Percutaneous versus Side Graft Perfusion for Peripheral Extracorporeal Membrane Oxygenation Therapy; A Single Center Experience

Ekstrakorporeal Membran Oksijenasyon Tedavisi İçin Perkütan ve Yan Greft Perfüzyon Tekniklerinin Karşılaştırılması; Tek Merkez Deneyimi

Cemal KEMALOĞLU

Akdeniz University Faculty of Medicine, Department of Cardiovascular Surgery, Antalya, Turkey

Yazışma Adresi
Correspondence Address

Cemal KEMALOĞLU
Akdeniz Üniversitesi Tıp Fakültesi, Kalp Damar Cerrahisi Anabilim Dalı, Antalya, Turkey
E-mail: cemalkemaloglu@hotmail.com
ORCID ID: 0000-0002-3326-1990

Received \ Geliş tarihi : 08.11.2017
Accepted \ Kabul tarihi : 20.11.2017
Elektronik yayın tarihi : 17.04.2018
Online published

Kemaloğlu C. Percutaneous versus side graft perfusion for peripheral extracorporeal membrane oxygenation therapy; A single center experience. Akd Med J 2018;3:270-5.

ABSTRACT

Objective: Extracorporeal Membrane Oxygenation (ECMO) usage, as a technology for the support of critically hypoxic patients, has become a widely accepted therapy for severe respiratory or cardiac failure. ECMO support can be performed by central or peripheral cannulation. Central cannulation still remains a good option for post cardiotomy patients, while peripheral cannulation with the Seldinger technique is feasible in the intensive care unit without any need of surgical exploration. Different centers have their own techniques to avoid complications like bleeding or ischemia of the cannulated extremity. The objective of this study was to compare two cannulation techniques, side-graft and percutaneous cannulations, in terms of avoiding ischemia and bleeding at the cannulation sites.

Material and Methods: Nineteen patients who received peripheral venoarterial ECMO were divided into two groups according to their perfusion technique; percutaneous femoral artery cannulation (n=10) and side-graft perfusion.(n=9). The patients were analysed for complication development.

Results: Seven of the 9 patients had bleeding from the cannulation site in the PTFE graft group, while none of the patients had same complication in the direct cannulation group. (p<0,001).

Conclusion: Using a PTFE graft for arterial cannulation results in higher rates of bleeding than direct percutaneous arterial cannulation for ECMO therapy.

Key Words: Extracorporeal membrane oxygenation, Catheterization, Vascular grafting

ÖZ

Amaç: Ekstrakorporeal Membran Oksijenasyonu (ECMO) kullanımı, ciddi solunum ya da kalp yetmezliği olan, kritik hipoksik hastaların desteklenmesi için kabul gören bir teknoloji haline gelmiştir. ECMO desteği santral veya periferik kanülasyon ile yapılabilir. Santral kanülasyon, kardiyotomi sonrası hastalar için halen iyi bir seçenek olarak kalırken, Seldinger tekniği ile periferik kanülasyon, yoğun bakım ünitesinde herhangi bir cerrahi operasyona gerek duyulmadan yapılabilir. Merkezlerin, kanüle edilmiş ekstremitenin kanaması veya iskemi gibi komplikasyonları önlemek için kendi teknikleri vardır. Çalışmanın amacı, kanülasyon yerlerinde iskemi ve kanamadan kaçınma açısından iki kanülasyon tekniği, yan greft ve perkütan kanülasyonun karşılaştırılmasıdır.

Gereç ve Yöntemler: Periferik venoarteriyel ECMO tedavisine alınan 19 hasta perfüzyon tekniğine göre iki gruba ayrıldı; Perkütan femoral arter kanülasyonu (n = 10) ve yan greft perfüzyonu (n = 9). Hastalar gelişen komplikasyonlar açısından analiz edildi.

Bulgular: PTFE greft grubunda yedi hastanın kanülasyon yerinden kanaması vardı, ancak direkt kanülasyon grubunda hiçbir hastada aynı komplikasyon gelişmedi. (P <0.001).

Sonuç: Arteriyel kanülasyon için bir PTFE greft kullanılması, ECMO tedavisi için doğrudan perkütan arteryal kanülasyondan daha yüksek kanama oranları ile sonuçlanır.

