



HAL
open science

Percutaneous angio-guided versus surgical veno-arterial ECLS implantation in patients with cardiogenic shock or cardiac arrest

Gabriel Saiydoun, Emmanuel Gall, Madjid Boukantar, Antonio Fiore, Nicolas Mongardon, Paul Masi, François Bagate, Costin Radu, Eric Bergoend, Andrea Mangiameli, et al.

► To cite this version:

Gabriel Saiydoun, Emmanuel Gall, Madjid Boukantar, Antonio Fiore, Nicolas Mongardon, et al.. Percutaneous angio-guided versus surgical veno-arterial ECLS implantation in patients with cardiogenic shock or cardiac arrest. *Resuscitation*, 2022, 170, pp.92-99. 10.1016/j.resuscitation.2021.11.018 . hal-04392241

HAL Id: hal-04392241

<https://hal.science/hal-04392241>

Submitted on 22 Jul 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

1 **Percutaneous angio-guided versus surgical veno-arterial ECLS implantation in patients**
2 **with cardiogenic shock or cardiac arrest**

3
4 Gabriel Saiydoun, MD^{1*}; Emmanuel Gall, MD^{2*}; Madjid Boukantar, MD²; Antonio Fiore,
5 MD¹; Nicolas Mongardon, MD, PhD^{3,4}; Paul Masi, MD^{5,6,7}; François Bagate, MD^{5,6,7}; Costin
6 Radu, MD, PhD¹; Eric Bergoend, MD¹; Andrea Mangiameli, MD²; Quentin de Roux, MD^{3,4};
7 Armand Mekontso Dessap, MD, PhD^{5,6,7}; Olivier Langeron, MD, PhD³; Thierry Folliguet,
8 MD, PhD¹; Emmanuel Teiger, MD, PhD^{2,4}; Romain Gallet, MD, PhD^{2,4}.

9 * GS and EG equally contributed to the manuscript.

10

11 ¹ Department of Cardiac Surgery, APHP, Hôpitaux Universitaires Henri Mondor, F-94010
12 Créteil, France

13 ² Service de Cardiologie, APHP, Hôpitaux Universitaires Henri Mondor, F-94010 Créteil,
14 France

15 ³ Service d'anesthésie-réanimation chirurgicale, DMU CARE, DHU A-TVB, Assistance
16 Publique-Hôpitaux de Paris (AP-HP), Hôpitaux Universitaires Henri Mondor, F-94010
17 Créteil, France

18 ⁴ U955-IMRB, Equipe 03, Inserm, Univ Paris Est Creteil (UPEC), Ecole Nationale
19 Vétérinaire d'Alfort (EnVA), F-94700 Maisons-Alfort, France

20 ⁵ AP-HP, Hôpitaux Universitaires Henri-Mondor, Service de Médecine Intensive
21 Réanimation, F-94010, Créteil, France

22 ⁶ Univ Paris Est Créteil, CARMAS, Créteil, F-94010, France

23 ⁷ Univ Paris Est Créteil, INSERM, IMRB, Créteil, F-94010, France

24

25 **Word count : 2914**

26

27 **Corresponding author:**

28 Romain Gallet, MD, PhD,

29 Department of Cardiology,

30 Hôpitaux Universitaires Henri Mondor, 1 rue Gustave Eiffel, 94000, Créteil, France.

31 romain.gallet@aphp.fr

32

1 **Abstract:**

2 **Background:** Veno-arterial Extracorporeal Life Support (V-A ECLS) has gained increasing
3 place into the management of patients with refractory cardiogenic shock or cardiac arrest.
4 Both surgical and percutaneous approach can be used for cannulation, but percutaneous
5 approach has been associated with fewer complications. Angio-guided percutaneous
6 cannulation and decannulation may further decrease the rate of complication. We aimed to
7 compare outcome and complication rates in patients supported with V-A ECLS through
8 percutaneous angio-guided versus surgical approach.

9 **Methods:** We included all patients with emergent peripheral femoro-femoral V-A ECLS
10 implantation for refractory cardiogenic shock or cardiac arrest in our center from March 2018
11 to March 2021. Survival and major complications (major bleeding, limb ischemia and groin
12 infection) rates were compared between the percutaneous angio-guided and the surgical
13 groups.

14 **Results:** One hundred twenty patients received V-A ECLS, 59 through surgical approach and
15 61 through angio-guided percutaneous approach. Patients' baseline characteristics and
16 severity scores were equally balanced between the 2 groups. Thirty-day mortality was not
17 significantly different between the 2 approaches. However, angio-guided percutaneous
18 cannulation was associated with fewer major vascular complications (42% vs. 11%,
19 $p > 0.0001$) and a higher rate of V-A ECLS decannulation. In multivariate analysis,
20 percutaneous angio-guided implantation of V-A ECLS was independently associated with a
21 lower probability of major complications.

