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Case report

Utilization of ECMO in vascular surgery: A presentation of two cases

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ABSTRACT

Introduction: Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) is a form of temporary mechanical circulatory support commonly used during cardiothoracic interventions. Malperfusion during complex vascular procedures remains a significant risk that may potentially lead to multiple complications. Here, we report two cases highlighting the efficacy of VA-ECMO in both planned and emergent vascular interventions.

Presentation of case: In our first case, VA-ECMO was used to support an 82-year-old male during a high-risk thoracoabdominal aortic aneurysm repair. Our second case details an emergent pulmonary embolectomy in which VA-ECMO was used as a bridge to cardiopulmonary bypass. In both cases, the procedures were well-tolerated, and the patients were discharged 17 days postoperatively.

Discussion: VA-ECMO has been increasingly used as a form of post-operative circulatory support following cardiothoracic and vascular interventions. However, only few instances of perioperative VA-ECMO use have been reported in the field of vascular surgery.

Conclusion: The presented cases highlight that the perioperative use of VA-ECMO may be a viable modality for required perfusion during complex planned or emergent vascular procedures.

1. Introduction

Extracorporeal membrane oxygenation (ECMO) is a temporary mechanical cardiopulmonary support system that has been utilized to maintain perfusion in critically ill patients. It allows for either pulmonary or cardiopulmonary support, depending on the chosen configuration. While veno-venous (VV) ECMO mainly provides respiratory support, veno-arterial (VA) ECMO provides both cardiac and pulmonary support [1]. It does so by draining deoxygenated blood from the right atrium via a venous cannula, while an arterial cannula returns oxygenated blood in a retrograde fashion to the aorta (Fig. 1). Arterial cannulation, through vascular cutdown or percutaneous access, can occur in multiple different sites including the femoral and axillary arteries, or ascending aorta. In emergent situations where rapid cannulation is needed, peripheral VA-ECMO is most common. Due to ease of vascular access, femoro-femoral VA-ECMO allows cannulation to be achieved even in patients undergoing active resuscitation [2].

According to the Extracorporeal Life Support Organization registry, >25,000 adults have been treated using VA-ECMO with 44% surviving to discharge or transfer [3]. VA-ECMO in particular has been utilized for the effective management of a variety of complications such as cardiogenic shock, pulmonary hypertension, and massive pulmonary embolism (PE) [1]. In addition, it has been extensively explored as a method of circulatory support for high-risk cardiothoracic procedures. For example, VA-ECMO has been successfully used throughout the entire perioperative care of lung transplant patients, including as a bridge to lung transplantation, intraoperatively, or extended into the post-operative period in select patients [4,5]. However, its utilization in vascular surgery has been limited. While few studies have documented the use of ECMO for post-operative circulatory support following vascular interventions, even fewer have explored its peri-operative uses in vascular surgery. We present two cases highlighting the efficacy of VA-ECMO during both planned and emergent vascular interventions.

This work has been reported in accordance with the SCARE 2020 criteria [6].

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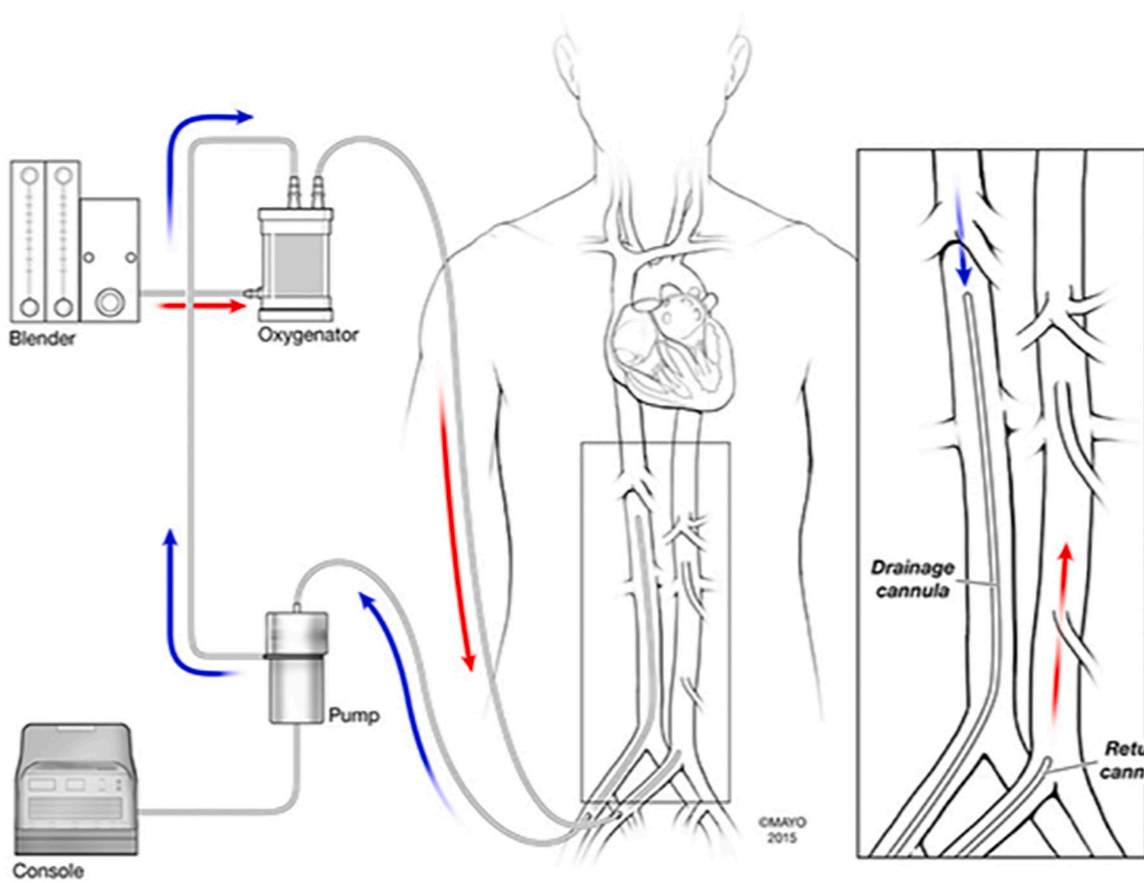