Anahtar Sözcükler: Ekstrakorporel membran oksijenasyonu, Kateterizasyon, Vasküler greftleme

DOI: 10.17954/amj.2018.139

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) can be a life-saving measure for patients with respiratory or cardiac failure (1). The indications for extracorporeal membrane oxygenation (ECMO) have been well established (2,3). In brief, if the cause is reversible, and the damage is recoverable, it provides time for the patient to recover. ECMO is a life-saving tool although it comes with many different complications, including cannulation-related bleeding, ischemia of the ipsilateral extremity, vascular injury and infection. Access for the initiation of ECMO can be challenging, and a number of approaches have been reported. For patients with postcardiotomy shock, central cannulation is typically used, because it is easy to switch the cardiopulmonary bypass circuit to ECMO with the existing cannulas. Alternatively, in cases in which immediate support is necessary, such as acute cardiogenic shock after myocardial infarction, percutaneous access can be achieved by way of a peripheral vessel using the Seldinger technique or open arteriotomy (4). Peripheral ECMO support can be established as either Venovenous (VV) or Venoarterial (VA). VV extracorporeal membrane oxygenation can be a life-saving treatment modality in patients with hypoxia due to pulmonary disease such as acute respiratory distress syndrome (5) This study involves patients who received peripheral VA ECMO using different cannulation sites and techniques. Two different techniques to avoid ischemia (grafting of the target artery and using retrograde perfusion of the cannulated extremity) are compared.

MATERIALS and METHODS

This is a retrospective, case-control study. All patients data was available in the electronic database of the institution. Between January 2011 and February 2015, 19 patients with ECMO treatment were included in the study. 21 ECMO implantations were made to 19 patients. Re-implantation (changing both arterial cannulation site and arterial cannula) was required in two patients due to bleeding which caused hemodynamic instability.

Deltastream® model of Medos with Novalung iLA active Xlung tubing set (Inspiration Healthcare Ltd, UK) is used for all patients. Medos femoral arterial cannulas (18-22 F) and Medos femoral vein cannulas (22-24 F) were used for cannulation. Choice of cannula was made according to body surface area and the theoretical flow as determined by reference nomograms. Flow rates were usually 4-6 L per minute.

The femoral artery was directly cannulated by the Seldinger technique in 52.6 % (n=10) of the procedures at the intensive care unit with a dialysis catheter for the perfusion of the extremity. The remaining 9 (47.4%) cannulations were performed in the operation room by anastomosing an eight mm polytetrafluoroethylene (PTFE) graft to the target artery.

In the open technique, first the target artery (femoral or axillary artery) was harvested. After heparinization and side clamping, the arterial incision was made longitudinally and an 8-mm PTFE graft was anastomosed with a 6/0 prolene suture. The graft is carried out of the skin from a subcutaneous tunnel. The arterial cannula was inserted through the graft until the anastomosis level, in order to avoid possible kinking of the graft at the skin incision. The femoral vein was cannulated with the Seldinger technique using the appropriate venous cannula.

Percutaneous cannulation was performed in ICU the with the Seldinger technique. An 11.5 F hemodialysis catheter was used for antegrade perfusion of the extremity. After the initiation of heparin, all guidewires (for arterial cannula, venous cannula and hemodialysis catheter as back perfusion cannula) were placed first. Ultrasound guidance was always used for punctures. Insertion of guidewires of all cannulas first makes the punctures easier, and prevents possible damage of the inserted cannulas due to puncture (Figure 1). Arterial, venous and back-perfusion cannulas were placed respectively after the dilatation of the target artery and vein (Figure 2). After de-airing of all cannulas, ECMO circulation was started with the antegrade perfusion of the extremity (Figure 3).

Hemodialysis catheters are more resistant to kinking than the introducers. Both lumens of these catheters are used for perfusion and if one lumen of the catheter is thrombosed, the other lumen can provide sufficient perfusion to the extremity. This is another advantage of dialysis catheters.

Continuous intravenous heparin infusion was administrated for anticoagulation to achieve an activated clotting time ratio (ACT) of 180 to 250 seconds. All patients were admitted to the intensive care unit with daily monitoring of bleeding complications.

STATISTICAL ANALYSIS

The statistical analysis was performed with SPSS for Windows 20 (SPSS Science, Chicago, IL, USA). Clinical data was acquired and the pairwise independent t-test and Chi-square test were used as indicated. The differences were considered to be significant for p values < 0.05.

RESULTS

Nineteen peripheral cannulation patients were involved. The demographic data of the patients are summarized in Table I. The patients were divided into two groups by their cannulation technique; Group 1: percutaneous femoral artery cannulation (n=10); Group 2: arterial cannulation with open technique through a PTFE graft (femoral or axillary) (n=9).

Figure 1: Right Femoral vessels cannulation, the placement of all guidewires.

