

Shifting Surgical Archetypes of ICG Fluorescent-Angiography for Bowel Perfusion Assessment in Cardiogenic Shock Under ECMO Support

Rene Aleman¹, Matthew Labkovski², Sinal Patel¹, Nikita Zadneulitca¹, Joel S. Frieder¹, Raul J. Rosenthal¹, Cedric Sheffield¹, Jose Navia¹, and Nicolas Brozzi¹

¹Cleveland Clinic Florida

²no affiliation

March 28, 2022

Abstract

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. In the presence of pulmonary embolism, mesenteric ischemia (MI) can present as a life-threatening disorder that leads to intestinal ischemia. Due to the nature and acuity of these conditions, determining adequate perfusion upon surgical intervention is challenging for the operating surgeon, especially in the presence of cardiogenic shock despite ECMO support. Indocyanine green fluorescent angiography (ICG-FA) has proven to be useful for real-time vascular perfusion assessment, which may potentially decrease the rate of development of perfusion-related complications. The case report here-in presented, breaks the paradigm of performing noncardiac surgical procedures on ECMO support via a pioneering visual aid technique. Learning objective Indocyanine green fluorescent angiography (ICG-FA) is a promising visual trans-operatory 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 acute ECMO provides stabilization yet lacks any curative solutions. 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, said approach has never been attempted, yet trails a promising therapy for the improvement of associated mortality rates.

Rene Aleman MD¹Matthew Labkovski BS

Sinal Patel MD¹Nikita Zadneulitca MD¹Joel S. Frieder MD¹

Raul J. Rosenthal MD, FACS, FASMBS¹

Cedric Sheffield MD, FACC¹

Jose Navia MD, FACC¹

Nicolas A. Brozzi MD, FACC¹

¹Heart, Vascular & Thoracic Institute

General Surgery Department

Cleveland Clinic Florida

Corresponding Author

Nicolas A. Brozzi MD, FACC

Cardiothoracic Surgeon Surgical Director, Mechanical Circulatory Support Program Director of Cardiovascular Research

Heart, Vascular & Thoracic Institute

Cleveland Clinic Florida

2950 Cleveland Clinic Blvd, Weston FL 33331

BROZZIN@CCF.ORG

+1 (954) 405-4851 *Word count: 1493*

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. In the presence of pulmonary embolism, mesenteric ischemia (MI) can present as a life-threatening disorder that leads to intestinal ischemia. Due to the nature and acuity of these conditions, determining adequate perfusion upon surgical intervention is challenging for the operating surgeon, especially in the presence of cardiogenic shock despite ECMO support. Indocyanine green fluorescent angiography (ICG-FA) has proven to be useful for real-time vascular perfusion assessment, which may potentially decrease the rate of development of perfusion-related complications. The case report here-in presented, breaks the paradigm of performing noncardiac surgical procedures on ECMO support via a pioneering visual aid technique.

Learning objective

Indocyanine green fluorescent angiography (ICG-FA) is a promising visual trans-operative 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 acute ECMO provides stabilization yet lacks any curative solutions. 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, said approach has never been attempted, yet trails a promising therapy for the improvement of associated mortality rates.

Keywords: ICG fluorescent-angiography, cardiogenic shock, bowel perfusion, ECMO.

Introduction

Mesenteric ischemia (MI) is a life-threatening disorder with almost half of the cases caused by embolisms of cardiac origin. If left untreated, severe hypoperfusion can lead to intestinal transmural necrosis, peritonitis, sepsis, free intra-abdominal air, or extensive gangrene, thus requiring prompt surgical intervention [1]. In the presence of pulmonary embolism (PE), a mortality rate of 30% adds on. 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 [2]. The high mortality associated in said dual clinical presentation, deems surgical intervention to be the main therapeutic approach.

Venoarterial (VA) extracorporeal membrane oxygenation (ECMO) support can provide acute support in CS or advanced heart failure (HF) with survival rates ranging from 20 to 50% [3]. Indocyanine green fluorescent

angiography (ICG-FA), has gained popularity as a trans-operative 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 tissue anastomoses and ischemia prevention [4]. While current surgical tendencies consider noncardiac surgical procedures (NCSPs) in patients under ECMO support non-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).

Case report

A 61-year-old male consulted 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. After leaving against medical advice, the patient presented to our institution 5 days after symptoms began. The initial evaluation revealed no abdominal pain, but presence of fever, chills, nausea, emesis, and diarrhea. An ultrasound sonography revealed thickening of the gallbladder wall with mild pericholecystic fluid without gallstones, compatible with acute cholecystitis. Computed tomography (CT) showed a right sided pleural effusion with a 2.3 cm mass at the right lower pulmonary lobe. On ECHO 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 bi-caval 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 trans-operative initiation of VA-ECMO support.

