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Indocyanine Green Videoangiography and Intraoperative Catheter Digital Subtraction Angiography in the Treatment of Intracranial Aneurysms: A Consecutive Series of 235 Cases

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Disclosures can be found in Additional Information at the end of the article

Abstract

Background

The introduction of indocyanine green videoangiography (ICGV) has impacted significantly the practice of operative microneurosurgery over the past decade. Several clinical studies have compared the use of ICGV to conventional catheter intraoperative digital subtraction angiography (DSA) during aneurysm surgery. We describe our experience with the combined use of ICGV and DSA in this setting.

Material & Methods

From January 2010 to December 2012, we performed both ICGV and intraoperative DSA in 235 consecutive aneurysm surgeries. Immediately after clip placement, ICGV was performed; if a problem was identified, the clip was removed and then repositioned or additional clips were added and ICGV repeated. Once the ICGV appearance was acceptable, DSA was then performed by an interventional neuroradiologist through a femoral arterial sheath that was placed either immediately preoperatively or during surgery. The number of cases in which ICGV as well as subsequent DSA resulted in clip repositioning or additional clip placement was assessed.

Results

Diagnostic images were obtained using ICGV in 230 of 235 cases and using DSA in 234 of 235 cases. After aneurysm clipping, ICGV resulted in clip removal and repositioning in seven cases when poor distal flow was encountered and the addition of extra clips in six cases to address clear residual aneurysm filling. When ICGV appeared satisfactory, DSA then resulted in clip repositioning in four instances of parent artery stenosis and the addition of extra clips in five cases of large, giant, or atheromatous aneurysms when additional filling not seen with ICGV was detected. Overall, ICGV resulted in a change in 13 cases, and then subsequent DSA resulted in a change in an additional nine cases. Our combined paradigm thus effected a change in the surgery in a total of 22 cases (9.3%).

Conclusion

In our experience, ICGV carries the distinct advantages of rapid feedback of information and

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excellent visualization of local perforators, while DSA provides optimal visualization of residual aneurysm and non-flow-limiting parent artery stenosis. Their combined use may provide optimal information to microsurgeons who continue to operate on intracranial aneurysms.

Categories: Neurosurgery
Keywords: digital subtraction angiography, indocyanine videoangiography, intracranial aneurysm

Introduction

In the past decade, indocyanine green videoangiography (ICGV) has made a significant impact in the field of neurovascular surgery [1-7]. Several clinical studies have compared the use of ICGV to conventional catheter intraoperative digital subtraction angiography (DSA) as methods to approach aneurysm surgery [8]. Most reports have generally emphasized the usefulness of ICGV in place of DSA [9]. We relied solely on intraoperative DSA in all aneurysm surgeries prior to 2010 and described our experience with more than 1,000 cases of intraoperative DSA at the American Academy of Neurological Surgeons annual meeting in 2008. After introducing ICGV into our aneurysm surgeries in 2010, we began to compare the effectiveness of the two modalities for intraoperative evaluation of aneurysm clipping. We have found the combined use of ICGV and DSA may represent the most effective strategy for maximizing the safety and efficacy of aneurysm surgery, as each method offers different, yet complementary information. This report details our experience with a policy combining the routine use of DSA and ICGV for intraoperative assessment during aneurysm surgery.

Materials And Methods

From January 2010 to December 2012, we performed both ICGV and intraoperative DSA in 235 consecutive aneurysm surgeries. Immediately after clip placement, ICGV was performed using intravenous injection of 25 mg of indocyanine green dissolved in 5 ml of solvent administered over a rapid intravenous injection period followed by a limited 5 ml saline fluid flush through the same intravenous catheter. If a problem was identified, the clip was removed and then repositioned and ICGV repeated or additional clips were added (Figures *1*-*3*) (Videos *1*-*3*). Once the ICGV appearance was acceptable, DSA was then performed. All DSA cases were performed by an interventional neuroradiologist through a femoral arterial sheath that was placed either immediately preoperatively or during surgery. The number of cases in which ICGV as well as subsequent DSA resulted in clip repositioning or addition of clips was assessed. Approval from our Institutional Review Board (Health East Care System, St. Joseph Hospital, St. Paul MN) was obtained. We used our Neuro-registry (Nussbaum.Defillo) as a source of data. All patients were consented prior to surgery/Data collection. IRB protocol # HE 1403001.

