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Clinical Study

Use of indocyanine green videoangiography during intracranial aneurysm surgery reduces the incidence of postoperative ischaemic complications

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ABSTRACT

Microscope-integrated near-infrared indocyanine green videoangiography (ICGVA) has been shown to be a useful adjunct for intracranial aneurysm surgery. That the routine application of this technique reduces the risk of postoperative ischaemic complication, however, has not been reported. We present a retrospective matched-pair comparison of ICGVA guided aneurysm surgery *versus* historic control surgical cohort treated by the same author. Index patients and controls were matched for aneurysm size, location, patient demographics, risk factors, comorbidities, and surgical treatments. Ninety-one eligible patients with 100 intracranial aneurysms were treated using ICGVA assistance. There were no statistically significant differences between the two groups in terms of patient age, sex, risk factors, comorbidities and aneurysm characteristics. Of the 100 aneurysms in the ICGVA group, 107 investigations of ICGVA were performed. In 79 aneurysms (79.0%), ICGVA was considered useful but did not affect surgical management. In six patients (6.0%), ICGVA led to a crucial change of intraoperative strategies. In nine patients (9.0%), it was considered critical in assuring patency of small perforators. ICGVA was of no benefit in four patients (4.0%) and was misleading in two (2.0%). Postoperative ischaemic complications occurred in three patients (3.3%) in the ICGVA group compared with seven patients (7.7%) in the control group ($p < 0.001$). Our study supports the use of ICGVA in aneurysm surgery as a safe and effective modality of intraoperative blood flow assessment. With all limitations of a retrospective matched-pair comparison, the use of ICGVA during routine aneurysm surgery reduces the incidence of postoperative ischaemic complications.

1. Introduction

Microscope-integrated near-infrared indocyanine green videoangiography (ICGVA) is a recent innovation in vascular neurosurgery. It enables real-time intraoperative assessment of blood flow and is routinely utilised in intracranial aneurysm surgery to assess the degree of aneurysm obliteration, exclude parent vessel compromise, and evaluate patency of perforators.[1–8] The application of ICGVA is rapid and reliable, and in many instances, obviates the need for intraoperative catheter-based angiography.[8–10] Since its application to vascular neurosurgery in 2005,[9] numerous studies have demonstrated the safety and efficacy of ICGVA in aneurysm surgery.[1–10] However, to our knowledge objective assessments as to whether the use of ICGVA reduces ischaemic complications have not been adequately addressed in the literature. The purpose of this investigation was to examine whether the routine use of ICGVA during intracranial aneurysm surgery at our institution have led to a reduction in the incidence of postoperative ischaemic events as compared with the prior standard of care.

2. Methods

This study was approved by the Macquarie University Human Ethics Committee and performed in accordance with institutional Ethics Committee guidelines. The ICGVA-integrated microscope (OPMI Pentero Flow800, Carl Zeiss Surgical, Oberkochen, Germany) was available at our institution as of December 2010, and since then, we have maintained a prospective database with information regarding patient demographics, aneurysm characteristics, the number and dosages of indocyanine green (ICG) used, treatment related outcomes, and complications directly associated with the use of the ICG dye. During the study period in which ICGVA was available, all patients who underwent surgical repair of intracranial aneurysms by the senior author (M.K.M.) were eligible for review. All aneurysms were diagnosed through magnetic resonance angiography, high-resolution three-dimensional CT angiography

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(CTA), or digital subtraction angiography (DSA). Mycotic, traumatic, and dissecting aneurysms were excluded from the current study. In addition to our standard protocol for intracranial aneurysm surgery, a history of iodine allergy, pregnancy, and previous anaphylactic reactions to contrast media or dye injection was acquired either from the patients or their relatives depending on the clinical condition. Written informed consent was obtained prior to enrolling patients into the study.

Eligible patients treated with ICGVA assistance were matched with historic control patients with aneurysms of similar characteristics (size, location, and rupture status), general demographics (age, sex, risk factors, and comorbidities) and treatment related profiles (types of procedures and the use and duration of temporary occlusion). Information regarding the control aneurysms was obtained from our database of aneurysms surgically treated by the senior author (M.K.M.) between December 1995 and October 2010. Patients treated prior to 1995 were not selected as this period was considered to be a learning curve in the senior author's surgical experience with intracranial aneurysms.[11] Index patients and controls were compared for the combined primary end point related to ischaemic complication.

