



Intraoperative indocyanine green angiography in intracranial aneurysm surgery: Microsurgical clipping and revascularization

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ABSTRACT

Background: The goal of this report is to illustrate the use of intraoperative indocyanine green (ICG) angiography in the surgical management of intracranial aneurysms, including microsurgical clipping and revascularization.

Methods: This study included a series of 45 patients who were surgically treated between June 2007 and May 2008 for intracranial aneurysms. Forty-three of the patients had anterior circulation aneurysms, and 2 had posterior circulation aneurysms. Forty-one patients were treated with microsurgical clipping. Four patients underwent revascularization combined with aneurysm dissection or trapping. Intraoperative ICG angiography was used to visualize the aneurysm clipping, patency of parent artery or graft. The ICG angiography technique is described, with particular reference to evaluation of the aneurysm clipping and revascularization.

Results: Eighty-nine ICG angiography procedures were performed in 45 patients with intracranial aneurysms. The aneurysms were completely obliterated for all patients, and the grafts were patented for all except 1 patient. Pre-clipping ICG angiography showed the relationship of aneurysm and its parent artery clearly. After aneurysms being clipped, intraoperative ICG angiography found remnant of aneurysms, stenosis or occlusion of parent arteries and grafts in 8 cases, which were revised in the same surgical procedure. The results of ICG angiography correlated well with postoperative DSA in 97% patients.

Conclusion: ICG angiography can provide real-time information and guide revision in the same surgical procedure for the management of intracranial aneurysms.

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The goals of intracranial aneurysm surgery are to occlude the lesion from the brain blood circulation and maintain blood flow in parent, branching, and perforating vessels [11,17]. The majority of intracranial aneurysms can be treated by microsurgical clipping, while a small group of aneurysms may require vascular reconstruction [5,8–11,13,17]. The surgeon may be unable to confirm the surgical results with visual inspection and visual microscopic inspection. Postoperative angiography can be used to ensure the surgical results [2,4,7,9,12,18]. However, the patient may require repeat surgery if a residual aneurysm or stenotic artery exist. Although digital subtraction angiography (DSA) remains the “gold standard” in the intraoperative evaluation of aneurysms, indocyanine green (ICG) angiography technique has gained more and more credibility for evaluating in aneurysm surgery [6,14,15,19].

The goal of this project was to illustrate the use of intraoperative ICG angiography in the surgical treatment of aneurysms, including microsurgical clipping and revascularization.

1. Patients and methods

1.1. Patients

This study included 45 patients with intracranial aneurysms who underwent surgical management in Nanjing Jinling Hospital from June 2007 to May 2008. There were 16 male and 29 female patients, with ages from 22 to 73 years (mean, 52 years). The characteristics of the patients and ICG findings are detailed in Table 1.

1.2. Microscope-integrated intraoperative ICG angiography [15]

ICG is a near-infrared (NIR) fluorescent dye. The absorption and emission peaks of ICG (805 and 835 nm, respectively) lie within the “optical window” of tissue, where absorption attributable to endogenous chromophores is low. Within 1–2 s of intravenous injection, ICG is bound, primarily to globulins (α 1-lipoproteins), and remains intravascular. Operating microscope (Carl Zeiss Co. Oberkochen, Germany) integrates a narrow-spectrum laser light source and video camera capable of exciting and visualizing ICG, respectively. An attached video camera continuously records high-

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Table 1
Summary of demographics and surgical information in 45 patients with intracranial aneurysms.

Case no.	Age (year)/sex	Diagnosis	Procedure	ICG finding	Influence of ICG on surgery	Postoperative DSA
1	55/M	Left carotid-ophthalmic aneurysm	Clipping	Success clipping, patency of ICA	NA	Success clipping
2	50/F	Right SHA aneurysm	Clipping and wrapping	Success clipping, patency of ICA	NA	Success clipping
3	40/F	Left PICA aneurysm	Clipping	First ICG showed remnant aneurysm, second ICG showed success clipping	Revision	Success clipping
4	66/M	Left MCA aneurysm	Clipping	Success clipping, patency of MCA	NA	Success clipping
5	62/F	Left SHA aneurysm	Clipping	Success clipping, patency of ICA	NA	NA
6	42/F	Left A2 aneurysm, left frontal meningioma	Aneurysm dissection and vascular reconstruction	Unsuccess anastomosis	Excellent collateral perfusion	Contralateral blood supply
7	52/F	Right SHA aneurysm	Clipping	Success clipping, patency of ICA	NA	NA
8	55/F	Right MCA aneurysm	Aneurysm dissection and vascular reconstruction	Success anastomosis	NA	Thrombosis
9	38/M	Right cavernous sinus segment aneurysm	Aneurysm trapping and EC-IC bypass	Graft patency	NA	Success anastomosis
10	54/F	Right Pcom aneurysms and left SHA aneurysm	Clipping	Success clipping, patency of ICA	NA	Success clipping
11	68/F	Left Pcom aneurysm	Clipping	Success clipping, patency of ICA	NA	Success clipping
12	60/M	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
13	44/M	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
14	45/M	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
15	40/M	Left PCA aneurysm	Resection	Pre ICG show aneurysm and promaximal PCA thrombosis	Resection instead of clipping	Success clipping
16	49/M	Right SHA aneurysm	Clipping	Success clipping, patency of ICA	NA	Success clipping
17	47/F	Right carotid-ophthalmic aneurysm	Clipping	First ICG showed ICA stenosis, second ICG showed ICA patency	Revision	Success clipping
18	37/M	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
19	63/M	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
20	53/M	Right MCA bifurcation aneurysm	Clipping	Success clipping, patency of M2	NA	Success clipping
21	53/F	Right MCA bifurcation aneurysm	Clipping	Delayed pacification of aneurysm	Revision	Success clipping
22	39/F	ACA A2 aneurysm and left cavernous segment of ICA	Clipping	Success clipping, patency of A2	NA	Success clipping
23	59/M	Left MCA bifurcation aneurysm	Clipping	Success clipping, patency of M2	NA	Success clipping
24	59/F	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
25	63/F	Left Pcom aneurysm	Clipping	Success clipping, patency of Pcom	NA	Success clipping
26	62/F	Left Pcom aneurysm	Clipping	Success clipping, patency of Pcom	NA	Success clipping
27	51/M	Left MCA bifurcation aneurysm and Moyamoya	Clipping	Success clipping, but one of M2 occlusion	Revision, but helpless	Success clipping
28	37/F	Right MCA bifurcation aneurysm	Clipping	Success clipping, patency of M2	NA	Success clipping
29	49/F	Right ACA A3 aneurysm	Clipping and wrapping	Success clipping, patency of A3	NA	Success clipping
30	55/F	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
31	52/M	Right Pcom aneurysm	Clipping	Success clipping, patency of Pcom	NA	Success clipping
32	61/F	Right MCA bifurcation aneurysm	Clipping	Success clipping, patency of M2	NA	Success clipping
33	37/M	Right MCA bifurcation aneurysm	Clipping	Success clipping, patency of M2	NA	Success clipping
34	50/F	Right Pcom aneurysm	Clipping and wrapping	Success clipping, patency of Pcom	NA	Success clipping
35	65/F	Acom aneurysm	Clipping	Success clipping, patency of A1 and A2	NA	Success clipping
36	22/F	Three aneurysms on left PCA and SCA aneurysm	Clipping	Residue of SCA aneurysm	Success revision	Success clipping, patency of PCA and SCA

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