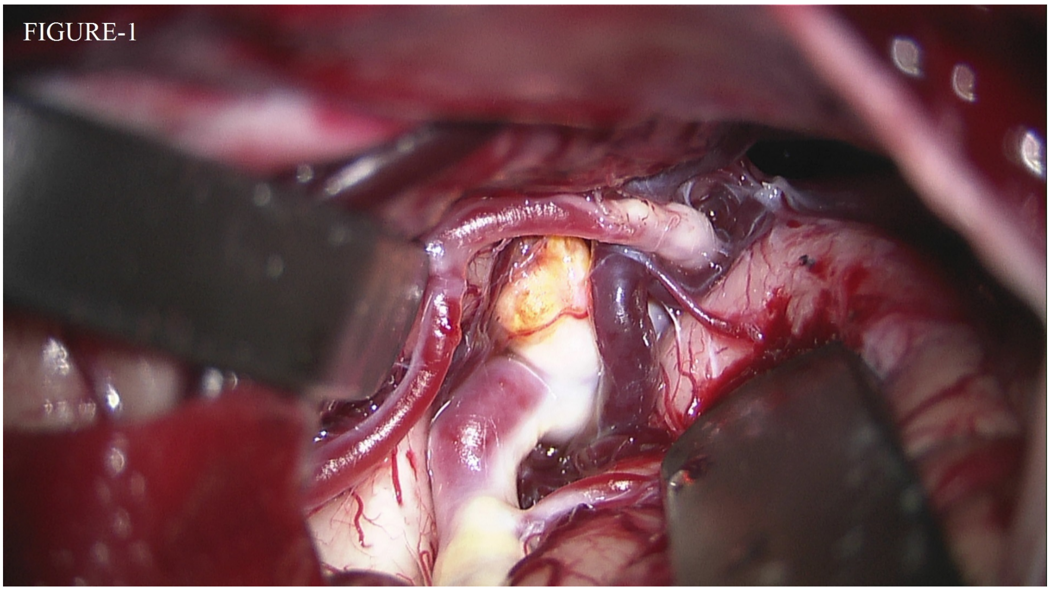

FIGURE 1: Microsurgical photograph demonstrating MCA atheromatous aneurysm

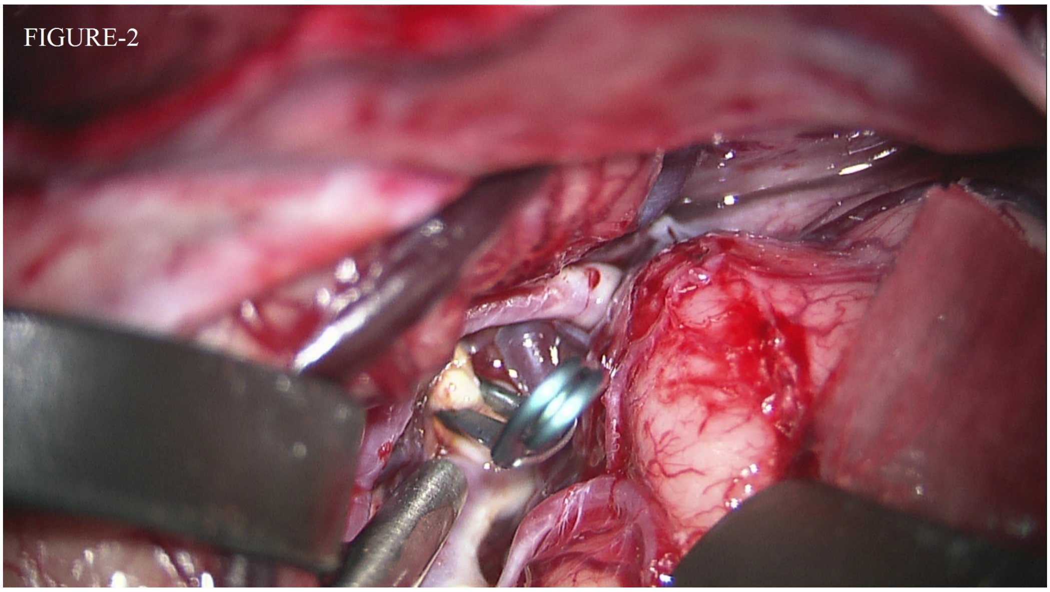

FIGURE 2: Showing the surgical clip demonstrating what seems to be a complete obliteration of the aneurysm fundus

