated at will, and is therefore of particular value in the emergency situation. Echo-contrast enhancers are available for use in patients with thick cranial bones in whom ultrasound penetration might not be optimal.<sup>1,2,7</sup>

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