

Intraoperative indocyanine green videoangiography to guide decision making regarding need for vessel bypass: A case report and technical note

Michael Avery, Somar Chehab, John H. Wong, Alim P. Mitha

Division of Neurosurgery, Foothills Medical Centre, University of Calgary, Calgary, Alberta, Canada

E-mail: Michael Avery - mbavery@gmail.com; Somar Chehab - somar_ss@hotmail.com; John H. Wong - jwong@ucalgary.ca;

*Alim P. Mitha - alimmitha@gmail.com

*Corresponding author

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Abstract

Background: Indocyanine green (ICG) videoangiography is an intraoperative technique recently used in vascular neurosurgery to assess the presence or absence of blood flow during critical times of a procedure. These include, but are not limited to, detecting whether daughter branches or perforators are patent after placing a vascular clip or determining whether an aneurysm has been completely isolated from the cerebral circulation after clipping. We present a case of a less-commonly reported application of ICG videoangiography involving the selection of a vessel to act as the bypass recipient once the need is identified during the surgical treatment of a complex intracranial aneurysm.

Case Description: A 51-year-old male presented with a ruptured dissecting superior cerebellar artery (SCA) aneurysm that had two branches arising from the dome. Due to the difficult morphology of this aneurysm, a superficial temporal artery to SCA bypass was planned. We used ICG videoangiography to identify the branch that had insufficient retrograde flow via collateral circulation, to which the bypass was performed, followed by the isolation of the aneurysm from the cerebral circulation using permanent surgical clips.

Conclusion: Our case represents a possible use of ICG videoangiography during the operative treatment of a difficult aneurysm. Our patient suffered no infarcts postoperatively. In the correct clinical context, this method represents a possible treatment option for complex aneurysms requiring a bypass.

Key Words: Dissecting intracranial aneurysm, extracranial-intracranial bypass, indocyanine green videoangiography, revascularization

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BACKGROUND AND IMPORTANCE

Intraoperative angiography is a useful tool in cerebrovascular neurosurgery. One commonly used method is indocyanine green (ICG) videoangiography. ICG is a cyanine dye that has a peak spectral absorption of between 780 and 805 nm, with an emission spectrum peaking between 820 and 835 nm.^[10] Modern intraoperative microscopes are easily outfitted with a near-infrared

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emitter for dye excitation and a high-sensitivity detector specific for ICG videoangiography. Injecting ICG into the venous system will allow the surgeon to identify the presence or absence of blood flow in an area of interest. Applications are numerous and include identification of recipient vessels for bypass grafts, verification of bypass patency, the degree of an aneurysm or arteriovenous malformation obliteration, identifying important perforating vessels, among others.^[1] Our case describes a novel use of ICG videoangiography in aneurysm bypass surgery that incorporated the intraoperative findings in our decision-making process.

CLINICAL PRESENTATION

History

A healthy 51-year-old male presented to our institution with a headache, complete left oculomotor nerve palsy and increasing lethargy secondary to a ruptured 10 mm left proximal superior cerebellar artery (SCA) dissecting aneurysm with the two branching vessels emerging from its distal aspect [Figure 1]. A cerebral angiogram was performed to better characterize the aneurysm's morphology [Figure 2]. Nimodipine was prescribed for vasospasm prophylaxis and an external ventricular drain (EVD) was inserted for obstructive hydrocephalus resulting in clinical stabilization.

Operation

On post-SAH day 10, the patient was taken to the operating room for definitive management of the aneurysm. A left-sided orbitozygomatic craniotomy was

performed in the usual fashion with care to expose and isolate 12 cm of the superficial temporal artery (STA), which was identified transcutaneously with a handheld Doppler. The STA was protected with a papaverine-soaked gauze. Using a subfrontal approach and with microscopic magnification, the left opticocarotid complex was identified. The left posterior communicating artery was then followed to the ipsilateral posterior cerebral artery. The proximal SCA was then identified and dissected for later clip placement.

We then followed a left subtemporal corridor to identify the aneurysm and two branches of the SCA emerging from its distal aspect. The trochlear nerve was divided to improve exposure; since the patient had presented with complete oculomotor nerve palsy with associated ptosis, it was felt that dividing the fourth nerve would result in no significant additional deficit. As expected, two branches of the SCA were found to be arising from the aneurysm, and temporary clips were placed proximally on each branch. Using intraoperative ICG videoangiography, we found that the smaller of the two SCA branches had retrograde flow while the larger did not, indicating a lack of collateral flow into the larger SCA branch [Figure 3]. Therefore, we elected to perform a left STA-SCA bypass to the larger branch.

