Outcomes of percutaneous femoral cannulation for venoarterial extracorporeal membrane oxygenation support

European Heart Journal: Acute Cardiovascular Care
1(2) 111–114

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DOI: 10.1177/2048872612449417

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Arnaud Roussel,¹ Nawwar Al-Attar,¹ Soleiman Alkhoder,¹
Costin Radu,¹ Richard Raffoul,¹ Mezher Alshammari,¹ Philippe
Montravers,² Michel Wolff³ and Patrick Nataf¹

Abstract

Introduction: We report and examine the outcomes of emergency venoarterial extracorporeal membrane oxygenation (ECMO) support initiated via percutaneous cannulation of the femoral vessels.

Patients and methods: Fifteen patients undergoing percutaneous venoarterial ECMO under emergency circumstances between January 2009 and July 2011 were identified. The implantation technique employed the Seldinger's technique for both arterial and venous cannulae. Whenever possible antegrade perfusion of the ipsilateral lower limb was performed through percutaneous catheterization of the superficial femoral artery (SFA).

Results: ECMO support was indicated mainly for cardiac arrest ($n=9$, 60%) or cardiogenic shock ($n=4$, 27%), while two (13%) patients required ECMO support for acute respiratory failure. In five (33%) patients, ECMO was implanted during cardiopulmonary resuscitation manoeuvres. ECMO support was maintained for a mean of 4.9 days. Eight patients (53%) were successfully weaned from the device. Thirty-day mortality was 53%. Seven patients (47%) suffered early complications, namely two wound infections, one thrombosis of the venous cannula, one erroneous implantation of the arterial cannula into the femoral vein, one local dissection of the femoral artery, one retroperitoneal bleeding and one acute limb ischaemia. No long-term vascular complications were noted.

Conclusion: Percutaneous femoral cannulation for ECMO support remains a prompt approach for establishing extracorporeal circulatory support in acute cardiopulmonary failure when conditions for performing femoral vessel cut down are not optimal. However, vascular complications are frequent and carry a significant morbidity and mortality.

Keywords

ECMO, cardiac arrest, outcomes, complications

Received: 12 April 2012; accepted: 2 May 2012

Introduction

Extracorporeal membrane oxygenation (ECMO) is a well established support and life-saving technique for patients with acute refractory cardiopulmonary dysfunction. The common femoral artery (CFA) provides easy access for arterial cannulation. This can be performed either through a percutaneous approach using Seldinger's technique or via an open approach by performing cut down of the CFA. Percutaneous femoral cannulation carries the advantage of allowing an expeditious procedure which is of particular value in an emergency situation. We report and examine the outcomes of venoarterial ECMO support with

percutaneous cannulation of the femoral vessels under emergency circumstances.

¹Department of Cardiac Surgery, Bichat Hospital, France

²Department of Anaesthesiology and Surgical Intensive Care Unit, Bichat Hospital, France

³Medical Intensive Care Unit, Bichat Hospital, France

Corresponding author:

Nawwar Al-Attar, Service de Chirurgie Cardiaque, Hôpital Bichat, AP-HP, 46 Rue Henri Huchard, 75877 Paris Cedex 18, France.

Email: nawwar.al-attar@bch.aphp.fr

Table 1. Demographic data of patients with percutaneous venoarterial extracorporeal membrane oxygenation (ECMO).

Characteristics	Patients (n = 15)
Male	7 (47%)
Mean age, years (range)	52 (22–86)
Comorbidities	
Arterial hypertension	3 (20%)
Dyslipidaemia	2 (13%)
Diabetes mellitus	2 (13%)
Smoking	6 (40%)
Coronary artery disease	4 (27%)
Peripheral artery disease	1 (7%)
ECMO indications	
Cardiac arrest	8 (53%)
Ventricular fibrillation caused by fulminant myocarditis	1
Dissection of the left main stem during coronary angiography	1
Acute myocardial infarctions	3
Following transcatheter aortic-valve implantation	2
Underdetermined aetiology	2
Cardiogenic shock	4 (27%)
Acute myocardial infarction	3
Aorto-coronary bypass	1
Acute respiratory failure	3 (20%)

