

# Single-center surgical site infection rate after peripheral ECMO decannulation and surgical repair

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## Abstract

**Objective:** Extracorporeal membrane oxygenation (ECMO) is used to provide heart–lung bypass support in cases of acute respiratory and cardiac failure. The two main classifications of ECMO are venoarterial (VA) and venovenous (VV). After the patient recovers from an acute state, ECMO decannulation from the groin often requires femoral exploration and vessel repair. This study was performed to quantify the rate of surgical site infection (SSI) after ECMO decannulation.

**Methods:** Retrospective single-institutional review of patients requiring ECMO from January 2016 to October 2019 was conducted. The study examined incidence of SSI. We evaluated preoperative risk factors, VA versus VV ECMO, Szilagyi infection score, and postoperative management.

**Results:** Initial search began with 176 ECMO cases, of which 106 patients were deceased before development of any infection. Eighteen were eliminated because of central ECMO access, and four were lost to chart privacy. Of the 154 patients requiring femoral ECMO, 48 (31%) survived, with 22 VA and 26 VV ECMO. Twelve patients were classified as infected, resulting in an overall SSI rate of 25%. Surgical repair of the femoral arterial cannulation site was required in the 22 VA ECMO patients, and 10 of these became infected, resulting in an infection rate of 45%. The remaining two infected were VV ECMO and did not require surgery. The VV ECMO SSI rate was 7.7%. The infected group of VA ECMO consisted of eight primary surgical repairs and two patch repairs. Eight of the patients required multiple reoperations and two required antibiotics and wound care alone. There was no instance of limb loss. Statistical analysis showed intraoperative transfusion of >250 ml and blood loss of >300 ml as the only predictive factors of infection. The Szilagyi score was found to be worse in patients requiring patch angioplasty.

**Conclusion:** Surgical repair of ECMO arterial cannulation sites had postoperative SSIs in nearly half of the patients (45%). The VV ECMO SSI rate was found to be 7.7%. Severity of infection was worse in more complicated repairs. Overall ECMO mortality was high at 69%. Although we found no clear correlation with common risk factors, transfusions >250 ml and blood loss >300 ml were found to be predictive. Vascular surgeons should be aware of high risk of SSI with repair of femoral ECMO cannulation sites.

**Keywords:** ECMO, femoral artery repair, surgical site infection, Szilagyi score

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## Introduction

Extracorporeal membrane oxygenation (ECMO) is used to provide heart–lung bypass support in cases of acute respiratory and cardiac failure. The

two main classifications of ECMO are venoarterial (VA) and venovenous (VV). The femoral vessels are the most common percutaneous access sites for cannulation in both VA and VV ECMO.

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Once the patient recovers from an acute state, VA ECMO decannulation from the groin requires femoral exploration and arterial repair. This decannulation and surgical repair is often completed by vascular surgeons and carries a high risk for complications such as vascular injury, hemorrhage, lymphocele, limb ischemia, and wound infection.<sup>1</sup> Peripheral VV ECMO decannulation most often requires removing the catheters at bedside and applying manual pressure for hemostasis.

Cannulation-related complications have been reported in 25% of patients on VA ECMO and are directly related to cannulation technique and decannulation repair.<sup>1</sup> This high incidence of complications in VA ECMO patients is concerning, especially in a critically ill population with high rates of morbidity and mortality. One of the major concerns for vascular surgeons performing decannulation is the possibility of surgical site infection (SSI). Previous investigations of femoral cannulation for VA ECMO have reported SSI rates between 7% and 20%.<sup>2</sup> Infections in this patient population are often attributed to existing comorbidities, which also increase the risk of infection in the femoral region.<sup>2</sup> Although the rate of SSI in the VV ECMO population is not well studied, recent literature reports an incidence of 9.7%.<sup>3</sup>

SSI rates after ECMO decannulation vary widely in the literature, and we believe it is important to evaluate this rate and associated risk factors to improve overall outcomes. Thus, we conducted the following study to quantify the rate of groin infection after ECMO decannulation and identify the leading risk factors for infection.

