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ORIGINAL ARTICLES

Percutaneous Cannulation for Minimally Invasive Cardiac Surgery: The Safest and Effective Technique for the Future.

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Abstract

Introduction: In recent years, contemporary minimally invasive cardiac surgery techniques have been used in many cardiac surgical clinics.

With the expansion of minimally invasive operations, ECMO, and some interventional therapies, the current cardiac surgical landscape requires a thorough knowledge of peripheral cannulation techniques. A venous cannulation that is not flawlessly performed can lead to serious life-threatening complications in several steps. The technique we describe step by step is the current gold standard in terms of safety and efficacy: from the use of ultrasound for ultrasound-guided puncture to the safe advancement of super stiff guidewires using a sentinel catheter and concluding with smooth insertion of the venous cannula over the stiff guidewire up to the SVC. Moreover, a list of bailout maneuvers to solve complications and a report of institutional clinical experience since adopting this technique are presented.

Conclusion: In our experience, however, the fact is that patients' perceptions and expectations have changed. Patients increasingly ask for a therapeutic approach that leaves the sternum intact. Those doctors who want to meet this new challenge must realize that minimal incisions in cardiac surgery require excellent technical skills. For this reason, doctors should become familiar with current study data.

Keywords: Venous cannulation, echo-guided venous puncture, wire skills, transesophageal echocardiography

Introduction

Peripheral puncture and cannulation of jugular, femoral venous, and artery vessels have become standard practice in contemporary minimally invasive cardiac surgery (MICS), which requires increasing adoption of guidewires, catheters, and interventional skills [1, 2]. If not performed correctly, following an established step-by-step approach, consequences can become fatal complications for patients (iliac or caval veins rupture with massive internal bleeding). The femoral venous puncture is used in many different clinical contexts, from the cannulation to institute the extracorporeal circulation for MICS (mainly valvular), either for the placement of veno-arterial and veno-venous ECMO cannulas and for structural transcatheter interventions in which surgeons are involved (e.g., tricuspid and transseptal procedures) [3]. To avoid fatal issues with patients, it is essential to know where and how to puncture the femoral vein, how to safely advance the venous cannula up to the superior vena cava, and which precautions to adopt to successfully cope with complications of this procedure. The technique may vary depending on the patient; every surgeon should know how to adapt the procedure. This study aims to cover the percutaneous puncture of the vein and the safe positioning of a two-stage percutaneous venous cannula in the superior vena cava step by step. There will be a focus on imaging to visualize the structures under echocardiographic guidance, and the final section is dedicated to troubleshooting.

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Materials and Equipment

- Sterile cover, 7.5-MHz linear ultrasound transducer, and ultrasound gel.
- Transesophageal TEE ultrasound transducer, the echocardiography unit.
- Luer slips syringe 20 ml, 18-gauge needle, blade scalpel.
- The femoral introducer sheath 6 Fr and curved Klemmer forceps to prepare subcutis.
- Vascular dilators for percutaneous cannulation technique:
- Standard Emerald diagnostic J-Tip guidewire 0.035 × 180 cm, Amplatz Super Stiff guidewire, or Back-Up Meier J-Tip guidewire of more than 180 cm
- Angiographic diagnostic catheters, pigtail-shaped, 90 cm (e.g., pigtail 5 or 6 Fr)
- Femoral venous cannulas (several models) with a dual-stage tip that drains from the superior and inferior vena cava, usually available in two sizes (22/22 and 23/25 Fr)
- Jugular venous cannulas that drain from the superior, usually available in two sizes (16-17-18 Fr)

Results

For seven years, 2016-2023, we analyzed all the cases operated on in our clinic with minimally invasive procedures, including 186 patients.

Venous cannulation during the procedure was performed according to the operating surgeon's preference, allowing a certain degree of variability and depending on the type of intervention.

In the analyzed cases, 152 patients were operated on with atrial septal defect ASD (with right mini-thoracotomy incision). 2 patients with aortic stenosis AS (with mini sternotomy incision). 2 patients with aortic insufficiency AI (right mini-thoracotomy incision). Nineteen patients with mitral insufficiency MI (right mini-thoracotomy incision).

11 patients with mitral stenosis MS (right mini-thoracotomy incision)

The data in the table below

Procedure	Patients
PVCSC	**180**
PVCIC	**6**
PFAC	**1**
SVCIC	**180**
SFAC	**185**

PVCSC- Percutaneous Venous Cava Superior Cannulation: PVCIC - Percutaneous Venous Cava Inferior Cannulation: PFAC - Percutaneous Femoral Artery Cannulation: SVCSC - Surgical Venous Cava Inferior Cannulation: SFAC - Surgical Femoral Artery Cannulation

Table 1- The patient's data.

In all cases, the superior vena cava cannulation was done percutaneously using an orienting guide and positioning with transesophageal echo. (Fig .1)

Figure 1. Placement of the cannula in the superior vena cava through the internal jugular vein

In all the cases we have operated on, we have not had any technical failure, and we have not had any complications.