1 **Conclusion:** Compared to surgical approach, angio-guided percutaneous V-A ECLS
2 implantation is associated with fewer major vascular complications. Larger studies are needed
3 to confirm those results and address their impact on mortality.

4

5

6

1 **Introduction:**

2 Venous-arterial Extracorporeal Life Support (V-A ECLS) has been described as an attractive
3 strategy for hemodynamic support in cardiogenic shock and refractory cardiac arrest¹⁻⁸.

4 Peripheral femoral cannulation is the primary line method for V-A ECLS cannulation and
5 surgical approach has been widely used for a long time. However, this invasive procedure
6 may be associated with severe vascular complications such as hemorrhage, limb ischemia and
7 infection^{9,10}. With the development of echographic guidance for vascular access and the
8 improvement of the techniques and devices, percutaneous approach for femoro-femoral V-A
9 ECLS is increasingly used and may be associated with a lower risk of vascular complications
10¹¹.

11 However, to date, even when percutaneous approach is used, V-A ECLS is usually implanted
12 in the operative room or at bedside, and very few studies focused on percutaneous approach
13 have used fluoroscopic guidance. Nevertheless, this latter helps to monitor wires and cannulas
14 progression in the vessels and might therefore increase the success rate and the safety of
15 implantation. Moreover, we recently reported that percutaneous removal using preclosing was
16 feasible and might further increase the safety of the procedure¹².

17 We therefore aimed to compare the outcomes of patients who received V-A ECLS using
18 percutaneous angio-guided or surgical approach.

19
20

21

22

23

24

1 **Methods:**

2 **Study design and population**

3 All consecutive adult patients admitted at Henri-Mondor University Hospital (Assistance
4 Publique des Hôpitaux de Paris, Créteil, France) and supported with peripheral V-A ECLS for
5 refractory cardiac arrest or refractory cardiogenic shock from January 2018 to March 2021
6 were included in a monocentric prospective observational registry. We excluded patients
7 supported by V-A ECLS following cardiac surgery.

8 Surgical approach was the only cannulation method performed before mid-2018. From mid-
9 2018, percutaneous approach was adopted and performed by the interventional cardiologists,
10 and both percutaneous and surgical cannulations were performed. The choice between
11 percutaneous and surgical approach depended on several factors including availability of the
12 operators and operative room, location of the patient and the choice of the intensivist in
13 charge of the patients.

14 All patients' data and outcome were analyzed. Study protocol was approved by Henri Mondor
15 University Hospital's ethics committee (registration code n°1778041).

16 **Surgical cannulation procedure**

17 All surgical V-A ECLS implantation were performed in the operative room or at bedside in
18 case of extreme emergency by trained cardiac surgeons.

19 For the surgical approach, femoral vessels were exposed with a limited transversal incision in
20 the groin. Purse string sutures were made before cannulation in the femoral artery and vein.
21 Access to the common femoral artery, to the femoral vein and to the superficial femoral artery
22 (anterograde access for distal perfusion line insertion) were obtained using the Seldinger's

1 technique¹³. Then, after preparation with adequate dilators, femoral vessels were cannulated.
2 The venous cannula was advanced under echocardiographic guidance to confirm its
3 progression and positioning. After cannulation, the skin was surgically sutured.

4 Decannulation procedures were performed in the operative room by cardiac surgeons. At the
5 time of decannulation, the operative field was reopened. Then, the arterial cannula was
6 removed and the purse string sutures were tied and, after clamping the femoral artery, the
7 arteriotomy was sutured. The distal reperfusion cannula was then retrieved from the distal
8 superficial femoral artery and the purse string suture was tied.

9 **Angio-guided percutaneous cannulation procedure**

10 For the percutaneous approach, V-A ECLS was implanted in the cardiac catheterization
11 laboratory under fluoroscopic guidance by senior interventional cardiologists trained to echo-
12 guided vascular puncture, preclosing and large bore vascular access as previously described¹².
13 The common femoral artery and femoral vein were punctured under ultrasound guidance
14 using the Seldinger's technique. The position of the wires was verified using angiography.
15 Preclosing using two Perclose ProGlides[®] (Abbott[®], Chicago, Illinois, USA) was performed
16 as often as possible before cannulation in both the femoral artery and the femoral vein, as
17 previously described¹⁴. Then, after preparation with adequate dilators, femoral vessels were
18 cannulated over a stiff wire (Amplatz Super Stiff[®], Boston Scientific[®], Marlborough,
19 Massachusetts, USA) under fluoroscopic guidance.

