

The Role of Intra-operative Indocyanine Green Video-angiography in Cerebrovascular Surgery

a report by

Reza Dashti,¹ Mika Niemelä² and Juha Hernesniemi³

1. Cerebrovascular Fellow; 2. Associate Professor; 3. Professor and Chairman, Department of Neurosurgery, Helsinki University Central Hospital

DOI: 10.17925/ENR.2007.00.02.11

Microscope-integrated near-infrared (NIR) indocyanine green video-angiography (ICG VA) is a new technique of blood-flow measurement that has recently been applied to neurosurgery.¹⁻⁴ This technique is safe and practical and has many potential applications in the field of cerebrovascular surgery.¹⁻⁵

Microscope-integrated Indocyanine Green Video-angiography

Microscope-integrated ICG VA technology focuses on obtaining high-resolution and high-contrast NIR images after intravenous injection of ICG dye, making it possible to assess the blood flow in the cerebral vasculature. ICG VA is integrated with a surgical microscope made by Carl Zeiss Ltd, (Oberkochen, Germany).

ICG dye is an NIR fluorescent dye that was originally used for the evaluation of vascular and hepatic function, and has since been used for ophthalmic angiography. After intravenous injection, ICG is bound almost immediately by globulins and remains intravascular until its excretion by the liver. ICG is not re-absorbed into the intestine; neither does it enter the hepatic circulation. The recommended dose of ICG VA is 0.2–0.5mg/kg with a maximum daily dose of 5mg/kg.^{1,2}

The surgical field is illuminated by a light source (NIR-light) with a wavelength covering the ICG absorption band (700–850nm). After intravenous injection of ICG dye, its fluorescence is induced and recorded by videocamera. As a result, realtime video images of arterial, capillary and venous phases of angiography can be seen.

ICG VA is a safe and practical method of realtime blood-flow measurement that can be used during microneurosurgical management of intracranial aneurysms, arteriovenous malformations (AVMs) and other vascular lesions. ICG VA has been routinely used in our centre since November 2005. The Department of Neurosurgery at Helsinki University is the only neurosurgical unit in southern Finland, serving a population of nearly two million, and admits all cerebrovascular patients regardless of age or neurological grade.

Applications of Indocyanine Green Video-angiography

The main application of ICG VA is the assessment of the quality of microneurosurgical clipping, a safe and durable method of treatment for intracranial aneurysms. The optimal microneurosurgical clipping of an intracranial aneurysm should include complete occlusion of the lesion and preservation of the blood flow in the parent, branching and perforating arteries. To assess the quality of treatment, a reliable, safe and cost-effective method of blood-flow measurement is of paramount importance.

Post-operative neck residuals carry risk of re-growth and rupture, or re-rupture, of the aneurysm.⁶⁻⁹ In post-operative angiographic series, the incidence of neck residuals ranges between 4 and 19%.¹⁰⁻¹⁴ Unexpected occlusion of major or perforating arteries after clipping is associated with a wide range of complications affecting surgical outcome and is seen in 0.3–12% of cases.^{10,12,14}

Intra-operative methods of blood-flow measurement bring the advantage of immediate replacement of the clip to achieve complete occlusion of aneurysm or enhancement of flow in compromised branches. Intra-operative angiography during microneurosurgical clipping of intracranial aneurysms is a well-known method that is suggested for routine use by many authors.^{15-19,20-24} The limitations of intra-operative angiography include difficulties of routine availability in every centre and a complication rate of 0–3.5%.^{10,19,20,25-29} Other methods of intra-operative blood-flow measurement, such as microvascular Doppler and flowmetry, also have their own limitations.³⁰⁻³⁴

The application of microscope-based ICG VA for the assessment of cerebral vessels was first described by Raabe et al. in 2003.¹ In this preliminary feasibility study, intra-operative ICG VA was performed in 14 patients, 12 with intracerebral aneurysms and two with other diagnoses. The authors reported no side effects or complications after intravenous injection of ICG dye, and reported their first neurosurgical experience with ICG VA to be promising. They have also recommended this technique as a simple and safe alternative to other methods of intra-operative assessment of cerebral vasculature.¹ In another publication by the same group,² the findings of NIR ICG VA were compared with intra- or post-operative digital subtraction angiography (DSA). ICG VA is reported to be a simple and fast method, having the advantage over



