Critical Care

CORRESPONDENCE

Open Access

Intraoperative extracorporeal blood purification therapy during major septic vascular surgery

Céline Monard[1,3*], Philippe Tresson[2,4], Antoine Lamblin[1], Farida Benatir[1], Xavier-Jean Taverna[1] and Thomas Rimmelé[1,3]

Keywords: Anesthesia, Aortic surgery, Extracorporeal blood purification therapy, Major surgery, Prosthetic infection, Renal replacement therapy, Sepsis, Vascular surgery

The development of complex surgical procedures requires simultaneous development of enhanced intraoperative resuscitation therapies. Procedures such as extracorporeal organ support, usually performed in intensive care units (ICU), could be transferred to operating rooms.

Continuous renal replacement therapy (CRRT) may improve metabolic homeostasis during surgeries with ischemia–reperfusion [1]. Other extracorporeal blood purification therapies (EBP) such as hemoperfusion may decrease surgery-associated inflammation by removing inflammatory mediators from the blood. Cytokine adsorbers have been used safely during cardiopulmonary bypass [2]. Seraph® 100 (Exthera Medical, Martinez, CA, USA) is a new hemoadsorption device designed to adsorb pathogens [3, 4]. Since it decreases the blood pathogen load, it may attenuate sepsis when initiated early after bacterial release in the blood.

Surgery for aortic vascular or endovascular graft infection (VEGI) requires aortic clamping and may cause disseminated pathogenemia, resulting in major inflammation and metastatic infection. This surgery is associated with prolonged postoperative ICU stay (14 ± 12 days), high incidence of complications, and in-hospital mortality may reach up to 50% [5]. We hypothesized that an intraoperative enhanced resuscitation protocol combining CRRT and Seraph® 100 is safe and feasible and could improve outcomes. This letter provides the protocol description and the outcomes of the first patients consecutively treated and discusses the benefits and limitations of this procedure.

After VEGI confirmation, patients were scheduled for surgery with intraoperative CRRT and Seraph® 100. Empirical broad-spectrum antimicrobial therapy was initiated preoperatively, immediately after bacteriological sampling.

In the operating room, general anesthesia was performed according to standard practices. After induction, a dialysis catheter was inserted and continuous venovenous hemodialysis (CVVHD) was initiated with regional citrate anticoagulation (RCA). An EMiC®2 hemofilter was used and the Seraph® 100 cartridge incorporated between the blood pump and the hemofilter. Blood flow was set between 100 and 120 mL min^{-1} and dialysate flow between 25 and 30 mL kg^{-1} h^{-1}. An ICU nurse, trained in CVVHD and Seraph® 100 use, was in charge of the session monitoring. Dialysate composition, citrate, and calcium replacement were adjusted during surgery as needed. At the end of surgery, blood was returned to the patient before transfer to the ICU where CRRT could be resumed (or not) depending on hemodynamic and metabolic status.

*Correspondence: celine.monard@chu-lyon.fr

[1] Service d'Anesthésie-Réanimation, Hôpital Edouard Herriot, Hospices Civils de Lyon, Lyon, France
Full list of author information is available at the end of the article

