



# Shifting surgical archetypes of ICG fluorescent-angiography for bowel perfusion assessment in cardiogenic shock under ECMO support

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## Abstract

**Summary:** Extracorporeal membrane oxygenation (ECMO) has been adopted to support patients with acute severe cardiac or pulmonary failure that is potentially reversible and unresponsive to conventional management. Mesenteric ischemia (MI) can present as a life-threatening complication in patients receiving veno-arterial echocardiogram (ECHO) support. Due to the nature and acuity of these conditions, determining adequate perfusion upon surgical intervention is challenging for the operating surgeon, especially in cardiogenic shock (CS) patients on ECMO support presenting low arterial pulsatility. Indocyanine green fluorescent angiography (ICG-FA) has proven to be useful for real-time assessment of vascular perfusion, which may help determine the extent of bowel ischemia in patients receiving ECMO support. The case report here-in presented, breaks the paradigm of performing non-cardiac surgical procedures on ECMO support via a pioneering visual aid technique.

**Learning Objective:** ICG-FA is a promising visual intraoperative technique providing real-time feedback for the adequate identification and assessment of target tissue/organs. The high morbidity and mortality rates associated to MI and CS—particularly when concomitantly present—hinders salvage surgical therapy. The use of ECMO provides hemodynamic stability. This case report highlights the importance of adequate surgical intervention under extracorporeal life support in the presence of both CS and MI. To the authors' knowledge, this is the first report of application of ICG-FA to evaluate mesenteric perfusion in a patient receiving ECMO support.

## KEYWORDS

bowel perfusion, cardiogenic shock, ECMO, ICG fluorescent-angiography

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## 1 | INTRODUCTION

Mesenteric ischemia (MI) is a life-threatening disorder with almost half of the cases caused by embolisms of cardiac origin, while the remainder of cases are more frequently related to low perfusion syndrome in patients with hemodynamic compromise. If left untreated, severe hypoperfusion can lead to intestinal transmural necrosis, bowel gangrene with perforation, peritonitis, and sepsis, thus requiring prompt surgical intervention.<sup>1</sup> Cardiogenic shock (CS) resulting from right ventricular (RV) failure secondary to hemodynamic collapse from primary PE is considered the most common cause of early death, particularly in the first 7 days of diagnosis with a superimposed 30%–50% mortality risk.<sup>2</sup>

Venoarterial (VA) extracorporeal membrane oxygenation (ECMO) support can provide acute support in CS or advanced heart failure with survival rates ranging from 20% to 50%.<sup>3</sup> Indocyanine green fluorescent angiography (ICG-FA), has gained popularity as a transoperative visual aid tool for the assessment of tissue perfusion. Thus far, ICG-FA has proven its capability to improve recognition of perfusion threshold indices in clinical-decision making in construction of vascular anastomoses and prevention of ischemia in tissue grafts.<sup>4</sup> General surgeons would frequently consider non-cardiac surgical procedures (NCSPs) in patients under ECMO support challenging, the case report herein presented confronts this concept by introducing ICG-FA as a visual aid tool in the performance of multiple abdominal surgeries during extracorporeal life support (ELS).

### 1.1 | Case report

A 61-year-old male consulted at outside hospital for a 4-day history of abdominal pain associated with weakness, fatigue, right upper quadrant pain, dizziness, and syncope. Initial emergent evaluation at an outside institution, resulted in the indication of a

primary laparoscopic cholecystectomy that patient declined, leaving hospital against medical advice, to subsequently present to our institution 5 days after symptoms began. The initial evaluation included abdominal ultrasound that revealed acute cholecystitis. Computed tomography (CT) showed a right-sided pleural effusion with a 2.3 cm mass at the right lower pulmonary lobe. On echocardiogram evaluation, a clot in-transit in the right atrium (RA) was observed. Upon informed consent, an emergent pulmonary embolectomy was performed. Surgical approach included median sternotomy, and cardiopulmonary bypass in the distal ascending aorta, and bicaval venous cannulation. A large clot in transit was removed from the RA through a 3 cm vertical incision. A severe RV failure resulted in failure to wean-off cardiopulmonary bypass, requiring transoperative initiation of VA-ECMO support (Figure 1).

Patient failed two subsequent attempts to wean-off support, leading to further evaluation with chest CT scan revealed residual bilateral hilar pulmonary artery clots and evidence of RV strain. A bilateral pulmonary embolectomy was performed through pulmonary arteriotomies at the level of the hilum to allow more extensive completion embolectomy from lobar and segmental branches. Patient progressed with acute kidney injury requiring renal replacement therapy.

On postoperative day 11, the patient developed acute MI requiring exploratory laparotomy under VA-ECMO support. Intraoperative use of ICG-FA allowed to determine the extent of bowel resection which resulted in subtotal colectomy and small bowel resection. Two days later the patient was taken back to the operative room for an ileostomy and cholecystectomy. Being under a CS state ensued by primary PE and complicated by acute MI, all abdominal surgeries were performed under ICG-FA in aims to preserve as much viable gastrointestinal tract as possible. During the performance of the subtotal colectomy, small bowel resection, and ileostomy, multiple infusions of ICG were administered intravenously (1–3 ml



**FIGURE 1** Initial laparoscopic exploratory laparotomy under VA-ECMO support. ICG-FA reveals segment of ischemic small bowel.

of ICG; 25 mg diluted in 10 ml of saline solution) to assess bowel perfusion.