Figure 2: Cannulas are inserted.

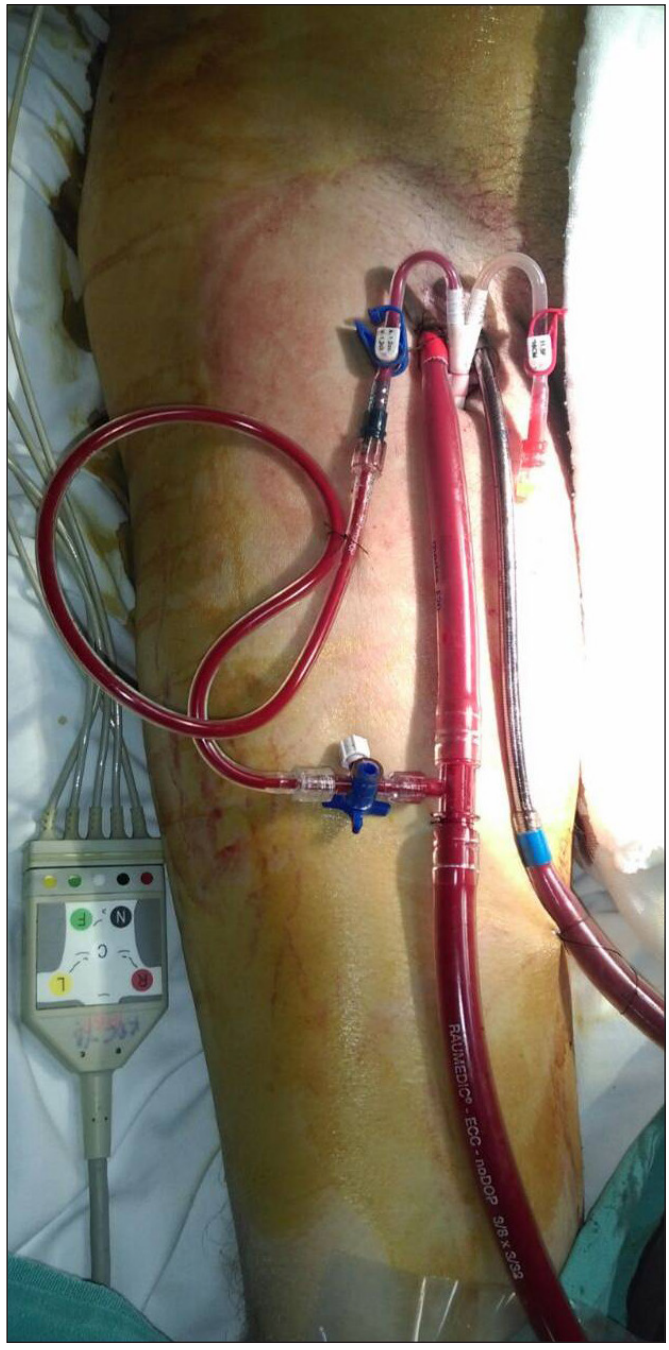

Figure 3: ECMO circulation is started with extremity perfusion.

Table I: Demographic data of patients with veno-arterial extracorporeal membrane oxygenation.

Characteristics	Patients(n=19)
Male	15 (75%)
Mean Age	57.05
ECMO indications	
• Unable to wean from cardiopulmonary bypass	7(37%)
• Acute respiratory distress syndrome (ARDS)*	2(10%)
• Hypoxia due to end stage heart failure (Lung edema)	7(37%)
• Pneumonia*	3(14%)

*VA ECMO is preferred in patients with ARDS and pneumonia because of concomitant left ventricle failure.

One patient's arterial cannulation was converted from axillary artery to percutaneous femoral artery by the Seldinger technique due to hemorrhage in the axillary artery cannulation site. One Patient with femoral outflow graft had arterial re-cannulation three times due to bleeding. First, arterial cannulation through a femoral graft was performed to the contralateral leg, and then femoral cannulation was performed percutaneously at the first cannulation site.

There was no difference in mean age and gender of the patient groups. Average duration of support was longer in Group 2. None of the cases developed ischemic leg complications. Vascular complications (dissection, rupture etc) requiring surgical treatment were not found in either group.

There was no episodes of cannula0related infection in either group. However, 2 patients in group 2 had graft infection and separation at the anastomosis.

There was a significantly higher rate of bleeding in group 2. Seven patients had bleeding and they all required surgical re-exploration (Table II). The grafting technique was abandoned because of this high rate of bleeding.

