Clinical Neurology and Neurosurgery 115 (2013) 870–878

Contents lists available at SciVerse ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

How reliable and accurate is indocyanine green video angiography in the evaluation of aneurysm obliteration?

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ARTICLE INFO

Article history:
Received 11 April 2012
Received in revised form 27 June 2012
Accepted 12 August 2012
Available online 7 September 2012

Keywords:
Clipping
ICG video angiography
Indocyanine green
Intracranial aneurysms

ABSTRACT

Introduction: Indocyanine green video angiography (ICG-VA) has been recently introduced into neurovascular surgery and gained a role in assessing vessel patency and obliteration of intracranial aneurysms (IA) after clipping. Although its correlation with intra-postoperative angiography was demonstrated in previous studies, difficulties in evaluating aneurysm obliteration have not been reported. We report reliability and accuracy of ICG-VA in 109 clipped aneurysms with attention given to five cases in which ICG-VA evaluation resulted in false indication that aneurysms were secure in terms of complete obliteration.
Materials and methods: A retrospective chart review was performed of IAs surgically treated by a single surgeon from January 2009. In all cases, aneurysm obliteration was confirmed by a combination of microdoppler ultrasonography (MUSG), ICG-VA, and post-operative angiography.
Results: ICG-VA appropriately assessed vessel patency and aneurysm obliteration in 93.5% of aneurysms clipped. In four cases (3.6%), puncturing the dome of the aneurysm after satisfactory clipping revealed persistent flow within the aneurysm despite ICG-VA showing no flow after clipping. In one case (0.9%), ICG-VA showed persistent flow within the aneurysm and MUSG did not, and puncture of the dome confirmed no flow within the aneurysm. In one case (0.9%), ICG-VA failed to demonstrate residual neck.
Conclusion: ICG-VA is a simple and safe procedure and an important adjunct to microsurgical clipping of aneurysm. Although ICG-VA assesses vessel patency and obliteration of aneurysms in most cases, applying the principles of microsurgery in aneurysm clipping remains a main tool for obtaining the complete obliteration of aneurysm along with preservation of the normal vasculature.

1. Introduction

Despite advances in alternative treatments such as coiling or stenting, microsurgical clipping should be considered as the definitive and durable treatment for intracranial aneurysms (IA's) [1–6]. Optimal treatment of aneurysms by clipping must be accomplished without a remnant, while preserving the parent artery and its branches. These goals can be achieved by careful microsurgical techniques and intraoperative adjuncts such as microdoppler ultrasonography (MUSG), intraoperative conventional catheter angiography, and indocyanine green videoangiography (ICG-VA). Since ICG-VA has been introduced into the neurosurgical armamentarium in 2003, it has found common usage in daily neurovascular surgery [3,7–16]. Recent studies have assessed its comparability with intraoperative angiogram and reported corresponding results in 90–98% of cases. Almost all of the studies published to date focused on ICG-VA's reliability in assessing residual aneurysm or perforating artery occlusion, with the exception of a case report by Mery et al. [5]. They reported two cases in which ICG-VA showed no filling of the aneurysm, giving the indication of complete obliteration, while puncturing the dome revealed persistent flow.

In this study, we report our experience with ICG-VA in 109 aneurysms, and we discuss in details the patients in whom ICG-VA revealed false indication that aneurysms were secure in terms of complete obliteration.

2. Materials and methods

This study was performed retrospectively in the Department of Neurological Surgery, University of Wisconsin-Madison after obtaining the approval by our Institutional Review Board.

2.1. Patient population

Between January 2009 and July 2011, 92 patients (mean age 54.2) harboring 117 aneurysms were operated on by a single

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http://dx.doi.org/10.1016/j.clineuro.2012.08.027

neurosurgeon (MKB). One hundred and two procedures were performed for clipping of 117 aneurysms in total. Two internal carotid artery (ICA) blister aneurysm cases were excluded from the study because the main treatment modality was EC–IC bypass rather than primary clipping. ICG-VA was available and performed during 96 of the 102 procedures. During six procedures, the ICG-VA mounted operating microscope was either in use at another operating room or was unavailable due to technical issues. Those six aneurysms clipped during these procedures were also excluded leaving a sum of 109 aneurysms in 86 patients (61 female, 25 male, mean age 54.9) included in the study. ICG-VA was used in every case at least two times, before and after the clipping.