The chest was left open with sterile dressing. On postoperative day 2, the patient was taken back to the operating room for a chest washout and attempt decannulation. Patient failed two subsequent attempts to wean-off support. Further evaluation with CT chest scans revealed high burden of procedural clots and evidence of RV strain. A bilateral pulmonary embolectomy was performed through pulmonary arteriotomies at the level of the hilum loop to provide improved exposure of lobar and segmented branches. Following intervention, acute kidney injury arose on postoperative day 4 requiring therapy and parallel increase of vasopressors with accompanying lactic acidosis. The presence of coagulopathy, congestive hepatopathy, and decremental renal failure, resulted in the development of CS.

On postoperative day 11, the patient developed acute MI and underwent exploratory laparotomy under VA-ECMO support, 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 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 supervened in a vegetative state, with sustaining therapies to continue life support. Ultimately, the patient's surrogate withdrew/withheld care and the patient was accordingly made DNR and started on a morphine drip and fentanyl for comfort care. The patient perished on postoperative day 16 after withdrawal of VA-ECMO and ventilatory support.

<<FIGURE1>>

Discussion

The ICG-FA technology serves as a trans-operative tool for real-time perfusion evaluation in multiple procedures, providing visual feedback for the improvement of clinical decision-making, especially in high morbidity and mortality cases. Acute MI continues to be a life-threatening condition with mortality rates comparable to CS [1,5]. 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 [6]. 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 extend the mortality risk of the patient. However, the resolution of the patient's PE, subsequent RV failure and MI, and ensuing CS, shifted priorities. 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 [CI]: 0.68–1.23, $p = 0.17$) [7].

This case report challenges the paradigm of no-intervention in the setting of ELS. After multidisciplinary discussions, abdominal surgery was performed despite VA-ECMO support. The benefits outweighed the risks because of the ultimate objective to correctly preserve tissue with the potential to recover. As it is well known, perfusion at the site of resection/anastomosis is challenging to evaluate. While models of prediction of intestinal viability using subjective clinical criteria have been reported, 57% accuracy is underwhelming [8]. Conversely, trans-operative perfusion assessment techniques via ICG-FA have reported multiple satisfactory outcomes, including the detection of necrotic intestinal segments otherwise non-discernable 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 [9]. Parallely, ICG-FA has assessed bowel perfusion during laparoscopic colorectal resection, eliminating the presence of postoperative leaks and reducing mortality rates [10].

While the dosing, approach, indications, presence of comorbidities vary, a standardized clinical guideline has yet to be placed in order 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). The main purpose of this case report is to propose the consideration of performing NCSPs even in critical cardiac condition patients.

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 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 leakage [10]. Finally, ICG has limits to take into account: Limited penetrance of 10 mm in target tissues, short vascular clearance of 3-4 minutes, and a relative dependency on albumin bonds [4]. These become relevant, especially in the presence of multiorgan failure from a secondary CS, consequent of a primary PE, further complicated by acute MI.

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.

No funding was provided for the present study. No acknowledgements.

Ethical 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.

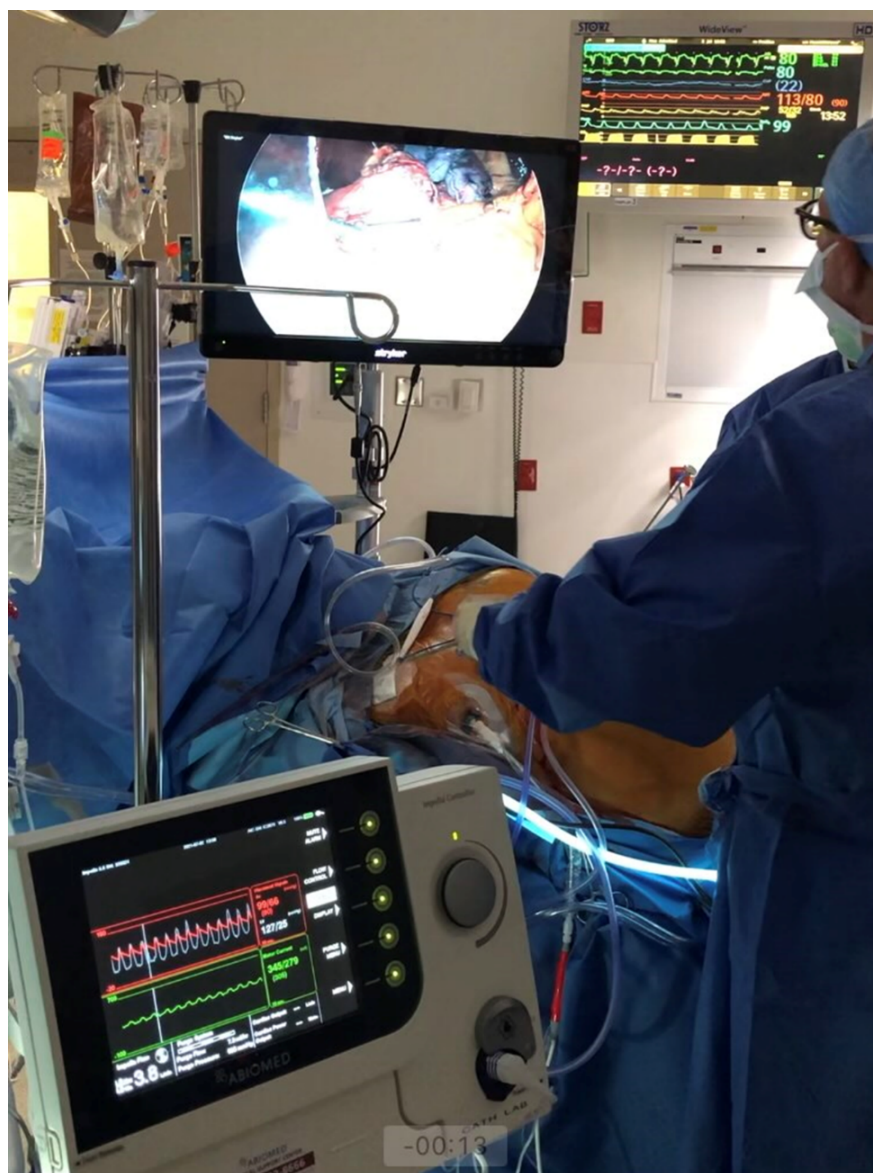
Conflict of interest: The authors have nothing to disclose.

