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Round table: Giant intracranial aneurysms

Giant and complex aneurysms treatment with preservation of flow via bypass technique

Traitement des anévrismes géants et complexes avec préservation du flux par technique de pontage

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ABSTRACT

Due to their anatomical characteristics and the complexity of the procedures required to obtain their complete occlusion, the treatment of giant intracranial aneurysms is a real challenge. Direct reconstructive strategies, whether by interventional neuroradiology (coils, stents) or microsurgical (clipping) means, are not always applicable and, in patients that would not tolerate parent or collateral artery sacrifice, the adjunction of a revascularization procedure using a bypass technique might be necessary. Cerebral arterial bypasses can be classified according to their function (3 types: flow replacement, flow reversal or protective), the branching mode of the graft used (3 types: pedicled, interpositional or in situ), the sites of anastomosis (2 types: extracranial-intracranial or intracranial-intracranial) and the class of flow they are supposed to provide (3 types: low-, intermediate- or high-flow). In this article, the authors review the different aspects in the management of patients with a giant intracranial aneurysm using a bypass: preoperative work-up, types of bypass and indications, surgical techniques and results.

Abbreviations: A1A2, subsequent segments of the anterior cerebral artery; ACA, anterior cerebral artery; AcomA, anterior communicating artery; BA, basilar artery; BTO, balloon test occlusion; CCA, common carotid artery; CE-TCD, contrast-enhanced transcranial Doppler; CSF, cerebro-spinal fluid; CTA, computerized tomography angiography; DSA, digital subtraction angiography; ECA, external carotid artery; EC-IC, extracranial-intracranial; EEG, electroencephalogram; ELANA, Excimer laser-assisted nonocclusive anastomosis; GIA, giant intracranial aneurysm; GOS, Glasgow outcome scale; HFB, high-flow bypass; ICA, internal carotid artery; IC-IC, intracranial-intracranial; IFB, intermediate-flow bypass; LFB, low-flow bypass; M1, M2, M3, M4, subsequent segments of the middle cerebral artery; MCA, middle cerebral artery; MEP, SEP, motor and somatosensory-evoked potentials; MRA, magnetic resonance angiography; MRI:, magnetic resonance imaging; OA, occipital artery; P1, initial segment of the posterior cerebral artery; PCA, posterior cerebral artery; PcomA, posterior communicating artery; PET, positron emission tomography; PICA, posterior-inferior cerebellar artery; STA, superficial temporal artery; VA, vertebral artery.

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RÉSUMÉ

En raison de leurs caractéristiques anatomiques et de la complexité des procédures requises pour obtenir leur occlusion complète, le traitement des anévrismes géants intracrâniens est un réel défi. Les stratégies de reconstruction directe, par des moyens endovasculaires (*coils*, stents) ou microchirurgicaux (clippage), ne sont pas toujours applicables et, chez les patients, ne pouvant tolérer le sacrifice de l'artère porteuse ou de ses collatérales, l'adjonction d'une procédure de revascularisation utilisant une technique de pontage peut s'avérer nécessaire. Les pontages artériels cérébraux peuvent être classifiés selon leur fonction (3 types : remplacement de flux, réversion de flux ou de protection), le mode de branchement du greffon utilisé (3 types : pédiculé, interposé ou in situ), les sites d'anastomoses (2 types : extracrânien-intracrânien ou intracrânien-intracrânien) et enfin la classe de débit qu'ils sont supposés fournir (3 types : bas débit, débit intermédiaire ou haut débit). Dans cet article, les auteurs font la revue des différents aspects de la prise en charge avec l'aide d'un pontage des patients porteurs d'anévrismes géants intracrâniens : bilan préopératoire, types de pontages et indications, technique chirurgicales et résultats.

