Indocyanine green videoangiography

Indocyanine green (ICG) fluorescence videoangiography is now widely used for the intraoperative assessment of vessel patency, providing high quality, valuable, real-time imaging of cerebrovascular anatomy.

Preservation of adequate blood flow and exclusion of flow from lesions are key concepts of vascular neurosurgery.

The overlay of fluorescence videoangiography within the field of view of the white light operative microscope allows real-time assessment of the blood flow within vessels during simultaneous surgical manipulation. This technique could improve intraoperative decision making during complex neurovascular procedures.

Simal-Julián et al. conducted a review to identify and assess the impact of all of the methodological variations of conventional ICGVA applied in the field of neurovascular pathology that have been published to date in the English literature. A total of 18 studies were included in this review, identifying four primary methodological variants compared to conventional ICGVA: techniques based on the transient occlusion, intra-arterial ICG administration via catheters, use of endoscope system with a filter to collect florescence of ICG, and quantitative fluorescence analysis. These variants offer some possibilities for resolving the limitations of the conventional technique (first, the vascular structure to be analyzed must be exposed and second, vascular filling with ICG follows an additive pattern) and allow qualitatively superior information to be obtained during surgery. Advantages and disadvantages of each procedure are discussed. More case studies with a greater number of patients are needed to compare the different procedures with their gold standard, in order to establish these results consistently.

Limitations

Intraoperative indocyanine green videoangiography (ICG-VA) has been widely used in vascular surgery, where vessels are clearly shown as white on a black background. However, other structures cannot be observed during ICG-VA.

Is not absolutely reliable as a stand-alone method during clipping of ophthalmic artery aneurysms and can be complemented with IA. ICGA can be used either as an alternative or complementary technique to IA during aneurysm surgery.

Indications

It can assist in intraoperative surgical management and/or stroke prevention particularly during aneurysm clipping, EC-IC bypass and AVM/DAVF surgery, and to document the intraoperative vascular flow.

Indocyanine green (ICG) angiography is commonly used to map the vascular configuration of cerebral arteriovenous malformations (AVMs) during resection.

ICG-VA is a safe and effective technique for locating the ICA in skull-base expanded endonasal
surgery. Furthermore, this technique can provide real-time guidance for the surgeon and increase safety for the patient. ⁶

**Vascular malformations**

Sato et al. developed a new, high-resolution intraoperative imaging system (dual-image VA [DIVA]) to simultaneously visualize both light and near-infrared (NIR) fluorescence images from ICG-VA, allowing observation of other structures.

The operative field was illuminated via an operating microscope by halogen and xenon lamps with a filter to eliminate wavelengths over 780 nm. In the camera unit, visible light was filtered to 400-700 nm and NIR fluorescence emission light was filtered to 800-900 nm using a special sensor unit with an optical filter. Light and NIR fluorescence images were simultaneously visualized on a single monitor.

The system clearly visualized the operative field together with fluorescence-enhanced blood flow. In aneurysm surgeries, we could confirm incomplete clipping with the neck remnant or with remnant flow into the aneurysm. In cases of arteriovenous malformation or arteriovenous fistula, feeding arteries and draining veins were easily distinguished.

This system allows observation of the operative field and enhanced blood flow by ICG together in real time and may facilitate various types of neurovascular surgery ⁷.
**Arteriovenous malformation**

see Indocyanine green videoangiography for arteriovenous malformation

**Intracranial aneurysm**

see Indocyanine green videoangiography for intracranial aneurysm.

**Spinal vascular malformation**

ICG video-angiography is a time-efficient and safe alternative to intra-operative spinal angiography. It provided useful information on haemodynamic changes intraoperatively and completeness of treatment.\(^8\)

Has the potential to shorten operating times, gives additional reassurance of completeness of surgical treatment and preservation of normal spinal vasculature.\(^9\)

Serves an important role in the microsurgical treatment of spinal dural arteriovenous fistula (DAVF). It is simple and provides real-time information about the precise location of spinal DAVF and result after obliteration of spinal DAVF.\(^10\)

**Patency of a bypass graft**

It has been established as a noninvasive technique to gauge the patency of a bypass graft; however, intraoperative graft patency may not always correlate with graft flow. Altered flow through the bypass graft may directly cause delayed graft occlusion.

