OSPEDALE SAN RAFFAELE
ISTITUTO DI RICOVERO E CURA A CARATTERE SCIENTIFICO

An emerging problem: Vascular access for ECMO

Dott.ssa Maria Grazia Calabrò

U.O. Anestesia e Terapia Intensiva Cardio-Toraco-Vascolare

Ospedale San Raffaele, Milano

Impossibile visualizzare l'immagine. La memoria del computer potrebbe essere insufficiente per aprire l'immagine oppure l'immagine potrebbe essere danneggiata. Riavviare il computer e aprire di nuovo il file. Se viene visualizzata di nuovo la x rossa, potrebbe essere necessario eliminare l'immagine e inserirla di nuovo.

Impossibile visualizzare l'immagine. La memoria del computer potrebbe essere insufficiente per aprire l'immagine oppure l'immagine potrebbe essere danneggiata. Riavviare il computer e aprire di nuovo il file. Se viene visualizzata di nuovo la x rossa, potrebbe essere necessario eliminare l'immagine e inserirla di nuovo.

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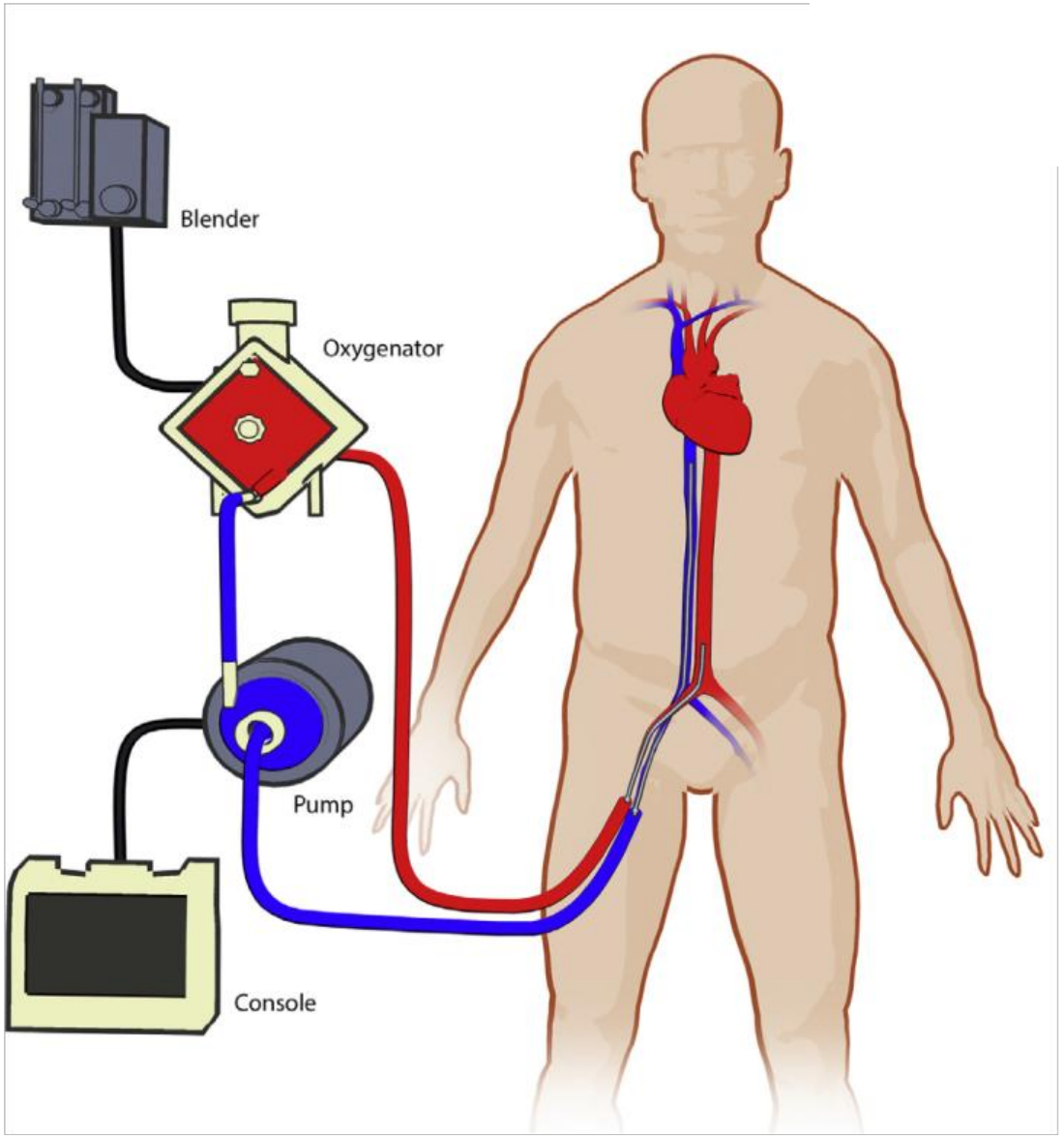
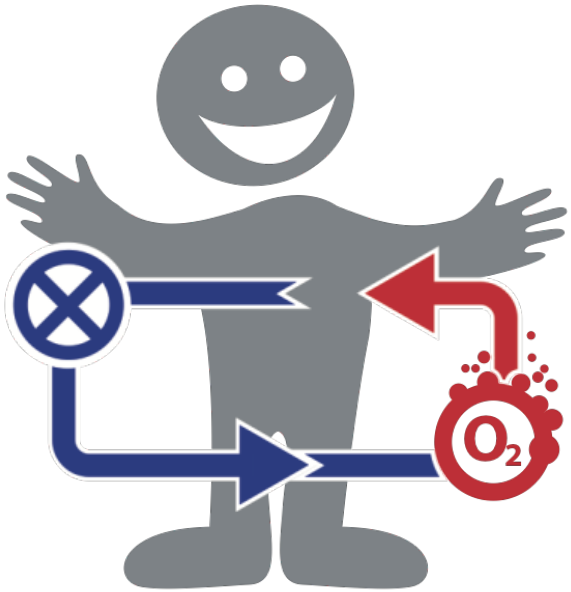
VA ECMO Circuit

- ✓Cannulae (outflow/inflow)
- ✓Tubing
- ✓Centrifugal pump
- ✓Controller
- ✓Membrane oxygenator
- ✓Blender
- ✓Heat exchanger



Clin Chest Med 36 (2015) 373–384

Setting

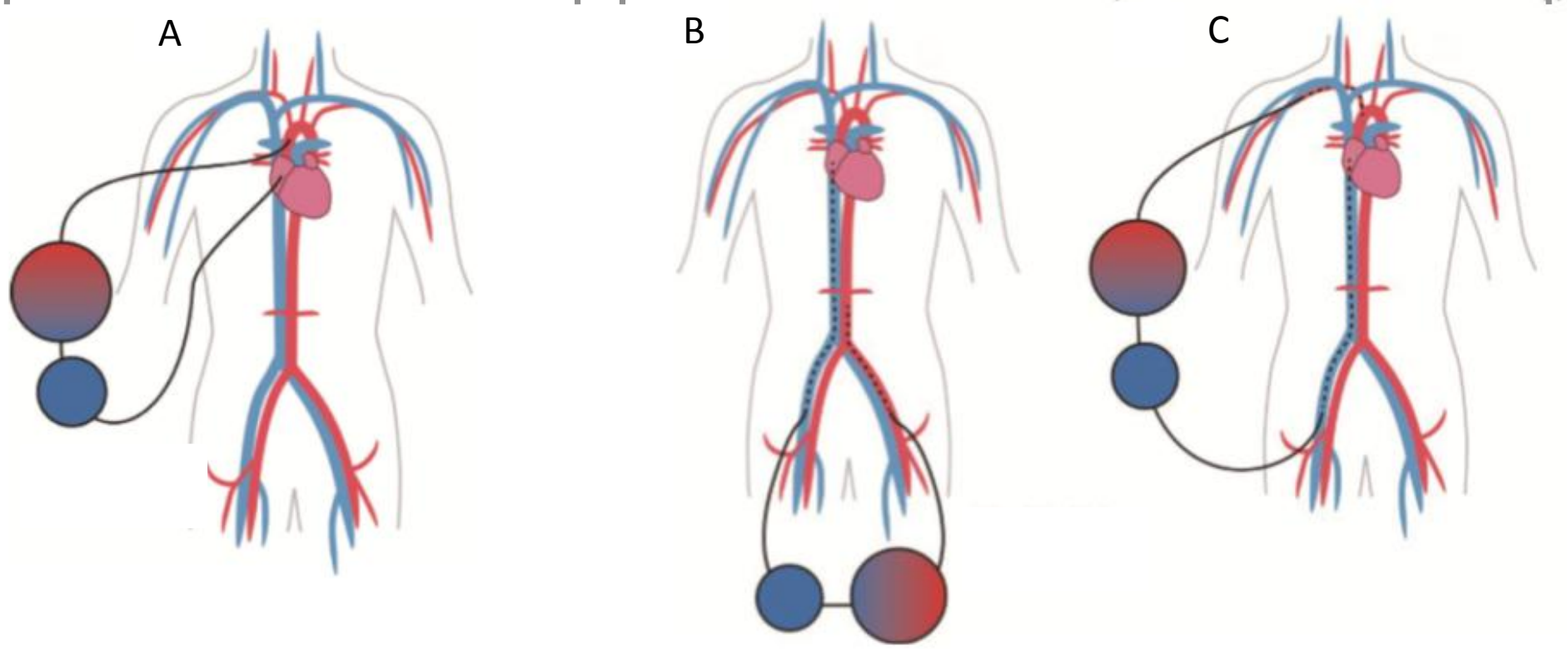


- ✓ Operating Room → Postcardiotomy CGS
- ✓ Intensive Care Unit → Refractory CGS
- ✓ Cath Lab → Prophylactic/urgent circulatory support
- ✓ Emergency Room → ECPR for IHCA/OHCA without ROSC

