The American Surgeon
2022, Vol. 0(0) 1–3

DOI: 10.1177/00031348221114520
journals.sagepub.com/home/asu
SAGE

# Decompressive Laparotomy for Veno-Venous Extracorporeal Membrane Oxygenation Failure due to Intra-Abdominal Hypertension in Critically Ill COVID-19 Patient

**Noam Kahana, MD[1,3], Alon D. Schwartz, MD[1,3], and Sharon Einav, MD[2,3]**

## Abstract

The use of extracorporeal membrane oxygenation (ECMO) has increased over the course of the SARS-CoV-2 pandemic. Intra-abdominal hypertension resulting in abdominal compartment syndrome (ACS) during ECMO support is a rare but life-threatening complication, with previous case series describing mortality rates of 44%-100%. Bleeding complications, linked to both patient-related and device-related factors, also characterize prolonged ECMO support and have been reported in up to 60% of ECMO patients. We hereby describe a critically ill COVID-19 patient who underwent emergent bed-side decompressive laparotomy for acute ECMO failure related to the development of ACS. The discussion is focused on surgical considerations including the delicate balance between anticoagulation and thrombosis, as anticoagulation-free ECMO support may be required due to hemorrhagic complications.

## Keywords

COVID-19, extracorporeal membrane oxygenation, intra-abdominal hypertension, abdominal compartment syndrome, decompressive laparotomy, hemorrhage

## Key Takeaways:

- Increasing used of ECMO will likely be accompanied by performance of more surgeries with their associated complications during ECMO support.
- In case of abdominal compartment syndrome, the potential magnitude of the hemodynamic response to decompressive laparotomy must be weighed against possible complications, most notably hemorrhage.
- Management options after decompressive laparotomy in ECMO patients may include leaving the abdomen open and prolonged avoidance of anticoagulation as required.

Critically ill patients are prone to develop acute intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS). Obesity, abdominal pathologies, fluid overload, positive pressure mechanical ventilation, and body position may all contribute to the development of these pathologies. Critically ill patients with COVID-19 may also develop IAH in association with acute kidney injury. IAH has been described in association with the use of extracorporeal membrane oxygenation (ECMO).[1] In this clinical setting, whether and when to perform abdominal decompression remains a major conundrum.[2]

One such case was recently treated in our intensive care unit. A 53-year-old patient with respiratory failure due to severe acute respiratory syndrome coronavirus 2 infection. Two weeks after PCR-confirmation the patient underwent intubation and mechanical ventilation. When oxygenation deteriorated further despite maximal treatment veno-venous extracorporeal membrane oxygenation (ECMO) was initiated with an anticoagulation regimen of continuous heparin.

[1]Department of General Surgery, Shaare Zedek Medical Center, Jerusalem, Israel
[2]Intensive Care Unit of the Shaare Zedek Medical Center, Jerusalem, Israel
[3]Hebrew University School of Medicine, Jerusalem, Israel

**Corresponding Author:**
Noam Kahana, Department of General Surgery, Shaare Zedek Medical Center, The Hebrew University School of Medicine, Samuel Byte 12, Jerusalem 9103102, Israel.
Email: noamk@szmc.org.il

On day-8 of ECMO support, computed tomography with angiography was performed due to periodic decreases in ECMO flow and abdominal distention. Anticoagulation was halted when free abdominal fluid and hemorrhage from a meso-cecal pseudoaneurysm were identified. The patient underwent laparotomy, right hemicolectomy, end ileostomy, and mucus fistula formation and fascia closure. Pathology slides showed colonic mucosal necrosis and vascular congestion with a transmural hematoma but no evidence of vasculitis.

One the day after surgery the patient deteriorated again. Hypotension and hemorrhage ensued, accompanied by multi-organ failure (ie oliguria and deteriorating respiratory mechanics and gas exchange), periodic falls in ECMO flow and arterial oxygen saturation (SaO2). ACS was diagnosed (intra-abdominal pressure 27 mmHg via the bladder catheter). Hematologic parameters (thrombocytopenia and hypofibrinogenemia) were corrected and decompressive laparotomy was performed emergently at the bedside with immediate normalization of ECMO parameters. Flow rose from 3.1 liters per minute [LPM] to 5.1 LPM and SaO2 rose to 97%. Surgery revealed diffuse intraperitoneal hemorrhage, which was packed.