References

- [1] Tilsed JVT, Casamassima A, Kurihara H, Mariani D, Martinez I, Pereira J, et al. ESTES guidelines: acute mesenteric ischaemia. *Eur J Trauma Emerg Surg* 2016;42:253–70. <https://doi.org/10.1007/s00068-016-0634-0>.
- [2] Duffett L, Castellucci LA, Forgie MA. Pulmonary embolism: update on management and controversies. *BMJ* 2020;370:m2177. <https://doi.org/10.1136/bmj.m2177>.
- [3] Bréchet N, Hajage D, Kimmoun A, Demiselle J, Agerstrand C, Montero S, et al. Venoarterial extracorporeal membrane oxygenation to rescue sepsis-induced cardiogenic shock: a retrospective, multicentre, international cohort study. *Lancet* 2020;396:545–52. [https://doi.org/10.1016/S0140-6736\(20\)30733-9](https://doi.org/10.1016/S0140-6736(20)30733-9).
- [4] Reinhart MB, Huntington CR, Blair LJ, Heniford BT, Augenstein VA. Indocyanine Green: Historical Context, Current Applications, and Future Considerations. *Surg Innov* 2016;23:166–75. <https://doi.org/10.1177/1553350615604053>.
- [5] Pontallier M, Demondion P, Lebreton G, Golmard J-L, Leprince P. Experience with Extracorporeal Life Support for Cardiogenic Shock in the Older Population more than 70 Years of Age. *ASAIO J* 2017;63:279–84. <https://doi.org/10.1097/MAT.0000000000000484>.
- [6] Karliczek A, Harlaar NJ, Zeebregts CJ, Wiggers T, Baas PC, van Dam GM. Surgeons lack predictive accuracy for anastomotic leakage in gastrointestinal surgery. *Int J Colorectal Dis* 2009;24:569–76. <https://doi.org/10.1007/s00384-009-0658-6>.
- [7] Taghavi S, Jayarajan SN, Mangi AA, Hollenbach K, Dauer E, Sjöholm LO, et al. Examining Noncardiac Surgical Procedures in Patients on Extracorporeal Membrane Oxygenation. *ASAIO J* 2015;61:520–5. <https://doi.org/10.1097/MAT.0000000000000258>.
- [8] Sheridan WG, Lowndes RH, Williams GT, Young HL. Determination of a critical level of tissue oxygenation in acute intestinal ischaemia. *Gut* 1992;33:762–6. <https://doi.org/10.1136/gut.33.6.762>.
- [9] Karampinis I, Keese M, Jakob J, Stasiunaitis V, Gerken A, Attenberger U, et al. Indocyanine Green Tissue Angiography Can Reduce Extended Bowel Resections in Acute Mesenteric Ischemia. *J Gastrointest Surg* 2018;22:2117–24. <https://doi.org/10.1007/s11605-018-3855-1>.
- [10] Shogan BD, Carlisle EM, Alverdy JC, Umanskiy K. Do we really know why colorectal anastomoses leak? *J Gastrointest Surg* 2013;17:1698–707. <https://doi.org/10.1007/s11605-013-2227-0>.

Figures

Figure 1



Initial laparoscopic exploratory laparotomy under VA-ECMO support