### Methods

This is a retrospective analysis of patients who presented to Houston Methodist Hospital requiring ECMO insertion from January 2016 to October 2019. Patient data were collected from electronic medical records under an institutional review board–approved protocol. Patients who died with ECMO cannula still in place, who received central ECMO without groin cannulation, or who had data privacy concerns were excluded. Prophylactic cefazolin was administered before ECMO cannulation and before decannulation and surgical repair. All ECMO cannulation was performed using percutaneous

sterile technique with single lumen cannulas only. No ECMO circuit reconfiguration was performed in the patients studied. After decannulation, our standard surgical wound care protocol is bandage removal on postoperative day 2, then daily evaluation of the wound after left open to the air by the surgical team. All SSIs were noted during the same hospital admission. Only patients with SSIs were included. All patients who developed other forms of infection were excluded from the study.

We collected patient data such as age, sex, body mass index (BMI), race, smoking status, estimated blood loss, packed red blood cell (pRBC) transfusions, and comorbidities including congestive heart failure (CHF), coronary artery disease (CAD), diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), hyperlipidemia (HLD), hypertension (HTN), chronic kidney disease (CKD), end-stage renal disease (ESRD), and history of transplant on known risk factors for SSI. Surgical and postsurgical data included ECMO operative details, time on ECMO, postoperative outcomes, reoperation outcomes, Szilagyi infection score, and postoperative management. The Szilagyi scoring system grades groin wound breakdown and infection into grades I–III, described in Table 1. Type of incision and indication for ECMO were not consistently noted in the operative details and, therefore, were not included in this analysis.

All analyses were performed with STATA version 16 (StataCorp. 2019. Stata Statistical Software Release 16; StataCorp LLC, College Station, TX). Statistical significance was defined as two-tailed  $p < 0.05$ . Data were presented as mean  $\pm$  standard deviation (SD) or median (interquartile range) for continuous variables and number (percentage) for categorical variables. The Mann–Whitney  $U$  test or Fisher's exact test was used for comparisons between types of ECMO and between infected and noninfected patients. Fisher's exact test was used to determine the correlation between risk factors and infected patients.

### Results

Of the 176 peripheral ECMO cases initially identified, 154 had femoral access, of whom 48 (31%) survived and were included in the study. We excluded 106 patients who died before developing any infection, 18 who had central access, and

**Table 1.** Szilagy classification of infections.

Szilagy classification	
Grade I	Ischemic necrosis and wound breakdown (dermis only)
Grade II	Ischemic necrosis and wound breakdown (subcutaneous)
Grade III	Open, infected wound with involvement of bypass graft

4 who were lost to chart privacy concerns. The 48 patients in our sample comprised 22 VA and 26 VV ECMO cases. Twelve patients had SSI, for an overall infection rate of 25%. Surgical repair of the femoral arterial cannulation site was required in all 22 VA ECMO patients. Ten developed SSI, giving a VA ECMO SSI rate of 45%. The infected VA ECMO group consisted of eight primary surgical repairs and two patch repairs. Eight of the VA ECMO patients with SSI required multiple reoperations, and two required antibiotics and wound care alone. Because all VA ECMO patients in our facility had a 6-French antegrade sheath placed, no patients suffered limb amputation. Two of the 26 VV ECMO patients developed SSI, resulting in an incidence of 7.7%. Neither required surgery.

The only predictive indicators for SSI revealed by statistical analysis were intraoperative blood transfusion >250ml and blood loss >300ml (Table 2). Szilagy scores were worse in patients requiring patch angioplasty (Table 3). While the only statistically significant predicative factors we identified were blood transfusion >250ml and blood loss >300ml, it is widely believed that comorbidities and technique can directly influence the risk of SSI<sup>4</sup> (Table 4).

## Discussion

SSIs have been identified as the most common and costly hospital-acquired infection and are responsible for a 2- to 11-fold increase in mortality.<sup>5</sup> Our aim was to quantify SSI rates in ECMO patients at our institution and identify predictive associations that placed patients at an increased risk of infection. The overall SSI rate in our

sample of 48 patients was consistent with national averages at 25%; however, we found a significantly elevated VA ECMO infection rate at our institution. This is a higher rate of infection compared with similar studies of VA ECMO SSIs, although these usually included both central and peripheral ECMO cannulation. Our VV ECMO SSI rate is lower than what has been previously reported, although literature regarding VV ECMO SSI is limited. It is important to note that many ECMO cannulations were done emergently, with inconsistent aseptic technique. Data regarding the exact number of emergent cases were unavailable, and therefore not included in our analysis.

