Intraoperative Blood Flow Evaluation with Indocyanine Green (ICG) Videoangiography for Surgical Removal of Cerebral AVMs: A Retrospective Analysis on 25 Cases

Morgan Broggi MD; Francesco Acerbi MD, PhD; Marco Schiariti; Paolo Ferroli MD; Giovanni Broggi MD
Department of Neurosurgery, Fondazione IRCCS Istituto Neurologico C. Besta
Milano, Italy

Introduction

ICG videoangiography (ICGV) has shown to be a useful technique to evaluate the blood flow during different neurovascular and neuro-oncological procedures.

Methods

A retrospective analysis was conducted on 25 consecutive patients with cerebral AVMs operated with the aid of ICGV, from 2010 to 2012, using the Zeiss Pentero microscope with ICG technology. The ICG dosage used was 12.5 mg for each injection. Since 2011, Flow 800 software was integrated in the microscope, to semi-quantitatively evaluate the blood flow in the exposed brain parenchyma. We performed ICGV before (*primary superficial survey*) and after (*terminal assessment*) the resection of the AVM. In selected cases, ICGV was used during AVM resection, with clips on main feeders, to evaluate hemodynamic changes and guide AVM resection (*progress analysis*).
All surgical reports, intraop videos and images were reviewed to analyze the data on intraoperative ICGV (duration, type, and its utility).

Results

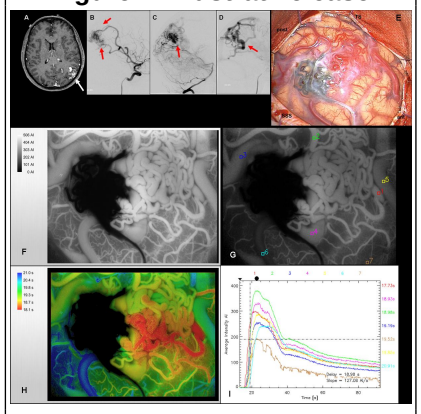
53 ICGV (32 Flow 800) during 25 procedures were performed. In 17 out of 21 cases submitted to a primary superficial survey (81%) ICGV was considered useful. ICG Flow 800 was used in 10 of these patients, allowing a simpler understanding of the AVM vessel architecture. A progress analysis was performed with ICG Flow 800 in 6 cases, allowing for a real on-time evaluation of hemodynamic effect of clipping of the main feeders. A terminal assessment was completed in 24 patients. In 21 cases, it confirmed the normalization of arterial and venous flow. In 3 cases the first terminal assessment showed a small portion of unexpected residual nidus or residual A-V, allowing for further AVM removal. DSA or CT-angio confirmed total AVM removal in all cases.

Figure 1 and 2 show an illustrative case with primary superficial survey, progress analysis and terminal assessment.

Conclusions

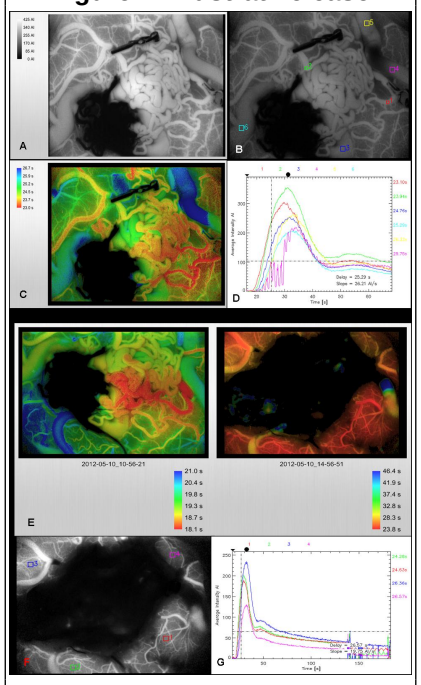
The result of our retrospective analysis confirmed the utility of ICGV during surgery for AVM.

Figure 1- Illustrative case



Pre-op MRI (A) and DSA (B-D): left parieto-occipital AVM, with feeders from MCA (B) and PCA (C), and superficial drainage (D). Intraop view (E) of the AVM with multiple feeders, partially embolized. F-I) ICGV with FLOW 800 software (primary superficial survey). Classic ICG (F) with ROIs positioning (G): in 2 feeders (MCA red; PCA green) and in 3 main drainage veins (blue, pink and yellow). H) Map of delay times delineating superficial feeders (red/yellow) and arterialized drainage veins (green). I) Evaluation of the time course of fluorescence and the time to half-maximal fluorescence in each ROI as positioned in G. This helped to distinguish the superficial feeders from the main drainage veins and from normal veins.

Figure 2- Illustrative case



A-D) ICVG with FLOW 800 software (progress analysis with clipping of the 2 main superficial feeders). A) The map of maximal fluorescence intensity did not allow a clear definition of hemodynamic changes before and after temporary clipping, but showed the absence of flow perturbation in normal peri-AVM parenchyma (see also Fig.1F). B) As Fig.1G, 2 ROIs are positioned in 2 feeders after clipping (red and green), 4 ROIs in 3 main drainage veins (blue, pale blues, pink, yellow). C) Map of delay time after clipping. D) The evaluation of the time course of fluorescence and the time to half-maximal fluorescence in each ROI (see also Fig. 1I) showed a clear modification of the hemodynamic of the AVM, with a slowing down of the flow in the venous site, particularly in the lateral-inferior vein (pink and yellow ROIs), and with an increase of the A-V difference of time to half-maximal fluorescence. E-G) ICVG with FLOW 800 software (terminal assessment). E) After removal of the AVM, the map of delay time confirmed the absence of residual nidus or A-V shunt (right side). F-G) 4 ROIs placed in the brain parenchyma near to the surgical cavity. The time course of fluorescence and time to half-maximal fluorescence were studied in these 4 ROIs, obtaining a comparable flow in the area exposed.

Learning Objectives

By the conclusion of this session, participants should be able to:
1. Recognize the importance of blood flow asessment during cerebral AVM surgery.
2. Know when and how to use ICGV for this kind of surgery.
3. Understand ICGV limitations.