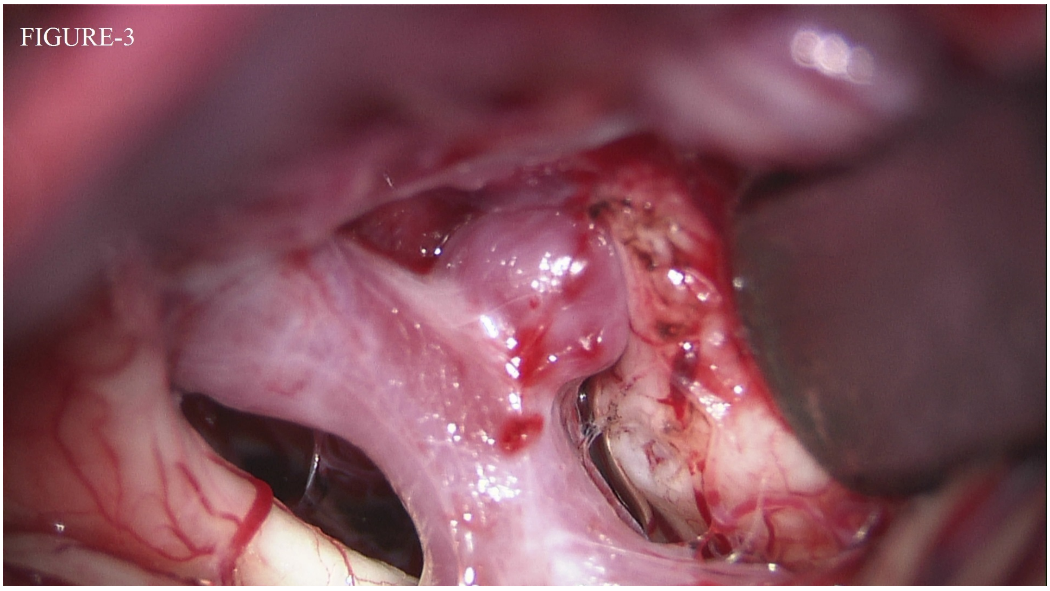

FIGURE 3: Microsurgical photograph demonstrating an anterior choroidal artery small wide-necked aneurysm. Notice the internal carotid artery-optic nerve characteristic anatomical landmark.

VIDEO 1: The ICGV demonstrated a residual neck with persistent aneurysm filling which prompted repositioning of the clip and additional clipping using tandem clipping technique.

View video here: http://youtu.be/XDkNYZPzIoY

VIDEO 2: ICGV demonstrating occlusion of the aneurysm with filling of normal vasculature

View video here: http://youtu.be/E6gW9J02Mr8

VIDEO 3: ICGV following clip reconstruction of a wide-necked MCA aneurysm demonstrates obliteration of the aneurysm dome but residual filling of the bulbous base of the aneurysm prompting clip replacement

View video here: http://youtu.be/qzAV7qIS0-U

Results

Diagnostic images were obtained using ICGV in 230 of 235 cases and using DSA in 234 of 235 cases. In one DSA case, femoral access could not be obtained in a timely fashion, and the procedure was aborted. In five of the ICVG cases, intravenous injection failed to present in diagnostic images obtained through the microscope due to inadequate fluorescence.

After aneurysm clipping, ICGV resulted in clip removal and repositioning in seven cases with poor distal flow (Figures *1*-*3*) (Videos *1*-*3*). The addition of extra clips in six cases was necessary to address clear residual aneurysm filling. Once ICGV appeared satisfactory, DSA then resulted in clip repositioning in four instances of parent artery stenosis and the addition of extra clips in five cases of large, giant, or atheromatous aneurysms when additional filling not seen with ICGV was detected. Overall, ICGV resulted in a change in 13 cases, and then subsequent DSA resulted in a change in an additional nine cases. Our combined paradigm thus effected a change in the surgery in 22 cases (9.3%).