VA ECMO configurations

Central VA ECMO

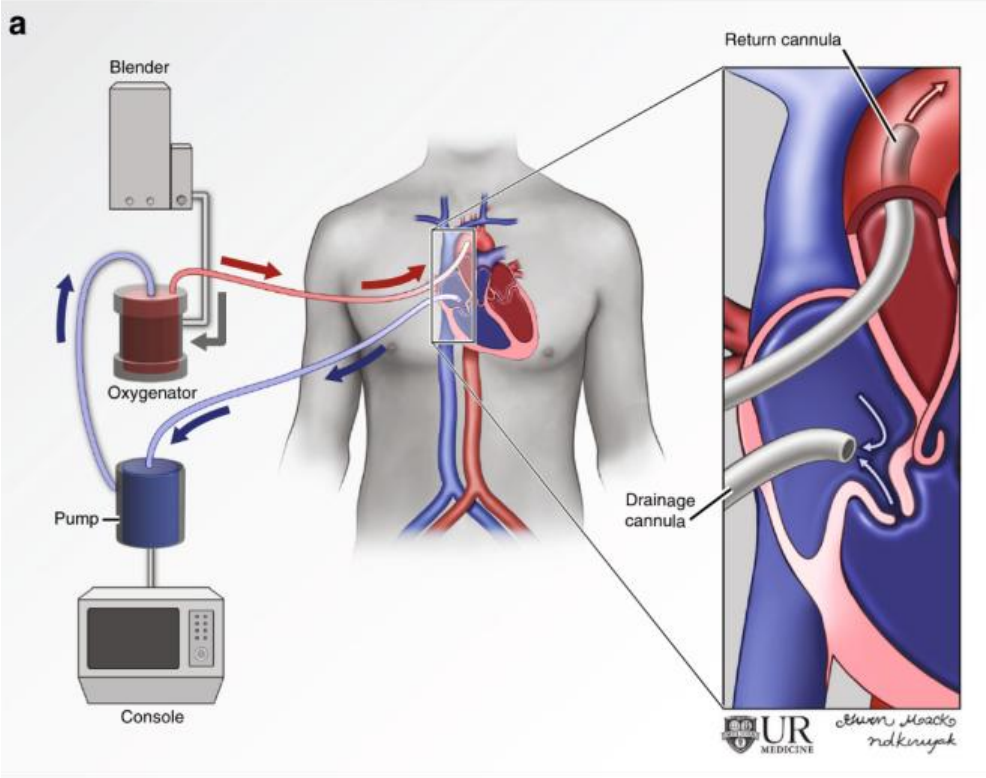
Peripheral VA ECMO

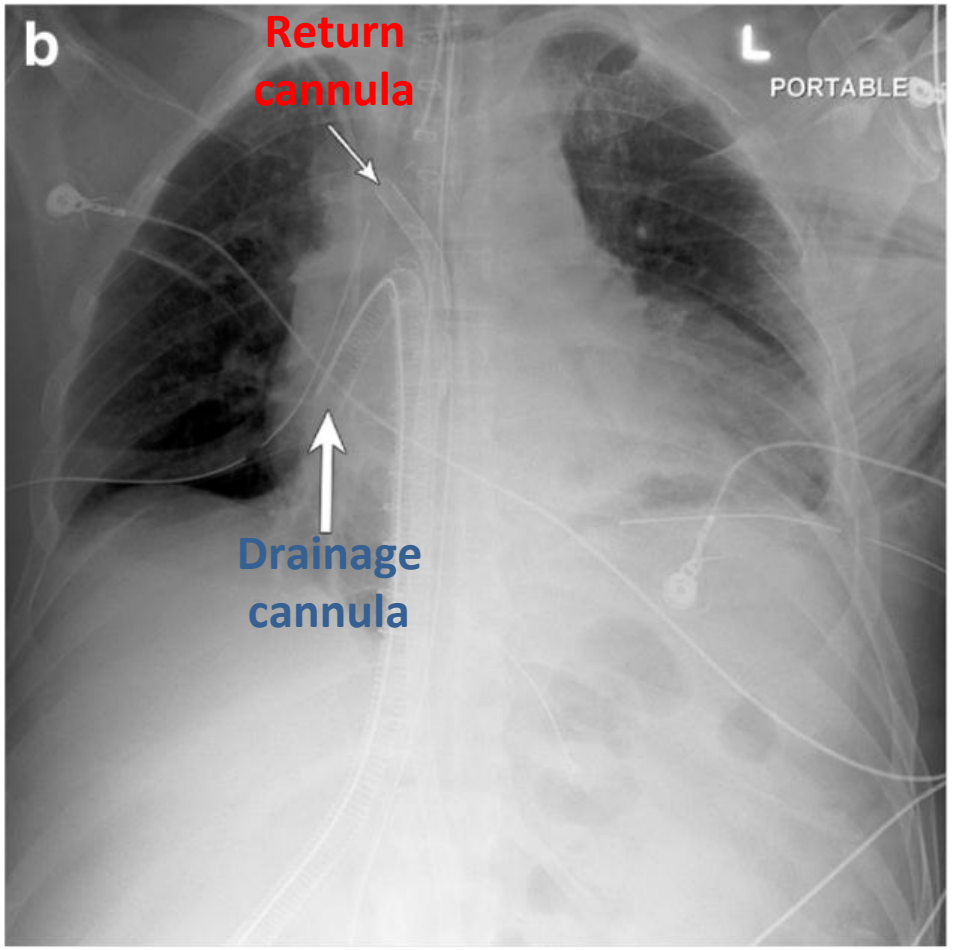


A. Central cannulation **B. Femoral artery cannulation** **C. Axillary artery cannulation**

Journal of Thoracic Disease, Vol 7, No 7 July 2015

Central VA ECMO





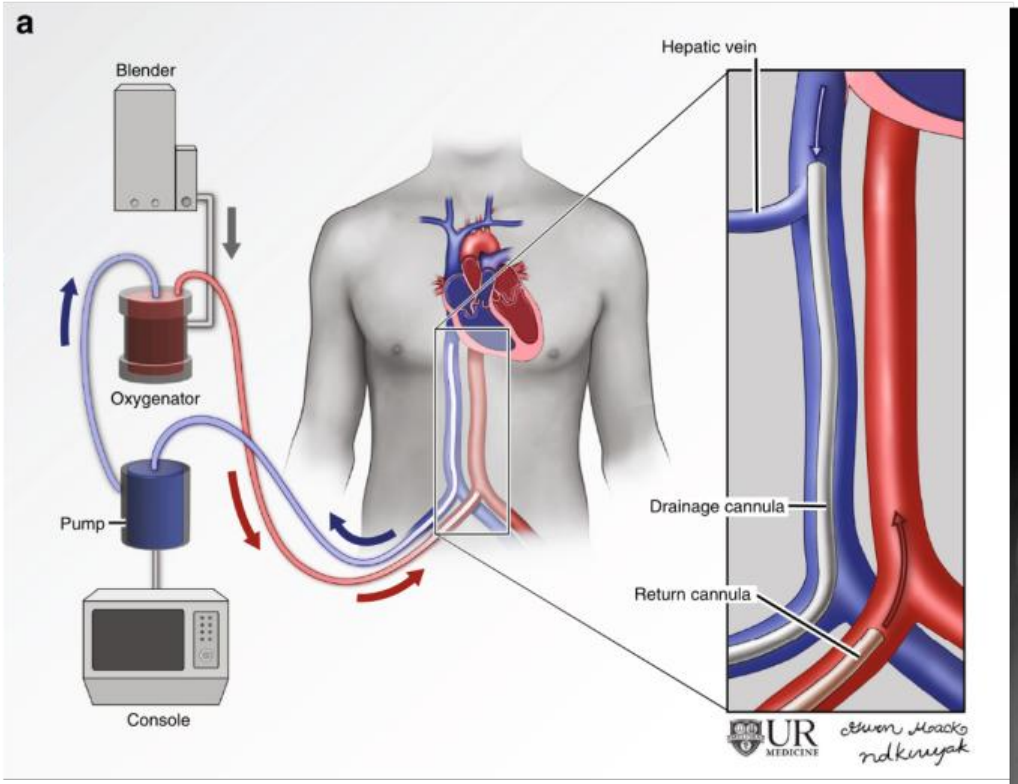
Drainage cannula: Right atrium

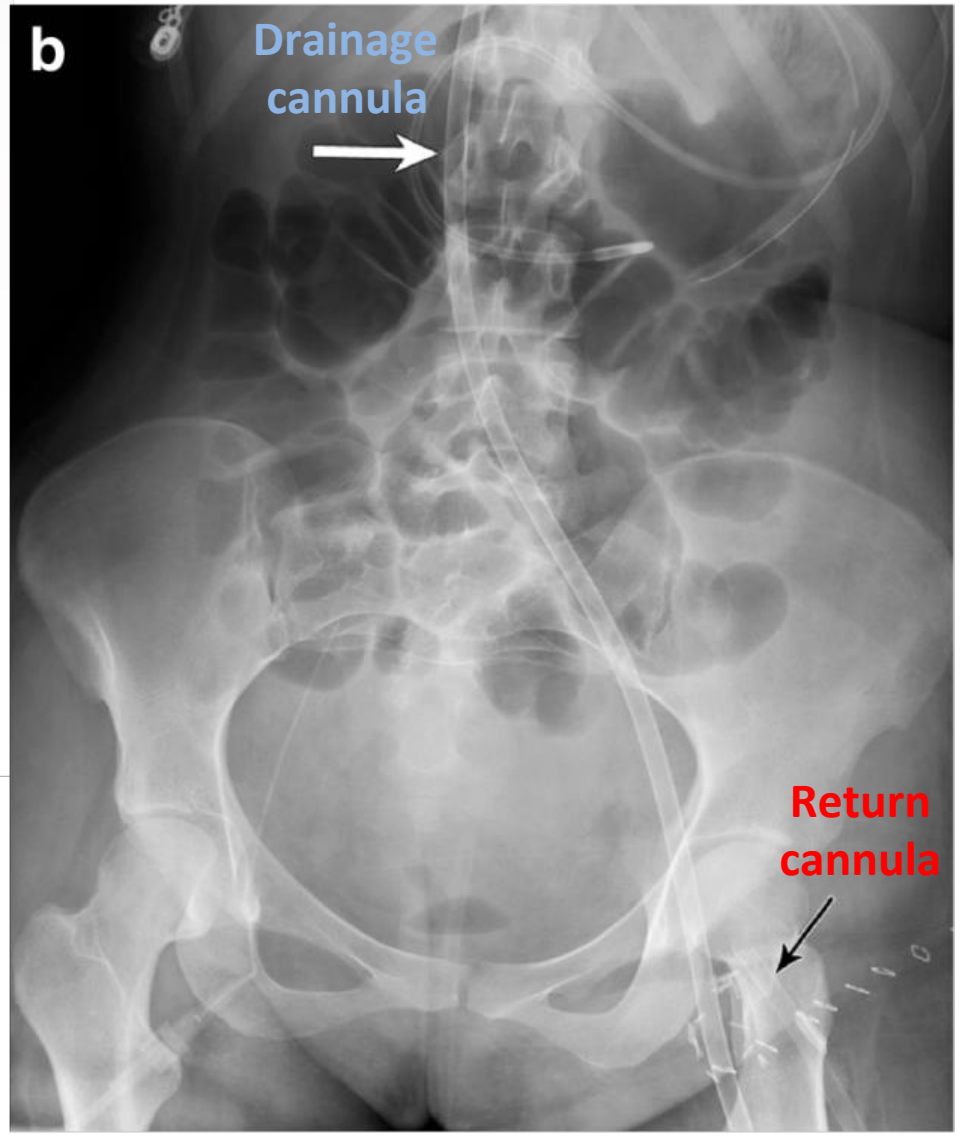
Return cannula: Aorta

Direct insertion into the mediastinal vessels

Insights Imaging (2014) 5:731–742

Peripheral Femoro-Femoral VA ECMO

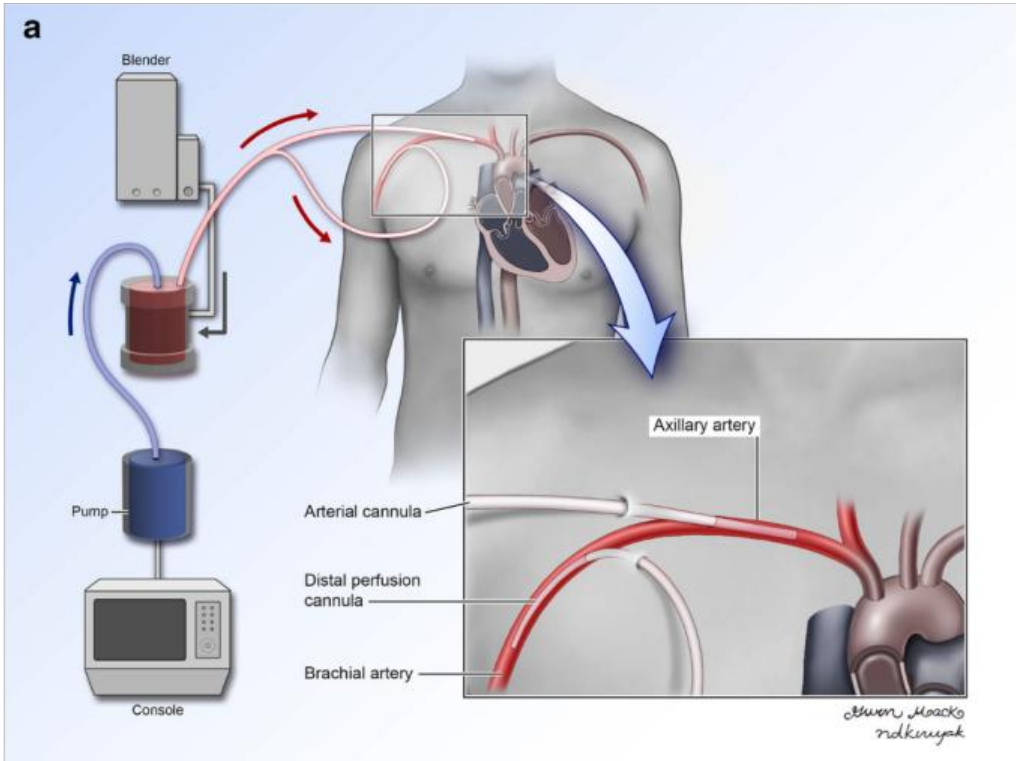


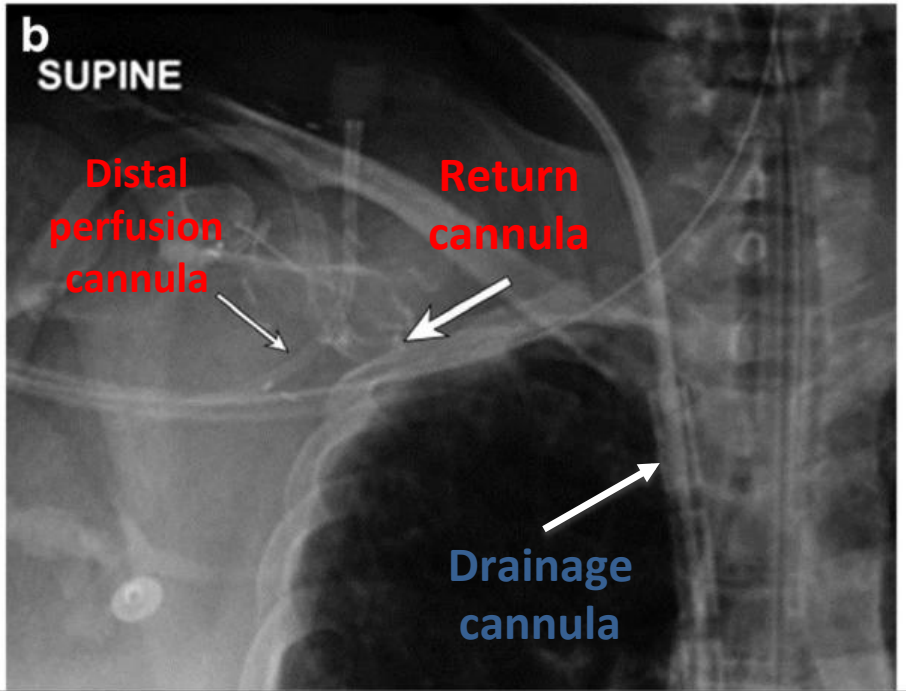


Drainage cannula: Distal IVC or SVC
Return cannula: Iliac artery
Insertion of cannulas in peripheral vessels

Insights Imaging (2014) 5:731–742

Peripheral – Right Axillary Artery VA ECMO

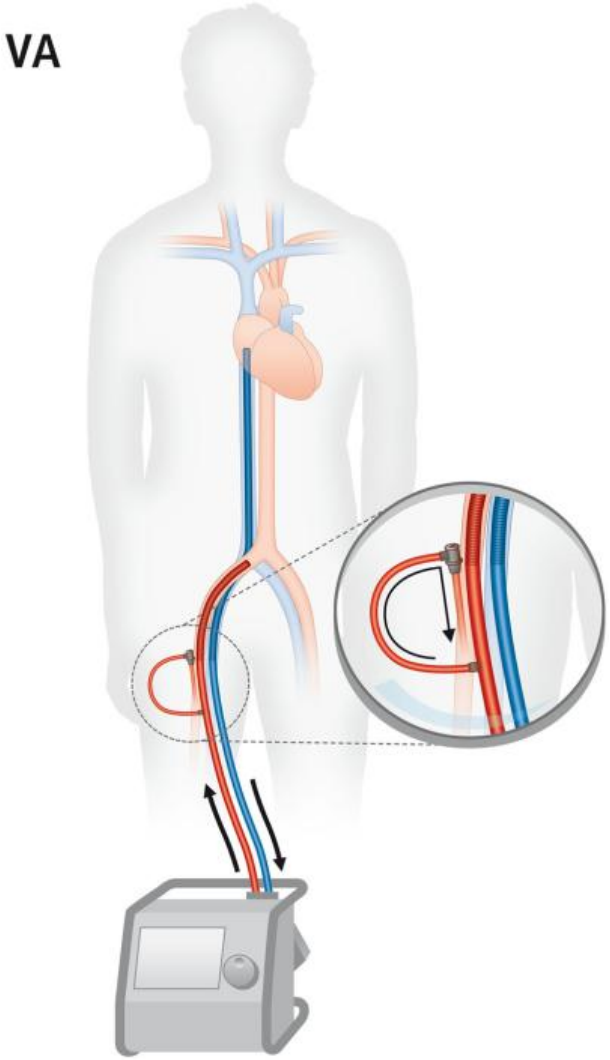




Drainage cannula: Distal IVC or SVC
Return cannula: Right Axillary Artery
Insertion of cannulas in peripheral vessels

Insights Imaging (2014) 5:731–742

Peripheral Femoro-Femoral VA ECMO



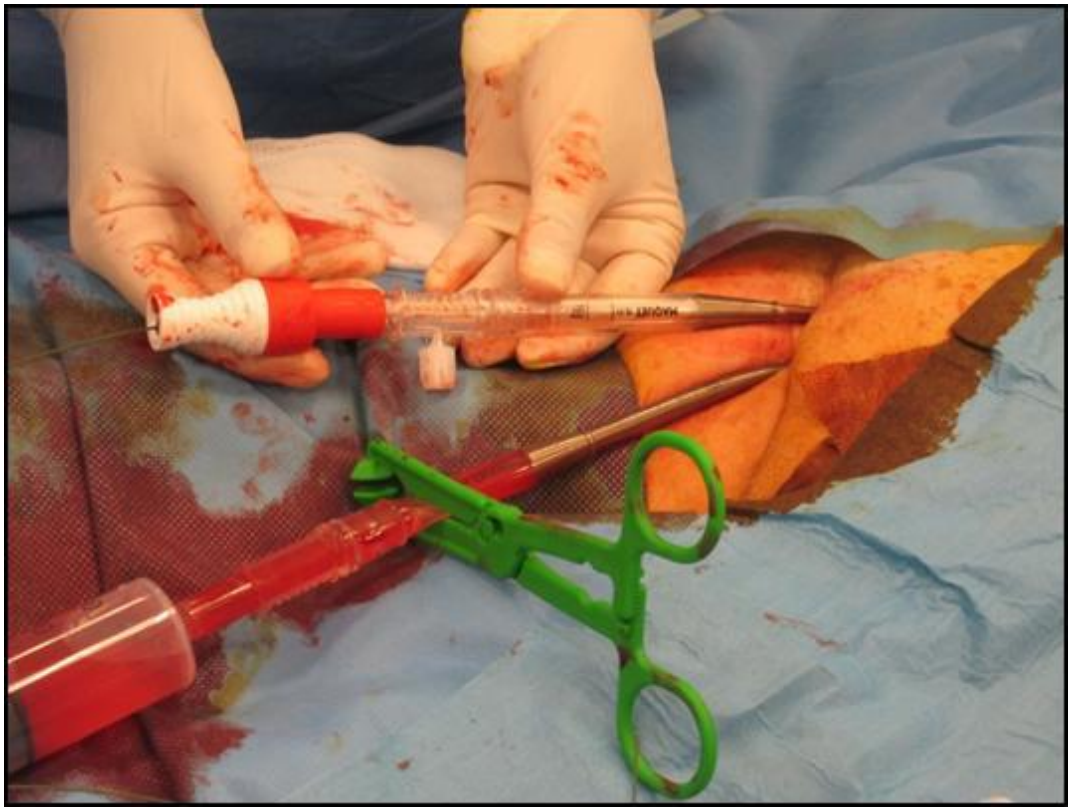


Fig. 3 Veno-arterial ECMO (VA). Blood is drained from the right atrium, oxygenated and decarboxylated in the ECMO device and returned to the iliac artery towards the aorta. Note the modified position of the venous cannula tip compared to veno-venous ECMO. Cannulation of the femoral artery requires an additional sheath for perfusion of the leg downstream of the cannulation site (*inset*)

Femoral Artery Cannulation Technique

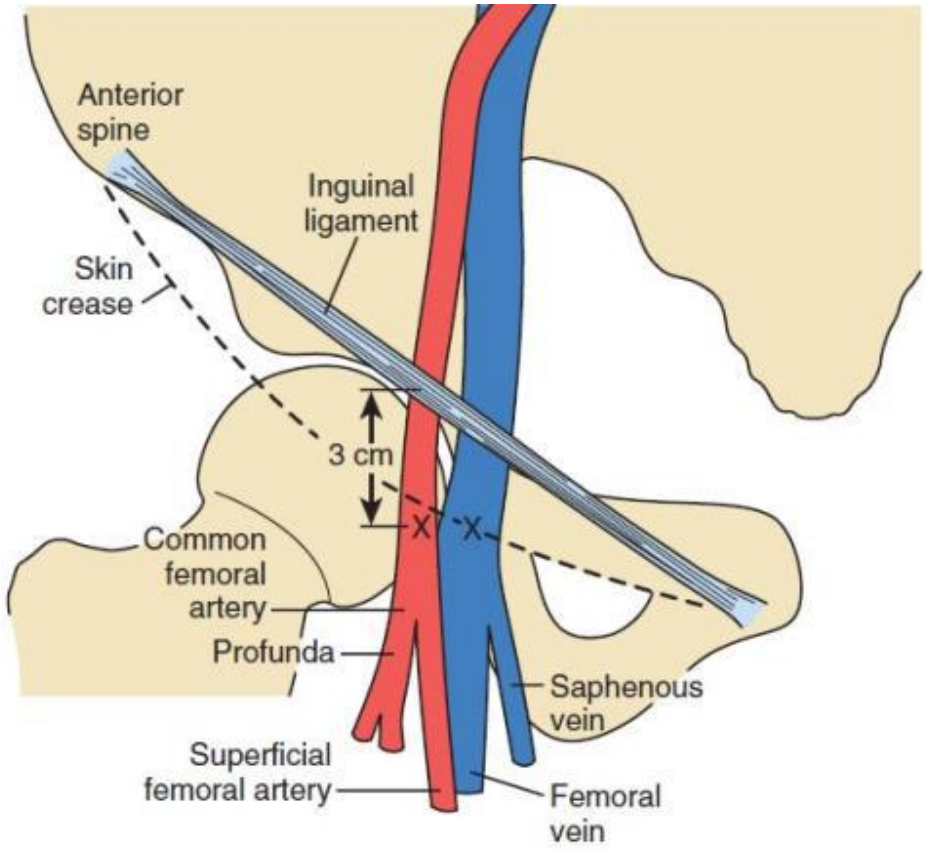
- ✓Direct cut down cannulation
- ✓Percutaneous cannulation (Seldinger technique)
- ✓Semi-Seldinger technique