Patients and methods

Patients undergoing percutaneous venoarterial ECMO under emergency circumstances between January 2009 and July 2011 were prospectively included in the department's database. Medical records were examined for the following factors: age, gender, cardiovascular risks factors, cardiovascular disease, peripheral arterial disease, cannula size, lower limb ipsilateral perfusion, ECMO duration, acute complications and mortality. The implantation technique was initiated percutaneously using Seldinger's technique. After puncture of the common femoral artery or vein, a soft tipped guide-wire was passed through the needle. Dilators were passed stepwise over the guide-wire to enlarge the access until the cannula size was achieved. Choice of cannula was made according to body surface area and the theoretical flow as determined by reference normograms. The cannula was inserted and connected to the ECMO system consisting of a BIOLINE coating tubing system, QUADROX-i Oxygenator and a ROTAFLOW Centrifugal Pump (Maquet, Germany). Then antegrade perfusion of the ipsilateral lower limb was achieved whenever possible through the superficial femoral artery (SFA) with a peripheral leg cannula connected to the arterial cannula via a Y adapter. Continuous intravenous heparin infusion was administered for anticoagulation to achieve an activated clotting time ratio (ACT) of 250 to 300 seconds. All patients were admitted to the intensive care unit with daily monitoring of blood gas analysis, bleeding tests (maintaining ACT values above 250 seconds), echocardiography and Doppler study of peripheral pulse.

Explantation of ECMO support was performed in a standardized operating room procedure. Cannulae were removed after surgical dissection of femoral vessels. Cannulation sites were repaired with 6/0 prolene sutures after assessment of the femoral artery pulsatility. Post-ablation Doppler study of the distal pulses was performed repeatedly during the first 24 hours.

Results are analysed by StatView software (StatView 5.0, SAS Institute Inc., Cary, North Carolina, USA) and expressed as means.

Results

Between January 2009 and July 2011, 15 consecutive patients underwent venoarterial ECMO through percutaneous cannulation of the femoral vessels. Of these seven (47%) were male with a mean age of 51.1 (22–86) years. The majority of patients were placed on ECMO support for cardiac arrest (nine patients, 60%) or cardiogenic shock (four patients, 27%). Four patients had known coronary artery disease and one patient had a peripheral artery disease with an endarterectomy of the carotid artery. Patients' characteristics are summarized in Table 1.

ECMO support was implanted under emergency circumstances in the operating room ($n=1$, 7%) intensive care unit ($n=6$, 40%) and the coronary angiography suite ($n=7$, 47%); only in the last group was fluoroscopic guidance possible during implantation. In the remaining two patients one procedure was performed in the emergency room and the other in the operating room. In all cases, ECMO was implanted during patient resuscitation manoeuvres and in

Table 2. Complications of percutaneous cannulation for venoarterial extracorporeal membrane oxygenation (ECMO).

Early complications	Number (%)	Management
Wound infection	2 (13%)	Wound revision (n=2), ECMO explantation (n=1)
Thrombosis of venous cannula	1 (7%)	
Complication of implantation	1 (7%)	
Dissection of femoral artery	1 (7%)	Anticoagulation, conservative management
Retroperitoneal bleeding	1 (7%)	
Acute limb ischemia	1 (7%)	ECMO explantation and fasciotomy

five of them (33%) under external cardiac massage. Arterial and venous cannulae were inserted in sizes ranging respectively from 16 to 23 Fr and from 24 to 27 Fr. In four cases, a single-lumen catheter (6 Fr) was then inserted along the arterial cannula anterogradely into the distal superficial femoral artery for lower limb perfusion. ECMO support was maintained for a mean of 4.9 (1–12) days. Eight patients (53%) were successfully weaned from the device. Of these eight patients, only one died after ECMO explantation. Thirty-day mortality after the initiation of ECMO support was 53% (eight of 15 patients), median follow-up time was 179 (1–844) days. Seven patients (48%) suffered early complications. These are summarized in Table 2. Two patients had wound infection requiring surgery and ECMO explantation in one of them, one patient had a thrombosis of the venous cannula on the third postimplantation day causing death of the patient, and in one patient, erroneous implantation of the arterial cannula into the femoral vein led to periprocedure death of the patient. Three patients had vascular complications: one local dissection of the femoral artery successfully treated conservatively; one retroperitoneal bleeding attributed to traumatic rupture of the inferior vena cava with consequent death of the patient and one acute limb ischaemia. The limb ischaemia occurred four days after ECMO implantation despite antegrade perfusion of the lower limb and was treated by ECMO explantation, thrombectomy by Fogarty's catheter and relief fasciotomy of the ischaemic limb. None of the eight patients weaned from ECMO support and discharged from hospital had late vascular complications.

