Editorial

Indocyanine green videoangiography or intraoperative angiography?

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In a little over 20 years, the field of aneurysm treatment has seen drastic changes. The catalyst for these changes was, of course, the advent of the endovascular revolution. The bar was suddenly raised for microsurgery, and the result of this duality of treatment options has been an impetus for surgeons to do better, to the benefit of the patient by and large. The need to “land the perfect clip” is more important than ever. Long gone are the days when microsurgery reigned supreme and unchallenged, when residual aneurysms and occluded vessels after clip placement were just part of the expected surgical complications, unavoidable in many cases.

Microsurgery has indeed advanced as well. On the road to striving for perfection, intraoperative angiography has made possible for the first time the visualization of the luminal aspect of the aneurysm and its related vessels, and allowed the surgeon to fix clipping imperfections before it is too late. The image complemented the surgeon’s judgment. Then indocyanine green (ICG) videoangiography came along and greatly simplified the process. An intravenous injection replaced the elaborate transfemoral arterial procedure; or did it?

In this article by the Washington University neurosurgery group in St. Louis, the authors retrospectively analyzed the concordance rate between ICG videoangiography and intraoperative digital subtraction angiography (IA) in 49 patients who underwent aneurysmal clipping. Are these techniques equivalent in accuracy, sensitivity, and specificity? Their data suggest a 14.3% discordance rate, higher than previously reported (< 10%). In these discordant cases, IA uncovered a technical issue, missed by ICG videoangiography, which led to clip replacement. The authors wish to conclude that IA remains the “gold standard” and that ICG videoangiography should not be thought of as a complete replacement.

While the conclusion is carefully phrased and one cannot really disagree with it, I do wish to elaborate on some of the limitations of the study briefly mentioned and recognized by the authors, and their bearing on such a conclusion.

Besides the small sample size of 7 discordant cases (out of 49) and the resulting lack of statistical power, there is a clear selection bias. Only 32% of the operated patients underwent both ICG videoangiography and IA, and thus form the basis of the concordance analysis. The need for both studies clearly implies a more complex aneurysm morphology. There is also undoubtedly a lack of homogeneity between operators, and all of the following characteristics likely differ among the various surgeons: skill level, threshold for obtaining the studies, thoroughness in establishing the field of view (FOV) for the ICG videoangiography, manner of interpreting the studies, and so on.

More importantly, there is the very real confounding bias introduced by the nonsimultaneity of both variables being compared. The knowledge that IA will follow ICG videoangiography implies that “best effort” is not being applied in the use of ICG videoangiography. This knowledge will systematically undervalue ICG videoangiography, similar to the historic bias that was introduced in the past when IA was first being used to evaluate clip placement. Far more “clip revisions” were “necessary” when IA became available, simply because there was no reason to push the envelope with a difficult clip placement. The surgeon’s state of mind was not too infrequently as follows: “Let’s place a clip safely and see if we get lucky. We can always revise after IA.” In statistical parlance, the “probability of ICG videoangiography revealing a clip issue, knowing that IA is being done next” is clearly higher than the “probability of ICG videoangiography revealing a clip issue, had IA not been available.” It is the latter that, ideally, should interest the surgeon, but it is the former that was measured in this study. The two events, “ICG videoangiography” and “subsequent IA,” are dependent, and the probability of an outcome from the first is conditional on the existence of the second. The concept that “the act of measuring affects the accuracy of what is being measured” is not novel, of course. Neither is the problem unique to the clinical sciences. At the very fundamental level of quantum physics and particle mechanics, as immortalized by the Heisenberg Uncertainty Principle, it seemingly plagues the nature of all things and is an insurmountable experimental limit to achieving “true knowledge.” Mercifully, the standards of accuracy that would satisfy most of us are well below those concerning the quantum world of the very small.

Of the 7 discordant cases in the study, 4 had vessel occlusions and 3 had residual aneurysms. In all of these cases, it was an FOV issue. The tips of the clip, the occluded vessels, and/or the residual aneurysm sac were beyond the FOV of the microscope. Was the FOV the widest obtainable in these cases, or was it intrinsically limited because of the specific arterial anatomy? There are clearly cases...
in which the latter is a problem, such as deep aneurysms partially obscured by the skull base or other immovable structures. But there are also other cases in which establishing the appropriate exposure can avoid the FOV problem. If a skull base modification can improve the safety and clarity of clip placement, it should be done, whether ICG videoangiography is in use or not. The basic tenet of clip placement still remains: dissect and prepare the field so thoroughly that the clipping maneuver will appear to be the easiest part of the case. There is a very recent report that describes the clever use of endoscopic ICG videoangiography. The surgeon can look “around corners” with an endoscope adapted for the purpose of visualizing vessels perfused with ICG, vessels that escape the line of sight of the microscope. This technique would seemingly minimize the FOV issue of ICG videoangiography.