Site of Puncture

Skin-Inguinal crease
2-3 cm below the mid point of the skin crease
Not a realiable marker in obese patients

Bony landmarks
2-3 cm below the mid inguinal point,
Between the anterior superior iliac spin
and pubic tubercle

Maximal femoral pulse
Could result in high or low puncture
(Obese patients)



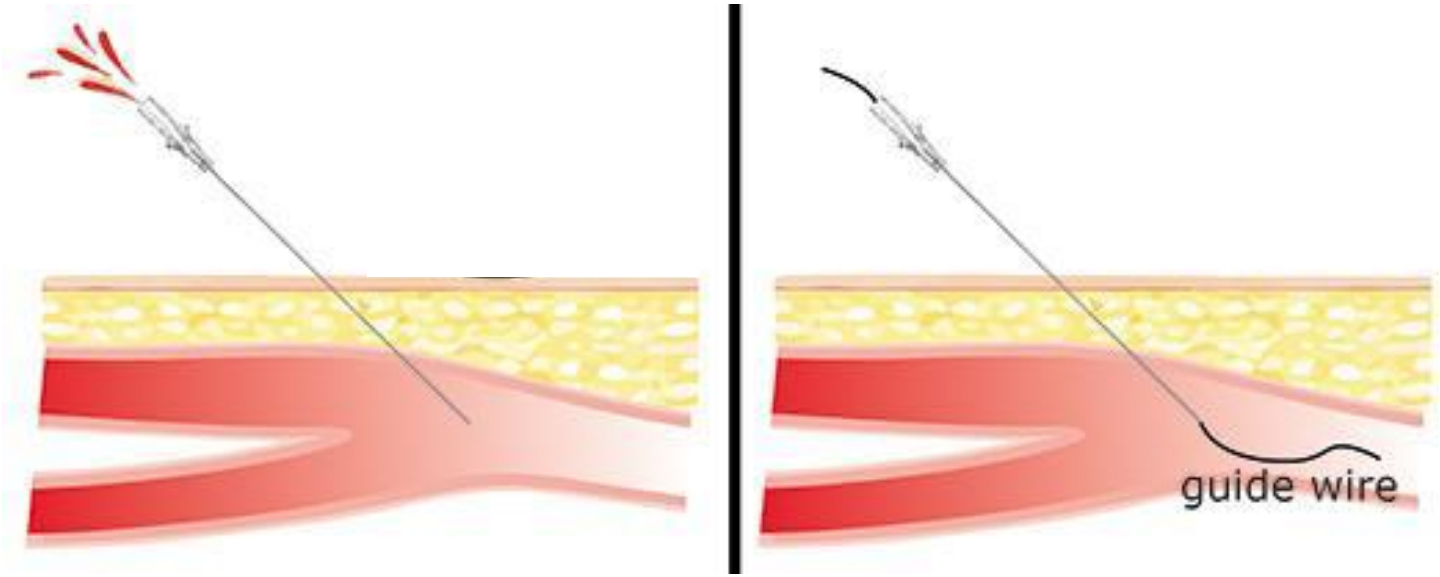
The Ideal Site of Puncture

Figure 1. Normal anatomy of the femoral artery as depicted on a right anterior oblique view of a femoral angiography. CFA indicates common femoral artery; PFA, profunda femoris artery; and SFA, superficial femoral artery.

<u>CFA is an ideal site for arterial access because it is:</u>

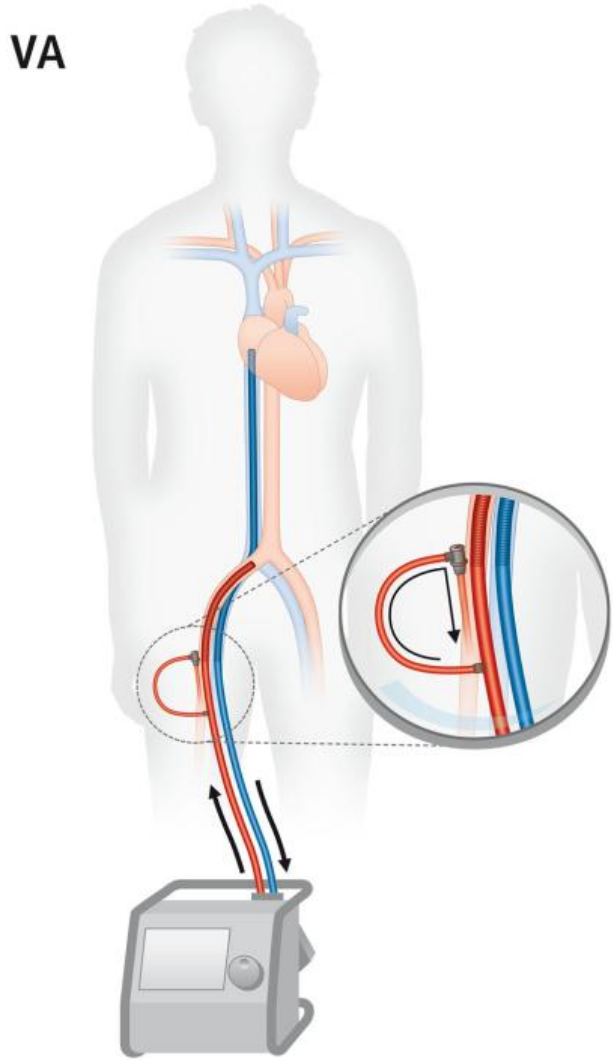
- ✓ relatively large
- ✓ less involved with atherosclerosis
- ✓ compressible against the underlying head of the femur

Femoral artery Puncture and Cannulation



- ✓30°- 45° angle to ensure that the artery will be cannulated 2 cm superior to the skin entry site
- ✓more vertical entry promotes kinking
- ✓lower the hub of the needle in obese
- ✓good pulsatile flow before any guidewire advancement

VA ECMO – Femoral artery cannulation



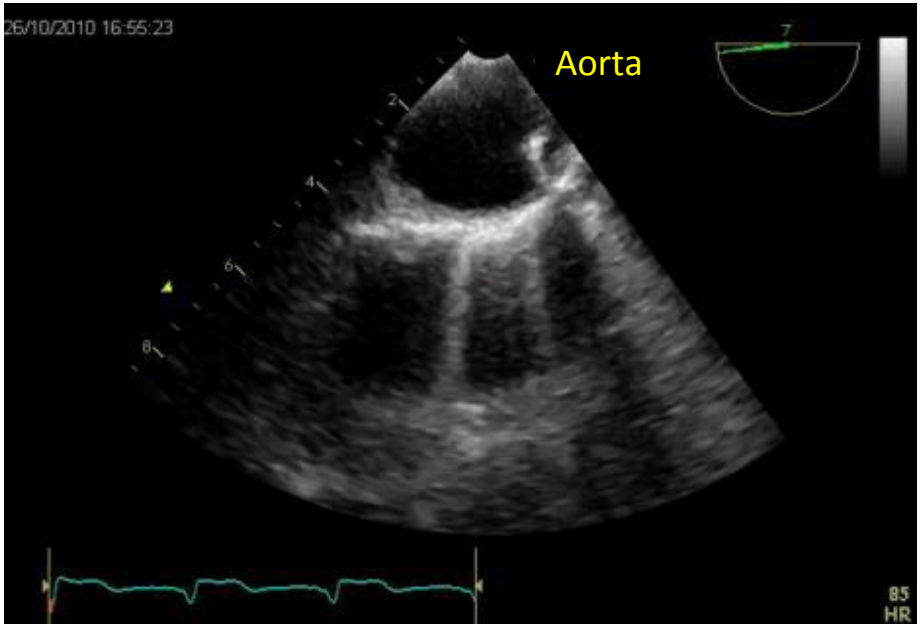
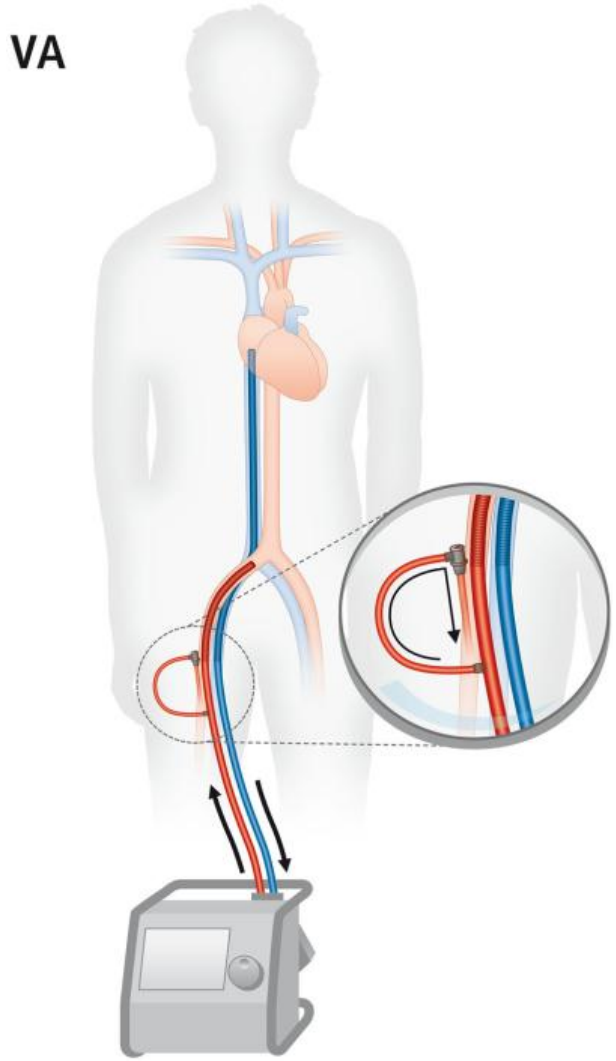


Fig. 3 Veno-arterial ECMO (VA). Blood is drained from the right atrium, oxygenated and decarboxylated in the ECMO device and returned to the iliac artery towards the aorta. Note the modified position of the venous cannula tip compared to veno-venous ECMO. Cannulation of the femoral artery requires an additional sheath for perfusion of the leg downstream of the cannulation site (*inset*)

Clin Res Cardiol (2016) 105:283–296

VA ECMO – Femoral vein cannulation



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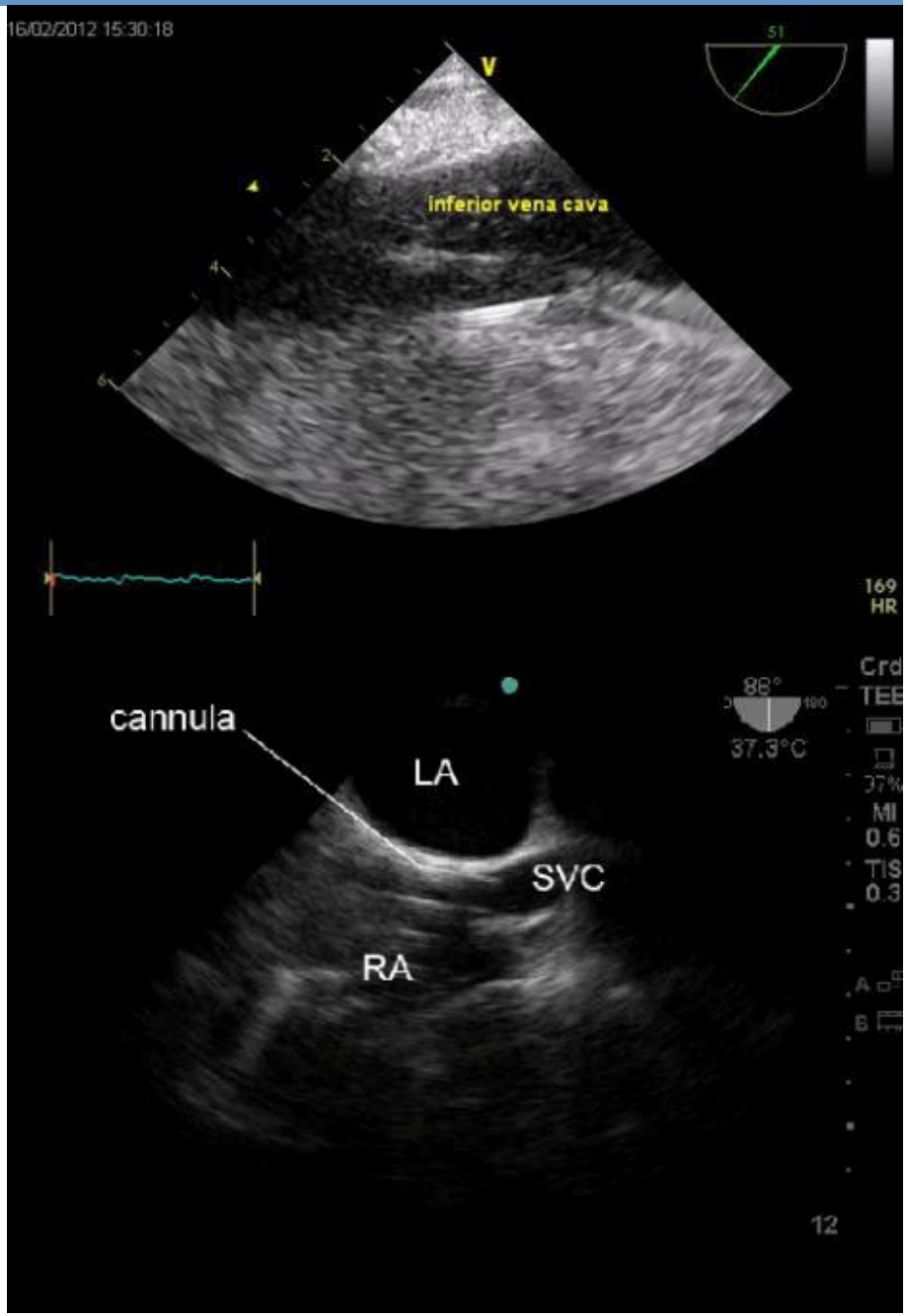
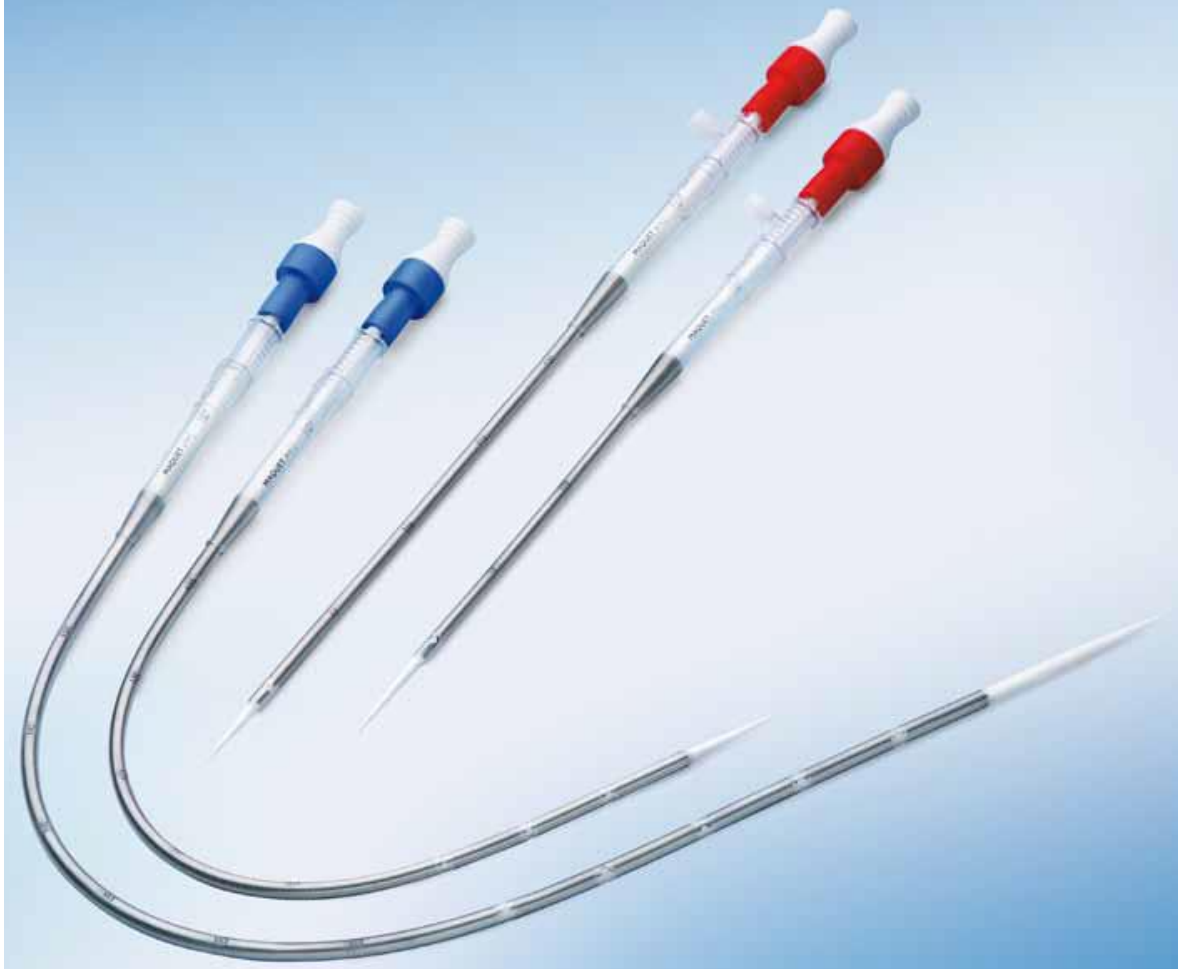
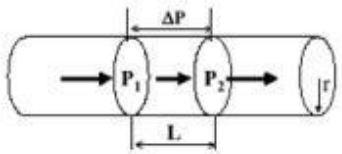