20 V-A ECLS decannulation was performed percutaneously in the catheterization room except
21 for exceptional cases (no preclosing performed or removal by the cardiac surgeon at the time
22 of LVAD implantation or heart transplant). All percutaneous decannulation were performed
23 using the "the crossover balloon occlusion technique" as previously described¹⁵. Briefly, the
24 contralateral femoral artery was punctured to obtain a crossover access. A balloon was

1 advanced in the external iliac artery and inflated, to allow a non-traumatic occlusion of the
2 vessel. The arterial cannula was removed and the knots were tied. The balloon was then
3 deflated and an angiography of the femoral artery was performed to ensure the proper closing
4 of the artery and the absence of complications.

5 For both approaches, a 23 cm length 17–19 Fr arterial cannula (Maquet® Rastatt, Germany)
6 (17 or 19 Fr depending on the patient’s morphology) and a 55 cm 23 Fr venous cannula
7 (Maquet®, Rastatt, Germany) were used. The venous cannula was advanced to the right
8 atrium. An additional antegrade perfusion line (6 Fr sheath, Terumo®, Shibuya, Tokyo,
9 Japan) was systematically inserted into the superficial femoral artery “y” connected to the
10 arterial cannula to reduce the risk of leg ischemia¹⁶. This antegrade perfusion line was
11 inserted visually for the surgical approach and under ultrasound guidance (usually before the
12 insertion of the arterial cannula) for percutaneous approach.

13 **Outcomes**

14 Outcomes included access-related complications (defined as major bleeding, lower limb
15 ischemia and groin infection), 30-day survival and 30-day decannulation rate. Major bleeding
16 was defined as peri-procedural bleeding at the sites of cannulation or the sites of puncture
17 with a drop in hemoglobin level of at least 3.0 g/dL and/or requiring transfusion (3 units of
18 packed red blood cells)¹⁷. Limb ischemia was suspected clinically, and confirmed when it
19 required a percutaneous or surgical intervention, or a change of cannulation site.

20 Groin infections were clinically suspected in the presence of local (inflammation, purulent
21 drainage) and general signs of sepsis with positive bacteriological sample.

22 Access related complications occurring at the time of cannulation, during V-A ECLS support
23 and after decannulation were recorded.

1 **Statistical analyses**

2 Continuous variables were expressed as median and interquartile range, and categorical
3 variables as number and percentages, as appropriate. Continuous variables were compared
4 using student t-test if normally distributed and Mann Whitney test if otherwise. Data's
5 distribution was assessed with the Shapiro-Wilk test. Welch correction was used in case of
6 non-homogeneous variance. Categorical variables were compared using chi-square test when
7 appropriate and Fisher's exact test otherwise.

8 Log-Rank test was used for univariate survival analysis. A Cox proportional hazard regression
9 model was performed to identify independent multivariable factors predictive of survival.

10 Variables included in the model were based on their clinical relevance (regardless of their p-
11 values), with others variables when their p-values was inferior or equal to 0.15 on univariate
12 analysis. The variables included were age, body mass index, chronic heart failure, Sequential
13 Organ Failure Assessment (SOFA) score at cannulation, LVEF, preclosing, cardiac arrest and
14 refractory cardiac arrest. The proportional hazards assumption was tested by Schoenfeld
15 residuals and inspection of hazard ratio (HR) plots.

16 Finally, risk factors for total complications including major bleeding, vascular complications,
17 groin infection and limb ischemia were assessed within the whole cohort using univariate and
18 multivariate logistic regression model. Variables were included in the multivariate logistic
19 model when their p-values was inferior or equal to 0.15 on univariate analysis. Odds-ratios
20 and their 95% confidence interval were calculated.

21 Differences were considered significant if two-sided $p < 0.5$.

22 Statistical analysis was performed using R software, version 3.6.0 (R Project for Statistical
23 Computing).

24

25

1 **Results:**

2 **Population**

3 Between January 2018 and March 2021, 120 patients were supported with V-A ECLS for
4 refractory cardiogenic shock or cardiac arrest. Among those 120 patients, 59 underwent
5 surgical cannulation and 61 underwent angio-guided percutaneous cannulation (Flowchart in
6 Figure 1). The use of percutaneous cannulation increased over time while the use of surgical
7 cannulation decreased ($P=0.001$, Figure 2). The baseline characteristics of the whole
8 population and of the surgical and percutaneous groups are presented in Table 1. The median
9 age of the population was 57 [47-66] years old and 72% of the patients were male (Table 1).
10 Patients in the percutaneous group were older (60 [51-67], vs. 53 [41-64], $P=0.007$) with
11 lower LVEF (15 [11-20] vs 26 [15-45], $P<0.0001$) and a higher rate of diabetes mellitus (34%
12 vs. 15%, $P=0.015$). They also presented more frequently with STEMI, while patients in the
13 surgical groups had more frequently a previous history of chronic heart failure. There was a
14 higher prevalence of long-term anticoagulation in the surgical group. No significant
15 difference in the rate of cardiac arrest and refractory cardiac arrest was observed, and the
16 SOFA scores at admission and before cannulation were similar.