We looked for associations between SSI status and baseline characteristics considered potential risk factors for ECMO SSI. Statistical analysis showed an association between blood transfusion (average 250ml) and increased risk of SSI. Although blood transfusion is not often a primary consideration for assessing SSI risks, prior research has reported an increase in morbidity and mortality in patients receiving 2 units of blood transfusion perioperatively, which was consistent with our findings.<sup>6</sup> None of the other risk factors evaluated had a statistically significant association with SSI, although smoking approached significance ( $p=0.06$ ).

Szilagy scoring was used to classify the extent of infection in our patients. We did not encounter any class III infections, so they were not included in our analysis. We compared baseline characteristics with the extent of infection classified with Szilagy scoring.<sup>7</sup> There were equal numbers of class I and class II infections, and none of the baseline characteristics proved to be statistically significant.

We also analyzed infections by type of ECMO compared with known risk factors and found that blood loss >300ml was significantly associated with SSI in VA ECMO patients. No other statistically significant risk factor was identified. In our literature review, we noted a lack of published data concerning peripheral VA ECMO cannulation SSI rates. Blood loss is not often cited as a risk factor for SSI, although blood transfusion is frequently associated with infection risk.<sup>6</sup> Our finding confirms that increased blood transfusions due to blood loss have a significant association with increased VA ECMO SSI rates.

**Table 2.** Baseline characteristics by infected status.

	Noninfected (n=36)	Infected (n=12)	p value
Age	51.8 ± 13.4	48.8 ± 14.4	0.65
Male	28 (77.8)	6 (50)	0.14
BMI	31.0 ± 9.3	31.9 ± 7.6	0.76
No. of days on ECMO	7.2 ± 5.3	7.9 ± 4.9	0.60
EBL	150 (50–600)	250 (125–450)	0.90
Intraoperative pRBC (ml)	0 (0–0)	250 (0–600)	0.01
Race	n = 35	n = 12	0.54
Caucasian	22 (62.9)	8 (66.7)	
Black	6 (17.1)	1 (8.3)	
Hispanic	4 (11.4)	3 (25.0)	
Asian	3 (8.6)	0 (0)	
Smoker			0.06
No	22 (61.1)	4 (33.3)	
Current	1 (2.8)	3 (25.0)	
Former	10 (27.8)	3 (25.0)	
Unknown	3 (8.3)	2 (16.7)	
DM	13 (36.1)	5 (41.7)	0.74
COPD	6 (16.7)	1 (8.3)	0.66
CAD	13 (36.1)	6 (50)	0.5
CHF	10 (27.8)	1 (8.3)	0.25
HLD	12 (33.3)	5 (41.7)	0.73
HTN	24 (66.7)	8 (66.7)	1
CKD	9 (25)	3 (25)	1
ESRD	5 (13.9)	0 (0)	0.31
Transplant			0.92
No	26 (72.2)	9 (75)	
Heart	4 (11.1)	2 (16.7)	
Lung	4 (11.1)	1 (8.3)	
Kidney	2 (5.6)	0 (0)	
PAD	1 (2.9)	1 (8.3)	0.45
Immunosuppressant drugs	13 (38.2)	6 (50)	0.51

(Continued)

**Table 2.** (Continued)

	Noninfected ( <i>n</i> =36)	Infected ( <i>n</i> =12)	<i>p</i> value
Type of CFA repair			0.41
Primary	27 (84.4)	10 (83.3)	
Patch	2 (6.2)	2 (16.7)	
PTFE	3 (9.4)	0 (0)	

Data were presented as mean  $\pm$  SD or median (interquartile range) for continuous variables and number (percentage) for categorical variables. The Mann–Whitney *U* test or Fisher’s exact test was used for comparison between infected and noninfected.