To use ICG videoangiography to full advantage, one also needs to utilize its semiquantitative features. There is software available that allows an assessment of flow patterns and characteristics during the videographic examination. Watching, replaying, and analyzing the flow dynamics exhibited in the “loop” feature allows the surgeon to detect and reverse sluggish flow. This technology was not utilized in this study, and it is not clear if it would have avoided some of the discordant cases. Perhaps the retrograde collateral flow in the anterior cerebral artery would have been recognized in Case 7 (Fig. 3).

Another simple, yet generally underutilized, technology that I have routinely used is flow quantitation. Applying a flow probe on an accessible vessel intraoperatively, the surgeon can determine the flow in cm3/min—not velocity (cm/sec), which would ignore the cross-sectional area of a vessel—in afferent and efferent vessels to the aneurysm, both before and after clip placement. This is the definitive quantitative way to establish preservation of flow and perfusion. Of course, this will not detect a residual aneurysm sac. It does not appear that the authors utilize flow quantitation in their routine armamentarium for complex aneurysms.

In summary, considering all of the above, I would view the discordance rate of 14.3% between ICG videoangiography and IA as an upper limit of the real value. I believe the “true” discordance, when one attempts to overcome all limitations, to be well less than 10%, consistent with other published reports. In my opinion, IA should thus be reserved for the occasional case (for example, the heavily calcified aneurysm wall), and not be used as a matter of routine. The use of ICG videoangiography is, after all, an invasive extra step with its own logistical issues. In an era in which efficiency and expediency are as desirable as safety, it behooves us to aspire for simplicity when justified. I believe that between ICG videoangiography and quantitative flow measurements, the vast majority of clipped complex aneurysms can be assessed accurately and efficiently intraoperatively by the experienced cerebrovascular surgeon.

Disclosure
The author reports no conflict of interest.

References

Response

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We would like to thank Dr. Morcos for his detailed evaluation and insightful comments related to our article. In this study we retrospectively analyzed the results from 49 patients who underwent both ICG videoangiography and IA after microsurgical clipping of cerebral aneurysms.

Dr. Morcos has raised a number of weaknesses of the study, with which we fully agree. The most significant of these weaknesses is perhaps related to an inherent selection bias due to only 32% of patients undergoing evaluation with both ICG videoangiography and IA. Also, due to these small patient numbers, there is undoubtedly a significant heterogeneity across patients related to differences between surgeons and aneurysm characteristics.

There are, however, a couple of conclusions made by Dr. Morcos that we wish to counter. It is true that ICG videoangiography has been improved through the introduction of software allowing for quantitative flow analysis. However, at the time of these surgeries, this tool was not available. Dr. Morcos also mentions the utility of flow probes for assessing flow. We agree and frequently do use this tool during aneurysm surgeries. Unfortunately, as is the case with all tools, there are limitations. First, there are occasions in which all pertinent vessels are not accessible (such as a contralateral anterior cerebral artery with an intervening superiorly projecting anterior communicating artery aneurysm). Second, the results when assessing small vessels can be inaccurate. Third, and perhaps the most significant limitation, this tool plays no role in assessing the completeness of aneurysm obliteration.

Lastly, we disagree with the idea that the surgeon’s
“best effort” is not being implemented in clip application prior to the use of ICG videoangiography, resulting in a bias against ICG videoangiography. In each of the 7 discordances reported, ICG videoangiography was interpreted as a complete aneurysm obliteration with patency of associated vessels. The subsequent IA demonstrated a finding necessitating the adjustment of the aneurysm clip. We believe that the surgeon’s state of mind was more consistent with this line of thought: “ICG videoangiography shows an adequate clip placement. Let us now verify with IA prior to closure.” There is a cost associated with IA related to its inherent risk to the patient and added operative time. With each of the ICG videoangiography–IA discordance-related clip adjustments, a second IA was performed, adding further to this cost. From this information, it is more reasonable to believe that IA is most often being performed as final verification rather than a “look and see.”

As stated by Dr. Morcos, the bar for microvascular neurosurgery has been raised, and the impetus for achieving this higher standard belongs to the surgeon. We agree that ICG videoangiography is a major technical advance in aneurysm microsurgery and we use it enthusiastically. However, our experience leads us to conclude that in certain cases limited FOV or collateral flow complicates the interpretation of the study. The surgeon should be aware of the limitations of ICG videoangiography in these situations and carefully consider if IA is required to obtain optimal results.

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