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Round table: Giant intracranial aneurysms

Intraoperative monitoring by imaging and electrophysiological techniques during giant intracranial aneurysm surgery

Contrôle peropératoire par les techniques d'imagerie et d'électrophysiologie lors de la chirurgie des anévrismes géants intracrâniens

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ABSTRACT

Difficulties in giant intracranial aneurysm surgery are the consequence of aneurysmal wall histology and the complex angioarchitecture of the vascular tree. In order to reduce complications and risks of those procedures, various imaging and electrophysiological techniques can be implemented perioperatively. The authors review the principles, goals and main results in this context of micro-Doppler and flowmeter techniques, near-infrared spectroscopy, operative microscope-integrated indocyanine green video-angiography, neuro-endoscopy, selective intraoperative angiography and electrophysiological monitoring.

Mots clés :
Anévrisme géant intracrânien
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Pontage extracrânien–intracrânien
Clippage

RÉSUMÉ

Les difficultés de la chirurgie des anévrismes géants intracrâniens résultent de l'histologie de l'anévrisme et de l'angioarchitecture complexe de l'arbre vasculaire. Afin de réduire les complications et les risques de ces procédures, diverses techniques d'imagerie et d'électrophysiologie peuvent être introduites pendant l'intervention. Les auteurs présentent les principes, les objectifs et les principaux résultats dans ce contexte de l'angiographie sélective peropératoire, des techniques de micro-Doppler et de débimétrie, de la spectroscopie infrarouge, de la vidéo-angiographie au vert d'indocyanine intégrée au microscope opératoire, de la neuro-endoscopie et du monitoring électrophysiologique.

1. Introduction

Surgery for giant intracranial aneurysms (GIA) is dependent on the histology of the aneurysmal wall, which tends to be atheromatous, thick and rigid, often including calcifications and/or thrombi.

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Table 1
Interests and limits of each intraoperative monitoring technique.
Intérêts et limites de chaque technique de surveillance peropératoire.

Technique	Availability	Time efficiency	Cost efficiency	Large branch patency	Perforators patency	Aneurysm occlusion	Brain ischemia
Micro-Doppler	++	++	++	+	–	–	–
Flowmeter	++	++	+	++	–	–	–
ICG video-angiography	++	++	++	++	++	+/–	–
Neuro-endoscopy	++	+	+	+	++	+	–
Angiography	–	–	–	++	+	++	–
Electrophysiology	+	–	+	++ (indirect)	+/– (indirect)	–	++

The angioarchitecture is also highly problematic because of the volume occupied by the sac itself and the frequently large size of the neck, which often incorporates the arterial collateral branches. Compression of adjacent structures and parietal inflammation frequently create an area of adhesion with the brain surface, collateral vessels and/or neighboring perforating arteries. These histological and anatomical features are responsible for most of the complications encountered during surgery: residual aneurysm neck in up to 30% of cases, more frequently than in other aneurysmal forms [1–3], stenosis, occlusion or thrombo-embolism of collateral or neighboring arterial branches and brain ischemia [3], uncontrolled intraoperative aneurysmal wall tearing and prolonged temporary clipping, parenchymatous lesions induced by cortical retraction or dissection and resulting morbi-mortality. In this article, we review the various imaging and electrophysiological techniques that can be implemented to reduce complications and risks associated with surgery in this context.

2. Micro-Doppler and flowmeter techniques

Micro-Doppler, whether quantitative or not, is an important aid in blood-flow assessment. Its main interest is that it provides useful information on vessel patency with a minimal risk of complications. It is also easy to use, without requiring a long learning curve [4]. Drawbacks of the technique are that it does not provide any information on neck or sac residue and it is not suited for controlling flow in small-diameter arteries such as the perforating arteries [5–7]. Reported sensitivity and specificity in the evaluation of proper clip placement were respectively 98% and 98.4% [8].

