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Round table: Giant intracranial aneurysms

Imaging of giant cerebral aneurysms

Imagerie des anévrysmes cérébraux géants

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ABSTRACT

The aim of this study was to review the different imaging techniques for analysing giant intracranial aneurysms (digital subtraction angiography [DSA], magnetic resonance imaging [MRI], computed tomography [CT]) imaging and explain their respective contribution to the understanding of the characteristics of these complex aneurysms. Giant aneurysms have a complex pathology with multiple stages of evolution and consequences. Therefore, complex imaging is mandatory to enhance the understanding of these parameters and to plan an often complicated treatment strategy. DSA remains the gold standard for analysing aneurysms, but non-invasive sectional imaging (CT, MRI) also provides essential information in the specific case of giant aneurysms.

Mots clés :
Angiographie numérisée
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RÉSUMÉ

L'objectif de cet article est de faire le point sur les différentes techniques d'imagerie utilisées pour l'étude des anévrysmes géants : angiographie digitalisée, imagerie par résonance magnétique, scanner; et, d'expliquer leur contribution respective dans la compréhension et l'exploration des caractéristiques spécifiques de ces formations anévrysmales complexes. Les anévrysmes géants sont des malformations complexes présentant de multiples types d'évolution et de complications. Un bilan d'imagerie complet est obligatoire afin de mieux évaluer toutes les caractéristiques de la malformation et permettre de planifier la stratégie d'une thérapeutique souvent complexe. Si l'angiographie numérisée reste l'examen diagnostique de référence, les examens non invasifs tels que tomodensitométrie crânio-encéphalique et imagerie en résonance magnétique procurent aussi des informations essentielles dans le cas particulier de ces malformations anévrysmales géantes.

1. Introduction

In the last two decades, major improvements in non-invasive (without injection), or minimally invasive (with intravenous injection), angiographic techniques have changed modalities in imaging aneurysms. Digital subtraction angiography (DSA) remains the gold standard [1], despite being an invasive technique with intra-arterial injection after supra-aortic catheterisation. However, computed tomography angiography (CTA) and magnetic resonance angiography (MRA) have made vascular intracranial examination both easier and more widespread.

A recent review [2] compared the spatial resolution of current imaging techniques (0.6–1 mm for MRA, 0.4–0.7 mm for CTA, 0.2 mm for DSA and, 0.15 mm for 3D rotational angiography) and assessed their important role in imaging aneurysms. Depicting a small size aneurysm is not the primary concern in imaging giant aneurysms, however 3D reconstruction, which requires good spatial resolution, may be useful with these different imaging modalities.

Giant aneurysms have specific morphological and physiological characteristics requiring further exploration than vascular examination alone. The thrombosed portion, mass effect, inflammatory wall and, hypoperfusion of the downstream parenchyma necessitate exploration by computed tomography (CT) and

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magnetic resonance imaging (MRI) as would any tissular brain lesion [1].

The aim of this chapter was to present the different available techniques and emphasize their essential role in understanding giant aneurysms, in order to ensure optimum patient management.

Many references from the literature, quoted in this section, refer to giant serpentine aneurysms, however the techniques can be extended to any type of giant aneurysm (saccular, fusiform or serpentine).

2. What needs to be analyzed?

The giant aneurysm and its subsequent consequences, which occur on the surrounding brain structure such as parenchymal, parent and distal arteries, perforating arteries should be analysed.

2.1. The aneurysm

A giant aneurysm is still an aneurysm and is defined as localized, pathological, blood-filled dilatation of a blood vessel caused by a disease or weakening of the vessel's wall. Therefore, it is essential to understand the circulating portion, comprising neck, depth and diameter, as well as the related arteries, which is made up of the parent artery and efferent arteries.

When it contains a thrombosed part, this must also be analysed for size and inflammation within the wall, using peripheral enhancement.

2.2. Consequences on surrounding brain structure

These aneurysms tend to manifest with a mass effect or embolic episodes. Thus, the aneurysm may be located in a bone canal, such as the petrous segment of the internal carotid artery, requiring exploration of the skull base. Alternatively, the aneurysm may be located on branches of the circle of Willis, requiring exploration of the brain parenchyma, meningeal structures, cranial nerves and ventricular system. This is especially the case for giant aneurysms of the posterior fossa, which can compress the fourth ventricle.