BMI, body mass index; CAD, coronary artery disease; CFA, common femoral artery; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; EBL, estimated blood loss; ECMO, extracorporeal membrane oxygenation; ESRD, end-stage renal disease; HLD, hyperlipidemia; HTN, hypertension; PAD, peripheral arterial disease; pRBC, packed red blood cell; SD, standard deviation; PTFE, polytetrafluoroethylene.

**Table 3.** Baseline characteristics by type of Szilagy.

	Type of Szilagy		<i>p</i> value
	1 ( <i>n</i> =6)	2 ( <i>n</i> =6)	
Age	51.3 $\pm$ 11.1	46.3 $\pm$ 17.9	0.85
Male	3 (50)	3 (50)	1.0
BMI	32.0 $\pm$ 8.4	31.8 $\pm$ 7.5	0.82
No. of days on ECMO	8.7 $\pm$ 4.8	7.2 $\pm$ 5.3	0.67
EBL	125 (0–400)	300 (200–1285)	0.16
Intraoperative pRBC (ml)	0 (0–300)	300 (200–1171)	0.27
Race			1.0
Caucasian	4 (66.7)	4 (66.7)	
Black	0 (0)	1 (16.7)	
Hispanic	2 (33.3)	1 (16.7)	
Asian	0 (0)	0 (0)	
Smoker			0.16
No	1 (16.7)	3 (50)	
Current	2 (33.3)	1 (16.7)	
Former	3 (50)	0 (0)	
Unknown	0 (0)	2 (33.3)	
DM	2 (33.3)	3 (50)	1.0
COPD	1 (16.7)	0 (0)	1.0

*(Continued)*

**Table 3.** (Continued)

	Type of Szilagyí		p value
	1 (n = 6)	2 (n = 6)	
CAD	3 (50)	3 (50)	1.0
CHF	0 (0)	1 (16.7)	1.0
HLD	2 (33.3)	3 (50)	1.0
HTN	4 (66.7)	4 (66.7)	1.0
CKD	2 (33.3)	1 (16.7)	1.0
ESRD	0 (0)	0 (0)	1.0
Transplant			1.0
No	4 (66.7)	5 (83.3)	
Heart	1 (16.7)	1 (16.7)	
Lung	1 (16.7)	0 (0)	
Kidney	0 (0)	0 (0)	
PAD	1 (16.7)	0 (0)	1.0
Immunosuppressant drugs	4 (66.7)	2 (33.3)	0.57
Type of CFA repair			0.46
Primary	6 (100)	4 (66.7)	
Patch	0 (0)	2 (33.3)	
PTFE	0 (0)	0 (0)	

Data were presented as mean  $\pm$  SD or median (interquartile range) for continuous variables and number (percentage) for categorical variables. The Mann–Whitney *U* test or Fisher’s exact test was used for comparison between the type of Szilagyí.

BMI, body mass index; CAD, coronary artery disease; CFA, common femoral artery; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; EBL, estimated blood loss; ECMO, extracorporeal membrane oxygenation; ESRD, end-stage renal disease; HLD, hyperlipidemia; HTN, hypertension; PAD, peripheral arterial disease; pRBC, packed red blood cell; PTFE, polytetrafluoroethylene; SD, standard deviation.

Baseline characteristics were also compared among infected VA ECMO patients. Patients were classified as either infected or not infected and statistical analysis was performed to determine whether any baseline characteristics could be attributed as an increased risk of infection in the VA ECMO patient. No statistically significant association was found, although smoking once again approached significance with a value of  $p = 0.07$ . Literature review showed limited data on SSI rates for peripheral VA ECMO patients. This population presents an opportunity for future investigation.