Discussion

ICGV and intraoperative DSA have unique and distinctive advantages and disadvantages during aneurysm surgery. DSA can be time-consuming, present additional risks associated with catheterization of the cervical vessels, and may not adequately visualize smaller perforating arteries due to low resolution [10-11]. At the same time, DSA provides excellent information regarding both exposed and unexposed vessels as well as collateral supply and local arterial stenosis, which may be caused by an improperly placed aneurysm clip [3, 5, 12-16].

Intraoperative microscope-based ICGV provides easy, inexpensive, real-time information about the patency of the parent vessels, visualization of blood flow, assessment of perforating arteries, and evaluation of residual aneurysm sac filling [10]. Limitations of ICGV include atheromatous, calcified, and giant aneurysms where thickened aneurysm walls may make it difficult to evaluate for residual aneurysm, deep-seated lesions for which exposure is limited and thus residual aneurysm filling may be difficult to assess, and lesions with hemodynamically significant spasm that may interfere with proper ICGV filling of the aneurysm [10, 13, 17].

Most importantly, only portions of the aneurysm and neighboring vasculature that are exposed in the operative field are reliably identified with ICGV [18-22]. In addition, it may also be difficult to detect parent artery kinking or stenosis with ICGV, when the ICG still fills the distal vasculature well and may not clearly show a partial stenosis of the artery [17-18]. One could argue that such non-flow-limiting stenosis may be inconsequential. However, the potential for delayed platelet aggregation or thrombosis does exist, and most surgeons would likely reposition a clip if they knew it was causing a 50% stenosis. One of the ICG's strongest advantages is the exposure of small perforating arteries <0.5 mm in opposition to <3 mm vessels with DSA [12].

Washington, et al. compared ICG to the gold standard intraoperative DSA during aneurysm surgery; the rate of ICG–DSA agreement was 75.5%, compared to a discordance rate of 14.3%. Clip adjustments were based on the presence of aneurysmal remnants. Differences between the techniques were attributed to obscuration of the residual aneurysm or the affected vessel from the field of view and the presence of dye in the affected vessel via collateral flow. Of note, there was a trend for ICG discordance in cases involving the anterior communicating artery complex [13].

Other methods of intra-operative neuromonitoring, including electrophysiological [23-30], microvascular Doppler sonography [21-25], and neuroendoscopy [31-35], have historically been used alone or in combination with intra-operative DSA during aneurysm surgery [36]. Gruber, et al. compared the value of ICG with data simultaneously generated from other intra-operative monitoring and vascular imaging techniques. ICG disclosed parent artery stenosis not detected by sonography in seven of the 123 cases. However, neuroendoscopy disclosed aneurysm misclipping in a single patient in whom ICG and DSA failed to perceive the abnormality. Noteworthy, the information obtained from ICG and DSA corresponded in 120 of 123 (97.5%) aneurysm operations. In a single case within the same cohort, ICG underestimated a relevant parent artery stenosis detected by DSA. Similarly, in two patients with relevant aneurysmal misclipping, DSA and ICG led to conflicting results that could be clarified only when both methods were employed and interpreted simultaneously. The authors concluded that different intraoperative monitoring and vascular imaging methods were complementary rather than competitive [13].

From a resource standpoint, intraoperative monitoring adds to the cost of performing aneurysm surgery. It is important for the surgeon to understand the individual and combined benefits of these technologies in order to minimize cost. A report by the Barrow Neurological Institute detailed the evaluation of how the rates of perioperative stroke, unexpected postoperative aneurysm residual, or parent vessel stenosis differed in 100 patients from each era (2002 - ''DSA era''; 2007 - ''ICG era''). The clip-repositioning rate for neck residual or parent vessel stenosis did not differ significantly between the two eras. There were no differences in the rate of perioperative stroke or rate of false-negative studies; however, the per-patient cost of intraoperative imaging within the DSA era was significantly higher than in the ICG era [1].

The incidence of residual aneurysm and parent artery occlusion on postoperative angiography generally varies from 1.8% to 3.6% and 1.6% to 21%, respectively [5, 9, 15-16, 36-43]. The use of intraoperative angiography during aneurysm surgery significantly alters the surgical procedure in 7% - 34% of cases. Under certain circumstances, DSA may be more reliable than ICG, including cases where vessels are difficult to visualize because of local hemorrhage or when they are outside the field of the microscope, and when assessing for residual neck in calcified and thrombosed aneurysms. In addition, studies have analyzed the value of clip repositioning rates for specific aneurysms and found ICG results to be questionable for aneurysms located on the anterior communicating artery (AComA) and ophthalmic artery specifically [37, 44-45].