Fig. 1. Femoro-femoral VA-ECMO with drainage and return cannulas in the right common femoral vein and artery, respectively.

2. Presentation of cases

2.1. Case 1

An 82-year-old male with a history of hypertension and supraventricular tachycardia presented with a type II, 6.8-cm thoracoabdominal aortic aneurysm (TAAA). The patient opted to proceed with surgical intervention by the vascular surgery team. A spinal drain was placed, and the aneurysm was exposed via a conventional thoracoabdominal approach. VA-ECMO was initiated via the left common femoral artery and vein. The patient received 12.5 g mannitol and 40 mg furosemide before aortic clamping. An aortic multi-branched graft was used (Gelweave, Terumo, Tokyo, Japan; Fig. 2). The proximal aortic graft anastomosis was created in the chest cavity while maintaining perfusion to the viscera, kidneys, and lower extremities through the ECMO system. Visceral (celiac and superior mesenteric arteries) and left renal anastomoses were created in a sequential fashion without interruption of the ECMO circulation. Ischemia time during each individual arterial anastomosis was under 13 min. The infrarenal aorta was clamped and ECMO discontinued. The aneurysm sac was accessed, and the origin of the right renal artery was anastomosed in an end-to-end fashion. Renal preservation solution was infused through an irrigating occluding catheter. The distal anastomosis to the aortic bifurcation was created in an end-to-end fashion. Total ECMO time was approximately 3 h with an average flow of 5 L/min. The patient maintained normal renal function and was discharged 17 days postoperatively.

2.2. Case 2

An 86-year-old male with a history of multiple risk factors presented with gross hematuria and a 6.4 cm right renal mass. Imaging demonstrated extensive cancer with a tumor thrombus extending into the inferior vena cava (IVC). The patient opted to proceed with an open nephrectomy with vena cava thrombectomy. Following excision of the kidney, transesophageal echocardiogram (TEE) showed that the IVC thrombus had dislodged towards the proximal right pulmonary artery. Blood pressure declined to 45/34 mmHg, desaturation by 17%, and ETCO2 reached 13 mmHg, with no response to standard treatment and resuscitation. In addition, echocardiogram revealed concomitant severe right ventricle dilatation and failure. Because the patient was not prepared for a sternotomy incision, we proceeded with femoral VA-ECMO in order to provide urgent cardiopulmonary support. We used a hybrid ECMO-cardiopulmonary bypass circuit which allows for a smooth transition from VA-ECMO to full cardiopulmonary bypass in minutes [7]. The patient stabilized immediately following the initiation of ECMO, facilitating the correction of acidosis, weaning off vasopressors, and preparation for a full sternotomy and pulmonary embolectomy by the cardiac team. The patient's blood pressure stabilized at 120/70 mmHg 50 min later, allowing for the conversion from VA-ECMO to full cardiopulmonary bypass using the same cannulas. The large tumor embolus was removed fully. The patient was weaned off cardiopulmonary bypass 1 h after initiation, remained hemodynamically stable following intervention, and was extubated on postoperative day 17.