Although anticoagulation therapy was never renewed, intra-abdominal hemorrhage continued intermittently. The patient underwent six additional abdominal explorations but a source of bleeding was never found. He received overall 340 blood products (81 packed red blood cells, 60 cryoprecipitate, 123 platelets, and 76 plasma units). Thirty-nine days after ICU admission the patient died of septic shock.

Intra-abdominal hypertension resulting in ACS during ECMO has a reported mortality rate of 44%-100%.[1,2] The pathophysiological interactions proposed for this relationship include caval compression with inadequate venous return to the ECMO pump, compromised end organ perfusion due to increased vascular resistance in systemic and splanchnic beds stemming from intra-abdominal pressure and transmission of intra-abdominal pressure to the thoracic compartment and pleural space, leading to compromise of lung mechanics and gas exchange.

There is no standard therapeutic approach to IAH during ECMO support. Generally, a "step-up" approach from less to more invasive measures has been proposed, with decompressive laparotomy as the last measure if ECMO circuit flow is not renewed otherwise. Surgical opening of the abdomen may be lifesaving. Our case highlights the potential magnitude of the immediate clinical response to decompressive laparotomy. However, surgery during ECMO support may also lead to several complications, including fluid loss, fistula formation, failure to achieve fascial closure, and hemorrhage.

Bleeding has been reported in up to 60% of ECMO patients, more commonly with VA-ECMO.[3] The high risk of bleeding is linked to both patient-related and device-related factors. Critically ill patients often have one or more risk factors for bleeding. The non-biologic components of the ECMO circuit and the shear stress created by the pump further induce an acquired coagulopathy manifested as thrombocytopenia, decreased platelet function due to loss of surface molecules, hypofibrinogenemia, and loss of high-molecular-weight von Willebrand multimers.[3,4] Similar rates of hemorrhage and thrombosis have been described during ECMO with and without continuous systemic anticoagulation for 4-5 days.[3] However, preventing thromboembolism without increasing the risk of hemorrhagic complications during prolonged ECMO support remains a subtle balancing act. Prolonged avoidance of anticoagulation is not required after most surgeries, including decompressive laparotomy and with meticulous hemostasis, post-surgical bleeding may be preventable even during ECMO support with anticoagulation. However, there have been reports of a high incidence of hemorrhage regardless of surgery particularly during long ECMO runs. In such cases prolonged avoidance of anticoagulation may be required. Descriptions of anticoagulation-free ECMO support with no thrombotic complications[4] suggest that such practice may be safer than previously considered.

Our experience suggests that patients developing ACS with extracorporeal mechanical oxygenation failure may glean immediate benefit from decompressive laparotomy but in patients likely to require prolonged ECMO support (eg those with COVID-19), the increased risk of hemorrhagic complications must be balanced against the magnitude of the expected improvement when escalation to surgical intervention is considered.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## Ethical approval

The local Helsinki ethics committee has provided an exempt for Helsinki approval.

## Reference

1. Glowka TR, Schewe JC, Muenster S, et al. Decompressive laparotomy for the treatment of the abdominal compartment syndrome during extracorporeal membrane oxygenation support. *J Crit Care*. 2018;47:274-279. doi:10.1016/j.jcrc.2018.07.024.

2. Schulz SA, Schaefer S, Richards DC, et al. The need for emergency laparotomy with open abdomen therapy in the course of ECMO-A retrospective analysis of course and outcome. *Front Surg*. 2020;7:63. doi:10.3389/fsurg.2020.00063.
3. Olson SR, Murphree CR, Zonies D, et al. Thrombosis and Bleeding in Extracorporeal Membrane Oxygenation (ECMO) Without Anticoagulation: A Systematic Review. *ASAIO J Am Soc Artif Intern Organs*. 2021;67(3):290-296. doi:10.1097/MAT.0000000000001230.
4. Chung YS, Cho DY, Sohn DS, et al. Is Stopping Heparin Safe in Patients on Extracorporeal Membrane Oxygenation Treatment? *ASAIO J Am Soc Artif Intern Organs*. 2017;63(1):32-36. doi:10.1097/MAT.0000000000000442.