A combined approach, in our experience, using both modalities has proven highly effective as an intraoperative strategy. ICGV provides a rapid assessment of the exposed vasculature and, in particular, the local perforating arteries to ensure the structure have not been compromised. Intraoperative DSA is then performed to confirm there is no "hidden" residual aneurysm neck or clip-induced parent artery stenosis. From an intuitive perspective, this approach should offer maximal information regarding adequacy of clip reconstruction. In an era when microsurgeons must increasingly produce results to justify treating unruptured and highly complex lesions, the complementary information offered by the two modalities has been integral to treating patients. As a practical concern, if a center only uses intraoperative DSA when it is critically important, ability with the technique may be lost and it may be more difficult to obtain the needed images in a timely fashion. Although the combined use of these techniques may provide optimal information, it is important to consider the additional costs incurred.

Conclusions

Although, ICGV is being increasingly viewed as a substitute for intraoperative catheter DSA, we have found a combined technique provides a comprehensive view of the vascular structures, allowing for a more informed situation, and optimal patient outcomes. In our experience, ICGV carries the distinct advantages of rapid feedback and clear layout of local perforators, while DSA provides optimal visualization of residual aneurysm and non-flow-limiting parent artery stenosis.

Additional Information

Disclosures

Human subjects: Consent was obtained by all participants in this study. Institutional review board: Health East Care System, St. Joseph Hospital, St. Paul MN issued approval We used our Neuro-registry (Nussbaum.Defillo) as a source of data. All patients were consented prior to surgery/Data collection IRB protocol # HE 1403001. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Hardesty DA, Thind H, Zabramski JM, Spetzler RF, Nakaji P: Safety, efficacy, and cost of intraoperative indocyanine green angiography compared to intraoperative catheter angiography in cerebral aneurysm surgery. J Clin Neurosci. 2014, 21:1377-82. 10.1016/j.jocn.2014.02.006
2. Chalouhi N, Theofanis T, Jabbour P, Dumont AS, Fernando Gonzalez L, Starke RM, Dalyai RT, Hann S, Rosenwasser R, Tjoumakaris S: Safety and efficacy of intraoperative angiography in craniotomies for cerebral aneurysms and arteriovenous malformations: a review of 1093 consecutive cases. Neurosurg. 2012, 71:1162-9.
3. Chiang VL, Gailloud P, Murphy KJ, Rigamonti D, Tamargo RJ: Routine intraoperative angiography during aneurysm surgery. J Neurosurg. 2002, 96:988-92.
4. Friedman JA, Kumar R: Intraoperative angiography should be standard in cerebral aneurysm surgery. BMC Surg. 2009, 9:7. 10.1186/1471-2482-9-7