3. Discussion

Since its invention, VA-ECMO has been commonly used as a lifesaving device for critically ill patients. It has been employed in the management of cardiac arrest and refractory postcardiotomy shock among other emergent scenarios. With recent advances, VA-ECMO has become more widely used in the field of cardiothoracic surgery as a bridge to transplant or recovery [4,5]. Additionally, many cases have

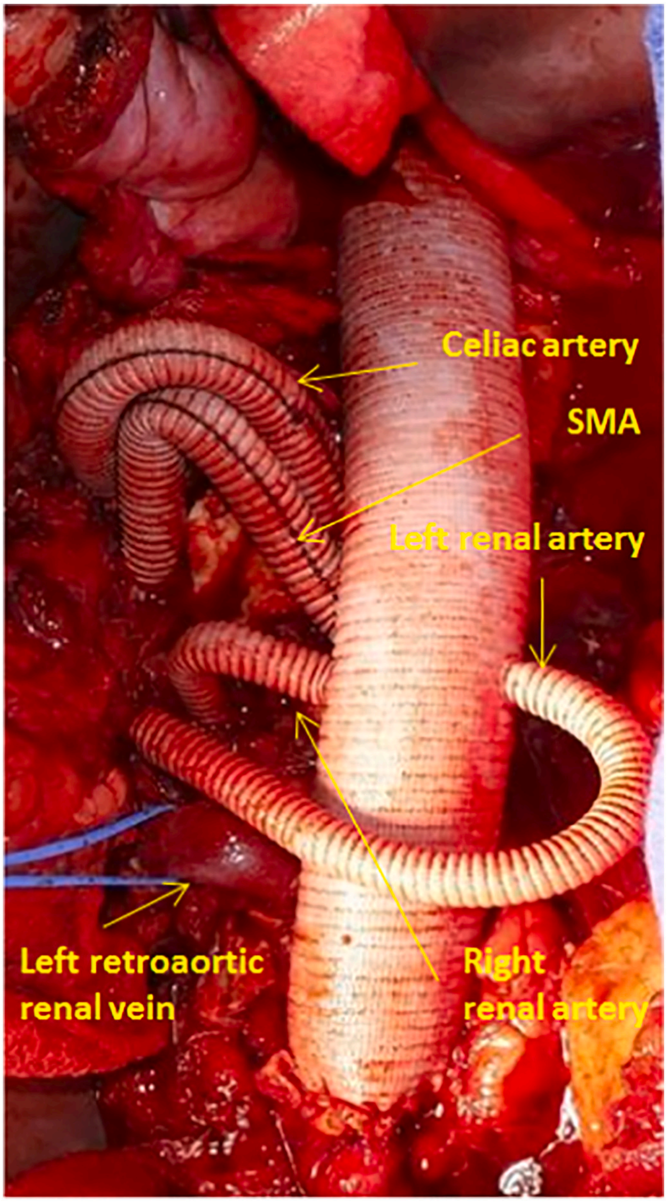

Fig. 2. Aortic multibranched graft. SMA, Superior mesenteric artery.

detailed its success in maintaining hemodynamic stability following surgical treatment of iatrogenic type A aortic dissections and acute respiratory distress syndrome, following thoracoabdominal aortic aneurysm (TAAA) repair [8,9]. The majority of these studies have emphasized the use of ECMO for post-operative circulatory support following vascular interventions, while peri-operative utilization of ECMO in the vascular surgery field remains largely unexplored in literature (Table 1).

The potential role of ECMO in planned vascular interventions remains unclear. Although open and endovascular surgical repair have been the preferred methods of treatment, complex vascular procedures such as TAAA are associated with a myriad of risks including paralysis, acute kidney injury, and in-hospital mortality [10]. However, there have been reports of successful implementation of VA-ECMO during abdominal aortic aneurysm (AAA) repair. A study by Abouliatim et al. reports two cases in which VA-ECMO was utilized in combination with an open AAA repair, following a failed endovascular attempt in a high-risk patient. Hemodynamic stability was maintained and both patients were discharged 12 days postoperatively [11]. Similarly, VA-ECMO can be an

Table 1
Review of literature reporting intraoperative ECMO use in vascular surgery.

Reference	Study design, patient data	Planned or emergent ECMO	Outcome
Abouliatim et al. [11], 2012	Case report, 82-year-old male & 70-year-old male	Planned	Patients were discharged 12 days following open AAA, 100% survival
Yusuff et al. [12], 2015	Literature review, 78 patients with an average age of 49.5 years	Planned & Emergent	ECMO + surgical embolectomy, 69.2% survival ECMO + thrombolysis, 43.8% survival ECMO alone, 100% survival
Cao et al. [13], 2016	Case report, 72-year-old female	Emergent	Patient was discharged 2 months post-op, 100% survival
Pavlovic et al. [14], 2014	Case report, 52-year-old female	Emergent	Patient was discharged 15 days post-op, 100% survival
Pasrija et al. [15], 2018	Retrospective review, 56 patients with a median age of 55 years	Planned	ECMO as primary intervention, 97% survival ECMO as a bridge to embolectomy, 82% survival

effective device in the management of TAAA when partnered with surgical intervention by allowing for uncompromised perfusion throughout the procedure. Limiting ischemia time and cardiac overload throughout the duration of aortic cross-clamping is crucial to preventing post-operative morbidities. In our first case, planned use of VA-ECMO allowed for preserved perfusion and reduced ischemia to major organs during an open TAAA repair. As a result, the patient had a stable post-operative course and maintained normal renal function. Further literature reporting the planned utilization of ECMO during vascular interventions is extremely limited.