In cases where we used only femoral percutaneous venous drainage with two-hole cannulas positioned in the inferior and superior cavities, it was necessary to use a vacuum in the oxygenator to have better venous drainage. (Fig.2)

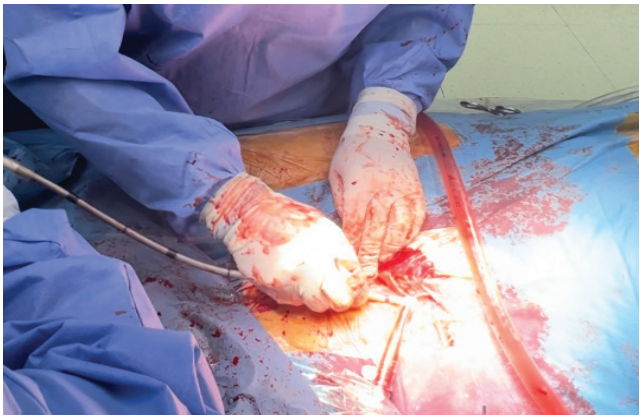

Figure 2. Placement of the cannula in the inferior vena cava through the femoral vein

In a case operated on with mitral stenosis, we used completely percutaneous extracorporeal circulation, with percutaneous annulation of the femoral artery with an 18 Fr cannula. Two sets of Perclose ProGlide™ Suture Mediated Closure (SMC) were used to close the arterial defect caused by cannulation. (Fig.3)

Figure 3. Closure of femoral artery puncture with Perclose ProGlide™

Using this Perclose ProGlide™ Suture Mediated Closure (SMC) kit in the postoperative period, compression was not necessary at the arterial puncture site, and there was neither hemorrhage nor hematoma at the puncture site

In cases of removal of femoral and jugular venous cannulas, the puncture sites were closed with a 5.0 and 6.0 prolene suture. They were kept compressed for 5-10 min after protamine administration. In no case did we have hematomas or hemorrhage from the puncture site.

From our experience, we have seen that the percutaneous venous and arterial cannulation technique is safe and allows for the advancement of mini-invasive cardiosurgical techniques.

Discussion

With the expansion of minimally invasive operations, ECMO, and some interventional therapies, the current cardiac surgical landscape requires thorough knowledge of peripheral cannulation techniques. In particular, venous cannulation may appear trivial and complication-free, but this does not reflect reality. A venous cannulation that is not performed perfectly can lead to serious life-threatening complications in several steps. The technique we have described step-by-step is the current gold standard in terms of safety and efficacy, from the use of ultrasound for ultrasound-guided puncture to the safe advancement of super stiff guidewires using a sentinel catheter and concluding with smooth insertion of the venous cannula over the stiff guidewire up to the SVC. Below, a list of bailout maneuvers to solve complications has been inserted.

Facing complications: Pitfalls and suggested tips during venous cannulation [1]

How to suspect an arteriovenous fistula

If inadvertent puncture of the femoral artery and, after that, the femoral vein occurs, a fistula between the artery and the vein will be created. Worse, subsequent dilation with dilators along the guidewire and insertion of the cannula by at least 20 Fr will damage the artery irreparably and make the fistula a surgical emergency during surgery or at the time of decannulation because of massive bleeding on systemic heparinization (usually necessitating replacement of the femoral artery with a vascular graft). This issue should always be ruled out when oxygenated blood, even in a small quantity, is gushing out from the venous groin puncture once the 6-Fr introducer or the small Fr dilator is removed. Urgent surgical repair/replacement of femoral vessels, according to the injury detected, is mandatory and the only solution.

Always preparing the subcutis with a Mosquito or small curved Klemmer is advisable to avoid kinking of the guidewire during the insertion of introducers, catheters, or dilators.[2]

How to manage resistance

Feeling resistance to the advancement of the guidewire is one of the things to be most careful about because, most of the time, the wire has taken the wrong route and is in the contralateral iliac vein, renal vein, or hepatic vein. Pushing against resistance will quickly produce tears, ruptures, and dissections of the vein and have fatal consequences for the patient. In this case, a 6-Fr sheath can be temporarily inserted in the vessel, and the target structure (superior vena cava or descending aorta) can be reached by inserting a pigtail.

How to avoid kinking a standard guidewire

Stay parallel to the skin while dilating, and do not point and push in an orthogonal manner concerning the vein.

How to manage a kinked guidewire

As previously mentioned, a habit of getting into when inserting and exchanging introducers, catheters, vascular dilators, or cannulas is moving the guidewire slightly back and forth inside them. If the wire moves without resistance, it means it is not kinked. If it gets stuck or offers resistance to movement, the wire is kinked and needs to be replaced to avoid further complications. In the case of a cannula, a sheath, or a dilator not advancing over a wire, the most common problem is kink. Forcing the advancement of catheters is dangerous and should be avoided.[3.5] The possible solutions are: pull back the wire a few centimeters until the kink becomes visible and try to advance the catheter/sheath/dilator beyond the kink under direct vision and after manual straightening of the wire (rarely a kinked wire can be successfully straightened). Another alternative solution is to advance over the kinked wire a dilatator of a small sheath (best is a 4 F or a 6F), having care of advancing slowly and concomitantly pulling back the wire a few millimeters. Once the dilator is inside the vessel, the kinked wire can be safely removed and replaced with a new wire in the vessel through the dilator.

Avoid advancing extra stiff guidewires in the veins without the protection of a sentinel catheter because there is a high risk of tearing the walls.[3.4]

Conclusion:

In our experience, however, the fact is that patients' perceptions and expectations have changed. Patients increasingly ask for a therapeutic approach that leaves the sternum intact. Those doctors who want to meet this new challenge must realize that minimal incisions in cardiac surgery require excellent technical skills. For this reason, doctors should become familiar with current study data.

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