Table 1 Patient characteristics

Patient	1	2	3	4	5	6
Age (years)	78	18	58	75	61	68
Comorbidities	Diabetes Solid tumor KB infection	Denutrition Multiple ECMO complications (CCA after PE)	Denutrition Ischemic cardiopathy OALL	Hypertension Aorto-enteric fistula	Denutrition Hypertension Solid tumor OALL	Hypertension Diabetes COPD
Medical history						
Previous graft	Aortic endograft for mycotic pseudoaneurysm	Ilio-femoral prosthetic graft for bypass rupture	Aorto-bifemoral graft	Aortic endograft for aorto-enteric fistula	Aorto-bifemoral graft	Aorto-bifemoral graft
Preoperative characteristics	Disseminated KB infection	Chronic sepsis, hospitalized in ICU for 4 months	Groin infection with wound leaking	Fistula between endograft and duodenum	Groin infection: drainage and NPWT	Groin and aortic graft infection
Surgical information						
Surgery description	Endograft removal with aorto-biiliac CAA reconstruction	Graft removal with in situ CAA reconstruction	Graft removal with CAA reconstruction	Endograft removal with CAA reconstruction + intestinal procedure	Graft removal with CAA reconstruction	Graft removal with CAA reconstruction
Surgery duration (minutes)	259	253	303	396	381	362
Aortic clamping duration (minutes)	80	89	72	71	101	102
Anesthesia information						
Red blood cell units (n)	3	2	2	2	2	0
Crystalloids (mL)	8600	3000	6500	7000	11,000	5000
Maximal norepinephrine dose (µg/kg/min)	0.9	0.4	1,7	0.4	0.8	0.4
Worst intraoperative pH	7.14	7.26	7.18	7.29	7.24	7.25
End-of-surgery K^+ level (mmol/L)	4.3	4.1	5.5	3.3	4.2	5.2
End-of-surgery lactate level (mmol/L)	5.4	3.1	3.8	3.7	5.9	2.9
Outcomes						
Postoperative MV duration (hours)	48	5	20	3	48	6
Postoperative RRT duration (h)	30	0	24	16	16	46
Postoperative vasopressors duration (days)	1	0	3	2	3	1
ICU LOS (days)	6	17	4	7	11	3
Hospital LOS (days)	17	146	11	17	20	27

Table 1 (continued)

Patient	1	2	3	4	5	6
Adverse events						
Intraoperative complications	None	None	None	Ionized hypocalcemia 1.06 mmol/L	Ionized hypocalcemia 0.93 mmol/L	Ionized hypocalcemia 1.08 mmol/L
Postoperative complications	At 4 months, relapse of aortic infection with KB	Pursuit of NPWT	None	None	Mesenteric ischemia at POD 6	None
Status at 3 months	Alive	Alive	Alive	Alive	Alive	Alive

Kb, Koch's bacillus; CAA, Cryopreserved arterial allograft; CCA, Cardiocirculatory arrest; ECMO, Extracorporeal membrane oxygenation; MV, Mechanical ventilation; OALL, Obliterating arteriopathy of the lower limbs; NPWT, Negative-pressure wound therapy; LOS, Length of stay; ICU, Intensive care unit; PE, Pulmonary embolism; POD, Postoperative day; RRT, Renal replacement therapy

Between December 2021 and May 2022, 6 patients underwent excision of vascular graft and infected tissues associated with in situ reconstruction using cryopreserved arterial allografts. They all received intraoperative CRRT and Seraph® 100. The median [interquartile range, IQR] end-of-surgery lactate and potassium levels were 3.7 [3.2–5] and 4.2 [4.1–4.9] mmol l^{-1}. The median [IQR] postoperative ICU length of stay was 6.5 [4.5–10] days. All patients were alive 3 months after the procedure. One patient required a secondary surgical procedure at postoperative day 6 for mesenteric ischemia. Three patients exhibited intraoperative ionized hypocalcemia. No other EBP therapy-related adverse event was observed (Table 1).

The procedure was easily implemented thanks to a productive collaboration between anesthesiologists and intensivists and met broad support from the surgical team as it did not interfere with the surgical procedure and was perceived as improving intraoperative hemodynamic stability. However, it required the presence of a dedicated and trained ICU nurse.

Because vascular clamping is prolonged during VEGI surgeries, patients often present major metabolic disturbances and up to 50% of them require RRT at ICU admission [5]. We initiated intraoperative RRT to target metabolic homeostasis, and none of these patients experienced severe acidosis or hyperkalemia. Importantly, RCA enabled EBP without heparin anticoagulation, which is safer in this surgical context. RRT was discontinued within 48 h after ICU admission for all patients.

The use of Seraph® 100 might have improved the intraoperative hemodynamic stability, as this pathogens' adsorption device may offer a better control of inflammation. All of intraoperative blood cultures remained negative, and we hypothesized that preoperative administration of antimicrobials decreased their sensitivity. Drug removal through the extracorporeal circuit should be questioned, although no interference with anesthesia was observed.

We report the first cases of intraoperative EBP combining RRT and pathogen hemoadsorption for VEGI surgeries. This treatment is feasible and associated with excellent outcomes compared to what is usually observed. Despite severe preoperative conditions, all patients were alive after 3 months. Intraoperative extracorporeal kidney and immunologic support may be combined in other specific situations including endocarditis, composite tissue allografts, and complex liver surgery. These findings need to be further evaluated in interventional trials.