17

1 **V-A ECLS duration and outcome**

2 Both arterial and venous cannula were successfully inserted in all patients except for one
3 patient in the surgical group. Distal perfusion line was inserted in 96% of patients in the
4 surgical group and 98% in the percutaneous group. Preclosing was performed in 75% of the
5 patients with percutaneous approach with an increase over time. Indeed, in the early months,
6 patients with refractory cardiac arrest did not undergo pre-closing, before becoming
7 systematic. Consequently, all of the last 39 patients implanted underwent pre-closing.

8 Overall, 45 (37%) of the 120 patients were weaned from V-A ECLS. This proportion was
9 higher in the angio-guided percutaneous group as compared to the surgical group (46% vs.
10 29%, $p=0.05$). In the percutaneous group, V-A ECLS decannulation was performed
11 percutaneously in the catheterization room in 22/28 patients. The reason for surgical
12 decannulation after percutaneous cannulation was absence of pre-closing in 4 and
13 decannulation during cardiac surgery (LVAD or heart transplant) in 2.

14 Although decannulation rate was higher in the percutaneous group, 30-day survival was not
15 different between the 2 groups, even after adjustment for confounding variables, with 30-day
16 survival rates of 26% and 17% in the percutaneous and surgical groups respectively (Figure
17 3).

18 19 **V-A ECLS related complications**

20 In the whole population, 36 major complications occurred in 32 patients (Table 2) with no
21 significant decrease over time ($P=0.2$). Three patients experienced multiples major
22 complications, all in the surgical group. The most frequent major complication of V-A ECLS
23 was major bleeding ($n=22$), followed by lower limb ischemia ($n=7$) and groin infection ($n=7$).
24 No amputation was required. Overall, the rate of major vascular complications (i.e. major
25 bleeding, limb ischemia and groin infection) was higher in the surgical group compared to the

1 angio-guided percutaneous group (29 complications in 25 patients vs. 7 complications in 7
2 patients, $P < 0.0001$ for both the patient level and complication level analysis). Individual
3 analysis of the different sub-types of complications revealed a statistically significant 4.5 fold
4 increase in the rate of major bleeding (31% vs. 7%, $P = 0.0007$), but no significant increase in
5 the rate of groin infection (10% vs. 2%, $P = 0.059$) and limb ischemia. The only infection that
6 occurred in the percutaneous group occurred after surgical removal of the cannulas following
7 heart transplant.

8 Last, we investigated the variables associated with the occurrence of vascular complications
9 using multivariable logistic regression. Only two variables were associated with vascular
10 complications. Percutaneous cannulation was strongly associated with a lower risk of vascular
11 complications of V-A ECLS (OR 0.23 (0.08-0.70)); $p = 0.009$) while increased body mass
12 index (OR 1.11 (1.01-1.23) for every 1-unit increase in BMI; $p = 0.04$) was associated with a
13 higher risk (Table 3).

14

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

Discussion:

In this study, we compared angio-guided percutaneous approach to surgical approach for V-A ECLS implantation in patients with cardiac arrest or refractory cardiogenic shock. No difference in 30-day mortality was observed between angio-guided percutaneous and surgical approaches for V-A ECLS cannulation. However, angio-guided percutaneous approach was associated with a significant reduction in vascular complications including major bleeding, limb ischemia and groin infection.

Surgical approach for cannulation and decannulation of V-A ECLS has been used for long. It provides a fast access to the femoral vessels and allows cannulas insertion under visual guidance¹⁸. However, it is associated with a non-negligible number of vascular complications including major local bleeding (2-15%) limb ischemia (8-30%) and surgical site infection (25-40%)^{11,19-22}.

With the development of structural heart disease interventions and the improvement in the techniques and devices, percutaneous approach for V-A ECLS implantation has been described, with attractive results^{11,23}. However, to date, in most of the studies that focused on percutaneous approach, the cannulation of the femoral vessel was performed at bedside or in the operative room, without fluoroscopic guidance. Moreover, retrieval of the cannula was also performed bedside without systematic assessment of the results. In our study, all percutaneous implantation were performed under fluoroscopic guidance in the catheterization laboratory with punctures under echographic guidance. This approach was associated with a significant reduction of vascular complication especially of major bleeding. Indeed, echographic guidance increases the safety of the vascular access as previously described²⁴ and, fluoroscopic guidance enables to monitor closely the progression of the wires and of the cannula. Regarding retrieval, we set up a systematic approach for cannula explantation. During implantation, preclosing using two ProGlide (Abbott®, Chicago, Illinois, USA)