To perform the bypass, a temporary clip was placed on the proximal aspect of the exposed left STA, and the vessel was longitudinally transected distally. After clearing the vessel of its adventitia, the STA was laid down along the floor of the middle cranial fossa to the aneurysm site. Temporary clips were positioned on the proximal and distal aspects of the larger SCA branch. The bypass was performed end-to-side on the SCA branch between the clips with 10-0 nylon sutures. The three temporary

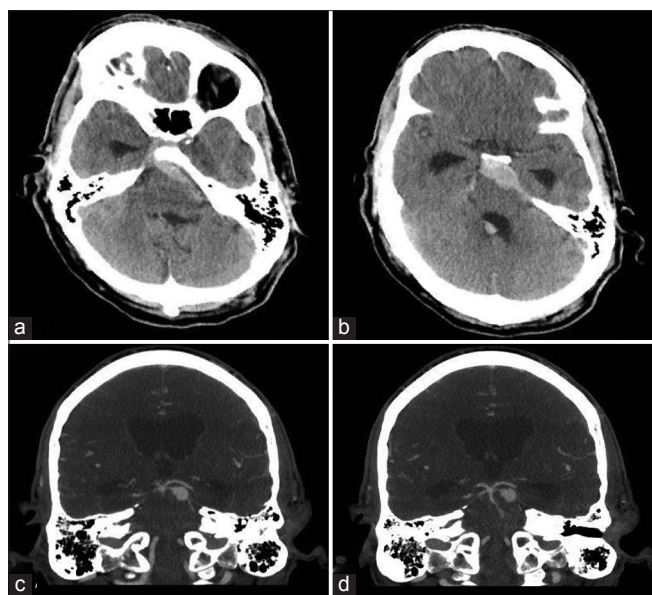


Figure 1: Axial computed tomography head (a and b) showing a hemorrhage in the prepontine and interpeduncular cisterns with mass effect on the brainstem from the left superior cerebellar artery aneurysm, demonstrated on coronal computed tomography angiography (c and d)

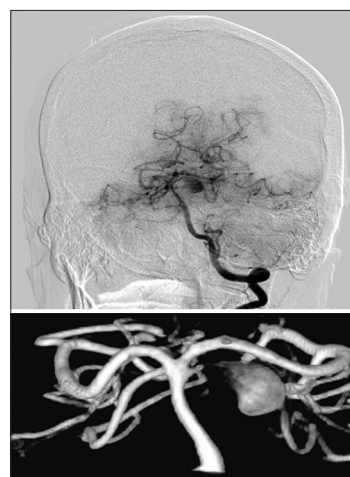


Figure 2: Anteroposterior view of left internal carotid artery injection digital subtraction angiograph (above), demonstrating left superior cerebellar artery aneurysm and bifurcating branches emerging from the aneurysm dome. Three-dimensional reconstruction of aneurysm complex (below)



Figure 3: Intraoperative microscopic view of aneurysm complex viewed during left subtemporal approach (right = anterior, up = inferior) (above). Identical intraoperative view during indocyanine green videoangiography after applying temporary clips proximally on the branches of the superior cerebellar artery (below). Smaller branch (*) is seen fluorescing, while larger branch (**) and aneurysm dome (#) are not seen. The location of these nonfluorescing structures is outlined in white

clips were removed, establishing flow through the bypass. Finally, permanent clips were applied to the SCA proximal to the aneurysm, as well as on the proximal aspects of the two SCA branches as they emerged from the aneurysm, thus isolating the aneurysm from the cerebral circulation. The bone was replaced, and the craniotomy was closed in the usual fashion.

Postoperative course

A postoperative CTA demonstrated patency of the bypass and no residual filling of the excluded dissecting aneurysm [Figure 4]. The EVD was removed on postoperative day 4 and the patient recovered well with no treatment-related complications. At follow-up, the patient demonstrated persistent left oculomotor and trochlear nerve palsies as expected but recovered well otherwise.

DISCUSSION

Treatment options for complex aneurysms include open surgical and endovascular approaches. Open surgical approaches include clipping, proximal vessel occlusion, trapping of the aneurysm with or without distal bypass, or wrapping. Endovascular options include coiling with or without stent or balloon assistance, flow diversion or parent artery occlusion. In our particular case of a distal dissecting SCA aneurysm, clipping was not an option as the aneurysm involved both branches of the SCA, and so clip occlusion would have likely resulted in an SCA territory infarct. Furthermore, endovascular treatment was not a great option as coil embolization of a dissecting aneurysm is technically very challenging. Using a flow-diverting stent would require prior knowledge of collateral circulation to the efferent branches, as only one branch could be stented.