Abbreviations

CRRT: Continuous renal replacement therapy; CVVHD: Continuous veno-venous hemodialysis; EBP: Extracorporeal blood purification; ICU: Intensive care unit; IQR: Interquartile range; RCA: Regional citrate anticoagulation; RRT: Renal replacement therapy; VEGI: Vascular or endovascular graft infection.

Acknowledgements

The authors thank the ICU and anesthetic nurses, particularly Caroline Frno (Service d'Anesthésie-Réanimation, Hôpital Edouard Herriot, Hospices Civils de Lyon, Lyon, France), for their active and determinant contribution in this protocol. They also thank P[r] Xavier Armory, PharmD, PhD (Pharmacy department, Hôpital Edouard Herriot, Hospices Civils de Lyon, Lyon, France), and Dr Andre Boibieux, MD (Unité mobile de maladies infectieuses, Hôpital Edouard Herriot, Hospices Civils de Lyon, Lyon, France), for their support, as well as Valérie Cerro (Service d'Anesthésie-Réanimation, Hôpital Edouard Herriot, Hospices Civils de Lyon, Lyon, France) and Hélène Boyer, PhD, (Hospices Civils de Lyon) for their help in manuscript preparation.

Author contributions

CM and TR developed the protocol, collected and interpreted data, and drafted the manuscript. PT and XJT developed the protocol, participated in patients' enrollment, and critically reviewed the manuscript. AL and FB participated in patients' enrollment and critically reviewed the manuscript. All authors read and approved the final manuscript.

Funding

This study was not funded. Exthera Medical provided the Seraph 100® cartridges for the study at no charge. However, the company did not participate in the protocol development, data collection, analysis, and interpretation, nor in the manuscript writing.

Availability of data and materials

The dataset is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

NA.

Consent for publication

Signed informed consent for publication of case report was obtained from all patients, and all of them had the opportunity to read the manuscript.

Competing interests

CM has received speakers fees from Fresenius Medical Care. PT has no competing interest to declare. AL has no competing interest to declare. FB has no competing interest to declare. XJT has no competing interest to declare. TR has received speakers fees from Fresenius Medical Care and Exthera Medical.

Author details

[1]Service d'Anesthésie-Réanimation, Hôpital Edouard Herriot, Hospices Civils de Lyon, Lyon, France. [2]Service de Chirurgie Vasculaire et Endovasculaire, Hôpital Louis Pradel, Hospices Civils de Lyon, Bron, France. [3]EA 7426, PI3 (Pathophysiology of Injury-Induced Immunosuppression), Université Claude Bernard Lyon 1-Biomérieux-Hospices Civils de Lyon, Lyon, France. [4]Centre de Référence des Infections Vasculaire Complexes (CRIVasc Network), Hospices Civils de Lyon, Lyon, France.

Received: 12 December 2022 Accepted: 16 December 2022
Published online: 27 December 2022

References

1. Karvellas CJ, Taylor S, Bigam D, et al. Intraoperative continuous renal replacement therapy during liver transplantation: a pilot randomized-controlled trial (INCEPTION). Can J Anaesth. 2019;66(10):1151–61. https://doi.org/10.1007/s12630-019-01454-0.
2. Poli EC, Alberio L, Bauer-Doerries A, et al. Cytokine clearance with CytoSorb® during cardiac surgery: a pilot randomized controlled trial. Crit Care. 2019;23(1):108. https://doi.org/10.1186/s13054-019-2399-4.
3. Chitty SA, Mobbs S, Rifkin BS, et al. A multicenter evaluation of the Seraph 100 microbind affinity blood filter for the treatment of severe COVID-19. Crit Care Explor. 2022;4(4):e0662. https://doi.org/10.1097/CCE.0000000000000662.

4. Seffer MT, Cottam D, Forni LG, Kielstein JT. Heparin 2.0: a new approach to the infection crisis. Blood Purif. 2021;50(1):28–34. https://doi.org/10.1159/000508647.
5. Garot M, Delannoy PY, Meybeck A, et al. Intra-abdominal aortic graft infection: prognostic factors associated with in-hospital mortality. BMC Infect Dis. 2014;14:215. https://doi.org/10.1186/1471-2334-14-215.

Publisher's Note