When containing a thrombosed portion, some clots may migrate, occlude arterial branches and cause ischaemia. The size of the brain infarction varies depending on the size of the branch: from punctate lesions, when micro thrombi occlude very distal branches, to a major stroke, when an arterial trunk is occluded. This is usually tolerated in giant serpentine aneurysms where slow flow induces collateral development [2–4]. Similar to other aneurysms, giant aneurysms may bleed and be responsible for subarachnoid hemorrhage and/or intra-parenchymal haematoma. Usually the onset of acute symptoms leads to an emergency diagnosis.

3. Which examinations are used?

Different well-known imaging techniques (X-ray, MRI) are performed in order to diagnose and analyse aneurysms, mainly digital subtraction angiography (DSA), CT and MRI. The aim of this section was to describe the different patterns of giant aneurysms for each examination modality.

3.1. Digital subtraction angiography

The common carotid, internal carotid and verterbral arteries, were selectively catheterised through arterial access (primarily femoral) using the Seldinger technique. Then, intra-arterial injection of an iodine contrast agent (ICA) was administered while cranial radiographs were taken at regular time intervals (usually two per second for intra-cranial aneurysms). DSA remains the gold standard for imaging aneurysms since spatial and time resolutions are excellent. As a result, we were able to obtain precise images of circulating vessels and important dynamic information. However, DSA does not explore non-circulating elements, i.e. the thrombosed section, the wall and the surrounding brain parenchyma.

To assess the size and morphology of the circulating portion, we used plain 2D radiographs and 3D rotational angiography, which is not always useful in the case of major flow disturbances within a large circulating portion. Fanning et al. [5] described sinusoidal angiographic appearance as the Pretzel sign in serpentine aneurysms (Fig. 1b).

To understand the quality of vascularisation of the aneurysm, we used 2D angiographic series searching for:

- dynamic study of the filling of arteries located after the aneurysm;
- presence of collateral arterial network in distal territory.

Therefore, it is important to selectively catheterise the common carotid and vertebral arteries one after the other, and sometimes also to catheterise internal and external carotid arteries. In cases of very slow flow within the aneurysm, recruitment of pial collaterals from nearby distal cerebral arteries is possible, as well as the development of trans-dural anastomosis between meningeal arteries and distal pial branches (Fig. 2f). Balloon test occlusion (BTO) of the parent artery may also be performed, entailing occlusion of the parent artery of the aneurysm while injecting the other axis, to evaluate the efficient collaterals and confirm if the parent artery is occluded. A BTO is considered positive when collateral arteries vascularise the occluded territory with less than one second delay on the venous phase, compared to the side of the injected artery.

3.2. CT scan

3.2.1. Non-enhanced CT (NECT) scans

The first examination for any neurological symptom is most often a NECT scan of the brain. It is of paramount importance to be able to differentiate between a vascular and non-vascular lesion, especially when presenting with mass effect, due to surrounding oedema (hypodensity), which may lead to a misdiagnosis of the neoplasm ([6–9]). The giant intracranial aneurysm is a well-circumscribed lesion with heterogeneous density:

- high density for the acute thrombosed section;
- lower density for the circulating channel;
- low density for the chronic thrombosed section.

There may also be a peripheral rim of calcification (high density), indicating the chronic nature of the lesion [1,6,8]. A NECT scan can also be used to evaluate the degree of mass effect (midline shift, loss of cortical sulcus and basal cisterna) and the presence of acute hydrocephalus (enlargement of ventricles, transependymal resorption), which can both lead to severe intracranial hypertension requiring emergency treatment (Fig. 3a, b). Bone filter reconstruction, enables analysis of skull base deformation, which occurs primarily in giant carotid aneurysms.

In emergency cases, a ruptured aneurysm can be diagnosed with hyperdensity related to blood collection either in the subarachnoid space (subarachnoid haemorrhage) or within the brain parenchyma (intra-cerebral haematoma).

3.2.2. Post contrast CT (PCCT) scan

The PCCT scan is a brain scan performed a few minutes after injection of ICA, which infiltrates the brain parenchymal structures,

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