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. It has been successfully used to support patients with cardiac arrest failing to respond to conventional cardiopulmonary resuscitation (CPR).¹ Its use is increasing both in children and adults, although survival rates have not improved despite increasing experience.¹ Given the often unpredictable nature of the need for ECMO, and the urgency in installing the cardiopulmonary circulatory

support, percutaneous implantation of the cannulae has been advocated for expediting the procedure.

ECMO implanted in a cardiac arrested patient carries a very reserved prognosis; nevertheless, it still may help in some patients failing to respond to conventional CPR therapies. Shin et al. compared outcomes of patients with cardiac arrest requiring CPR for more than 10 minutes managed with conventional CPR and with ECMO. They show that the odds of mortality and having more than minimal neurologic disability was lower (odds ratio, 0.17; 95% confidence interval, 0.04–0.71) for patients supported with ECMO compared with those managed with conventional CPR. These improved outcomes for ECMO patients persisted up to six months following the episode of cardiac arrest. Improved survival was also seen in a subgroup of patients with cardiac disease, which was the largest diagnostic group in their cohort. Thus the authors conclude that ECMO improved survival in patients with refractory in-hospital cardiac arrest.²

In the present study, overall 30-day mortality rate is 53%, which is comparable to previous studies. Bisdas et al. reported a 30-day mortality after the initiation of ECMO support of 61%. The study population had a majority of venoarterial ECMO support (143 patients, 82%) with percutaneous femoral arterial cannulation in 136 patients (95%).³ In their series of percutaneous cannulation for extracorporeal life support including 158 venoarterial ECMO with 88 percutaneous femoral access, Ganslmeier et al. had a success rate of only 20%, probably because 45% required cardiac resuscitation before implantation of venoarterial ECMO.⁴

We perform percutaneous femoral artery cannulation for ECMO implanted under emergency circumstances given the speed of installation and in the absence of logistic necessities required to perform vessel cut down. A major concern is the difficulty to insert an antegrade catheter percutaneously for limb perfusion with a non-detectable femoral pulse. Huang et al. addressed this issue by proposing a pressure criterion for placement of a distal perfusion catheter to prevent limb ischaemia during extracorporeal life support. Thus when the pressure is less than 50 mmHg measured by direct needle puncture 2 to 3 cm distal to the femoral cannulation site, a perfusion catheter is advocated.⁵ In our population, a distal perfusion catheter was attempted in every case but was successful in only one-third of our patients.

Previous studies report early arterial vascular complications rates ranging from 3.2% to 28%.^{3,4,6,7} In our series three patients (20%) had early arterial vascular complications: one dissection of the femoral artery, one retroperitoneal bleeding and one limb ischaemia. Acute limb ischaemia occurred in a 46 year old woman despite the presence of a distal perfusion catheter. The catheter was occluded and since all reperfusion catheters have been substituted by a size 9 Fr reinforced catheter. In their series of percutaneous venoarterial ECMO support with systematic distal limb perfusion catheter Bisdas et al. had a 4.4% (6/136) rate of limb ischaemia.³ Foley et al. reported no limb ischaemia in the prophylactic SFA cannulation cohort (0/10) and seven cases of limb ischaemia in the cohort with no prophylactic SFA cannulation (7/33).⁷ Ganslmeier et al. reported a 3.2% rate of limb ischaemia even though distal perfusion catheters were implanted only for small femoral vessels as demonstrated by sonography.⁴ Besides the pressure drop described by Huang, younger age and peripheral arterial disease are identified as predictor factors of ipsilateral arterial vascular complications.^{3,7} Post-implantation Doppler study allows to detect early limb ischaemia and echo-guided puncture of the run-off can facilitate limb reperfusion. Fluoroscopy remains extremely useful but rarely applicable unless the implantation was performed in the coronary angiography suite or in an equipped operating room.

To limit vascular limb complications, alternative cannulation sites such as the axillary artery have been considered.^{8,9} However, these cannulation sites are not practical in emergency circumstances as they may interfere with CPR because they require an open surgical access to the vessels. Moreover, several complications have also been reported (thrombosis, brachial plexus traction injury).⁸

In conclusion, percutaneous femoral cannulation for ECMO support remains a prompt approach for establishing extracorporeal circulatory support in acute cardiopulmonary failure. However, vascular complications are frequent and carry a significant morbidity and mortality. Peripheral limb ischaemia worsens outcome and insertion of a perfusion catheter should be attempted to reduce this risk.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

None declared.

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