2.2. Indocyanine green video angiography

The detailed technical principles of ICG-VA have been reported previously [7,17]. ICG (IC-Green; Akorn Inc., IL, USA) is a near-infrared fluorescent dye and has a plasma half-life of 3–4 min, which allows repeated visualizations every 4–5 min. There is no need for an arterial line and ICG can be injected intravenously. Briefly, after the intravenous injection of ICG dye, the field of interest is illuminated with near-infrared light which is integrated to the microscope. A real-time angiographic image with its arterial, capillary, and venous phases is seen on a video screen and recorded. Recordings can be repeated as needed. A dose of 0.2–0.5 mg/kg is recommended for ICG-VA, with a maximum daily dose limit of 5 mg/kg [3,18].

ICG-VA was performed at least two times after complete dissection of the neurovascular structures around the aneurysm and sufficient exposure of the neck and the dome of the aneurysm before and after clipping. A Leica M720-FL800 operating microscope with integrated ICG-VA technology (Leica Microsystems GmbH, Wechsler, Germany) was used in this series.

2.3. Surgical technique

All anterior circulation and basilar tip aneurysms were operated via conventional pterional craniotomy or modified orbitozygomatic (OZ) approach except the ones located in the distal anterior cerebral artery. For those, a central craniotomy with interhemispheric approach was performed. For posterior circulation aneurysms, either a conventional suboccipital craniotomy or a far lateral transcondylar approach was performed. All patients received mannitol and dexamethasone for brain relaxation and antibiotics for prophylaxis. The patients with ruptured aneurysms had CSF diversion with ventriculostomy if indicated.

MUSG and ICG-VA were used before and after clipping. Post-clipping ICG-VA was performed once satisfactory clipping was thought to be done or when it was felt to be necessary. In all cases, final obliteration of the aneurysm was confirmed with needle puncture or cutting a part of the dome. All cases were evaluated by post-operative four vessel angiography and computer tomography (CT) scan before discharge to exclude possible complications and asymptomatic structural changes such as silent strokes and contusions and to have a baseline postoperative imaging for future comparisons.

3. Results

Forty-five of the 109 aneurysms (41.2%) were ruptured. Three had Hunt & Hess grade I, 21 had grade II, 7 had grade III, 10 had grade IV, and 4 had grade V subarachnoid hemorrhage (SAH). Of the 109 aneurysms clipped, 33 were located in the origin of the ICA branches (superior hypophyseal, ophthalmic, posterior communicating, anterior choroidal arteries, and uncal artery origin) or ICA bifurcation, 37 were located in the middle cerebral artery (MCA) and branches, 35 were located in the anterior cerebral artery (ACA) territory and 4 were located in the posterior circulation branches. No anaphylaxis or side effects of ICG were observed during surgery, nor were there any dermal or allergic reactions from ICG in the post-operative period. Surgical approach had no negative or positive effect on the use of the ICG-VA, while MUSG was limited in some cases by the depth of the aneurysms and narrow spaces due to surrounding neurovascular structures.

Fig. 1. Angiograms of the patient with a large ruptured ophthalmic aneurysm. (A) Preoperative antero-posterior and lateral view angiograms. (B) First post-operative angiogram demonstrating the residual neck of the aneurysm. (C) Second post-operative angiogram showing the obliteration of the residual neck with angled fenestrated clip.

One significant neck remnant (0.9%) was found by post-operative angiogram in a patient with a ruptured 18 mm ophthalmic aneurysm (Fig. 1A and B). In this case, ICG-VA did not