Cannulae



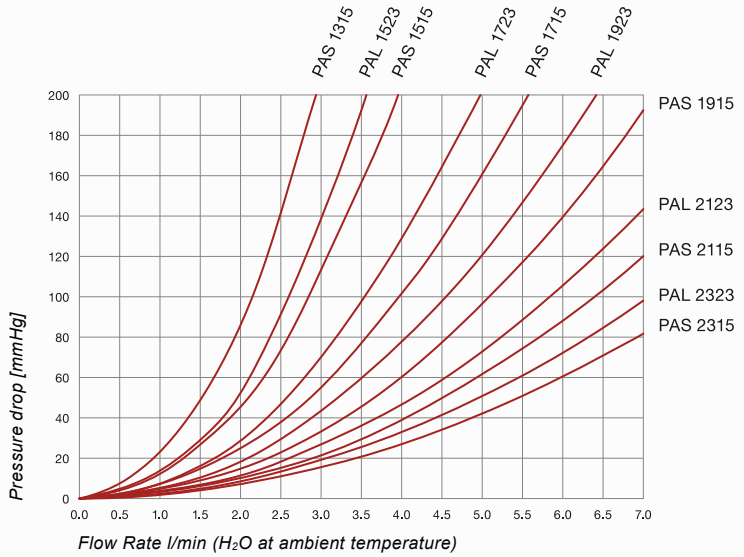
Poiseuille's Law



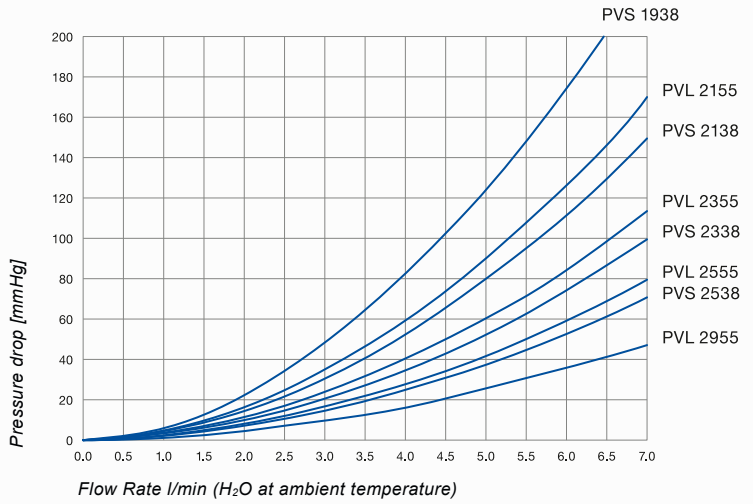
$$\text{Flow } \alpha \frac{\pi \Delta P r^4}{8 \eta L}$$

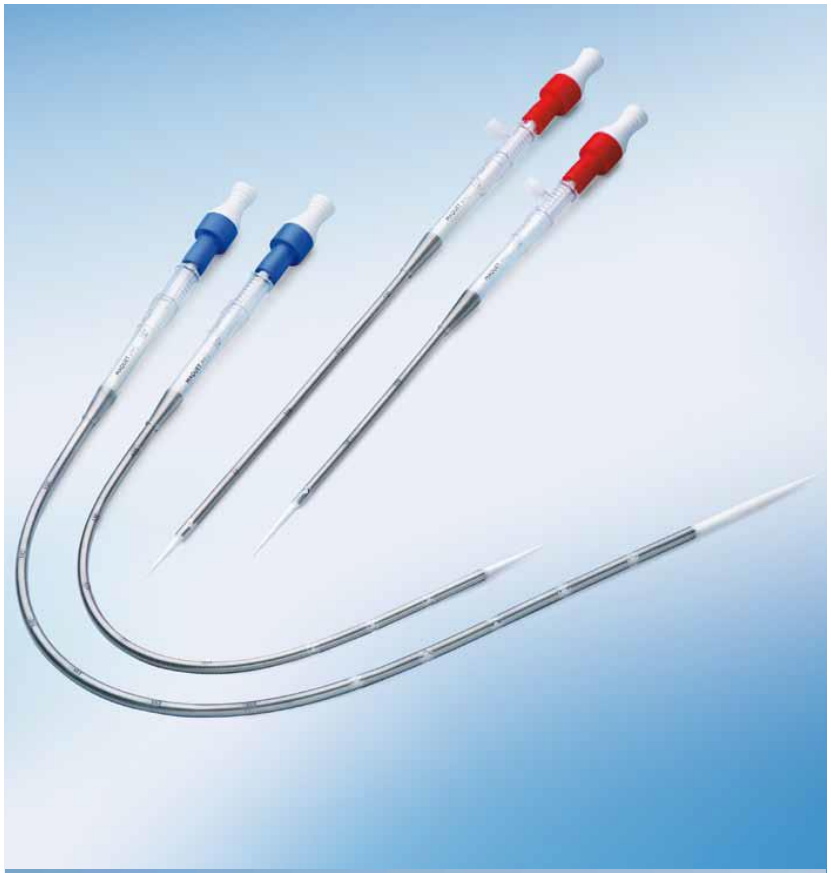
r	radius of vessel
ΔP	pressure gradient
η	viscosity
L	vessel length

Pressure drop vs. flow for all arterial HLS cannulae



Pressure drop vs. flow for all venous HLS cannulae





Cannulae

Order details arterial HLS cannulae:

Type	Outer Diameter	Insertion Length	Side Holes	Perforation Length	Connector
PAS 1315	13 Fr. (4.3 mm)	15 cm	2	1 cm	3/8" LL
PAS 1515	15 Fr. (5.0 mm)	15 cm	2	1 cm	3/8" LL
PAS 1715	17 Fr. (5.7 mm)	15 cm	2	1 cm	3/8" LL
PAS 1915	19 Fr. (6.3 mm)	15 cm	2	1 cm	3/8" LL
PAS 2115	21 Fr. (7.0 mm)	15 cm	2	1 cm	3/8" LL
PAS 2315	23 Fr. (7.7 mm)	15 cm	2	1 cm	3/8" LL
PAL 1523	15 Fr. (5.0 mm)	23 cm	2	1 cm	3/8" LL
PAL 1723	17 Fr. (5.7 mm)	23 cm	2	1 cm	3/8" LL
PAL 1923	19 Fr. (6.3 mm)	23 cm	2	1 cm	3/8" LL
PAL 2123	21 Fr. (7.0 mm)	23 cm	2	1 cm	3/8" LL
PAL 2323	23 Fr. (7.7 mm)	23 cm	2	1 cm	3/8" LL

One cannula per carton

Order details venous HLS cannulae:

Type	Outer Diameter	Insertion Length	Side Holes	Perforation Length	Connector
PVS 1938	19 Fr. (6.3 mm)	38 cm	12	10 cm	3/8"
PVS 2138	21 Fr. (7.0 mm)	38 cm	12	10 cm	3/8"
PVS 2338	23 Fr. (7.7 mm)	38 cm	16	10 cm	3/8"
PVS 2538	25 Fr. (8.3 mm)	38 cm	20	10 cm	3/8"
PVL 2155	21 Fr. (7.0 mm)	55 cm	20	20 cm	3/8"
PVL 2355	23 Fr. (7.7 mm)	55 cm	20	20 cm	3/8"
PVL 2555	25 Fr. (8.3 mm)	55 cm	24	20 cm	3/8"
PVL 2955	29 Fr. (9.7 mm)	55 cm	32	20 cm	3/8"

One cannula per carton

Percutaneous Insertion Kits

- 4 multi-step dilators: 10/12 Fr., 12/14 Fr., 14/16 Fr., 16/18 Fr.
- 0.038” x 100 cm with J-tip guidewire for arterial cannulae
- 0.038” x 150 cm with J-tip guidewire for venous cannulae
- Guidewire advancer
- 18 ga. puncture needle
- Mini scalpel blade
- 10 cc syringe
- Additional dilator sizes and guidewires available

Peripheral Femoro-Femoral VA ECMO
Achilles heel

1. **Lower Limb Ischemia**
2. Harlequin Syndrome
3. Pulmonary Edema

Clin Res Cardiol (2016) 105:283–296

Leg ischemia - Femoral artery ECMO cannulation

Early and late outcomes of 517 consecutive adult patients treated with extracorporeal membrane oxygenation for refractory postcardiotomy cardiogenic shock

Ardawan Julian Rastan, MD, PhD, Andreas Dege, MD, Matthias Mohr, MD, Nicolas Doll, MD, PhD, Volkmar Falk, MD, PhD, Thomas Walther, MD, PhD, and Friedrich Wilhelm Mohr, MD, PhD

ECMO leg complications

Leg ischemia (no.)	28/141 (19.9%)
With distal leg perfusion cannula (no.)	3/33 (9.1%)
Without distal leg perfusion cannula (no.)	25/108 (23.1%)
Leg fasciotomy (no.)	13/141 (9.2%)
With distal leg perfusion cannula (no.)	1/33 (3.0%)
Without distal leg perfusion cannula (no.)	12/108 (11.1%)

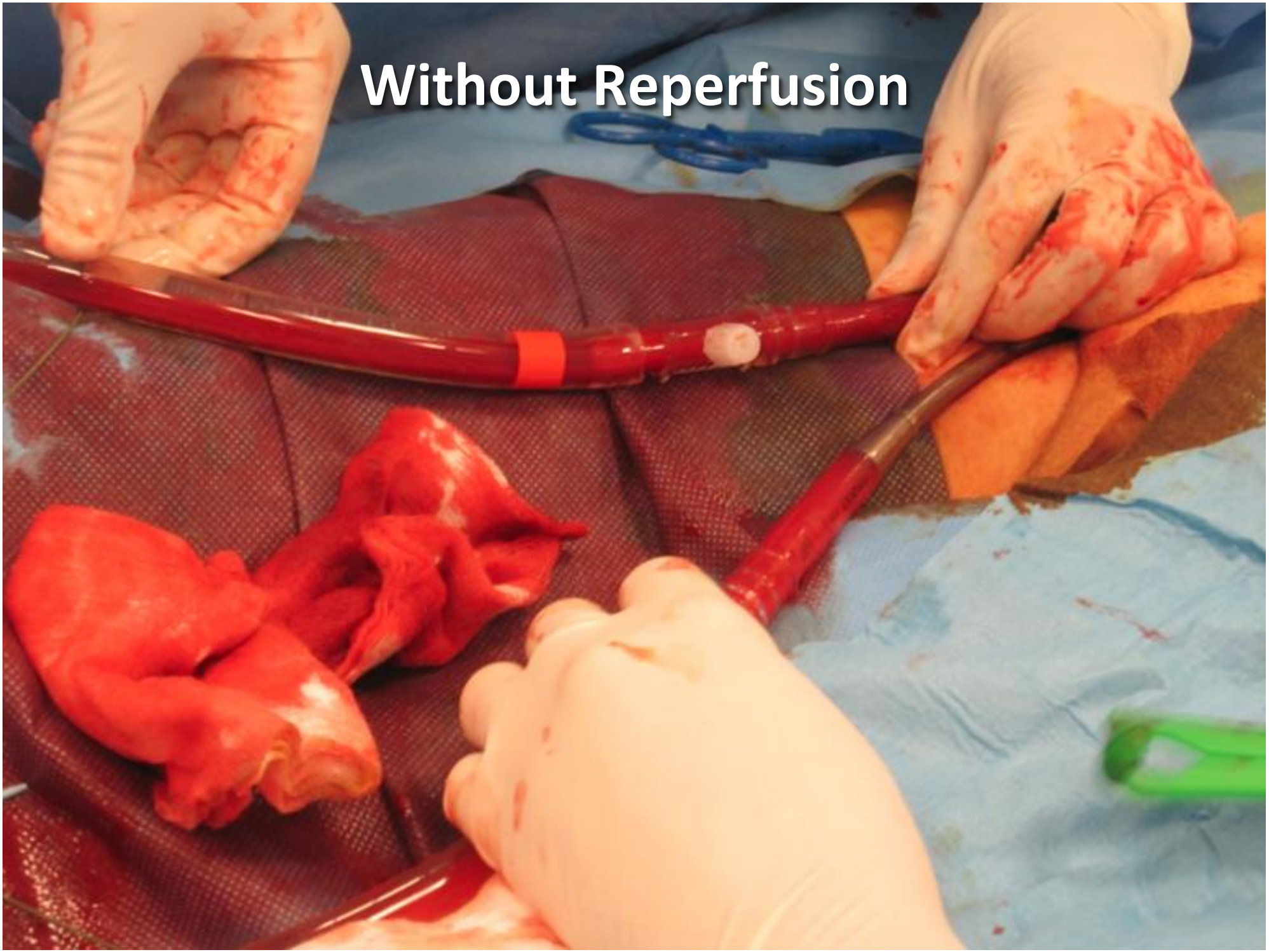
Lower Limb Ischemia

Monitoring

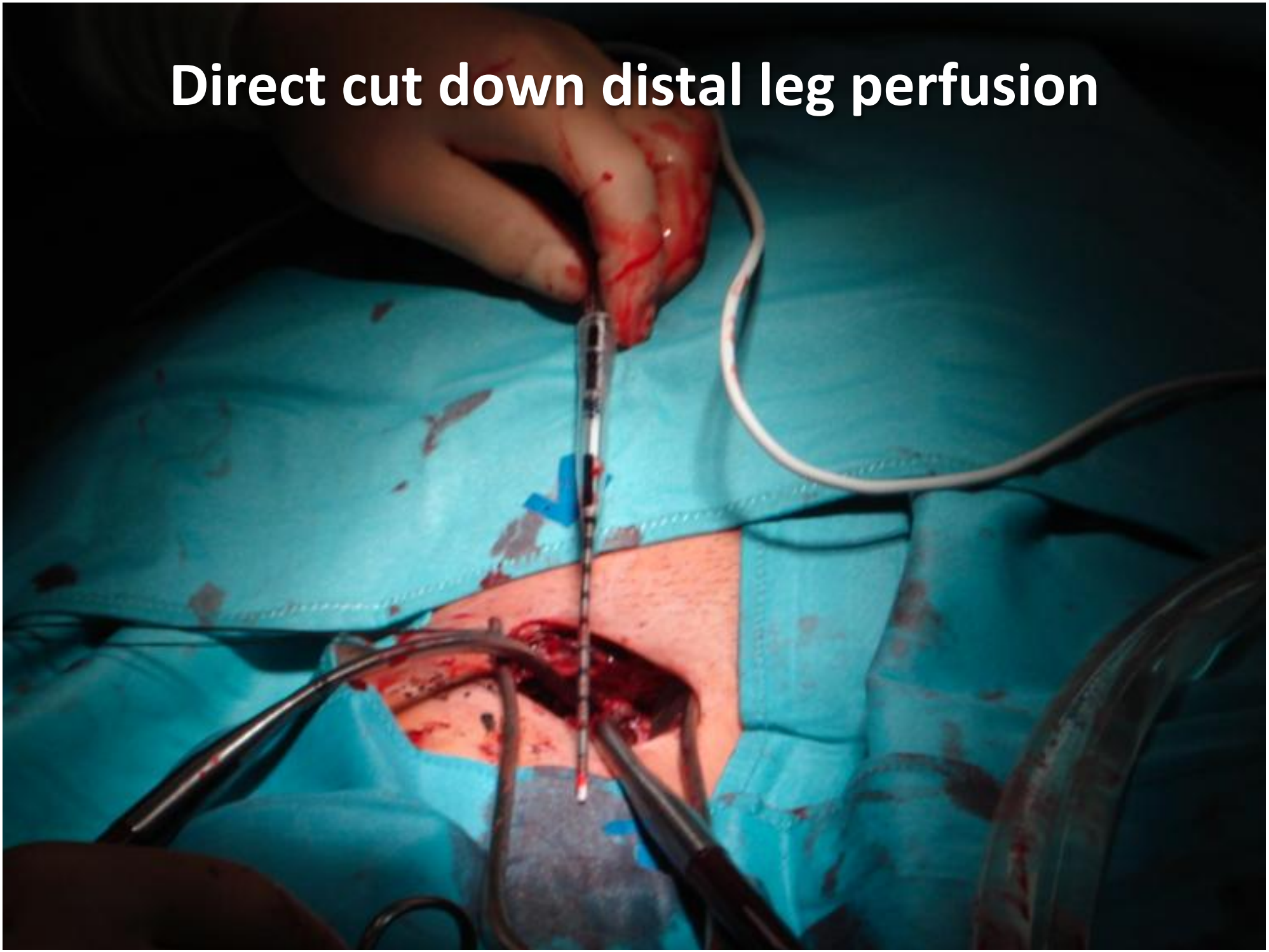
1. NIRS
2. Doppler imaging
3. Clinical Assesment
4. Lab Tests

LIMITS

- ✓Global state of hypoperfusion
- ✓Continous Flow
- ✓Vasculopathies
- ✓Hypercoagulable state
- ✓CK not reliable (AMI)
- ✓TOO LATE!