Additionally, VA-ECMO can be a life-saving tool when utilized in emergent settings. Peri-operative massive PE, for example, is generally associated with severe complications. Due to its rarity, a standard treatment strategy has not yet been determined, although options include surgical embolectomy, thrombolysis, and catheter embolectomy. Studies have shown that surgical embolectomy or thrombolysis partnered with the use of ECMO for rapid reperfusion can reduce in-hospital deaths involving acute PE. For instance, a study by Yusuff et al. reports a variety of cases in which ECMO was used in conjunction with surgical embolectomy and thrombolysis, with ECMO + embolectomy yielding the highest survival rate (69.2%) when compared to ECMO + thrombolysis (43.8%) [12]. Additionally, a case report by Cao et al. details an occurrence of acute PE successfully managed through thrombolysis partnered with ECMO following 100 min of cardiopulmonary resuscitation (CPR). Despite requiring renal replacement therapy, the patient recovered and was discharged two months postoperatively [13]. ECMO can also be utilized as a sole treatment for PE when conventional methods are contraindicated. In a case by Pavlovic et al., VA-ECMO was used as a therapeutic method providing hemodynamic stability until clot dissolution occurred. The patient was successfully weaned off ECMO on postoperative day 3 and was discharged on postoperative day 15 [14]. Similarly, the aforementioned study by Yusuff et al. summarizes 15 additional cases in which ECMO was used alone in the setting of PE with 100% survival [12]. The use of ECMO alone or in combination with surgical treatments highlights its versatility while yielding favorable results in literature. A study by Pasrija et al. further emphasizes this through its discussion of the use of VA-ECMO both as a primary intervention as well as a bridge to surgical embolectomy with comparable in-hospital survival rates of 97% and 82%, respectively [15]. As highlighted in the literature, early detection and reperfusion are crucial to reducing patient mortality.

In our second case, the PE was quickly identified via TEE as the patient became unstable. Through collaborative effort, he was placed on emergent VA-ECMO about 20 min following the initiation of effective CPR. ECMO support allowed for the quick restoration of organ perfusion and oxygenation, especially to the brain, as well as resuscitation of the patient while preparing for the pulmonary embolectomy. Thereby, the risk of neurological and end-organ damage was reduced by providing sufficient tissue perfusion and oxygenation throughout the median sternotomy. Furthermore, because ECMO requires a lower level of anticoagulation (activated clotting time (ACT) from 180 to 250 s) than full cardiopulmonary bypass (ACT >500 s), there is much less bleeding, especially with the extensive abdominal dissection seen in our second patient [7].

When weighing the risks and benefits of intraoperative VA-ECMO use, several patient-specific factors and potential complications should be taken into consideration. For instance, femoral arterial cannulation can potentially lead to vascular injuries such as arterial dissections or acute thrombosis. However, while such complications may require future vascular intervention, they have not been associated with increased mortality [16]. In some severe cases, reduced distal perfusion caused by femoral arterial cannulation has also been found to result in lower limb ischemia requiring amputation [17]. Notably, peripheral arterial disease and pulmonary disease have been found to be predictors of the above-mentioned vascular complications, independent of other cardiovascular risk factors such as diabetes mellitus [16,18]. A correlation between younger age and increased incidence of limb ischemia following VA-ECMO has also been documented [18]. This is thought to be due to a lack of existing collateral circulation which is typically seen in elderly populations and those with peripheral arterial disease. Therefore, it should be noted that younger adults without adequate collateral circulation as well as those with severe peripheral arterial disease or pulmonary disease may not be appropriate candidates for intraoperative VA-ECMO. In our case, the patients did not suffer any vascular complications following their respective procedures.

4. Conclusion

ECMO has proven to be an effective tool in managing a variety of complications during complex surgical interventions. Yet, its use in vascular surgery remains limited. Our cases showed that utilization of VA-ECMO during both emergent and planned vascular interventions allowed for continuous and successful perfusion to key organs. Therefore, VA-ECMO can be considered a safe alternative or bridge to conventional mechanical bypass support systems for selected vascular surgeries. Future studies exploring the perioperative use of ECMO in vascular surgery are warranted.

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Ethical approval

Not applicable.

Consent

Informed consent was obtained from the patients for the publication of these cases. Proof of consent is available to the Editor-in-Chief of this journal upon request.

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Declaration of competing interest

None declared.