1 devices was performed as often as possible (75% of the patients, 39 of the last 39 patients).
2 Then, decannulation was performed under fluoroscopic guidance using a “TAVR-like
3 strategy” with a final angiography as previously described^{12,15}. This strategy further increased
4 the safety of the percutaneous approach and decreased vascular complication. Indeed, very
5 few vascular events were observed in the percutaneous group (including events after
6 decannulation), unlike what had been observed in previous studies using manual or and/or
7 device assisted compression for hemostasis^{11,25,26}. In those studies, the rate of major bleeding
8 was superior when percutaneous approach was used. It is likely that the discrepancy between
9 these studies and our results is due to the use of preclosing and angiographic guidance for
10 percutaneous removal of the cannula in our study. Indeed, the closure using the ProGlide
11 devices associated to the performance of a final angiographic control enables, not only a safe
12 and non-invasive closure of the artery, but also a reliable assessment of the proper closure.
13 Thus, we may assume that this strategy is superior to strategies using either manual
14 compression or post-closing although randomized studies are yet to be performed. It must
15 however be noted that, in our study, the rate of major bleeding observed in the surgical group
16 was high. Nevertheless, unlike in previous published studies, all implantations were
17 performed in extreme emergency in patients with refractory cardiac arrest or cardiogenic
18 shock and no patients underwent semi-urgent or post-operative V-A ECLS. The critical
19 condition of our population is further demonstrated by the high 30-day mortality, and may
20 explain, at least partially, the rate of major bleeding observed in the surgical group. On the
21 other hand, these data reinforce the interest of angio-guided percutaneous V-A ECLS in these
22 patients. Indeed, despite the very high-risk profile of this population, the number of major
23 bleeding and other vascular complication observed in the percutaneous group was
24 dramatically low. Additionally, the rates of limb ischemia after cannulation were also rather
25 low as compared to previous studies including both surgical and percutaneous approaches

1 ^{11,27-29}. This is probably related to the systematic insertion of a distal perfusion line, which has
2 been showed to decrease the risk of limb ischemia³⁰. Last, the number of infections was also
3 notably low, especially in the percutaneous group in which only one infection was observed,
4 and it must be highlighted that this latter occurred after surgical decannulation of the V-A
5 ECLS. Thus, none of the patients with percutaneous removal of the V-A ECLS had a groin
6 infection. This finding is not surprising since several studies had found a decrease in the
7 number of cannulation site infections with the use of the percutaneous approach, this latter
8 being far less invasive than open surgery^{31,32}.

9 Last, this study confirms the safety and feasibility of angio-guided percutaneous V-A
10 ECLS implantation, with a very high rate of cannulation success and a low rate of
11 complication. These results may promote the development of V-A ECLS as an emergency
12 support in centers without onsite cardiac surgery, providing that dedicated teams (medical and
13 paramedical) are trained to the priming of the ECMO machine and to the management of
14 patients with ECLS, and that dedicated network are set up in case heart surgery is considered.

15

16 **Limitations :**

17 This study has several limitations. First, this is a monocentric observational study including a
18 small number of patients with all the potential bias inherent to such studies. Moreover, the
19 exact benefit of angiography as not been examined since no direct comparison with
20 ultrasound alone guided cannulation was performed. Therefore, further studies will be needed
21 to confirm our results. Secondly, complications were recorded up to 30 days, and some very
22 late events may have been missed. Another limitation is that V-A ECLS cannulation was
23 performed by two different teams. Indeed, while in most of the previous studies both surgical
24 and percutaneous cannulation were usually performed by the same team (the surgeons), in our
25 study, surgical V-A ECLS cannulation was performed by cardiac surgeons and angio-guided

1 percutaneous V-A ECLS cannulation was performed by the interventional cardiologists.
2 However, all operators were familiar with the technique and trained to V-A ECLS
3 cannulation.
4 Finally, the studied population was composed of instable patients with a high mortality rate
5 (even though consistent with other studies) and these results may not be applicable to semi-
6 urgent or post-operative patients with mild hemodynamic instability. Moreover, percutaneous
7 cannulation will not completely replace surgical cut down technique in special groups of
8 patients such as patients with anatomical vessels abnormalities.
9

1

2 **Conclusion :**

3 In this observational study, angio-guided percutaneous V-A ECLS is associated with fewer
4 major vascular complications compared to surgical approach. Larger studies are needed to
5 confirm those results and address their impact on mortality.