Without Reperfusion

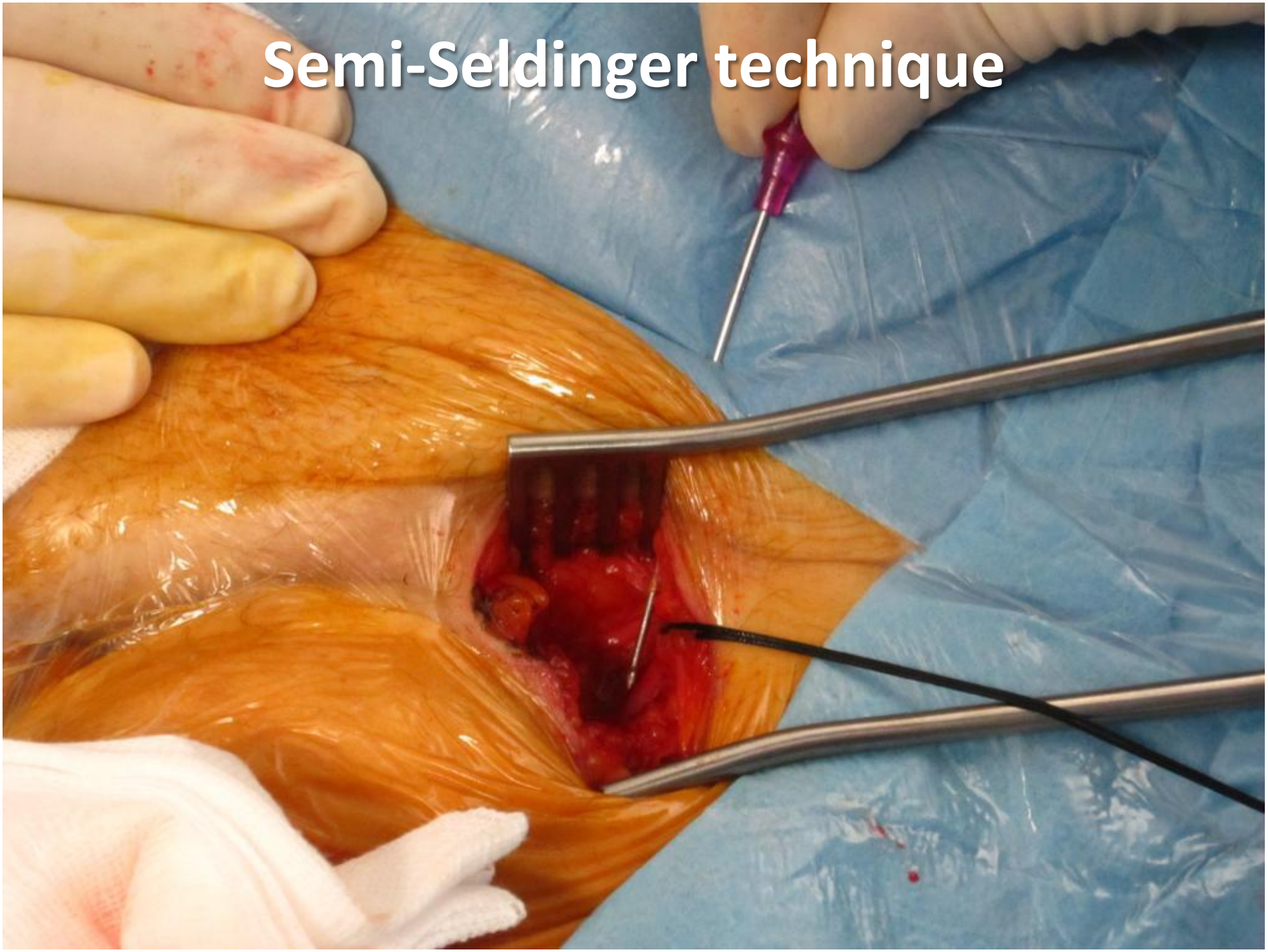
Direct cut down distal leg perfusion



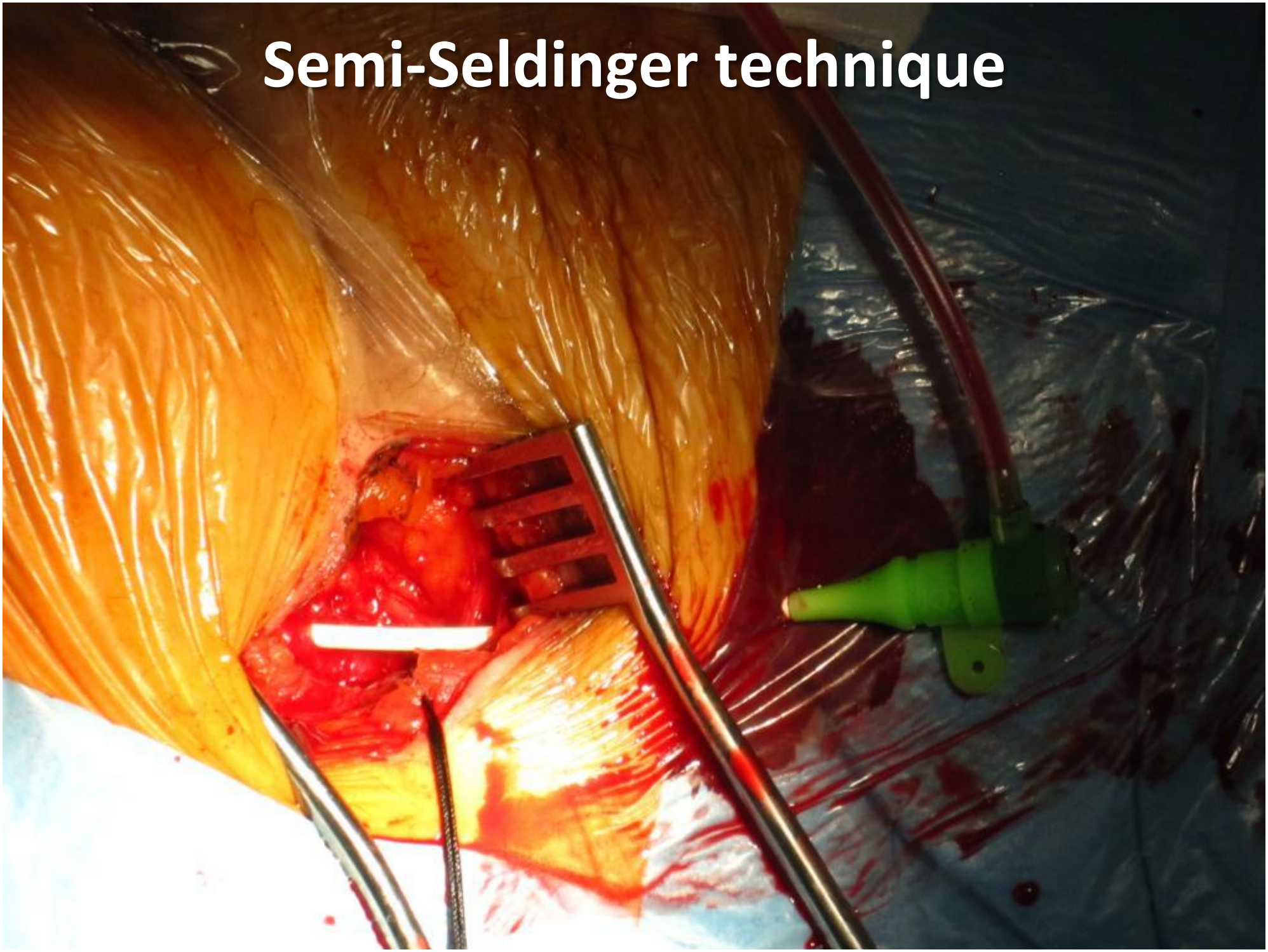

Direct cut down distal leg perfusion
8-Fr cannula


Direct cut down distal leg perfusion
8-Fr cannula and 3/8”→ 3/8”- 1/4” Connector

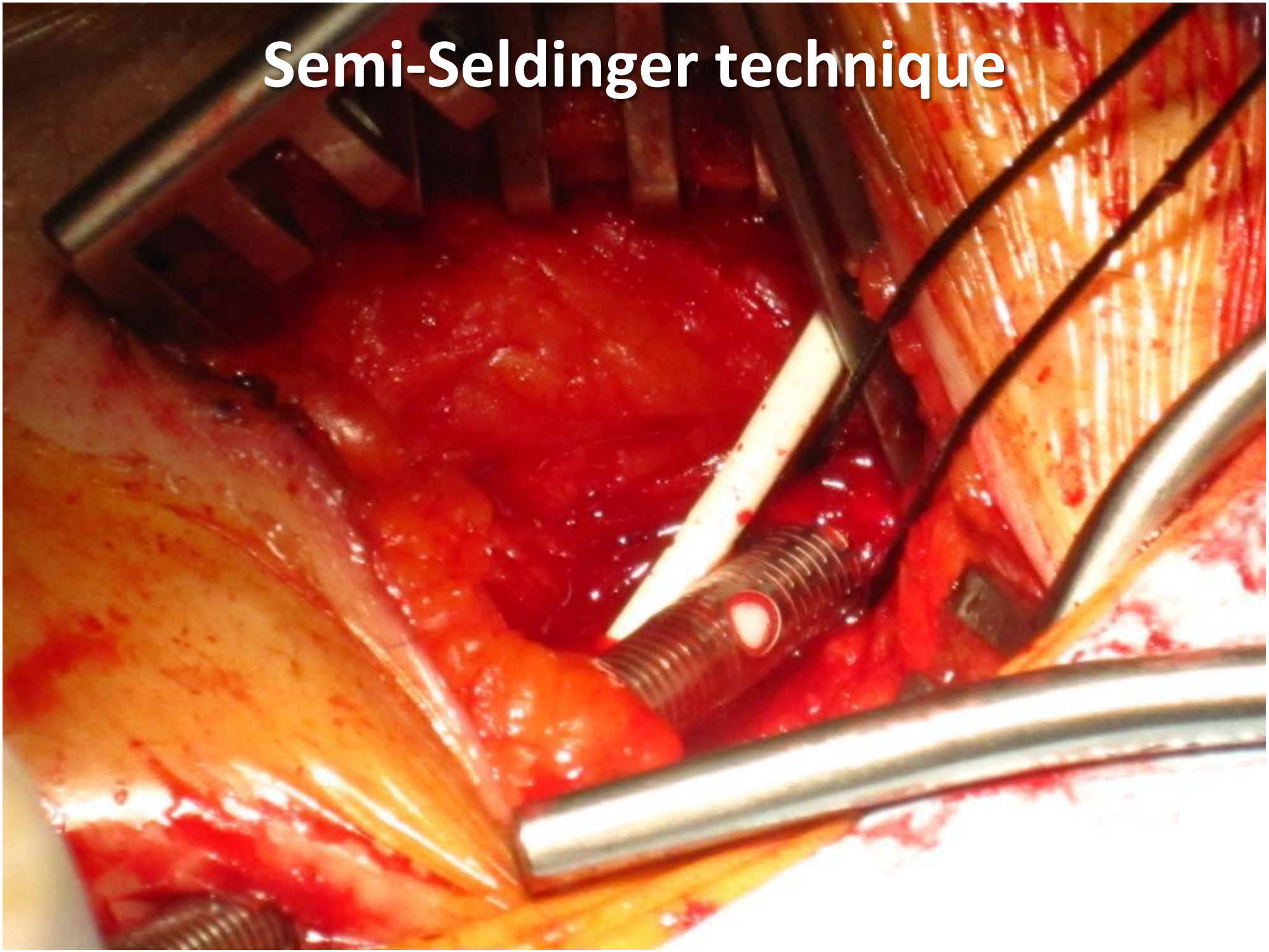
Semi-Seldinger technique



Semi-Seldinger technique

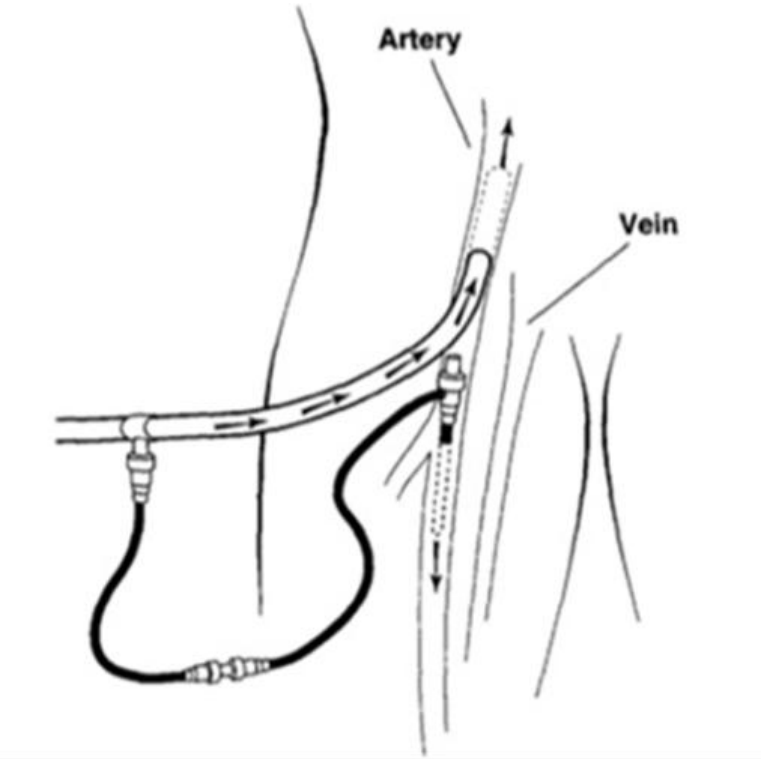


Semi-Seldinger technique




Percutaneous distal leg perfusion
5-Fr Introducer Sheath
OFF

VA ECMO – Femoral artery cannulation and distal leg perfusion



An arterial return cannula inserted into the right common femoral artery (RCFA) with a backflow cannula providing perfusion to the leg distal to the cannula.

Is Lower Limb Venous Drainage During Peripheral Extracorporeal Membrane Oxygenation Necessary?

Isidoro Di Bella,* Enrico Ramoni,* Uberto Da Col,* Angela Vidili,† Alessia Rossi,* Ayiomamitis Michalis,* and Temistocle Ragni*

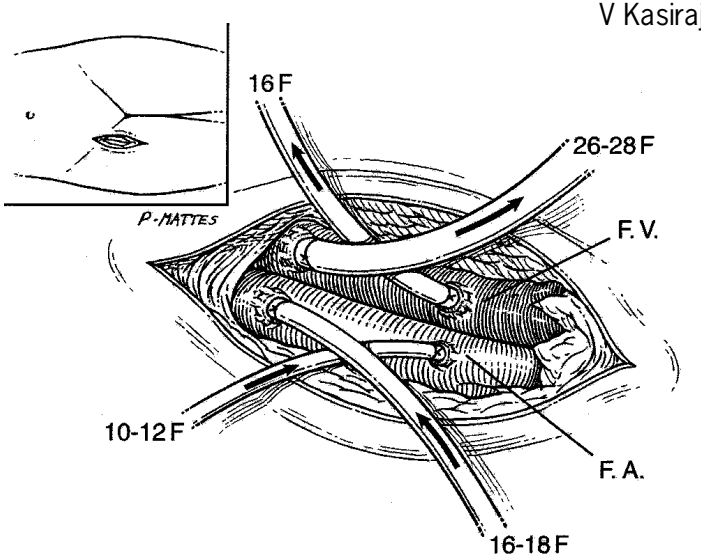
Women

Long period

Large Cannula

Thrombosis of the Catheter

Technique to prevent limb ischemia during peripheral cannulation
V Kasirajan *et al.*

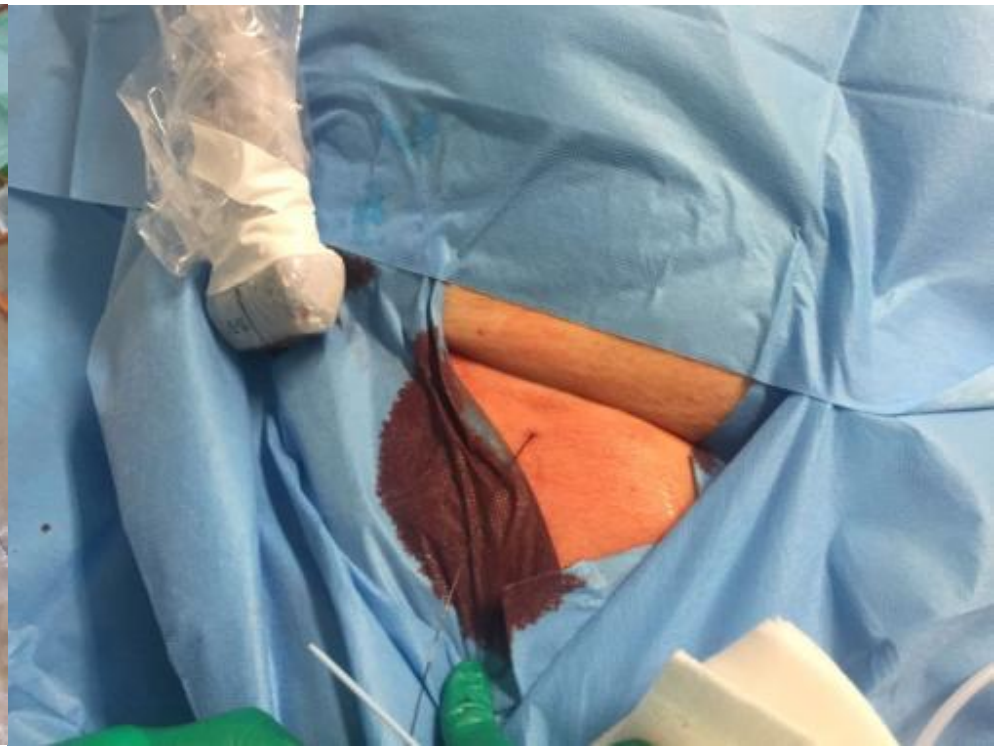


In conclusion, we believe that, in peripheral ECMO, distal venous drainage is not mandatory, although it implies a continuous clinical limb surveillance.

