



Diagnostic approach to cerebral aneurysms



Vitor Mendes Pereira^a, Philippe Bijlenga^b, Ana Marcos^a, Karl Schaller^b,
Karl-Olof Lovblad^{a,*}

^a Division of Diagnostic and Interventional Neuroradiology, Geneva University Hospitals, Switzerland

^b Department of Neurosurgery, Geneva University Hospitals, Switzerland

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ABSTRACT

Cerebral aneurysms are an important cause of morbidity and mortality due to their causal effect in non-traumatic subarachnoid hemorrhage. Neurosurgical progress in the 20th century helped to improve patient outcomes greatly. In recent years, techniques such as intravascular treatment by coiling and/or stenting have found an additional place in the management of the disease. With the development of less and less invasive surgical and endovascular techniques, there has also been a continuous development in imaging techniques that have led to our current situation where we dispose of CT and MR techniques that can help improve treatment planning greatly. CT is able to detect and together with its adjunct techniques CT angiography and CT perfusion, it can allow us to provide the physicians in charge with a detailed image of the aneurysm, the feeding vessels as well as the status of blood flow to the brain. Angiography has evolved by becoming the standard tool for guidance during decision making for whatever therapy is being envisioned be it endovascular procedures and or surgery and has even progressed more recently due to the development of so-called flat panel technology that now allows to acquire CT-like images during and directly after an intervention. Thus nowadays, the diagnostic and interventional techniques and procedures have become so much entwined as to be considered a whole.

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1. Introduction

Subarachnoid hemorrhage (SAH) is a well-known cause of high mortality and morbidity. As a clinical entity SAH is considered to be one of the many possible types of stroke or cerebrovascular diseases. Until recent advances in interventional neuroradiology, a strict neurosurgical approach with operation, and mainly clipping was the accepted approach [1]. Initially the approach to aneurysms was cautious due to its high mortality, but after having known great strides in the improvement of surgical techniques, it was established that early operation will prevent re-bleeding, and thus aneurysm treatment has become an emergency situation [2]. While surgery is the approach which has historically defined the management since one could evacuate blood and exclude the aneurysm by clipping, progress in interventional neuroradiology with the development of coiling and stenting techniques have provided us with more choices for treatment. In most centers, there is a tendency for the management of aneurysms to become a multidisciplinary effort that will involve many specialists from the field of clinical

neuroscience beside neurosurgeons such as neuroradiologists (both diagnostic and interventional), neuroanesthesiologists, neurointensivists and even neurologists. While the initial bleed will have an important devastating effect with between 10 and 20% dying initially, the remainder of the patients can benefit from surgery or interventional neuroradiology, which will obliterate the aneurysm and evacuate blood.

Globally, it can be considered that 90% of aneurysms are located on the anterior circulation and 10% in the posterior cerebral circulation. Originally a diagnosis of an aneurysm could be made clinically upon rupture due to the typical signs of thunderclap headache accompanied by neck stiffness and neurological signs, all of which would be confirmed with a lumbar puncture; in a few select cases the aneurysm would cause deficits by pressing on a cranial nerve directly (mostly in cases of giant aneurysms).

The initial examination of choice for aneurysms in the acute stage is at the moment clearly still computed tomography (CT). Indeed, its capacity to clearly define newly extravasated blood is still unchallenged by magnetic resonance imaging. Over the last decade, additional CT-based methods such as CT angiography (CTA) and CT perfusion have evolved enough so that they can provide results that can be reliably used in the clinical setting. The referral for a suspicion of cerebral aneurysm can be extremely varied because while many patients arrive acutely with signs of acute headache and deterioration, some will arrive with an “incidental”

* Corresponding author at: Service Neurodiagnostique et Neuro-interventionnel DISIM, Hôpitaux Universitaires de Genève, 4 rue Gabrielle-Perret-Gentil, 1211 Geneva, Switzerland. Tel.: +41 22 372 70 33; fax: +41 22 372 70 72.

E-mail address: Karl-olof.lovblad@hcuge.ch (K.-O. Lovblad).