6

7 **Disclosures: none**

8

9

10

1 References:

- 2 1. Combes, A. *et al.* Outcomes and long-term quality-of-life of patients supported by
3 extracorporeal membrane oxygenation for refractory cardiogenic shock. *Crit Care Med* **36**, 8
4 (2008).
- 5 2. Han, K. S. *et al.* Experience of extracorporeal cardiopulmonary resuscitation in a
6 refractory cardiac arrest patient at the emergency department. *Clin. Cardiol.* **42**, 459–466
7 (2019).
- 8 3. Pozzi, M. *et al.* Extracorporeal Life Support for Refractory Cardiac Arrest: A 10-Year
9 Comparative Analysis. *Ann. Thorac. Surg.* **107**, 809–816 (2019).
- 10 4. Yannopoulos, D. *et al.* Advanced reperfusion strategies for patients with out-of-
11 hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single
12 centre, open-label, randomised controlled trial. *Lancet Lond. Engl.* **396**, 1807–1816 (2020).
- 13 5. Abrams, D. *et al.* Extracorporeal cardiopulmonary resuscitation in adults: evidence
14 and implications. *Intensive Care Med.* (2021) doi:10.1007/s00134-021-06514-y.
- 15 6. Rob, D. & Bělohávek, J. The mechanical support of cardiogenic shock. *Curr. Opin.*
16 *Crit. Care* **27**, 440–446 (2021).
- 17 7. Conrad, S. A. *et al.* The Extracorporeal Life Support Organization Maastricht Treaty
18 for Nomenclature in Extracorporeal Life Support. A Position Paper of the Extracorporeal Life
19 Support Organization. *Am. J. Respir. Crit. Care Med.* **198**, 447–451 (2018).
- 20 8. Broman, L. M. *et al.* The ELSO Maastricht Treaty for ECLS Nomenclature:
21 abbreviations for cannulation configuration in extracorporeal life support - a position paper of
22 the Extracorporeal Life Support Organization. *Crit. Care Lond. Engl.* **23**, 36 (2019).
- 23 9. Zimpfer, D. *et al.* Late vascular complications after extracorporeal membrane
24 oxygenation support. *Ann. Thorac. Surg.* **81**, 892–895 (2006).
- 25 10. Burns, S., Constantin, N., Robles, P., & RECOVER Program Investigators.
26 Understanding the long-term sequelae of ECMO survivors. *Intensive Care Med.* **44**, 1144–
27 1147 (2018).
- 28 11. Danial, P. *et al.* Percutaneous versus surgical femoro-femoral veno-arterial ECMO: a
29 propensity score matched study. *Intensive Care Med.* **44**, 2153–2161 (2018).
- 30 12. Martin-Tuffreau, A.-S. *et al.* Complete percutaneous angio-guided approach using
31 preclosing for venoarterial extracorporeal membrane oxygenation implantation and
32 explantation in patients with refractory cardiogenic shock or cardiac arrest. *Crit. Care Lond.*
33 *Engl.* **25**, 93 (2021).
- 34 13. Chen, Y. S., Ko, W. J. & Lin, F. Y. Insertion of percutaneous ECMO cannula. *Am. J.*
35 *Emerg. Med.* **18**, 184–185 (2000).
- 36 14. Griese, D. P., Reents, W., Diegeler, A., Kerber, S. & Babin-Ebell, J. Simple, effective
37 and safe vascular access site closure with the double-ProGlide preclose technique in 162
38 patients receiving transfemoral transcatheter aortic valve implantation. *Catheter. Cardiovasc.*
39 *Interv. Off. J. Soc. Card. Angiogr. Interv.* **82**, E734-741 (2013).
- 40 15. Genereux, P. *et al.* Clinical outcomes using a new crossover balloon occlusion
41 technique for percutaneous closure after transfemoral aortic valve implantation. *JACC*
42 *Cardiovasc. Interv.* **4**, 861–867 (2011).
- 43 16. Juo, Y.-Y. *et al.* Efficacy of Distal Perfusion Cannulae in Preventing Limb Ischemia
44 During Extracorporeal Membrane Oxygenation: A Systematic Review and Meta-Analysis.
45 *Artif. Organs* **41**, E263–E273 (2017).
- 46 17. Kappetein, A. P. *et al.* Updated standardized endpoint definitions for transcatheter
47 aortic valve implantation: the Valve Academic Research Consortium-2 consensus document.
48 *J. Am. Coll. Cardiol.* **60**, 1438–1454 (2012).