Reza Dashti is an Attending Neurosurgeon in the Department of Neurosurgery at Cerrahpasa Medical Faculty, Istanbul University. He is also a Clinical Cerebrovascular Fellow in the Department of Neurosurgery at Helsinki University Central Hospital, under the patronage of Professor Hernesniemi. Dr Dashti completed his medical studies and residency at Istanbul University.



Juha Hernesniemi is Professor of Neurosurgery and Chairman of the Department of Neurosurgery at Helsinki University Central Hospital. He has personal experience of 10,000 operations, including 3,500 cerebral aneurysms and arteriovenous malformations and more than 2,500 brain tumours. Dr Hernesniemi has been Visiting Professor at many universities and is the author of more than 150 original articles, reviews and textbook chapters.

E: juha.hernesniemi@hus.fi

DSA of providing a high-resolution image. However, restriction of images to the field of view and limited area of observation are considered among the disadvantages of ICG VA.^{2,3}

According to our experience, ICG VA is a reliable and practical method for intra-operative assessment of clipping. However, the main disadvantage of direct exposure in the visual field remains. Although painstaking dissection of the aneurysm base and related branches and perforators before clipping is our main principle during microneurosurgical clipping of aneurysms, those neck residuals located behind the aneurysm still cannot be detected by ICG-VA. Ultimately, the main factor determining the rate of neck residuals is dissection and direct

...indocyanine green video-angiography is unique in its ability to assess the blood flow in perforating arteries with high-resolution images.

observation of the part of the neck to be studied. In cases of deep-sited, giant, thick-walled and complex aneurysms, there may be a need for verification of the results by intra-operative DSA.

ICG VA is also a reliable technique for assessing the blood flow in parent artery and major branches distal to aneurysm after its complete occlusion. Based on our experience, apart from proper dissection and a clean,

bloodless surgical field, the proper timing of ICG injection is also very important. Repeated injections of ICG within short intervals may cause false-positive findings. Furthermore, filling of the arteries from proximal to distal should be undertaken carefully to avoid misdiagnosing the retrograde filling of the branches distal to aneurysm. ICG VA is not a quantitative method, and any suspicious or delayed detection of fluorescence should be verified by other techniques such as microvascular Doppler or intra-operative DSA.

Assessment of blood flow in perforating branches after microneurosurgical clipping is another important issue. Perforating arteries may be distorted or occluded during stages of approach, dissection, clipping or coagulation of the aneurysm. Intra-operative assessment of blood flow in these arteries may be very important. According to our experience, as well as that of other practitioners,⁵ ICG VA is unique in its ability to assess the blood flow in perforating arteries with high-resolution images. However, due to a lack of high-resolution post-operative imaging techniques it is not possible to assess the accuracy of ICG findings.

Conclusion

ICG VA is a simple, fast and cost-effective method of blood-flow assessment with acceptable reliability. ICG VA can provide realtime information to assess blood flow in vessels of different sizes, as well as occlusion of the aneurysm. Due to the magnification of the operating microscope and the high resolution of the image, intra-operative assessment of blood flow in the perforating branches is one of the most important advantages of the ICG VA. According to our experience, in selected cases such as giant, complex and deep-sited aneurysms, intra-operative angiography is still the gold standard. ■