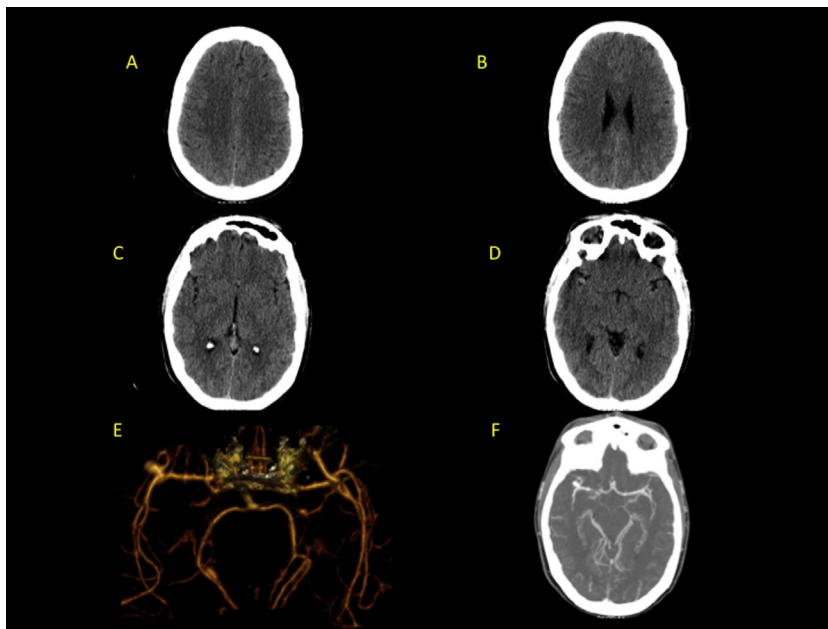


Fig. 1. Patient with typical “warning leak”. He presented with headaches, went to CT which failed to show any clear SAH. However there was a suspicious dilatation of the right MCA (D). On angio-CT an aneurysm was demonstrated (E)–(F).

discovery of an aneurysm having usually occurred during imaging (CT or MRI) for headache or something completely different at times. Also, one population that is very important to identify is that of patients who will have suffered a so-called warning leak: these hemorrhages are known to have occurred in between 20 and 35% of patients [3,4]; if correctly identified, the patients could benefit from CT and CTA in order to identify a not yet completely ruptured aneurysm that could be treated quickly (Fig. 1). The aim of this paper is to discuss the state-of-the-art diagnostic workup irrespective of the treatment modality chosen.

1.1. Computed tomography

Blood at least in the early stage is seen as a hyperdensity (i.e. a structure more “white” than the adjacent brain parenchyma) and is very easily detected with CT. The most common case of SAH is traumatic (85%), but most cases of non-traumatic SAH are due to aneurysms. In the situation of traumatic SAH very often, a trauma is known, but in some cases it must be suspected if the blood is located in locations less typical for aneurysms (e.g. subarachnoid blood on the convexity of the brain) or if radiologically there are evident signs of an external traumatic event. CT is also the preferred method for imaging whenever a trauma to the head is known or suspected. However in 15–20% of cases of non traumatic SAH there is no aneurysm to be found and 2/3 of these cases are due to peri-mesencephalic SAH. Peri-mesencephalic SAH, which is characterized by the presence of blood in the basal cisterns in front of the mesencephalon mainly is usually not of aneurysmatic origin and has a good prognosis (Fig. 2). Cerebral angiography after the initial clinical event was the technique that would allow to demonstrate or exclude a cause of the symptoms. All of this was drastically changed when computed tomography (CT) appeared in the early 70’s and one could see the contents of the skull and its different structures; one was thus able to directly visualize the subarachnoid blood. Initially, even with CT displaying blood, angiography was necessary until only just a decade ago; indeed, CT has evolved enormously since its development: it is no longer simply used as a tool to rule out hemorrhage, but can in itself be used for very advanced imaging and pre-therapeutic purposes.

Blood accumulation on the scanner is graded according to the Fisher classification [5] with a grade 1 being no blood visible and a grade 4 with diffuse or no subarachnoid blood but intraventricular or intraparenchymal clot (Figs. 3–5).

Very rarely a calcified aneurysm can be seen on the conventional X-ray image (Fig. 6) as a calcified crescent: this is nowadays much better seen on the CT and CTA images.

In a study using multi-slice CTA, Wintermark et al. found a sensitivity of 94.8%; this study was done in the early stages of multi-slice imaging: i.e. with scanners with 8 and 16 detector rows; with subsequent actual advances the number of rows allowing simultaneous acquisition has increased even more [6,7]. CTA was also found to be sufficient to exclude aneurysms in patients with subarachnoid hemorrhage in cases with patterns of peri-mesencephalic SAH with a sensitivity of 96.4%. It still remains important to go through and look at all axial slices (Fig. 7), before using the reconstructions. While reconstructions using more sophisticated software packages will often enhance the anatomic detail (Figs. 8–13), very often simple maximum intensity projection (MIP) type reconstructions will be very useful in a first evaluation.

CTA is even believed to be able to exclude SAH with more than 99% in a recent publication [8].

Perfusion CT: even though CT perfusion techniques had been around for quite some time [9], they were also only implemented clinically recently due to advances in multi-slice techniques. Xenon CT had initially been done but this technique had not found a vast acceptance [9]. CT perfusion protocols have been used with great success in the diagnosis and management of acute stroke. In the case of patients with aneurysms, it has been restricted mostly to the study of vasospasm or more rarely ischemia that may occur after vessel occlusion (Fig. 13). Vasospasm, which usually occurs during the two weeks after SAH, if severe enough may cause ischemia and the so-called delayed neurological deficits that may even cause significant morbidity progress to death. Sanelli et al. found the use of CBF and MTT to bring the most useful information [10].

When using all these CT techniques together, conventional CT, CTA and CTP the idea is to maximally orient the clinician by demonstrating, hemorrhage, eventual tissular damage as well as prepare for intervention by providing maximum resolution imaging in 3 D

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