2.1. Outcome assessment

Clinic visits were routinely scheduled at 6 weeks and at 1 year following surgery. The modified Rankin Score of individual patients was assessed preoperatively, at 6 weeks following surgery, and at the final clinical review. A postoperative CTA or DSA within the first 6 weeks of the postoperative period or at 1 year was also performed. It is not our routine practice to perform intraoperative angiography. The postoperative CT scans were compared with preoperative images. We defined the presence of an ischaemic complication when an infarct had occurred following surgery in which a new hypodensity appeared in the area supplied by a branch artery or a perforating artery that usually arises from the parent vessel of the treated aneurysm. Non-fatal complications that did not produce a neurological deficit, as well as postoperative morbidity with causes other than aneurysm treatment were not considered. We used the risk of surgical complication per patient rather per individual aneurysm or operation.

2.2. Surgical management

All patients underwent surgery with a standard pterional or orbitozygomatic approaches, except for those with aneurysms located at the vertebral or posterior inferior cerebellar arteries, which were treated by a far lateral approach. The arterial reconstructions varied and were classified as: simple clipping; suture repair of aneurysm supplemented with clipping; surgical trapping only; or surgical trapping supplemented with bypass surgery. Intraoperative ICGVA was performed following a complete dissection of the aneurysm complex including parent vessels and immediate branches. The decision to perform ICGVA before or after clip application or both was based on the individual patient and morphological complexity of the aneurysm.

2.3. Principles of ICG VA

ICG dye is a near-infrared (NIR) fluorescent tricarbocyanine dye, which has been widely used in ophthalmology for the assessment of retinal microcirculation. The application of fluorescein sodium to evaluate brain surface microcirculation has been utilised since 1967,[12–14] although the specific use of this method to assess the macro-circulation during aneurysm surgery has only been recently

Table 1
Comparison of patient demographics and aneurysm characteristics for the historic *versus* indocyanine green videoangiography cohorts

	Control	ICGVA	*p* value
Time period	1995–2010	2010–2012	
Number of patients, n (%)	91	91	
Mean age ± SD in years (range)	54.1 ± 11.6 (25–78)	54.1 ± 12.0 (27–76)	1.0
Female	66 (72.5)	67 (73.6)	1.0
Hypertension	29 (31.9)	34 (37.4)	0.36
Smoking history	21 (23.1)	20 (22.0)	0.69
Family history of intracranial aneurysms	18 (19.8)	30 (33.0)	0.23
Previous SAH	0	8 (8.8)	NA
Previous GDC treatment	4 (4.4)	3 (3.3)	0.70
Number of aneurysms, n (%)	100	100	
Mean size ± SD (mm)	6.7 ± 5.0	6.6 ± 4.9	1.0
Small (<7 mm)	75 (75.0)	77 (77.0)	
Medium (7–12 mm)	18 (18.0)	16 (16.0)	
Large (13–24 mm)	2 (2.0)	3 (3.0)	
Giant (⩾25 mm)	5 (5.0)	4 (4.0)	
Unruptured	95 (95.0)	95 (95.0)	1.0
Anterior circulation aneurysms, n	86	86	
Cavernous segment of internal carotid artery	2	2	
Paraclinoid segment of internal carotid artery	20	20	
Posterior communicating artery	10	10	
Anterior choroidal artery	5	5	
Internal carotid artery bifurcation	5	5	
Anterior communicating artery	10	10	
Distal anterior cerebral artery	6	6	
Middle cerebral artery	28	28	
Posterior circulation aneurysms, n	14	14	
Basilar bifurcation	6	6	
Posterior cerebral artery	2	2	
Superior cerebellar artery	1	1	
Posterior inferior cerebellar artery	1	1	
Vertebral artery	4	4	

GDC = Guglielmi detachable coil, ICGVA = indocyanine green videoangiography, NA = not applicable, SAH = subarachnoid haemorrhage, SD = standard deviation.