### Limitations

The primary limitation of this study was that it was a retrospective chart review with a small sample size of 48 patients conducted at a single center, and therefore may not be generalizable to the broader ECMO patient population. In addition, our database does not provide uniform information on all patients because of varying complexities of each case. This caused some challenges in determining the definitive infection status for each patient. Looking forward, we will continue to prospectively add ECMO patients

**Table 4.** Baseline characteristics by infected status among those with VA ECMO.

	Noninfected (n = 12)	Infected (n = 10)	p value
Age	54.8 ± 14.8	49 ± 15.9	0.32
Male	8 (66.7)	5 (50)	0.66
BMI	31.6 ± 8.0	32.7 ± 7.7	0.72
No. of days on ECMO	5.9 ± 5.0	7.2 ± 4.4	0.32
EBL	300 (100–1000)	300 (200–500)	0.92
Intraoperative pRBC (ml)	0 (0–400)	300 (0–600)	0.24
Race			0.53
Caucasian	7 (58.3)	6 (60)	
Black	2 (16.7)	1 (10)	
Hispanic	1 (8.3)	3 (30)	
Asian	2 (16.7)	0 (0)	
Smoker			0.07
No	10 (83.3)	4 (40)	
Current	0 (0)	2 (20)	
Former	2 (16.7)	2 (20)	
Unknown	0 (0)	2 (20)	
DM	5 (41.7)	5 (50)	1.0
COPD	1 (8.3)	0 (0)	1.0
CAD	7 (58.3)	6 (60)	1.0
CHF	4 (33.3)	1 (10)	0.32
HLD	7 (58.3)	4 (40)	0.67
HTN	10 (83.3)	6 (60)	0.35
CKD	3 (25)	2 (20)	1.0
ESRD	1 (8.3)	0 (0)	1.0
Transplant			0.82
No	9 (75)	7 (70)	
Heart	1 (8.3)	2 (20)	
Lung	2 (16.7)	1 (10)	
PAD	0 (0)	1 (10)	0.46
Immunosuppressant drugs	3 (25)	5 (50)	0.38
Type of CFA repair			0.35

*(Continued)*

**Table 4.** (Continued)

	Noninfected (n = 12)	Infected (n = 10)	p value
Primary	7 (58.3)	8 (80)	
Patch	2 (16.7)	2 (20)	
PTFE	3 (25)	0 (0)	

BMI, body mass index; CAD, coronary artery disease; CFA, common femoral artery; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; EBL, estimated blood loss; ECMO, extracorporeal membrane oxygenation; ESRD, end-stage renal disease; HLD, hyperlipidemia; HTN, hypertension; PAD, peripheral arterial disease; pRBC, packed red blood cell; PTFE, polytetrafluoroethylene; SD, standard deviation. Data were presented as mean  $\pm$  SD or median (interquartile range) for continuous variables and number (percentage) for categorical variables. The Mann–Whitney *U* test or Fisher’s exact test was used for comparison between infected and noninfected.

All analyses were performed with STATA version 16 (StataCorp. 2019. Stata Statistical Software Release 16; StataCorp LLC, College Station, TX). Statistical significance was defined as two-tailed  $p < 0.05$  for all tests.

and patients receiving cardiac devices to our cohort to increase the power of our future investigations.

### Conclusion

We evaluated rates of SSI in patients receiving femoral-access ECMO over a 46-month period and found that, although our institution’s overall peripheral ECMO SSI rate was similar to the national average, rates of infection after VA ECMO were higher than expected. We also found that blood transfusions  $>250$  ml and blood loss  $>300$  ml were associated with increased risk of SSI in our VA ECMO patients. Vascular surgeons must be vigilant about the high risk of SSI for ECMO patients. We believe further research should focus on prophylactic surgical techniques and treatment to minimize risk in this vulnerable patient population.

### Declarations

#### *Ethics approval and consent to participate*

IRB approval was obtained from Houston Methodist Research Institute Institutional Review Board (#Pro000024971). Patient data were collected from electronic medical records under the institutional review board–approved protocol. Consent was waived as this study is a retrospective chart review. The waiver will not adversely affect the rights and welfare of the participants included in this study because on data entry, there will be no way to link the data in the study database to any individual subjects.

#### *Consent for publication*

Not applicable.

#### *Author contributions*

**Paul Haddad:** Data curation; Formal analysis; Methodology; Writing – original draft; Writing – review & editing.

**Cara Chasin:** Formal analysis.

**Jiaqiong Xu:** Formal analysis.

**Eric Peden:** Conceptualization.

**Maham Rahimi:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration.

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#### *Competing interests*

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#### *Availability of data and materials*

Not applicable.

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