1. Introduction

Because of their anatomical characteristics and of the complexity of the procedures required to obtain their complete occlusion, the treatment of a giant intracranial aneurysm (GIA) is a real challenge either for interventional neuroradiologists or neurosurgeons, with respective morbi-mortality rates oscillating around 15–25% for anterior circulation aneurysms and 40–75% for posterior circulation aneurysms [1–6]. Nevertheless, treatment difficulties and risks are largely counterbalanced by the dismal clinical course of the disease after the onset of symptoms since cumulated 5-years follow-up morbi-mortality can reach 80% as a result of hemorrhage, ischemia (embolic events or perforator thrombosis) or mass effect [7,8]. This is explained to a great extent by a very high risk of spontaneous rupture at 5-year follow-up as shown in the results of the ISUIA trial [2]: 6.4%, 40% and 50%, respectively for intracavernous internal carotid artery (ICA), anterior circulation and posterior circulation aneurysms. Direct reconstructive strategies, whether by interventional neuroradiology (coiling, stenting) or microsurgical (clipping) means, are not always applicable and in patients that would not tolerate parent artery sacrifice, usually documented after balloon test occlusion, the adjunction of a revascularization procedure using a bypass technique might be necessary in order to minimize the risk of postoperative cerebral ischemia [9]. Furthermore, bypass procedures can render unclippable aneurysms clippable by supplying blood flow to collateral arterial branches that could not otherwise be preserved.

The first attempts of bypasses from extracranial to intracranial arteries, namely from the common carotid artery (CCA) to the intracranial ICA or the middle cerebral artery (MCA), were described by Woringer and Kunlin [10] and Lougheed et al. [11] respectively in 1963 and then in 1971. In 1969, Yasargil described the first superficial temporal artery (STA) to MCA intracranial-intracranial (EC-IC) bypass for the treatment of a complex aneurysm that required the ligation of the MCA [12]. Since then and until recently, several authors have described their results in the management of GIA with the use of such techniques [5,9,13–23]. In an effort to reduce the risk of postoperative ischemia due to the temporary cross-clamping of the recipient intracranial artery, nonocclusive anastomosis techniques have also been added to the treatment armamentarium (i.e.: ELANA technique) [24–28].

In this article, the authors review the different aspects in the management of patients with a GIA for whom a bypass has already been selected as the treatment option: preoperative work-up, types of bypass and indications, surgical techniques and results.

2. Preoperative radiological work-up

2.1. Computerized tomography angiography (CTA)

CTA is useful to understand the 3D architecture of the Willis polygon and particularly the collateral pathways to the distal vascular bed of a parent artery carrying an aneurysm: posterior communicating artery (PcomA) and anterior communicating artery (AcomA). CTA also provides useful details about the aneurysm content (circulating and thrombosed portions) and should always be used to detect calcifications, which are the indicator of a thick and rigid wall, often atheromatous, that will preclude direct aneurysm reconstruction by clipping, even after aneurysm deflation by proximal clamping, puncture or endoaneurysmorraphy (Fig. 1). CTA is also interesting to understand the relationship of the aneurysm with the bony structures at the skull base: anterior and posterior clinoid processes, optic strut and cavernous sinus, jugular foramen and posterior aspect of the petrous bone.

2.2. Magnetic resonance imaging (MRI)

MRI and magnetic resonance angiography (MRA) are the most accurate means to analyze the aneurysmal structure and content, although they are not able to demonstrate aneurysmal wall calcifications. The filling part of the aneurysm will be shown on MRA (Fig. 1). This technique is also informative in the analysis the angioarchitecture of the Willis polygon (Fig. 1). Gradient echo sequence is used to look for previous asymptomatic perianeurysmal or intramural hemorrhage (Fig. 1). T2 or FLAIR sequence will also be useful to depict the aneurysmal wall thickness and detect the presence of an intrasaccular thrombus. In addition, MRI flow measurements can be interesting in the preoperative estimation of the flow to be replaced by the bypass (Quantitative MRI) [22].

2.3. Three-dimensional digital subtraction angiography (3D-DSA)

3D-DSA remains the gold standard for the analysis of the intraluminal angioarchitecture of the aneurysm and its collateral arteries (main trunk and branches of bifurcation). Reconstructions can be used to understand the 3D anatomy of the aneurysm by allowing multiple angles of view around the aneurysm volume (Fig. 1). This technique is also very precise to depict the relationship of the neck and sac with the surrounding perforating arteries, which is of paramount importance while considering the surgical treatment of these types of vascular lesions. To a certain extent, conventional DSA will also enable to visualize the anatomy of the