Gross viable perfusion was examined at 140 cm from the ligament of Treitz via ICG-FA and confirmed by adequate hemostasis. The small bowel was then brought through the abdominal wall for an end-loop fashion conversion with the afferent limb being superior. The stoma rod was placed and secured to the skin. The edges of the bowel were re-evaluated for perfusion and hemostasis showing both fluorescent and subjective angiographic satisfactory appearance. All procedures were tolerated by the patient who continued support and was later transferred in critical condition to the intensive care unit.

On postoperative day 15, multiorgan failure with increasing lactic acidosis supervened deeming life support therapies futile and patient's surrogate requested withdrawal of support, leading to patient demise.

## 2 | DISCUSSION

The ICG-FA technology serves as an intra DNR method for real-time evaluation of perfusion in multiple procedures, providing visual feedback for the improvement of clinical decision-making. Acute MI represents a life-threatening condition with mortality rates comparable to CS.<sup>1,5</sup> Owing to the nature of these, evaluation of bowel vitality and cardiac stability is critical for successful outcomes when performing a surgical approach. The clinical decision-making based on surgeons' clinical judgment has low sensitivity and specificity for all kinds of anastomosis.<sup>6</sup> Adequate surgical navigation is a culprit for successful surgical intervention in the presence of MI, and so is the ability to diagnose accompanying conditions that may preclude operative outcomes.

This case conveys multiple conditions that further increase the mortality risk of the patient. While pulmonary embolectomy, RV failure and CS have been described as a cascade of cardiac complications, this case stands out due to the ELS provided to address NCSPs. In a recent study examining NCSPs in patients on ECMO, after logistic regression analysis, the requirement of NCSPs was not associated with mortality (odds ratio [OR]: 0.91, 95% confidence interval: 0.68–1.23,  $p = .17$ ).<sup>7</sup>

This case report challenges the paradigm of no-intervention in the setting of ECMO. After multidisciplinary discussions, abdominal surgery was performed despite VA-ECMO support. The benefits outweighed the risks because of the ultimate objective to correctly preserve bowel with potential to recover. Evaluation of perfusion at the site of resection/anastomosis is challenging in this scenario. While models of prediction of intestinal viability using subjective clinical criteria have been reported, 57% accuracy is underwhelming.<sup>8</sup> Conversely, transoperative perfusion assessment techniques via ICG-FA have reported multiple satisfactory outcomes, including the detection of necrotic intestinal segments otherwise nondiscernable by the naked eye, and the improved outcomes of acute MI cases when implementing ICG-FA as part of protocol intervention. A larger study determined the applicability of ICG-FA to reduce extended

bowel resections in acute MI by leading to major changes in operative strategy and better clinical outcomes.<sup>9</sup> Parallely, ICG-FA has assessed bowel perfusion during laparoscopic colorectal resection, eliminating the presence of postoperative leaks and reducing mortality rates.<sup>10</sup>

While the dosing, approach, indications, presence of comorbidities vary, a standardized clinical guideline has yet to be placed to serve as a navigational course when considering ICG-FA. While our patient ultimately succumbed, the NCSPs performed safely with outstanding preservation of viable gastrointestinal segments and cardiac stability. It is important to highlight that the patient presented with a superimposed high mortality risk (primary PE, irreversible RV, acute MI, and CS).

This case report's strength holds sound in the pioneering venture of safely performing NCSPs under ELS. The weaknesses are directed towards the relative novelty of the application of this technique and its lack of standardized societal clinical guidelines. Our experience with ICG-FA is based on time to peak intensity and dose-dependent, regardless of ELS. Thus, although visual aid was achieved, a level of subjectivity accompanies the clinical decision-making of the resection/anastomotic approach. Whether these variables have a true effect on the adequacy of the perfusion evaluation, its preservation and absence of anastomotic leak was still achieved. More so, ICG-FA models have yet to determine the precise and optimal blood flow rate needed to ensure tissue salvage/preservation. Previous efforts to assess blood supply have yet to define the optimal blood flow needed to avoid anastomotic leak.<sup>10</sup> Finally, ICG has limits to take into account: Limited penetrance of 10 mm in target tissues, short vascular clearance of 3–4 min, and a relative dependency on albumin bonds.<sup>4</sup> These become relevant, especially in the presence of multiorgan failure secondary to CS, further complicated by acute MI.

## 3 | CONCLUSIONS

ICG-FA is a safe, costly effective, useful visual aid tool for the real-time assessment of end-organ perfusion. The case report presented breaks the paradigm of performing NCSPs on ELS. Further larger prospective studies are needed to draw comprehensive conclusions from this initial premise.

### CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

### ETHICS STATEMENT

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the provided manuscript are appropriately investigated and resolved.

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