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Improving cannulation time for extracorporeal life support in refractory cardiac arrest of presumed cardiac cause – Comparison of two percutaneous cannulation techniques in the catheterization laboratory in a center without on-site cardiovascular surgery☆

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ABSTRACT

Background: Cardiac arrest (CA) without return of spontaneous circulation can be treated with veno-arterial extracorporeal membrane oxygenation (vaECMO) implemented surgically or percutaneously. We performed a study assessing time for vaECMO percutaneous cannulation in the catheterization laboratory.
Methods: Single-centre retrospective study in a University hospital without on-site cardiovascular surgery, including patients aged >18 receiving vaECMO for out- or in-hospital refractory CA of presumed cardiac cause between 2010 and 2016, cannulated by interventional cardiologists. Cannulation time using anatomic landmarks vessel puncture and conventional wires (first period) was compared with ultrasound guidance puncture and stiff wires (second period). Data are expressed as medians (interquartile range) and percentages.
Results: Forty-six patients were included, age 56 (49–62), 34 in the first period. Shockable initial rhythm occurred in 29 (63%), 36 (78%) had ischemic heart disease and 26 (57%) acute myocardial infarction (AMI). Out-of-hospital refractory CA occurred in 27 (59%) patients. Time from out-of-hospital refractory CA to admission was 100 (80–118) min.

Cannulation was successful in 42 (91%) patients. Cannulation time was 14 (10–21) min, 17 (12–26) (first) and 8 (6–12) min (second period), $p < 0.001$. Survival to discharge was 9%. In out-of-hospital versus in-hospital, time from CA to vaECMO was 120 (115–140) versus 82 (58–102) min, $p = 0.011$, survival was 7% (two patients) versus 11% (two patients), $p = 0.35$ respectively. All survivors had shockable initial rhythm.
Conclusion: In these refractory CA patients with high prevalence of AMI and good feasibility of percutaneous vaECMO in the catheterization laboratory, cannulation time was shorter using ultrasound guidance and stiff wires.

Introduction

Cardiac arrest (CA) is associated with high mortality when return of spontaneous circulation is achieved [1,2], and an even more severe prognosis when the CA is refractory despite well-performed advanced life support [3–5]. When appropriate resuscitation does not restore spontaneous circulatory function, patients are declared deceased unless life-saving measures such

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as veno-arterial extracorporeal membrane oxygenator (vaECMO) devices are used [6].

VaECMO devices are supplanting circulatory and pulmonary function and are connected to the patient through arterial and venous cannulae inserted in refractory CA patients in the femoral vessels under cardiopulmonary resuscitation [6,7].

The insertion of the vaECMO cannulae can be performed by surgical technique using femoral dissection [3–5,8,9] or by percutaneous technique under ultrasound guidance or in the catheterization laboratory under fluoroscopic guidance [10–14].

Since 2005, in our center, vaECMO support is implemented in refractory CA patients using surgical cannulation [4], but more recently, we also used the percutaneous technique performed by interventional cardiologists. In our center, the puncture of the femoral vessels was initially performed using anatomic landmarks and the insertion of the cannulae was performed by the Seldinger technique using conventional wires provided by cannulae manufacturers. More recently, we used Doppler ultrasound-guided puncture of the femoral vessels and stiff wires in an attempt to improve cannulation delays. Several studies evaluated the results of the vaECMO inserted by the percutaneous technique with variable success rates [10–14], but no precise analysis of strategies improving cannulation delays were performed. Moreover, limited data exists on the coronary lesions in refractory cardiac arrest patients [15,16] and regarding survival according to the initial rhythm in this population [5].

We therefore performed a retrospective study analyzing the feasibility and the time interval required for percutaneous cannulation for vaECMO in refractory cardiac arrest patients in the two strategies. Our hypothesis was that cannulation using ultrasound guidance and stiff wires may be faster than anatomic landmark cannulation using standard wires.

The study also analyzed the coronary lesions including those responsible for acute coronary syndrome, and survival according to the initial rhythm of the CA.

Methods

This single-centre retrospective study was performed in Lariboisière University Hospital in Paris, France. The ethics committee of our institution approved the study and informed consent from the patients or the next of kin was not required. The study was conducted according to the principles of the Declaration of Helsinki (2008 version) of the World Medical Association.