ASAIO Journal 2010

Peripheral Femoro-Femoral VA ECMO: tips and tricks

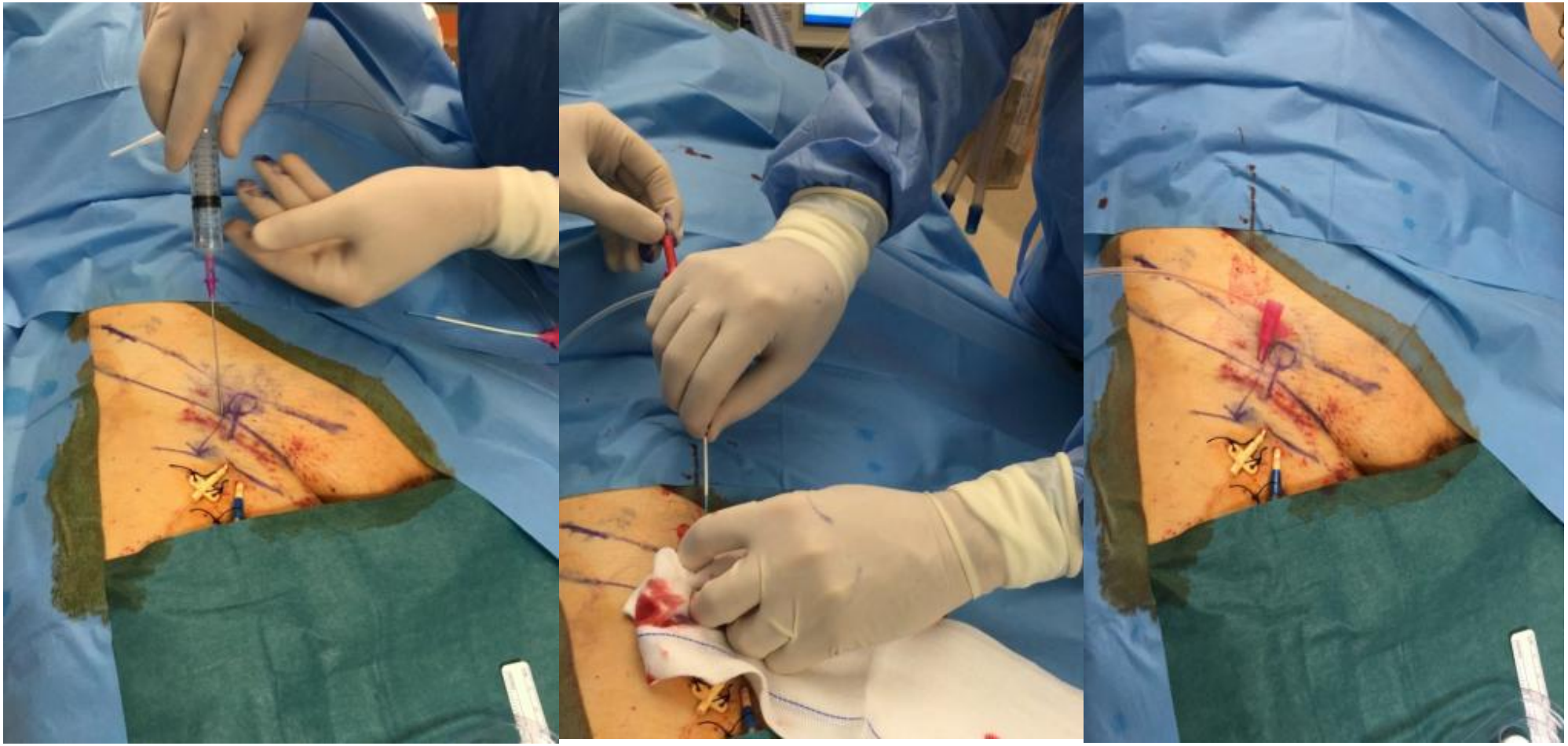
Choice of Puncture Site



Anatomical landmarks

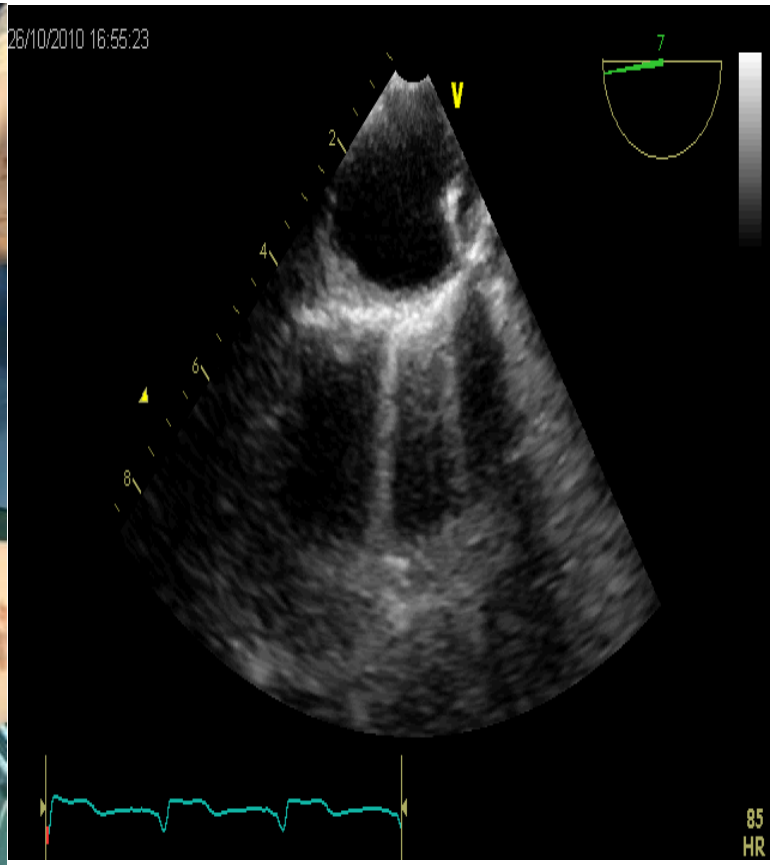
I STEP

Distal perfusion catheter

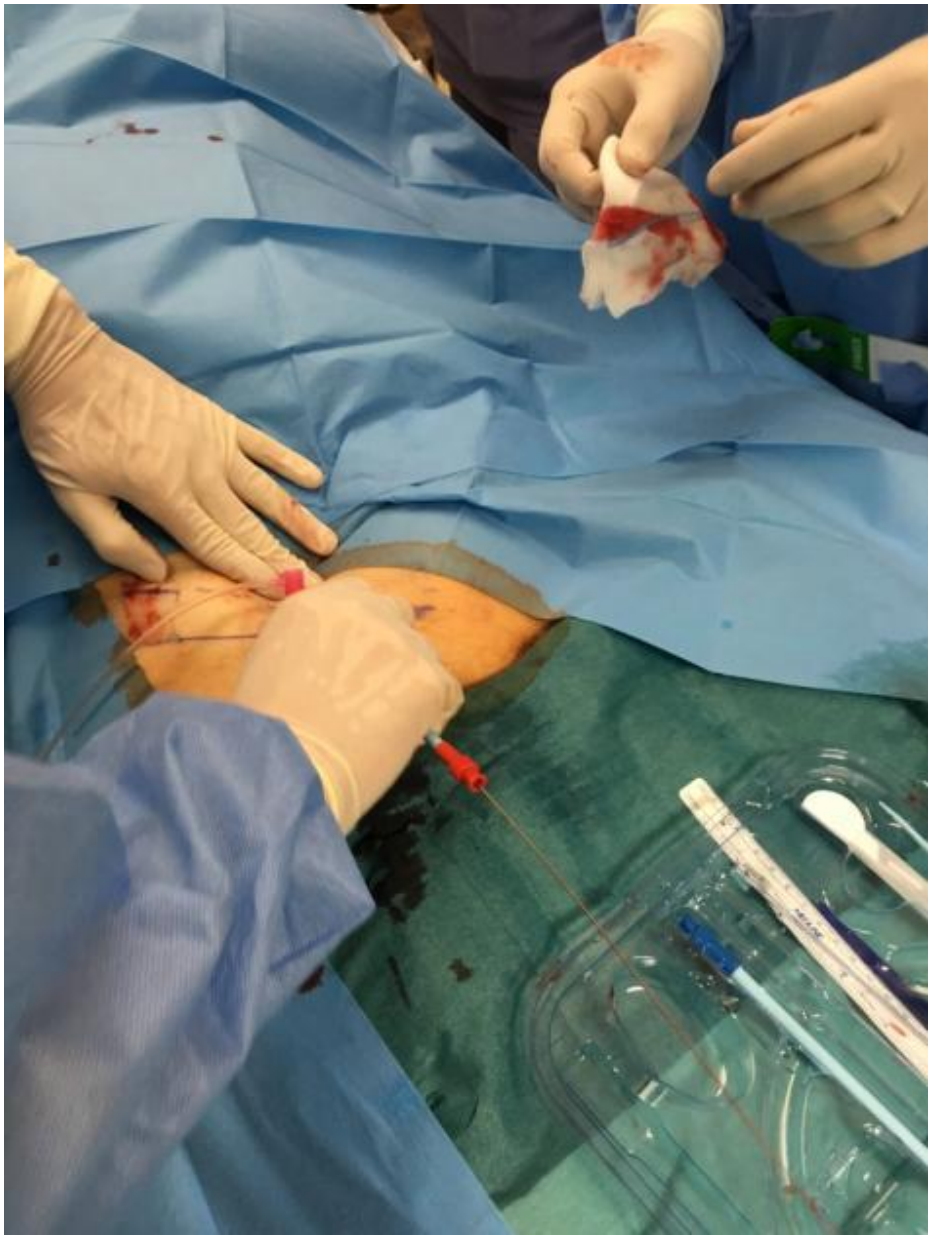


II STEP

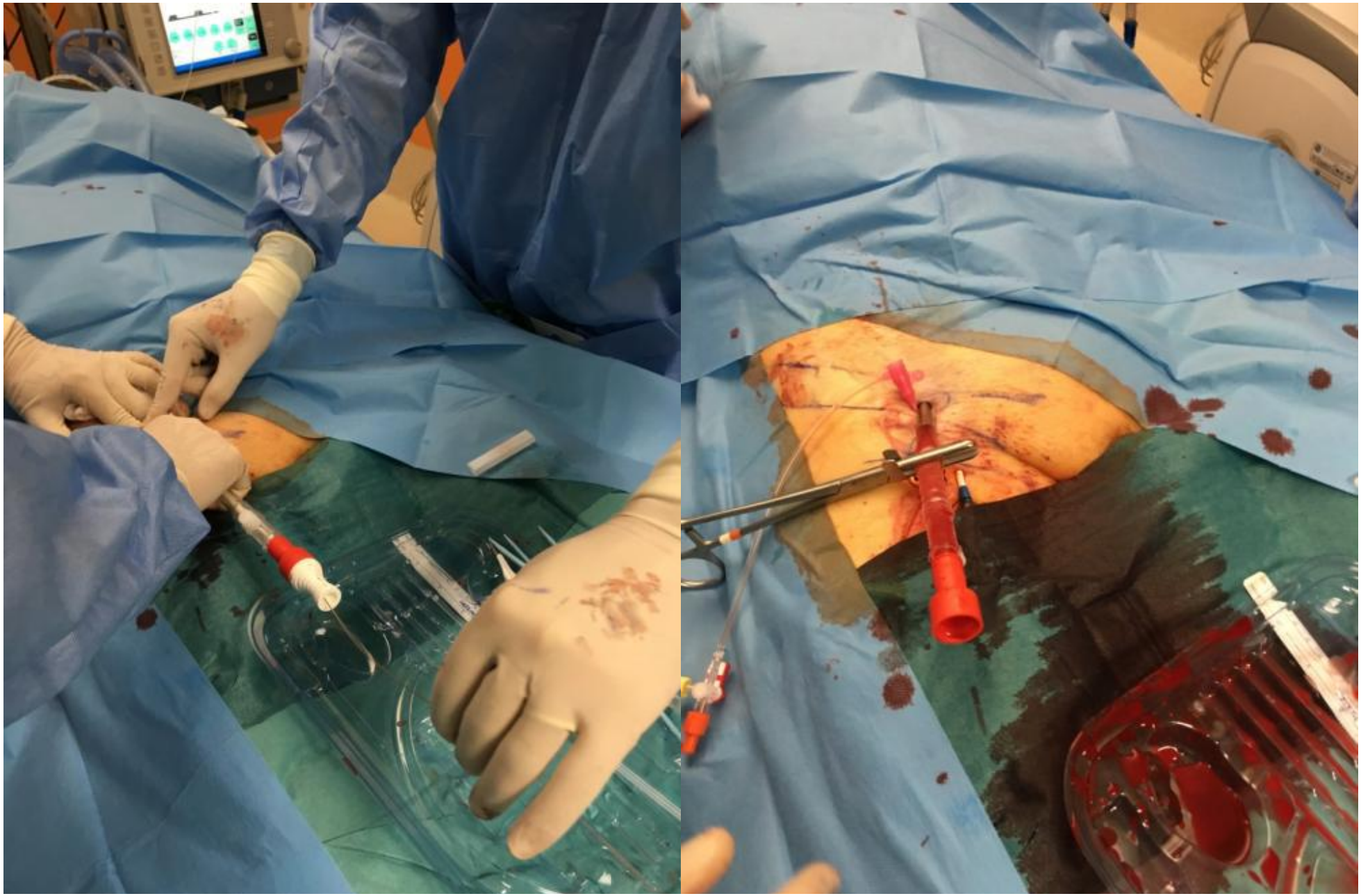
Percutaneous arterial puncture guidewire placement



Serial dilation (Seldinger technique)