Precise measurement of flow with a flowmeter is also a valuable tool to certify that brain perfusion is preserved in the main distal arteries after occluding a GIA (Fig. 1). Its use is also strongly recommended if a bypass procedure is added to the microsurgical treatment of a GIA in order to certify that the target flow is obtained in the bypass before occluding the parent artery carrying the aneurysm (Fig. 2). The risk of secondary occlusion of superficial temporal artery to middle cerebral artery bypass could also be predicted by measuring the cut flow index perioperatively. It is defined as the ratio between the final bypass flow and the primary flow obtained at the sectioned end of the donor artery ("cut flow"). An index inferior to 0.5 seems to be a strong indicator of bypass dysfunction with a high risk of secondary thrombosis (50%) [9].

3. Near-infrared spectroscopy (NIRS)

NIRS is a non-invasive monitoring technique of brain blood perfusion that uses a scalp probe that can measure tissue hemoglobin, deoxyhemoglobin, total hemoglobin, and brain tissue oxygen saturation. This technique has been applied in neurovascular or balloon test occlusion procedures [10]. Although promising, this technique is not suitable for the monitoring of GIA surgery since it only explores a very restricted (1 cm^2) and superficial (1 cm depth from the scalp) area of the cortical surface [11].

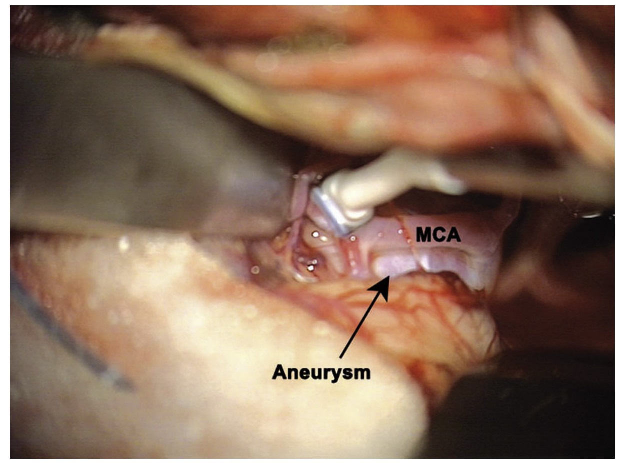

Fig. 1. Measurement of initial flow with a flowmeter in the distal branches of the left middle cerebral artery (MCA) before the occlusion of a giant proximal aneurysm (left pterional operative view).
Mesure du flux avec un débimètre dans les branches distales de l'artère cérébrale moyenne gauche (MCA) avant l'occlusion d'un anévrisme géant proximal (vue opératoire ptérionale gauche).
Flowmeter Transonic systems Inc® Ithaka, NY, USA.

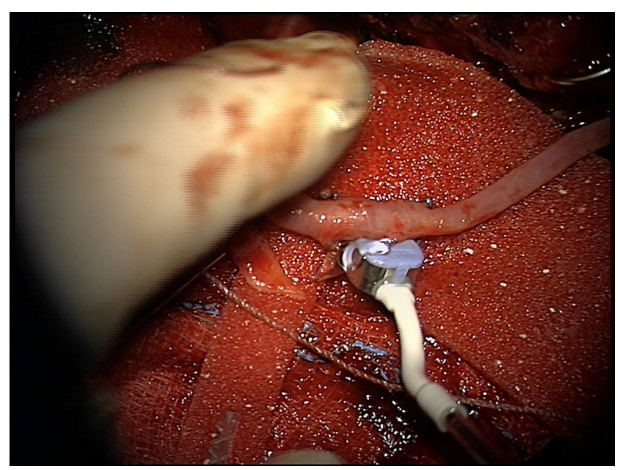

Fig. 2. Measurement of flow with a flowmeter in a saphenous vein extracranial–intracranial bypass.
Mesure du flux avec un débimètre dans un pontage extracrânien–intracrânien saphène.
Flowmeter Transonic systems Inc® Ithaka, NY, USA.

4. Microscope-integrated video-angiography

Fluorescent video-angiography is a new technique, providing simple real-time control of arterial patency and flow [12–14]. First described in 2003 by Raabe et al. [15], it requires the intravenous injection of indocyanine green (ICG) and the use of a microscope with an integrated near-infrared camera to detect the ICG molecular wavelength and convert it into a digital signal (Fig. 3).

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