was 43.6 h (range, 14–74 h). The 3D-CTA was performed in all cases; and in 13 out of 38 patients (34%) represented the only preoperative exam. In all patients that underwent surgery with the sole 3D-CTA, the images collected allowed a good visualisation of the morphology of aneurysms and of the anatomical relationship with the vascular structures. 3D-CTA allows accurate diagnosis with an excellent visualisation of ruptured aneurysms of the anterior circulation. Our results suggest that, in selected cases, ruptured anterior circulation aneurysms could be successfully treated on the basis of 3D-CTA alone.

Key words
Ruptured anterior circulation aneurysm • Early surgery • 3D-CT angiography

Introduction

Subarachnoid haemorrhage (SAH) secondary to ruptured intracranial aneurysms is a critical clinical situation with significant rates of mortality and morbidity. The mortality is 20%–25% within the first few days and the morbidity is due not only to the initial bleeding but also to a number of secondary complications including rebleeding and vasospasm that cause severe neurological deficits. The goal of early surgery is to reduce this risk and to improve medical treatment [1, 2].

Digital subtraction angiography (DSA) is widely regarded as the gold standard in the diagnostic modalities available for intracranial aneurysm detection. On the other hand DSA is invasive and time consuming and requires a high level of expertise.

It has been demonstrated that 3-dimensional computed tomographic angiography (3D-CTA) can reliably detect intracranial aneurysms [3].

The advantages of CTA compared with DSA are as follows: it is noninvasive and requires only venous access and
In centres a SAH patient is studied both with CTA and DSA; in this setting, early surgery is difficult to achieve. In addition, the risk of complications or morbidity and the time invested to perform both CTA and DSA become additive. The clinical implications of CTA cannot be evaluated appropriately until a prospective protocol is adopted, in which CTA replaces DSA in clinical practice.

The aim of this prospective study was to address the question if 3D-CTA is able to replace DSA as the “gold standard” for pretreatment planning and to evaluate whether clipping of ruptured aneurysms of the anterior circulation can be based on 3D-CTA alone.

**Clinical materials and methods**

From May 2005 to May 2007 our Hospital adopted a prospective protocol in evaluating the possibility of CTA replacing DSA as the only diagnostic pretreatment planning study in SAH patients that were candidates for early surgery. Inclusion criteria were patients presenting with SAH from an anterior circulation aneurysm confirmed by a non-contrast cerebral computed tomographic scan or by cerebrospinal fluid findings from a lumbar puncture; exclusion criteria were patients who had undergone prior DSA, or were suffering from severe contrast medium allergy or severe renal failure. Patients with ruptured aneurysm in the posterior circulation, patients without cerebrovascular lesion recognisable at CTA or candidates for endovascular management were also excluded.

Each CTA study generated by 3D reconstruction was reviewed by an expert neuroradiologist and two senior neurosurgeons. When the aneurysm was correlated to the SAH localisation and no further information regarding the aneurysm’s anatomy for planning the surgical procedure was needed, the patient underwent microsurgical treatment without additional DSA.

All patients clipping of the neck of aneurysms was planned and performed through a pterional approach and standard microsurgical techniques [6].

**CTA technique**

A multislice helical CT scanner with eight detector rows (GE Lightspeed QX/i; GE Medical Systems, Milwaukee, WI) was used for CTA. The raw images were acquired with the following parameters: slice thickness, 1.25 mm; 120 kV; 230 mA; field of view, 23 cm; table speed, 3.75 mm/s; rotation speed, 0.8 s. A total volume of 100 ml of contrast medium (Ultravist 300; Schering Pharmaceuticals, Berlin, Germany) was injected into the cubital vein with an automated injector, at an injection speed of 3.5 ml/s. Contrast medium injection began 18 s before image acquisition for patients younger than 60 years of age and 20 s before acquisition for patients older than 60 years of age. The imaged region included from the C1 vertebral to the roof of the lateral ventricles. Thick slab reformatted images in the axial, coronal and sagittal planes were reconstructed using a GE Advantage Windows workstation to produce two-dimensional, multi-projection volume reconstructions and three-dimensional, surface-shaded images. Once an aneurysm was detected, the aneurysm size was measured. Manipulation of the reconstructed images was performed by the scanner neuroradiologist together with a senior neurosurgeon to provide editing assistance.

**Results**

A total of 38 SAH patients were considered for the prospective CTA protocol during the 2-year period. The male–female ratio was 11:27; the mean age was 52.4 years ranging from 41 to 72 years. Based on the inclusion exclusion criteria of the study, only 13 patients (34%) had their anterior circulation aneurysms secured by early surgical clipping with CTA as the only preoperative diagnostic investigation. Therefore, 25 (66%) patients underwent DSA in order to obtain a more detailed evaluation of the aneurysm; they underwent more delayed surgical clipping or endovascular occlusion, and are not considered in our results.

CTA was able to detect the ruptured aneurysm, based on the shape and site of haemorrhage, in all 13 cases: 3 anterior communicating aneurysms (A-coA) (3/13, 23%), 7 middle cerebral artery (MCA) aneurysms (7/13, 54%), 2 posterior communicating aneurysms (2/13, 15%) and one supraclinoid (1/13, 8%). One patient of our series (7%) was having multiple aneurysms, and only one was suitable for surgical clipping. The aneurysm size ranged from 2.5 to 12.5 mm (mean 4.3 mm).

Preoperative Hunt and Hess grade was: HH-I 1 patient (7%), HH-II in 3 patients (23%), HH-III in 6 patients (46%) and HH-IV in 3 (23%).

All 13 patients were operated on, 10 of them by simple clipping and 3 of them with a combined surgical approach including partial lobe hemispherectomy or wrapping.

The mean time between early surgery and SAH onset was 43.6 h (range, 14–74 h). The patient treated by 14 h was a 66-year-old man, HH-IV, Fisher grade 4, with a small (3 mm) MCA aneurysm detected at CTA 2 h post-SAH. The aneurysmal analysis at 3D-CTA indicated favourable findings for treatment. The operating time was long (5 h), due to the presence of extensive SAH with haematoma, requiring partial removal of the right temporal polar lobe (Fig. 1). In one patient 3D-CTA showed a very small aneurysm arising from the A-coA, without visualisation of the left A1. In this case, due to the very short and wide neck, the aneurysm was wrapped instead of clipped (Fig. 2). In a third case a left MCA saccular aneurysm originating at the vessel bifurcation was successfully clipped. Close by the saccular one another M2 fusiform aneurysm was wrapped with muscle in the same surgical session (Fig. 3).