1. Raabe A, Beck J, Gerlach R, et al., Near-infrared indocyanine green video angiography: A new method for intraoperative assessment of vascular flow, *Neurosurgery*, 2003;52(1):132–9.
2. Raabe A, Nakaji P, Beck J, Prospective evaluation of surgical microscope-integrated intraoperative near-infrared indocyanine green videoangiography during aneurysm surgery, *J Neurosurg*, 2005;103(6):982–9.
3. Raabe A, Beck J, Seifert V, Technique and image quality of intraoperative indocyanine green angiography during aneurysm surgery using surgical microscope integrated near-infrared video technology, *Zentralbl Neurochir*, 2005;66(1):1–6.
4. Woitzik J, Horn P, Vajkoczy P, Schmiedek P, Intraoperative control of extracranial-intracranial bypass patency by near-infrared indocyanine green videoangiography, *J Neurosurg*, 2005;102(4):692–8.
5. de Oliveira M, Beck J, Seifert V, et al., Assessment of blood in perforating arteries during intraoperative near-infrared indocyanine green videoangiography, *Neurosurgery*, 2007;61:ONS-63-ONS-73.
6. David C, Vishteh A, Spetzler R, Late angiographic follow-up review of surgically treated aneurysms, *J Neurosurg*, 1999;91(3):396–401.
7. Fogelholm R, Hernesniemi J, Vapalahti M, Impact of early surgery on outcome after aneurysmal subarachnoid hemorrhage. A population-based study, *Stroke*, 1993;24(11):1649–54.
8. Hernesniemi J, Vapalahti M, Niskanen M, et al., One-year outcome in early aneurysm surgery: A 14 years experience, *Acta Neurochir (Wien)*, 1993;122(1–2):1–10.
9. Ohman J, Heiskanen O, Timing of operation for ruptured supratentorial aneurysms: A prospective randomized study, *J Neurosurg*, 1989;70(1):55–60.
10. Alexander T, Macdonald R, Weir B, Kowalczyk A, Intra-operative angiography in cerebral aneurysm surgery: A prospective study of 100 craniotomies, *Neurosurgery*, 1996;39(1):10–17.
11. Drake C, Allcock J, Postoperative angiography and the “slipped” clip, *J Neurosurg*, 1973;39(6):683–9.
12. Macdonald R, Wallace M, Kestle J, Role of angiography following aneurysm surgery, *J Neurosurg*, 1993;79(6):826–32.
13. Feuerberg I, Lindquist C, Lindqvist M, Steiner L, Natural history of postoperative aneurysm rests, *J Neurosurg*, 1987;66(1):30–34.
14. Rauzzino MJ, Quinn CM, Fisher WS, Angiography after aneurysm surgery: Indications for “selective” angiography, *Surg Neurol*, 1998;49(1):32–40.
15. Bailes JE, Deeb ZL, Wilson JA, et al., Intraoperative angiography and temporary balloon occlusion of the basilar artery as an adjunct to surgical clipping: Technical note, *Neurosurgery*, 1992;30(6):949–53.
16. Barrow DL, Boyer KL, Joseph GJ, Intraoperative angiography in the management of neurovascular disorders, *Neurosurgery*, 1992;30(2):153–9.
17. Batjer H, Frankfurt A, Purdy P, et al., Use of etomidate, temporary arterial occlusion, and intraoperative angiography in surgical treatment of large and giant cerebral aneurysms, *J Neurosurg*, 1988;68(2):234–40.
18. Bauer BL, Intraoperative angiography in cerebral aneurysm and AV-malformation, *Neurosurg Rev*, 1984;7(2–3):209–17.
19. Derdeyn CP, Moran CJ, Cross DT, Intraoperative digital subtraction angiography: A review of 112 consecutive examinations, *AJNR Am J Neuroradiol*, 1995;16(2):307–18.
20. Chiang V, Gailloud P, Murphy K, et al., Routine intraoperative angiography during aneurysm surgery, *J Neurosurg*, 2002;96(6):988–92.
21. Katz J, Gologorsky Y, Tsiouris A, et al., Is routine intraoperative angiography in the surgical treatment of cerebral aneurysms justified? A consecutive series of 147 aneurysms, *Neurosurgery*, 2006;58(4):719–27.
22. Kivisaari RP, Porras M, Ohman J, et al., Routine cerebral angiography after surgery for saccular aneurysms: Is it worth it?, *Neurosurgery*, 2004;55(5):1015–24.
23. Klopfenstein J, Spetzler R, Kim L, Comparison of routine and selective use of intraoperative angiography during aneurysm surgery: A prospective assessment, *J Neurosurg*, 2004;100(2):230–35.
24. Tang G, Cawley C, Dion J, Barrow D, Intraoperative angiography during aneurysm surgery: A prospective evaluation of efficacy, *J Neurosurg*, 2002;96(6):993–9.
25. Barrow D, Boyer K, Joseph G, Intraoperative angiography in the management of neurovascular disorders, *Neurosurgery*, 1992;30(2):153–9.
26. Origiano TC, Schwartz K, Anderson D, et al., Optimal clip application and intraoperative angiography for intracranial aneurysms, *Surg Neurol*, 1999;51(2):117–24.
27. Payner TD, Horner TG, Leipzig TJ, Role of intraoperative angiography in the surgical treatment of cerebral aneurysms, *J Neurosurg*, 1998;88(3):441–8.
28. Tang G, Cawley CM, Dion JE, et al., Intraoperative angiography during aneurysm surgery: A prospective evaluation of efficacy, *J Neurosurg*, 2002;96(6):993–9.
29. Yanaka K, Asakawa H, Noguchi S, et al., Intraoperative angiography evaluation of the microsurgical clipping of unruptured cerebral aneurysms, *Neuro Med Chir*, 2002;42(5):193–200.
30. Bailes J, Tantuwaya L, Fukushima T, et al., Intraoperative microvascular Doppler sonography in aneurysm surgery, *Neurosurgery*, 1997;40(5):965–70.
31. Firsching R, Synowitz H, Hanebeck J, Practicability of intraoperative microvascular Doppler sonography in aneurysm surgery, *Minimally Invasive Neurosurgery*, 2000;43(3):144–8.
32. Charbel FT, Hoffman WE, Misra M, Ostergren LA, Ultrasonic perivascular flow probe: Technique and application in neurosurgery, *Neuro Res*, 1998;20:439–42.
33. Charbel F, Hoffman W, Misra M, et al., Role of a perivascular ultrasonic micro-flow probe in aneurysm surgery, *Neurologia Medico-Chirurgica*, 1998;38:35–8.
34. Amin-Hanjani S, Meglio G, Gatto R, et al., The utility of intraoperative blood flow measurement during aneurysm surgery using an ultrasonic perivascular flow probe, *Neurosurgery*, 2006;58[ONS Suppl 2]:ONS 305-ONS 312.