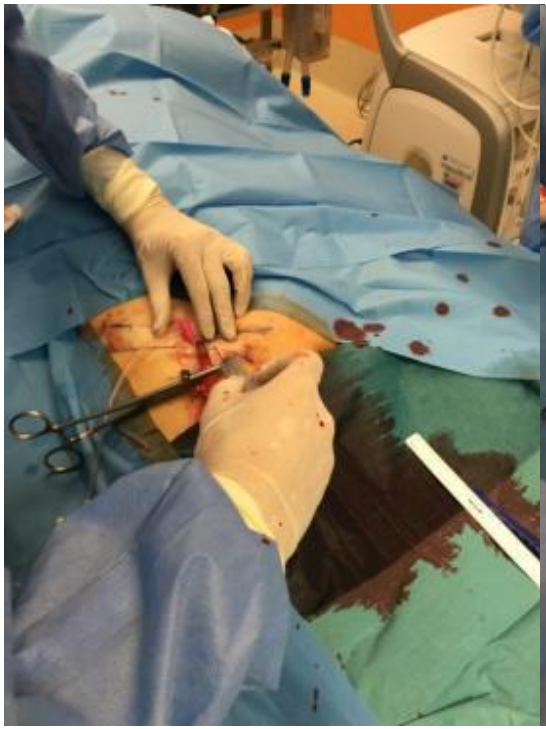


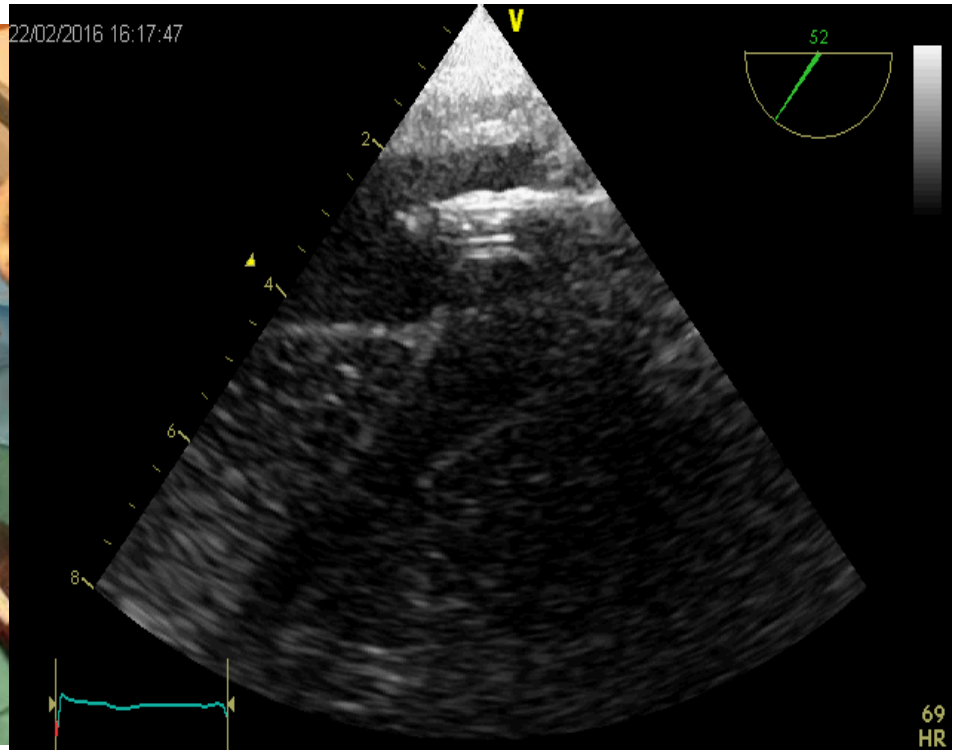
Arterial Cannulation



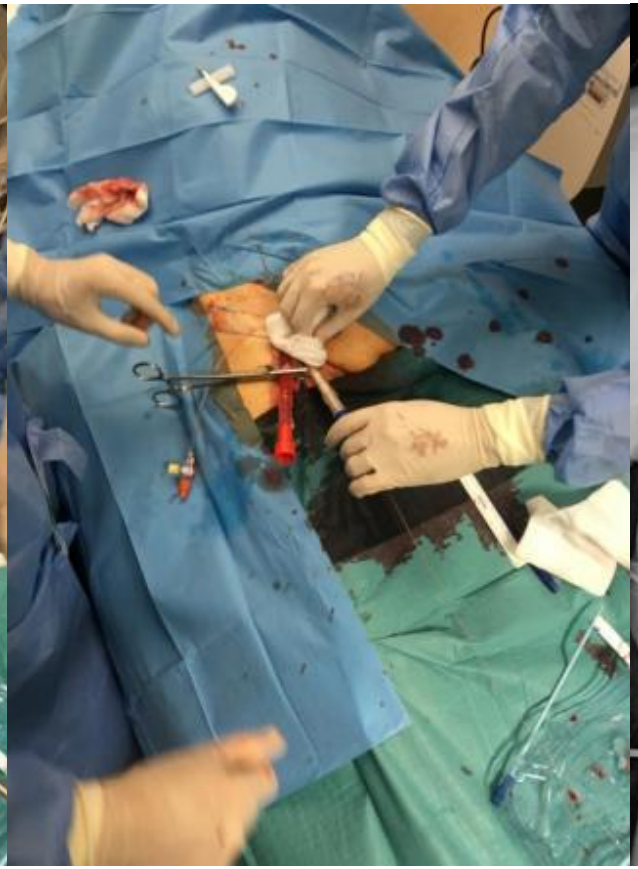
III STEP

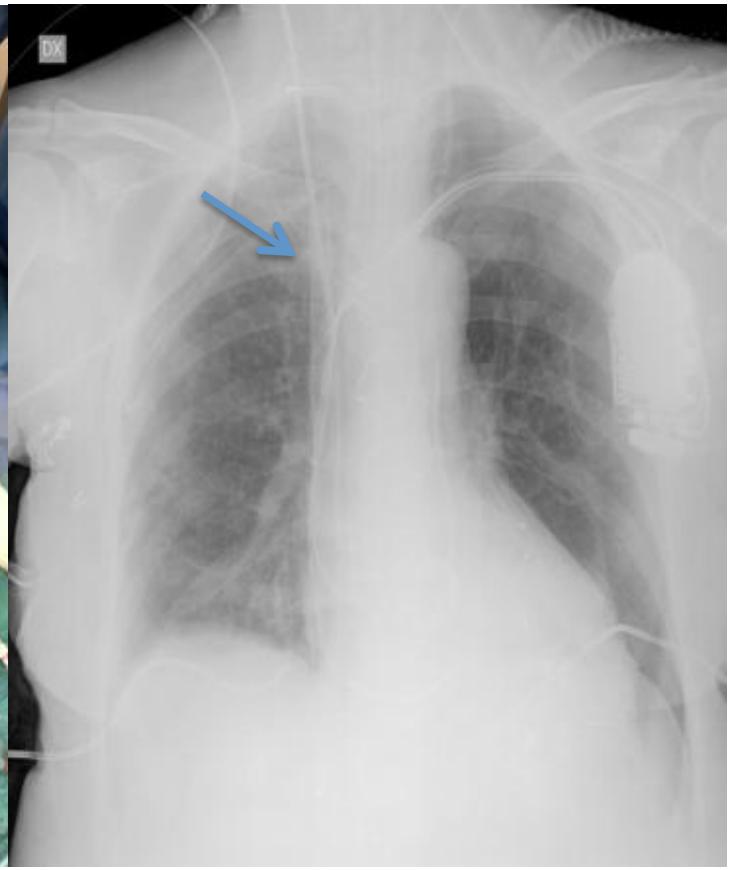
Percutaneous Vein puncture guidewire placement



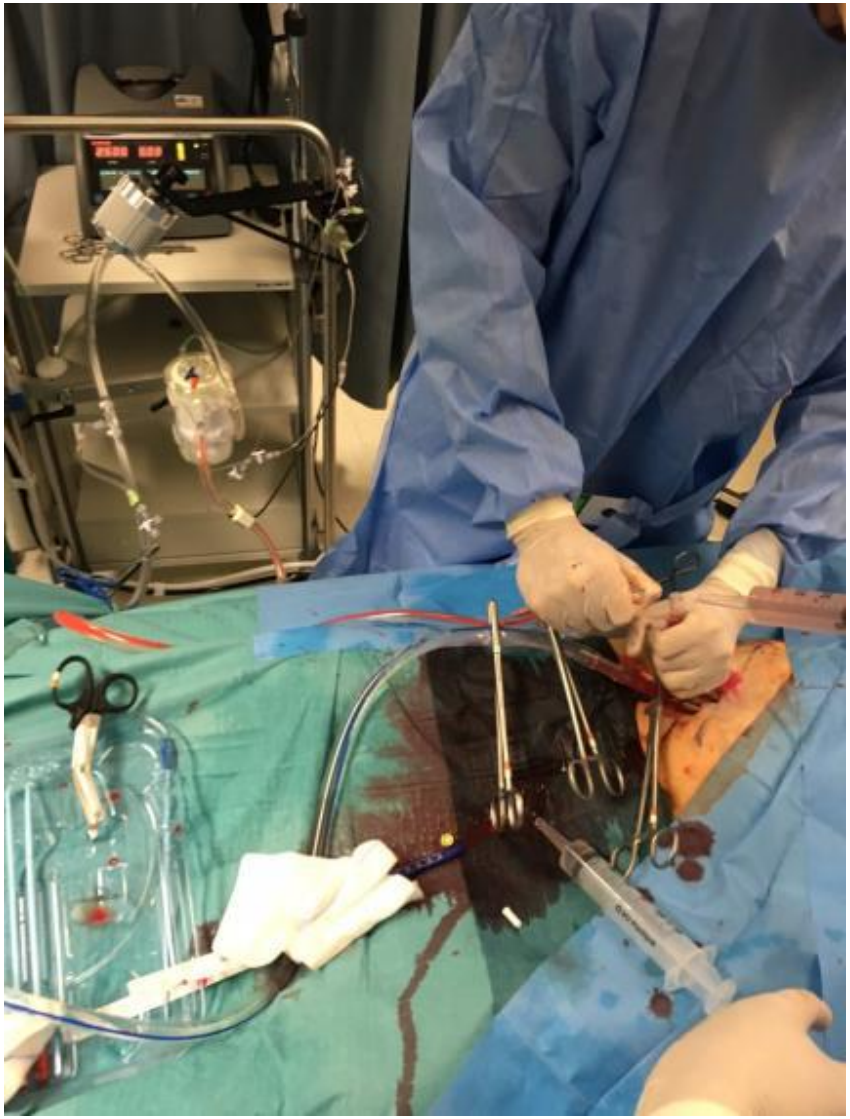


Vein cannulation





IV STEP
Start ECMO



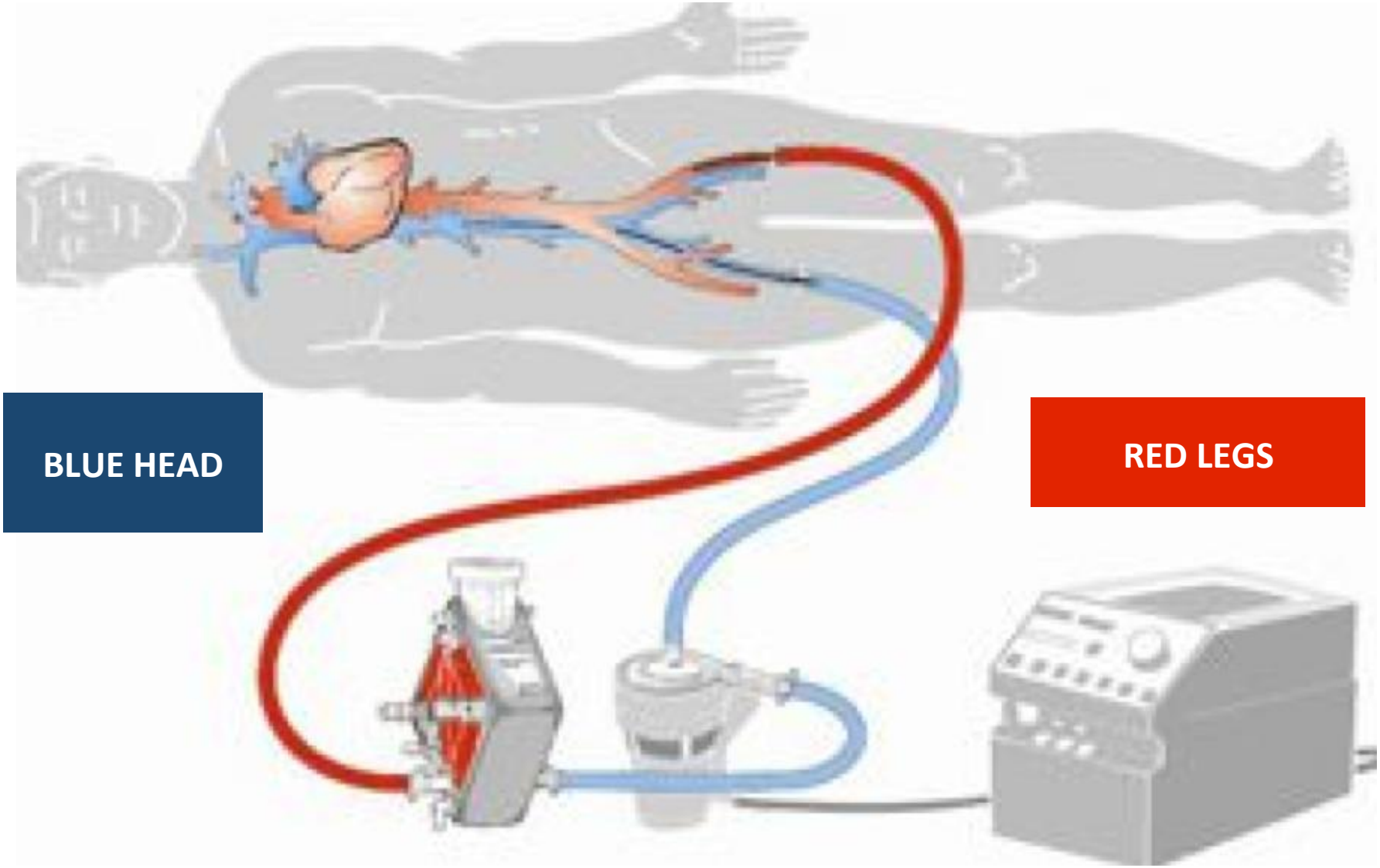
Peripheral Femoro-Femoral VA ECMO

Achilles heel

1. Lower Limb Ischemia
2. **Harlequin Syndrome**
3. Pulmonary Edema

Clin Res Cardiol (2016) 105:283–296

Harlequin Syndrome



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Heart against VA ECMO: Competition

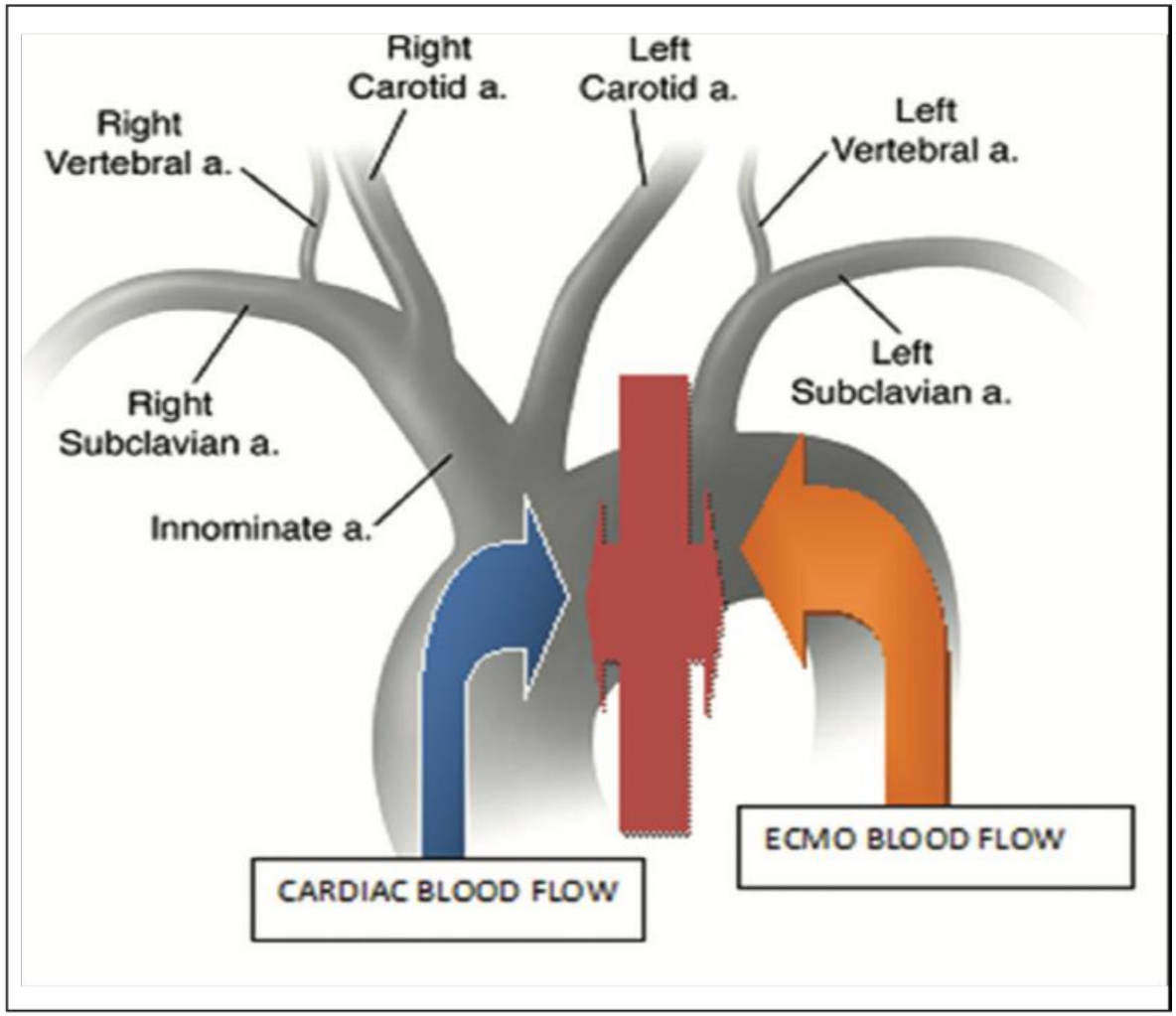
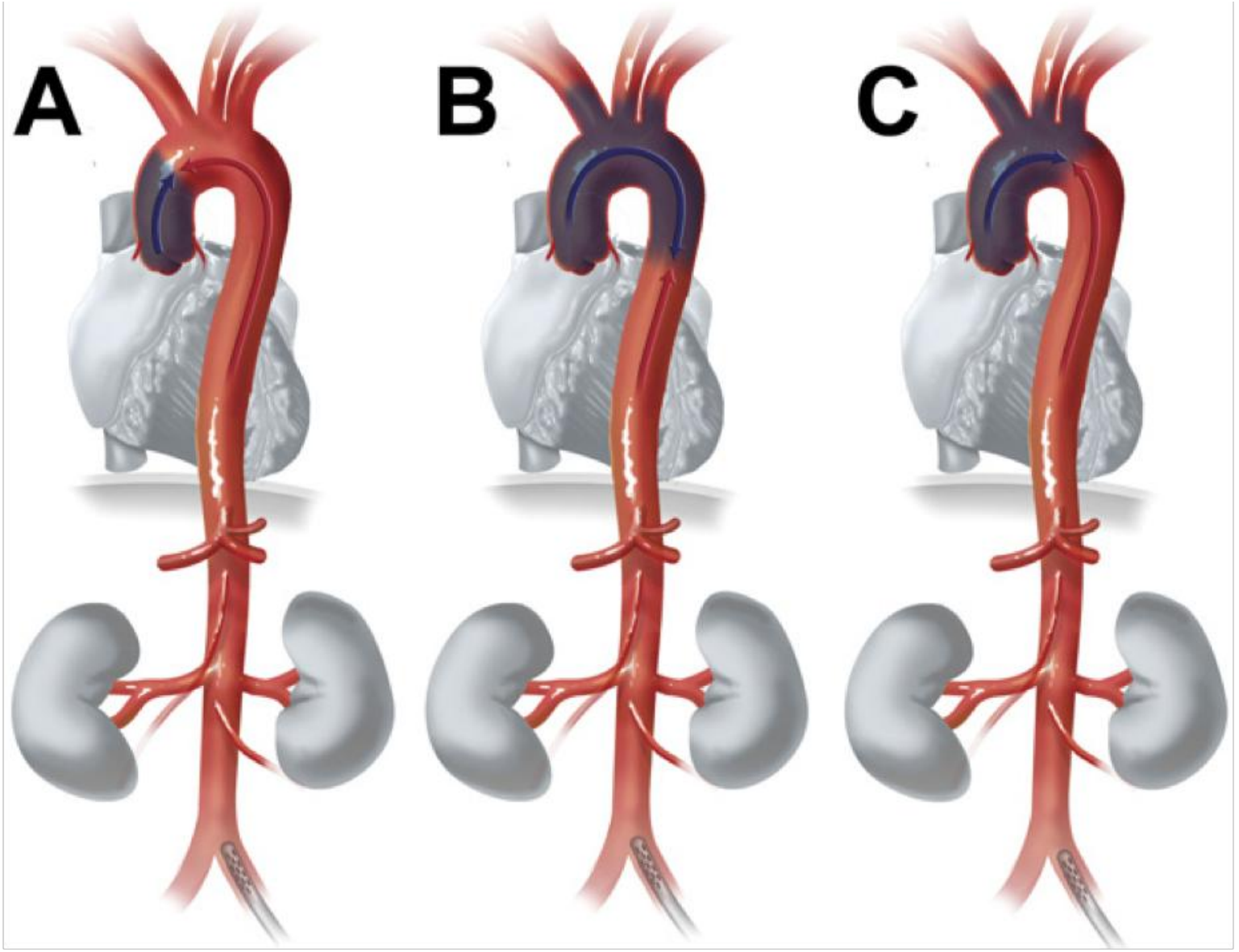


