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Commentary: Indocyanine green: The Green Lantern of congenital heart surgery?

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Angiography and computed tomography have been utilized to assess patency and location of vascular structures for many years. A surgeon must interpret the results of these studies and superimpose the images onto the surgical field with a healthy imagination or a hybrid operating room suite. The unique fluorescent property of indocyanine green (ICG) has been leveraged in imaging technology to allow intraoperative visualization of various vascular structures and assist with surgical planning and assessment of technical results. Said and colleagues¹ demonstrate their experience with the technology in myriad clinical situations. There are several important lessons to be gleaned.

Under what clinical circumstances is this methodology most useful? In its current form, the information gathered is qualitative rather than quantitative, so imaging can identify gross features such as location of a coronary artery or presence of perfusion in a coronary artery bed. We have used the system most commonly to identify the location of epicardial coronary arteries and determine the site of ventriculotomy in reoperative cardiac surgery when locations of key coronary arteries are not obvious.² It may be useful in identifying the location of coronary vasculature within a cardiac tumor to avoid injury during debridement. The depth of penetration is relatively shallow, thus coronary arteries that are embedded within myocardium, sheets of scar tissue, or tumor may not light up. The system can also demonstrate if there is perfusion to a particular region by revealing blush of ICG fluorescence in the distal perfusing

The Green Lantern is a superhero who saves humanity by harnessing the extraordinary power of a fluorescent ring. Can indocyanine green do the same?

CENTRAL MESSAGE

Intraoperative visualization of coronary arteries with fluorescent indocyanine green has potential to guide surgical management. The protocols for its use are being optimized.

myocardium. It may thus be useful in excluding complete occlusion of a particular vessel.

The potential of this technology to provide detail regarding adequacy of an anastomosis, or stenosis in a vessel (beyond complete occlusion) remains uncertain. The technique is extremely sensitive to the quantity of contrast administered as well as the speed at which it is administered. Fluorescence can scatter and impair resolution, making a relatively narrow anastomosis look wide open. Even in the face of a significant stenosis, one can demonstrate distal perfusion within the vascular bed. As the technology matures and the technique is standardized, this will likely improve. Although the authors utilized this technique to assess Blalock-Taussig shunt patency (with venous grafts), ICG cannot penetrate polytetrafluoroethylene or polyethylene terephthalate, thus limiting its use in this clinical scenario.

Said and colleagues¹ provide important details regarding dilution of ICG, dose, and method of delivery. The ICG can be administered into the aortic root in a crossclamped or perfusing heart after institution of cardiopulmonary bypass. The presence of aortic insufficiency may affect the dosing and timing of administration. As mentioned by the authors, the variables that can be modified include quantity of ICG administered, the rate at which it is administered, and its concentration. To adequately visualize the structure, several

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injections of varying injection rates and volumes may be necessary to obtain optimal visualization of the target structures. Short small bursts will delineate anatomy with high resolution for a brief period of time, whereas long slow infusions will provide prolonged visualization with less distinct borders. The contrast can be washed out by administration of additional cardioplegia in a crossclamped heart, or by allowing washout in the perfused heart, and imaging can be repeated. Fortunately, ICG has a favorable safety profile, and even multiple injections can be performed without reaching the upper limit of dosing.

One can certainly imagine the possible applications of intraoperative imaging with ICG. We look forward to well-designed prospective clinical trials that standardize the technique and demonstrate its advantages for our vulnerable patients.

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