Four of the 19 patients were weaned and 3 of them discharged while 15 patients were dead on ECMO support. None of the deaths were associated with complications of the cannulation technique. The mortality rate on ECMO was 78% .

DISCUSSION

ECMO is a form of extracorporeal life support that serves as an alternative to ventricular assist devices to provide prolonged but temporary support of heart or lung function (6).

Depending on center preference, the peripheral or central cannulation technique is used for ECMO implantation. The traditional approach for cannulation for ECMO is an open surgical approach (7), and this approach still remains an important option. The open approach typically involves surgical exposure of the vessel, placement of ligatures, arteriotomy (and/or venotomy), insertion of the cannula, and closure of the incision. The advantages of the open approach include the ability to properly size the cannula and ensure intraluminal placement while monitoring to avoid vessel injury. The disadvantages include the increased risk for surgical site bleeding, the need for surgical repair for decannulation, and obstruction of the vessel if ligation is required. Ischemic complications can be avoided by placement of an end-to-side graft to the artery with insertion of the cannula into the graft with ligation (8).

The femoral vessels are frequently cannulated for VA-ECMO because they provide easy access to the central circulation and femoral cannulation is associated with decreased bleeding and neurologic complications. Since the arterial cannula may approach the diameter of the femoral artery, distal leg perfusion can become compromised. The incidence of ischemia ranges from 10% to 50% in patients with femoral artery cannulation (9). The side arm graft technique avoids intraluminal cannulas entirely, which should nearly eliminate the occurrence of ischemia in addition to allowing antegrade and retrograde blood flow (10). This technique requires cutdown exposure and arteriotomy of the femoral artery, increasing cannulation time, and bleeding and infection due to foreign material risk requiring re-exploration in comparison with the percutaneous technique.

One of the most catastrophic complications of peripheral ECMO cannula implantation is ischemia of the extremity which can even result in amputation. In a study from China, 8 of 34 patients developed ischemia and 2 needed amputation (11). This is the most important reason for selecting the technique and site for cannulation. After our experiences with peripheral ECMO implantation, insertion of an arterial cannula without a side armed graft or backperfusion cannula was avoided. We did not observe any ischemic complication in patients with a backflow cannula. However, in another study in which peripheral ECMO implantation was performed in femoral vessels with a backflow cannula usage ratio of 91%, ischemic complications were observed at an incidence of 20.8%. (12). In this study, an 8-12F sheath was used for antegrade

Table II: Data of study groups.

	GROUP:1	GROUP:2	P:
Number of Patients	10	9	
Mean Age	53.12	59,87	
Male	7	8	0.678
Avarage Duration Time (hours)	112.6	198.83	0.163
Bleeding	0	7	0.001

perfusion of the extremity. We prefer to use an 11.5 F dialysis catheter and we always use both of the lumens for perfusion. Despite all precautions, and even in patients with central ECMO, limb ischemia may occur due to thromboembolic complications of device usage (13).

Using a PTFE graft as the outflow cannula is an important choice to avoid ischemia. This technique is challenging because of bleeding complications according to our experience. Another disadvantage is that this technique is not feasible to apply in the ICU. Seven of our patients had bleeding from the cannulation site. All of them underwent surgical re-exploration and 2 needed urgent surgery. Surgical exploration usually showed that the main reason of bleeding is separation at the anastomosis site, which is mostly due to local graft infection. During our experience with PTFE graft usage for arterial cannula insertion, many surgical techniques were used to avoid infection. Mostly, after the anastomosis is made end-to-side to the target artery, the outflow graft is carried out through a subcutaneous tunnel, which allows the surgical incision to close completely. Even if there are no signs of any infection or separation, anastomosis bleeding may occur as a result of coagulopathy, which is part of the natural course of a patient with an implanted device for extracorporeal circulation (14).

The grafting technique has another complication known as the 'hyperperfusion syndrome'. It is defined as an ipsilateral (on the side of the arterial cannulation) edematous limb that was hyperemic and warm to touch. It may proceed to the compartment syndrome which can have catastrophic results. None of our patients developed hyperperfusion syndrome.

Saeed et al. showed less ECMO-related bleeding and resternotomy requirement in patients who were cannulated peripherally from the femoral artery (15). Similarly, in another study from Kanji et al., the central cannulation technique was associated with a higher incidence of bleeding from the cannulation site (64% vs. 18%, $P = 0.002$) and reoperation (66% vs. 14%, $P < 0.0001$) (13). We always perform the ECMO implantation peripherally, except for patients who cannot be weaned from CPB.