INFRARED 800 from Carl Zeiss.

See more.

Built to fluoresce

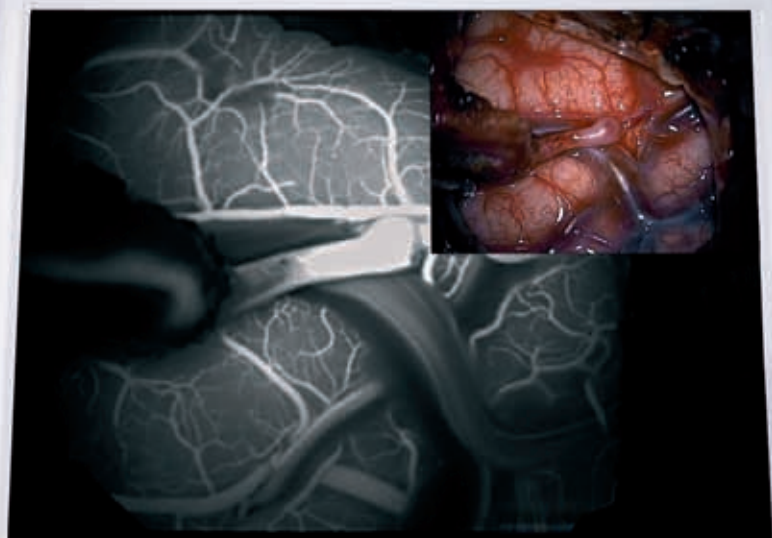
Easily visualize, check and interpret intra-operative blood flow quickly and reliably.

Superior Workflow Efficiency

Instant fluorescence module activation with a simple touch of a button.

Fully integrated

No additional system components obstructing procedural workflow or ergonomics. No re-balancing. No reduction of the working distance.



OPMI Pentero