- 1 18. Richardson, A. S. C. *et al.* Extracorporeal Cardiopulmonary Resuscitation in Adults.
2 Interim Guideline Consensus Statement From the Extracorporeal Life Support Organization.
3 *ASAIO J. Am. Soc. Artif. Intern. Organs* 1992 **67**, 221–228 (2021).
- 4 19. Yang, F. *et al.* Vascular complications in adult postcardiotomy cardiogenic shock
5 patients receiving venoarterial extracorporeal membrane oxygenation. *Ann. Intensive Care* **8**,
6 72 (2018).
- 7 20. Yau, P. *et al.* Factors Associated with Ipsilateral Limb Ischemia in Patients
8 Undergoing Femoral Cannulation Extracorporeal Membrane Oxygenation. *Ann. Vasc. Surg.*
9 **54**, 60–65 (2019).
- 10 21. Tanaka, D., Hirose, H., Cavarocchi, N. & Entwistle, J. W. C. The Impact of Vascular
11 Complications on Survival of Patients on Venous Arterial Extracorporeal Membrane
12 Oxygenation. *Ann. Thorac. Surg.* **101**, 1729–1734 (2016).
- 13 22. Chasin, C., Haddad, P., Xu, J., Peden, E. & Rahimi, M. High Groin Infection Rate
14 After Extracorporeal Membrane Oxygenation Decannulation and Surgical Repair. *J. Vasc.*
15 *Surg.* **72**, e120 (2020).
- 16 23. Ganslmeier, P. *et al.* Percutaneous cannulation for extracorporeal life support. *Thorac.*
17 *Cardiovasc. Surg.* **59**, 103–107 (2011).
- 18 24. Brass, P., Hellmich, M., Kolodziej, L., Schick, G. & Smith, A. F. Ultrasound guidance
19 versus anatomical landmarks for internal jugular vein catheterization. *Cochrane Database*
20 *Syst. Rev.* **1**, CD006962 (2015).
- 21 25. Hwang, J.-W. *et al.* Percutaneous removal using Perclose ProGlide closure devices
22 versus surgical removal for weaning after percutaneous cannulation for venous arterial
23 extracorporeal membrane oxygenation. *J. Vasc. Surg.* **63**, 998–1003.e1 (2016).
- 24 26. Bemtgen, X. *et al.* Venous arterial extracorporeal membrane oxygenation decannulation
25 using the novel Manta vascular closure device. *Eur. Heart J. Acute Cardiovasc. Care* **9**, 342–
26 347 (2020).
- 27 27. Muller, G. *et al.* The ENCOURAGE mortality risk score and analysis of long-term
28 outcomes after VA-ECMO for acute myocardial infarction with cardiogenic shock. *Intensive*
29 *Care Med.* **42**, 370–378 (2016).
- 30 28. Foley, P. J. *et al.* Limb ischemia during femoral cannulation for cardiopulmonary
31 support. *J. Vasc. Surg.* **52**, 850–853 (2010).
- 32 29. Ternus, B. *et al.* Initiation of Extracorporeal Membrane Oxygenation in the Cardiac
33 Catheterization Laboratory: The Mayo Clinic Experience. *J. Invasive Cardiol.* **32**, 64–69
34 (2020).
- 35 30. Lamb, K. M. *et al.* Arterial protocol including prophylactic distal perfusion catheter
36 decreases limb ischemia complications in patients undergoing extracorporeal membrane
37 oxygenation. *J. Vasc. Surg.* **65**, 1074–1079 (2017).
- 38 31. Kiran, R. P., El-Gazzaz, G. H., Vogel, J. D. & Remzi, F. H. Laparoscopic approach
39 significantly reduces surgical site infections after colorectal surgery: data from national
40 surgical quality improvement program. *J. Am. Coll. Surg.* **211**, 232–238 (2010).
- 41 32. Pellenc, Q. *et al.* Preclosing of the femoral artery allows total percutaneous
42 venous arterial extracorporeal membrane oxygenation and prevents groin wound infection after
43 lung transplantation. *Eur. J. Cardio-Thorac. Surg. Off. J. Eur. Assoc. Cardio-Thorac. Surg.*
44 **58**, 371–378 (2020).
- 45

1 **Figure 1:** Flowchart of the study

2 **Figure 2:** Evolution of the use of percutaneous angio-guided and surgical approach for V-A

3 ECLS cannulation from 2018 to 2021.

4 **Figure 3:** Panel A – Unadjusted Kaplan Meier survival curves for the percutaneous and

5 surgical approach. Panel B – Adjusted Kaplan Meier survival curves for the percutaneous and

6 surgical approach; survival was adjusted on age, body mass index, chronic heart failure,

7 SOFA score at cannulation, LVEF, preclosing, cardiac arrest and refractory cardiac arrest

8

9

- 1 **Table 1:** Baseline characteristics of the whole population and of the surgical and
- 2 percutaneous groups. V-A ECLS: Veno-arterial extracorporeal membrane oxygenation;
- 3 LVEF: Left ventricle ejection fraction; SOFA: Sequential Organ Failure Assessment; STEMI:
- 4 ST-elevation myocardial infarction; PCI: Percutaneous coronary intervention.