Patients

We included patients with refractory CA of presumed cardiac cause in whom vaECMO support was attempted by the percutaneous technique between March 2010 and October 2016.

We excluded patients with CA of non-cardiac etiology (poisoning, hypothermia, septic or haemorrhagic shock etc). In general, patients in our centre are eligible to receive vaECMO unless unfavorable prognostic criteria are present: major comorbidities, lactate concentration >16 mmol/L, end-tidal CO_2 <10 mmHg on admission, time interval from the CA to cardiopulmonary resuscitation >5 min [4,17]. However, given the retrospective nature of the study, no strict criteria were pre-established.

VaECMO assistance device, cannulation technique and rationale for the two-period analysis

In our center, the circulatory assistance device employed is Maquet Rotaflow® pump, (Hirrlingen, Germany) using Rotaflow Maquet BE-PLS circuit (Rastatt, Germany). Cannulation was performed preferably in the right femoral vessels using venous 21, 23 or 25 French BE-PVL cannulae and arterial 15, 17 or 19 French BE-PAL cannulae (Maquet, Rastatt, Germany), using the Seldinger technique.

Puncture of the femoral vessels was initially performed using anatomic landmarks, and vessel wiring was performed using the wires included by the manufacturer in the cannulae kits from March 2010 until November 2015 (first period). From December 2015 until October 2016, puncture of the vessels was performed under ultrasound guidance (second period) and wiring was performed with J-tipped stiff wires, Amplatz Super Siff™ (Boston Scientific, Marlborough, MA, USA).

Ultrasound-guided puncture was performed using a Vivid I ultrasound machine and a standard 9L-RS vascular ultrasound probe (GE, Healthcare, Waukesha, WI, USA) placed beneath the inguinal ligament. Once the artery and vein were identified, the punctures were performed 0.5–1 cm distal to the ultrasound probe and the trajectory of the needle was adjusted to puncture the vessels [18]. Some operators inserted directly the stiff wire in the vessel. Others inserted a Starter™ (Boston Scientific, Marlborough, MA, USA) wire, then inserted a 6F sheath and through the sheath the stiff wire, as this has a very soft tip and its insertion through the needle was occasionally found difficult. Wires were advanced up to the right atrium and the thoracic aorta and their position verified by fluoroscopy.

Ultrasound guidance was introduced because during some procedures in the first period the artery and/or vein were difficult to find due to more difficult anatomical situation, prolonging the procedure and potentially exposing to more cannulation failure. Stiff wires were introduced to avoid wire bending during cannulation, and avoid prolonging further the cannulation procedure. This decision was made following several cannulations in the first period during which the wires provided by manufacturers, which are too soft, bent easily and required changing. More supportive wires allow to advance the cannula without risking bending and/or vessel injury.

Predilatation was performed with progressive dilators sizes 8F, 12F and 16F, PICV kit, Edwards Lifesciences® (Irvine, CA, USA), then the cannulae were inserted, the venous cannula was advanced up to the right atrium under fluoroscopic control, and connected to the vaECMO circuit.

Cannulation time was defined as the interval before the first puncture and the end of the insertion of the last cannula.

After vaECMO initiation, distal perfusion of the cannulated femoral artery was insured by an antegrade 4F catheter inserted in the superficial femoral artery under ultrasound guidance and its position was verified by contrast media injection and fluoroscopy. After the vaECMO initiation, coronary angiogram was performed using the standard technique preferably by radial access, with angioplasty if indicated [19,20].

Management of the patients

Management of the out-of-hospital cardiac arrest (OHCA) patients has been previously described [19,20]. Briefly, ambulances provided with resuscitation material and staffed by physicians are dispatched to the cardiac arrest site. They may be preceded by firefighters, able to provide basic life support, defibrillation and oxygen until arrival of the medical personnel. When no return of spontaneous circulation was achieved despite well-performed advanced life support, the medical staff on site made the decision to transport the patient to the hospital for vaECMO. The hospital staff admitting the patients did not interfere with this decision. The time spent on site by the emergency medical team was at the discretion of the physician in charge. Patients were transported to the hospital under chest compressions using a LUCAS® device and mechanical ventilation.