Januszewski et al. report on 3 types of flow that were observed through cerebral revascularization procedures in 48 bypass procedures.

After anastomosis, bypass patency was assessed first using a noninvasive technique and then with ICG videoangiography, and flow through the graft was characterized. Patients who received a vein or radial artery graft were also evaluated with intraoperative angiography.

Thirty-three patients eligible for analysis were retrospectively analyzed. The patients had undergone extracranial-intracranial (EC-IC) or IC-IC bypass for ischemic stroke (13 patients), moyamoya disease (10 patients), and complex aneurysms (10 patients; 6 giant or large aneurysms, 2 carotid blister-like aneurysms, and 2 dissecting posterior inferior cerebellar artery (PICA) aneurysms). Thirty-six bypasses were performed including 26 superficial temporal artery (STA)-middle cerebral artery (MCA) bypasses (2 bilateral and 1 double-barrel), 6 EC-IC vein grafts, 1 EC-IC radial artery graft, 1 PICA-PICA bypass, 1 MCA-posterior cerebral artery bypass, and 1 occipital artery-PICA bypass. Robust anterograde flow (Type I) was noted in 31 grafts (86%). Delayed but patent graft enhancement and anterograde flow (Type II) was observed in 4 cases (11%); 1 of these cases with an EC-IC vein graft degraded gradually to very delayed flow with no continuity to the bypass site (Type III). Additionally, 1 STA-MCA bypass graft revealed no convincing flow (Type III). The 5 patients with Type II or III grafts were evaluated with a flow probe and reexploration of the bypass site, and in all cases the reason the graft became occluded was believed to be recipient-vessel competitive flow. In no case was there
evidence of stenosis or a technical issue at the site of the anastomosis. Three patients with Type II and the 1 patient with Type III flow (11% of procedures) did not have a patent bypass on postoperative imaging.

The type of flow observed through the graft has a direct relationship with postoperative imaging findings. Despite the possibility of competitive flow, Type III and some Type II flows through the graft indicate the need for graft evaluation and anastomosis exploration.

**Tumor**

see Indocyanine green videoangiography for tumor.

**Pituitary adenoma**

see Indocyanine green videoangiography for pituitary adenoma.

**Disadvantages**

ICG flow alone, but not other structures, can be observed using ICG-VA.

Sato et al., from Fukushima, Japan, Essen, Germany, published in 2018 a novel high-resolution intraoperative imaging system using laser light source for simultaneously visualizing both visible light and near infrared (NIR) fluorescence images of indocyanine green videoangiography (ICG-VA).

They used a novel system for 14 cerebrovascular cases. The operative field was illuminated via an surgical microscope using a novel laser light source with four bands at 464 (blue), 532 (green), 640 (red), and 785 nm (NIR region). The observed light from the operative field was split using a beam splitter cube into visible (420-660 nm) and NIR fluorescence emission light (832-900 nm). Images from the color video and NIR fluorescence emission windows were merged for visualization on a monitor screen simultaneously. Laser light was compared with xenon light, and both setups were tested for cerebrovascular surgery.

Laser light has numerous advantages over xenon light. The present setup clearly visualized the color operative field with enhanced blood flow. Complete clipping or incomplete clipping with neck remnant or remnant flow into an aneurysm was confirmed in aneurysm surgeries. Feeding artery and draining veins were easily distinguished in case of arteriovenous malformation.

Using the present setup, they can observe the color operative field and enhanced blood flow using ICG in real time. This setup could facilitate cerebrovascular surgery.

**References**

1. Indocyanine green videoangiography