5. Klopfenstein JD, Spetzler RF, Kim LJ, Feiz-Erfan I, Han PP, Zabramski JM, Porter RW, Albuquerque FC, McDougall CG, Fiorella DJ: Comparison of routine and selective use of intraoperative angiography during aneurysm surgery: A prospective assessment. J Neurosurg. 2004, 100:230-5.
6. Kumar R, Friedman JA: Intraoperative angiography during cerebral aneurysm surgery. Neurocrit Care. 2009, 11:299-302. 10.1007/s12028-009-9229-5
7. Tang G, Cawley CM, Dion JE, Barrow DL: Intraoperative angiography during aneurysm surgery: A prospective evaluation of efficacy. J Neurosurg. 2002, 96:993-9.
8. Balamurugan S, Agrawal A, Kato Y, Sano H: Intra operative indocyanine green video-angiography in cerebrovascular surgery: An overview with review of literature. Asian J Neurosurg. 2011, 6:88-93. 10.4103/1793-5482.92168
9. Payner TD, Horner TG, Leipzig TJ, Scott JA, Gilmor RL, DeNardo AJ: Role of intraoperative angiography in the surgical treatment of cerebral aneurysms. J Neurosurg. 1998, 88:441-8.
10. Roessler K, Krawagna M, Dörfler A, Buchfelder M, Ganslandt O: Essentials in intraoperative indocyanine green videoangiography assessment for intracranial aneurysm surgery: Conclusions from 295 consecutively clipped aneurysms and review of the literature. Neurosurg Focus. 2014, 36:E7. 10.3171/2013.11.FOCUS13475
11. Martin NA, Bentson J, Viñuela F, Hieshima G, Reicher M, Black K, Dion J, Becker D: Intraoperative digital subtraction angiography and the surgical treatment of intracranial aneurysms and vascular malformations. J Neurosurg. 1990, 73:526-33.
12. Raabe A, Beck J, Gerlach R, Zimmermann M, Seifert V: Near-infrared indocyanine green video angiography: a new method for intraoperative assessment of vascular flow. Neurosurg. 2003, 52:132-9.
13. Gruber A, Dorfer C, Standhardt H, Bavinzski G, Knosp E: Prospective comparison of intraoperative vascular monitoring technologies during cerebral aneurysm surgery. Neurosurg. 2011, 68:657-73. 10.1227/NEU.0b013e31820777ee
14. Alexander TD, Macdonald RL, Weir B, Kowalczuk A: Intraoperative angiography in cerebral aneurysm surgery: A prospective study of 100 craniotomies. Neurosurg. 1996, 39:10-17.
15. Barrow DL, Boyer KL, Joseph GJ: Intraoperative angiography in the management of neurovascular disorders. Neurosurg. 1992, 30:153-9.
16. Derdeyn CP, Moran CJ, Cross DT, Grubb RL Jr, Dacey RG Jr: Intraoperative digital subtraction angiography: A review of 112 consecutive examinations. AJNR Am J Neuroradiol. 1995, 16:307-18.
17. Raabe A, Nakaji P, Beck J, Kim LJ, Hsu FP, Kamerman JD, Seifert V, Spetzler RF: Prospective evaluation of surgical microscope-integrated intraoperative near-infrared indocyanine green videoangiography during aneurysm surgery. J Neurosurg. 2005, 103:982-9.
18. 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, 66:1-6.
19. Mohanty A: Near-infrared indocyanine green video angiography in aneurysm surgery . Neurol India. 2009, 57:366-7. 10.4103/0028-3886.55568
20. Li J, Lan Z, He M, You C: Assessment of microscope-integrated indocyanine green angiography during intracranial aneurysm surgery: A retrospective study of 120 patients. Neurol India. 2009, 57:453-9. 10.4103/0028-3886.55607