Cerebral revascularization is an important option in the surgical treatment of these complex aneurysms. One of the main issues with the procedure, however, is patient selection. This procedure carries with it greater technical difficulty and additional risks. Accurately identifying patients and situations where a bypass will be of benefit,

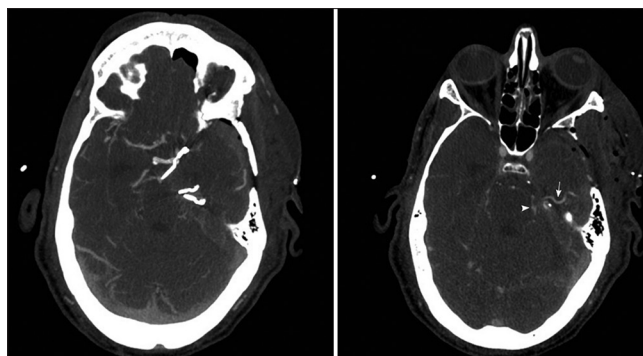


Figure 4: Postoperative axial computed tomography angiogram demonstrating complete clip occlusion of the left superior cerebellar artery aneurysm. A single clip was placed proximal to the aneurysm and one clip was placed proximally on each of the distal branches (left). The superficial temporal artery (arrow) is patent and feeding into the patent larger superior cerebellar artery (arrowhead) branch (right). No cerebellar infarcts were noted on postoperative imaging

and perhaps more importantly, when it is not warranted, will undoubtedly improve patient outcomes.^[5] For instance, there are some reports in the literature of performing parent artery occlusion or aneurysm trapping in cerebellar arteries without incurring neurological deficits. This is likely due to either good collateral anastomoses between cerebellar arteries or because small cerebellar infarctions are better tolerated by the majority of patients.^[2]

There have been several reports of the intraoperative use of ICG videoangiography during aneurysm surgery. In many cases, this technique has successfully identified the patency of a completed bypass or perforator vessels.^[7,11] Less-commonly reported is the use of ICG videoangiography to select a distal branch suitable for bypass.^[3,4] In these cases, distal middle cerebral artery (MCA) aneurysms were able to be isolated temporarily from the cerebral circulation via proximal and distal clips, thereby obstructing flow to the more distal branches. ICG videoangiography was then used to identify which distal MCA branch(s) required a bypass by finding the vessels that demonstrated delayed luminescence compared to adjacent branches not involved in the parent vessel harboring the aneurysm. Kim and Cohen-Gadol described two cases of distal MCA aneurysms whereby this technique demonstrated satisfactory collateral flow in the more distal branches with good retrograde filling, allowing them to avoid a bypass procedure altogether. They reported good outcomes with no evidence of infarction postoperatively.^[6] In our case, we were faced with a similar situation. However, the two branches of the SCA were unfortunately incorporated into the aneurysm itself. We only had the ability to perform a single bypass procedure with the isolated ipsilateral STA. Using ICG videoangiography, we identified that the smaller of the

two branches had sufficient collateral circulation, whereas the larger one demonstrated a complete lack of retrograde flow. This allowed us to select the larger branch for a bypass from the STA and avoid harvesting an additional vessel from a distant site in the case that both branches demonstrated insufficient retrograde filling. A control run of ICG videoangiography prior to temporary clipping was not completed since we had information from the preoperative angiogram that there was flow in both SCA branches. Had the ICG videoangiography demonstrated good collateral flow in both branches, simply trapping the aneurysm by placing a clip proximal to it and one on each of the two branches would likely have sufficed without performing a bypass, as has been described previously.^[6] Postoperatively the patient did not demonstrate any signs or symptoms of cerebellar infarction.

Despite the success, in this case, there are several limitations to the use of intraoperative ICG. For example, the available line of sight can restrict the complete visualization of an aneurysm and branch complex and may be affected by calcification or thrombosis.^[9] It is important to ensure optimal visualization of the aneurysm complex prior to ICG videoangiography, as the complete clearance time of ICG is between 5 and 10 min.^[9] Furthermore, a dose of 0.5 mg/kg is often utilized and the safe maximal daily dose is 5 mg/kg. Another important limitation to recognize is that ICG is effective at qualifying flow, but not quantifying flow.^[10] As Kim *et al.* found, they were successfully able to avoid a bypass in a vessel that demonstrated retrograde flow on ICG videoangiography. However, their reports and our case do not prove that this is always reliable. It is known that parent vessel occlusion after a successful balloon test occlusion may still result in devastating infarcts.^[8] Having an ancillary test to quantify blood flow, when present, could be of value. On the other hand, it is unclear whether a vessel demonstrating no flow on ICG videoangiography will actually require a bypass to avoid territory infarction.

CONCLUSION

Cerebral revascularization via direct bypass is a useful treatment option for some complex aneurysms for which conventional approaches pose exceptionally high risks. It

is well known that intraoperative ICG videoangiography can provide the surgeon valuable information regarding bypass patency. Less-commonly reported is the ability to use this technique in prebypass assessments to evaluate candidate recipient vessels for bypass based on either collateral flow or identification of the distal branches of interest.

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Conflicts of interest

There are no conflicts of interest.

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