	All (n=120)	Surgical approach (n = 59)	Percutaneous approach (n= 61)	P-value
Age (years)	57 (47 - 66)	53 (41 - 64)	60 (51 - 67)	0.007
BMI (kg/m ²)	26 (23 - 29)	27 (23 - 31)	25 (23 - 28)	0.43
Male	86 (72 %)	39 (66 %)	47 (77 %)	0.18
<u>Underlying medical conditions</u>				
Diabetes mellitus	30 (25 %)	9 (15 %)	21 (34%)	0.015
Tobacco use	30 (25 %)	19 (32%)	11 (18%)	0.073
Arterial hypertension	53 (44 %)	22 (37%)	31 (51%)	0.14
Peripheral artery disease	7 (6 %)	4 (7 %)	3 (5 %)	0.71
Long term anticoagulation before V-A ECLS	16 (13 %)	12 (20%)	4 (7%)	0.026
Antiplatelet therapy before V- A ECLS	25 (21 %)	14 (24%)	11 (18%)	0.44
<u>Admission</u>				
LVEF	20 (11 - 35)	26 (15-45)	15 (10-20)	<0.0001
Cardiogenic shock	108 (90 %)	51 (86%)	57(93%)	0.20
Cardiac arrest :	81 (68 %)	43 (73%)	38 (62%)	0.22
- Resuscitated cardiac arrest	43 (36 %)	22 (37 %)	21 (34 %)	0.85
- Refractory cardiac arrest	38 (32 %)	21 (36 %)	17 (28 %)	0.43
SOFA score at admission	10 (8 - 12)	10 (6-12)	10 (8-12)	0.97
SOFA score at cannulation	11 (9 - 13)	12 (10-13)	11(9-13)	0.10
Etiology :				
- STEMI	51 (42 %)	17 (29%)	34 (56%)	0.003
- Chronic heart failure	24 (20 %)	17 (29 %)	7 (11 %)	0.018
- Other	45 (38%)	25 (42%)	20 (33%)	0.34
PCI	47 (39 %)	18 (31 %)	29 (48 %)	0.056
<u>Procedural characteristics</u>				
Distal perfusion line	104 (97 %)	56 (96%)	60 (98%)	0.36
Pre-closing	46 (38 %)	0(0%)	46 (75%)	<0.0001

- 1 **Table 2:** Thirty-day outcome of patients with surgical and percutaneous approach. V-A
 2 ECLS: Veno-arterial extracorporeal membrane oxygenation; ICU: Intensive Care Unit. One
 3 patient had three simultaneous complications, and two patients had two simultaneous
 4 complications

	Surgical approach (n = 59)	Percutaneous approach (n= 61)	P-value
30-day survival n (%)	10 (17%)	16 (26 %)	0.22
Weaning from V-A ECLS n (%)	17 (29 %)	28 (46 %)	0.05
V-A ECLS duration (days)	2 (1 – 6)	4 (1 – 7)	0.30
ICU stay (days)	6 (2 - 14)	10 (1 - 22)	0.34
<u>Major complications</u>			
Patients with \geq 1 complication n (%)	25 (42 %)	7 (11 %)	0.0001
Patients with multiple complications n (%)	3 (5%)*	0 (0%)	0.11
Major bleeding n (%)	18 (31 %)	4 (7 %)	0.0007
Lower limb ischemia n (%)	5 (8 %)	2 (3 %)	0.27
Groin infection n (%)	6 (10 %)	1 (2 %)	0.059

5

6

1 **Table 3:** Univariate and multivariate analysis of factors associated with vascular
 2 complications following implantation of V-A ECLS. V-A ECLS: Veno-arterial extracorporeal
 3 membrane oxygenation; BMI: Body mass index.

4

Variables	Univariate		Multivariate	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Age	1.01 (0.98-1.04)	0.58		
BMI (kg/m²)	1.12 (1.01-1.23)	0.02	1.11 (1.01-1.23)	0.04
Diabetes Mellitus	1.25 (0.50-3.11)	0.63		
Long term anticoagulation before V-A ECLS	3.33 (1.13 – 9.82)	0.03	3.41 (0.90-13.00)	0.07
Chronic heart failure	1.90 (0.74-4.92)	0.18		
Peripheral artery disease	1.11 (0.20-6.01)	0.91		
Percutaneous approach	0.18 (0.07-0.45)	0.0003	0.23 (0.08-0.70)	0.009
Cardiac arrest	1.08 (0.45-2.58)	0.86		
Days of V-A ECLS	1.02 (0.96-1.09)	0.48		

5

6

7