21. Khurana VG, Seow K, Duke D: Intuitiveness, quality and utility of intraoperative fluorescence videoangiography: Australian Neurosurgical Experience. Br J Neurosurg. 2010, 24:163-72. 10.3109/02688690903518247
22. Imizu S, Kato Y, Sangli A, Oguri D, Sano H: Assessment of incomplete clipping of aneurysms intraoperatively by a near-infrared indocyanine green-video angiography (Niicg-Va) integrated microscope. Minim Invasive Neurosurg. 2008, 51:199-203. 10.1055/s-2008-1080916
23. Branston NM, Symon L, Crockard HA, Pasztor E: Relationship between the cortical evoked potential and local cortical blood flow following acute middle cerebral artery occlusion in the baboon. Exp Neurol. 1974, 45:195-208.
24. Hume AL, Cant BR: Conduction time in central somatosensory pathways in man. Electroencephalogr Clin Neurophysiol. 1978, 45:361-75.
25. Mizoi K, Yoshimoto T: Permissible temporary occlusion time in aneurysm surgery as evaluated by evoked potential monitoring. Neurosurg. 1993, 33:434-40.
26. Momma F, Wang AD, Symon L: Effects of temporary arterial occlusion on somatosensory evoked responses in aneurysm surgery. Surg Neurol. 1987, 27:343-52.
27. Quiñones-Hinojosa A, Alam M, Lyon R, Yingling CD, Lawton MT: Transcranial motor evoked potentials during basilar artery aneurysm surgery: technique application for 30 consecutive patients. Neurosurg. 2004, 54:916-24.
28. Schramm J, Koht A, Schmidt G, Pechstein U, Taniguchi M, Fahlbusch R: Surgical and electrophysiological observations during clipping of 134 aneurysms with evoked potential monitoring. Neurosurg. 1990, 26:61-70.
29. Wang AD, Cone J, Symon L, Costa e Silva IE: Somatosensory evoked potential monitoring during the management of aneurysmal SAH. J Neurosurg. 1984, 60:264-8.
30. Bailes JE, Tantuwaya LS, Fukushima T, Schurman GW, Davis D: Intraoperative microvascular Doppler sonography in aneurysm surgery. Neurosurg. 1997, 40:965-70.
31. Kalavakonda C, Sekhar LN, Ramachandran P, Hechl P: Endoscope-assisted microsurgery for intracranial aneurysms. Neurosurg. 2002, 51:1119-26.
32. Kato Y, Sano H, Nagahisa S, Iwata S, Yoshida K, Yamamoto K, Kanno T: Endoscope-assisted microsurgery for cerebral aneurysms. Minim Invasive Neurosurg. 2000, 43:91-7.
33. Kinouchi H, Yanagisawa T, Suzuki A, Ohta T, Hirano Y, Sugawara T, Sasajima T, Mizoi K: Simultaneous microscopic and endoscopic monitoring during surgery for internal carotid artery aneurysms. J Neurosurg. 2004, 101:989-95.
34. van Lindert E, Perneczky A, Fries G, Pierangeli E: The supraorbital keyhole approach to supratentorial aneurysms: Concept and technique. Surg Neurol. 1998, 49:481-9.
35. Taniguchi M, Takimoto H, Yoshimine T, Shimada N, Miyao Y, Hirata M, Maruno M, Kato A, Kohmura E, Hayakawa T: Application of a rigid endoscope to the microsurgical management of 54 cerebral aneurysms: results in 48 patients. J Neurosurg. 1999, 91:231-7.
36. Washington CW, Zipfel GJ, Chicoine MR, Derdeyn CP, Rich KM, Moran CJ, Cross DT, Dacey RG Jr: Comparing indocyanine green videoangiography to the gold standard of intraoperative digital subtraction angiography used in aneurysm surgery. J Neurosurg. 2013, 118:420-7. 10.3171/2012.10.JNS11818
37. Sharma M, Ambekar S, Ahmed O, Nixon M, Sharma A, Nanda A, Guthikonda B: The Utility and Limitations of Intraoperative near Infrared Indocyanine Green Video-angiography (ICGA) in aneurysm surgery. World Neurosurg. 2014, Jun 4:S1878-8750(14)00540-3. 10.1016/j.wneu.2014.05.033
38. Dashti R, Laakso A, Niemelä M, Porras M, Hernesniemi J: Microscope-integrated near-infrared indocyanine green videoangiography during surgery of intracranial aneurysms: The Helsinki experience. Surg Neurol. 2009, 71:543-50. 10.1016/j.surneu.2009.01.027
39. Macdonald RL, Wallace MC, Kestle JR: Role of angiography following aneurysm surgery. J Neurosurg. 1993, 79:826-32.
40. Origitano TC, Schwartz K, Anderson D, Azar-Kia B, Reichman OH: Optimal clip application and intraoperative angiography for intracranial aneurysms. Surg Neurol. 1999, 51:117-24.
41. Sindou M, Acevedo JC, Turjman F: Aneurysmal remnants after microsurgical clipping: classification and results from a prospective angiographic study (in a consecutive series of 305 operated intracranial aneurysms). Acta Neurochir (Wien). 1998, 140:1153-9.
42. Thornton J, Bashir Q, Aletich VA, Debrun GM, Ausman JI, Charbel FT: What percentage of surgically clipped intracranial aneurysms have residual necks?. Neurosurg. 2000, 46:1294-8.
43. Vitaz TW, Gaskill-Shipley M, Tomsick T, Tew JM Jr: Utility, safety, and accuracy of

intraoperative angiography in the surgical treatment of aneurysms and arteriovenous malformations. AJNR Am J Neuroradiol. 1999, 20:1457-61.

44. Gross BA, Du R: Microsurgical treatment of ophthalmic segment aneurysms . J Clin Neurosci. 2013, 20:1145-8. 10.1016/j.jocn.2012.11.005

45. Murai Y, Adachi K, Takagi R, Koketsu K, Matano F, Teramoto A: Intraoperative Matas test using microscope-integrated intraoperative indocyanine green videoangiography with temporary unilateral occlusion of the A1 segment of the anterior cerebral artery. World Neurosurg. 2011, 76:477.e7-477.e10. 10.1016/j.wneu.2011.03.044