LIMITATIONS

There are some limitations of this single centre study. The number of patients in both groups was low, even with statistically significant results. The reason for this is that the side grafting technique has been abandoned due to high bleeding rates. Another limitation is that the indication for ECMO implantation was similar in most patients. The diversification of the indications is likely to affect the results.

CONCLUSION

Two arterial cannulation techniques for the initiation of ECMO therapy were compared in this study: direct arterial cannulation (with the use of a back-perfusion cannula) versus arterial cannulation through a graft There was no statistically significant difference between the two techniques in terms of avoiding ischemia of the cannulated extremity while the grafting technique had a much higher rate of bleeding complications, which was statistically significant ($p<0.001$).

REFERENCES

1. Brodie D, Bacchetta M. Extracorporeal membrane oxygenation for ARDS in adults. N Engl J Med 2011;365:1905-14.
2. Blythe D. Percutaneous axillary artery insertion of an intra-aortic balloon pump. Anesth Intensive Care 1995;23:406-7.
3. Kaplon RJ, Smedira NG. Extracorporeal membrane oxygenation in adults. In: Golstein DJ, Oz MC, eds. Cardiac assist devices. Armonk, NY: Futura Publishing, 2000:263-73.
4. Themistokles C, Brian L, Alexis ES, Dave N, Julie AP, Jose LN, Mason D, Gonzalez-Stawinski GV. Outcomes of axillary artery side graft cannulation for extracorporeal membrane oxygenation. J Thorac Cardiovasc Surg 2013;145(4):1088-92.
5. Yüksel A, Tecimer ME ,Özgöz HM, Yolgösteren A, Kan İİ, Doğan Aİ, Sığnak IŞ. Venovenous extracorporeal membrane oxygenation for acute respiratory distress syndrome: Our single-center experience. Turk Gogus Kalp Dama 2017;25(1):61-7.
6. Thiagarajan RR, Brogan TV, Scheurer MA, Laussen PC, Rycus PT, Bratton SL. Extracorporeal membrane oxygenation to support cardiopulmonary resuscitation in adults. Ann Thorac Surg 2009; 87: 778-85.
7. Bartlett RH, Roloff DW, Custer JR, Younger JG, Hirschl RB. Extracorporeal life support: The University of Michigan experience. JAMA 2000; 283:904-8.
8. Javidfar J, Brodie D, Costa J, Miller J, Jurrado J, LaVelle M, et al: Subclavian artery cannulation for venoarterial extracorporeal membrane oxygenation. ASAIO J 2012; 58:494-8.

9. Bisdas T, Beutel G, Warnecke G, Hoeper MM, Kuehn C, Haverich A, Teebken OE. Vascular complications in patients undergoing femoral cannulation for extracorporeal membrane oxygenation support. Ann Thorac Surg 2011;92:626-31.
10. Jackson KW, Timpa J, McIlwain RB, O'Meara C, Kirklin JK, Borasino S, Alten JA. Side-Arm grafts for femoral extracorporeal membrane oxygenation cannulation. Ann Thorac Surg 2012;94:e111-2.
11. Guo Z, Li X, Xu LF, Chang X. Cannulation related complications and prevention for extracorporeal membrane oxygenation: Clinical report and reviews of experience of 34 cases. Zhonghua Wai Ke Za Zhi 2013;51(9):804-7.
12. Slottosch I, Liakopoulos O, Kuhn E, Deppe AC, Scherner M, Madershahian N, Choi YH, Wahlers T. Outcomes after peripheral extracorporeal membrane oxygenation therapy for postcardiotomy cardiogenic shock: A single-center experience. J Surg Res 2013;181(2):e47-55.
13. Kanji HD, Schulze CJ, Oreopoulos A, Lehr EJ, Wang W, MacArthur RM. Peripheral versus central cannulation for extracorporeal membrane oxygenation: a comparison of limb ischemia and transfusion requirements. Thorac Cardiovasc Surg 2010;58:459-62.
14. Murphy DA, Hockings LE, Andrews RK, Aubron C, Gardiner EE, Pellegrino VA, Davis AK. Extracorporeal membrane oxygenation - hemostatic complications. Transfus Med Rev 2015;29(2):90-101.
15. Saeed D, Stosik H, Islamovic M, Albert A, Kamiya H, Maxhera B, Lichtenberg A. Femoro-femoral versus atrio-aortic extracorporeal membrane oxygenation: Selecting the ideal cannulation technique. Artif Organs 2014;38(7):549-55.