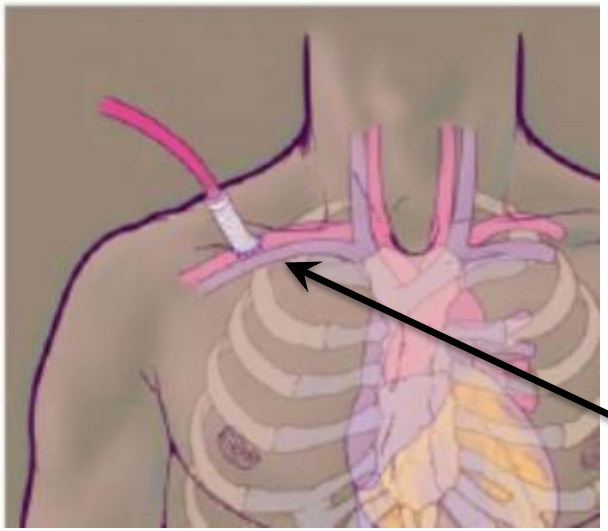
Figure 10 - *Harlequin syndrome.*

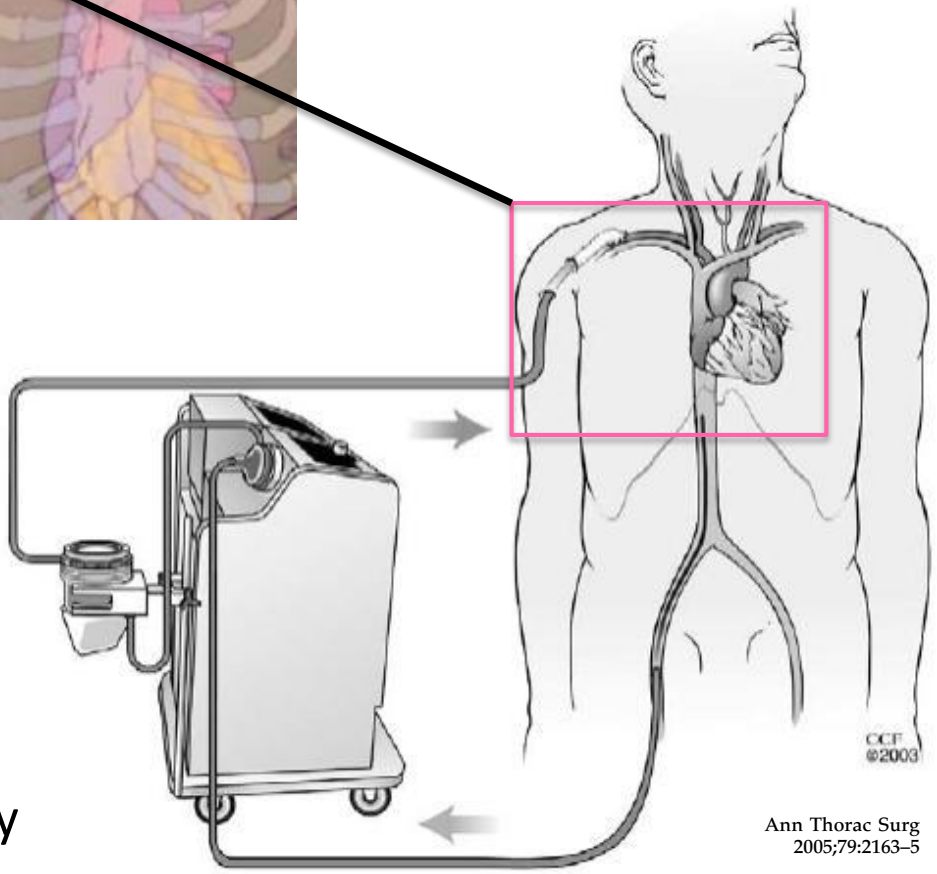
Watershed Phenomen



Ann Thorac Surg 2013;95:35

VA ECMO with Right Axillary Artery





Ann Thorac Surg
2005;79:2163–5

Advantages:

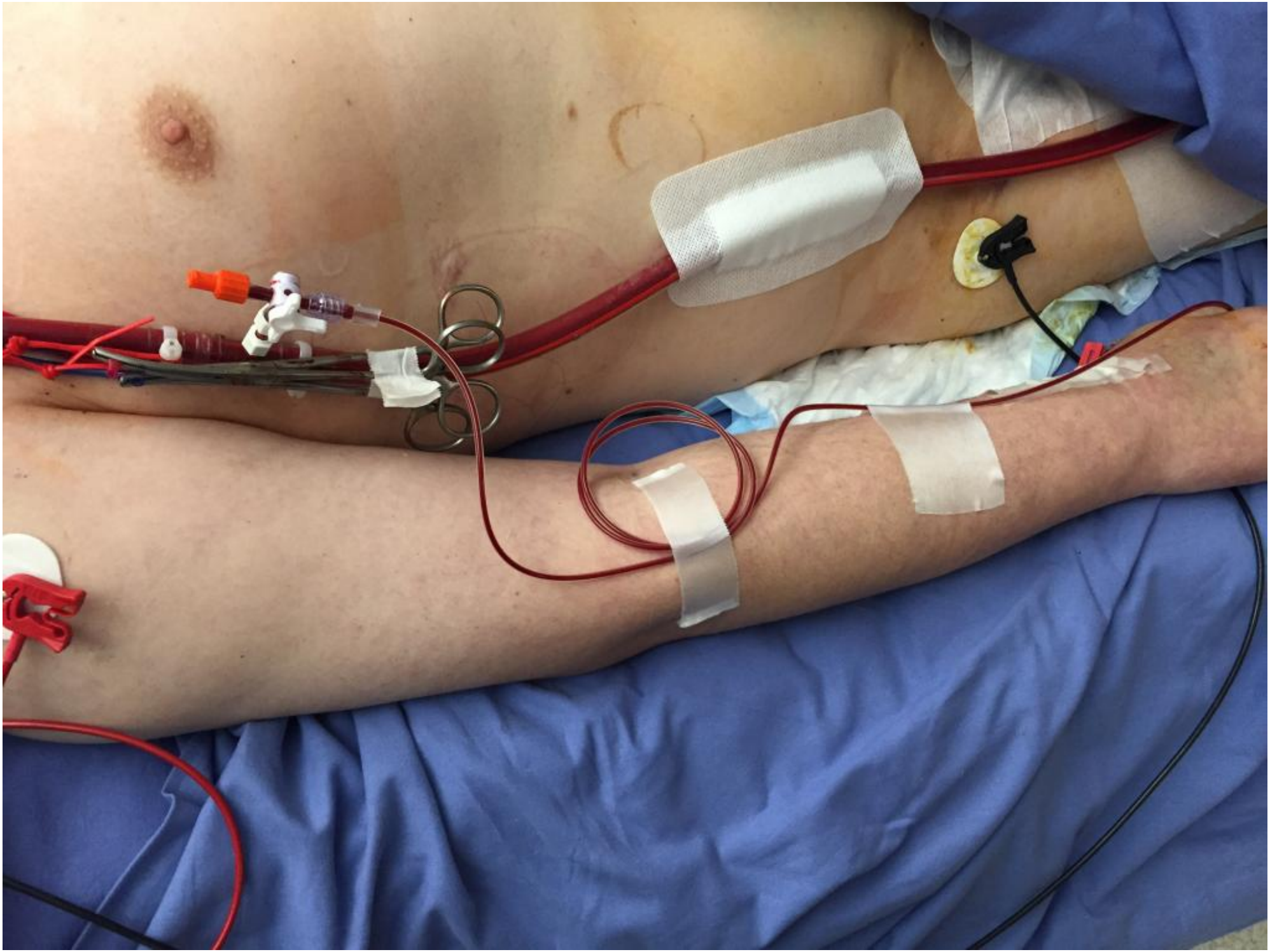
- ✓ Antegrade flow, “Central”
- ✓ Safe, low complication rates

Disadvantage:

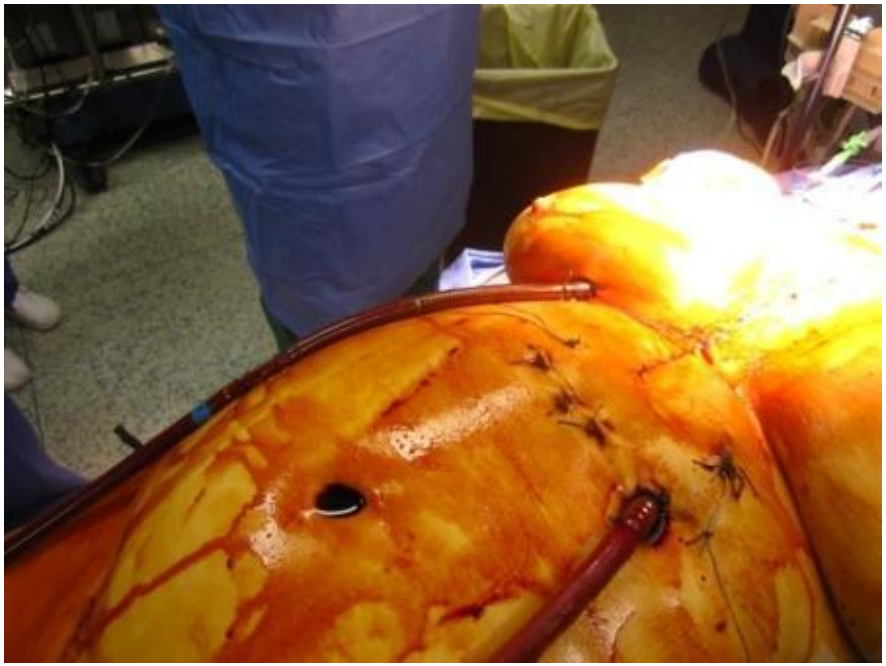
- ✓ More time consuming procedure
- ✓ Not percutaneously
- ✓ Direct cannulation/Side grafting
- ✓ Hyperperfusion syndrome

Contraindication

- ✓Extension of aortic disease into the artery
- ✓Known axillary/subclavian stenosis

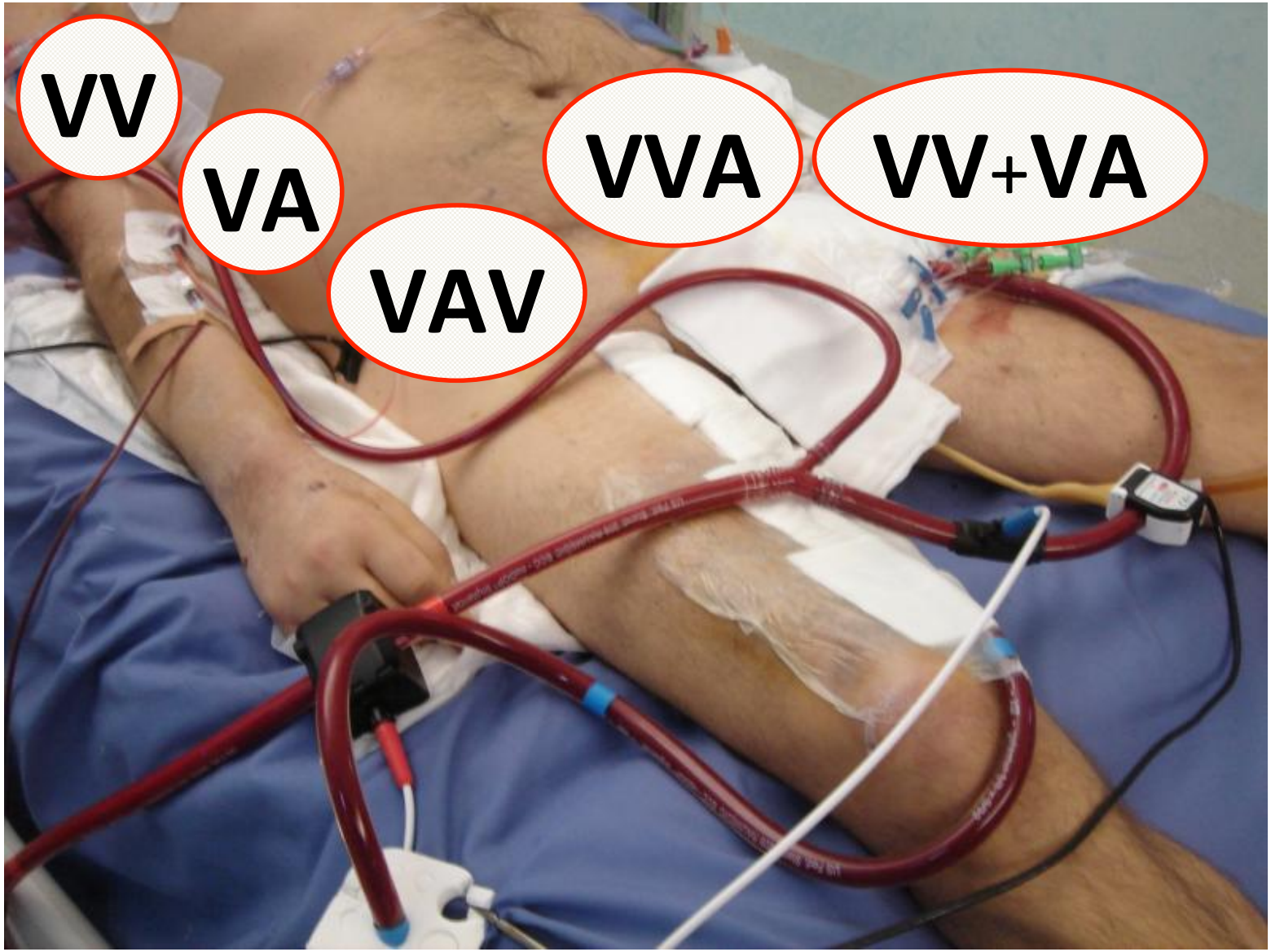


Central VA ECMO



Central VA ECMO

Hybrid configuration



Triple Cannulation

- ✓ an ‘‘upgrade’’ of an existing VV or VA ECMO circuit
- ✓ may either be instituted as VVA or VAV cannulation

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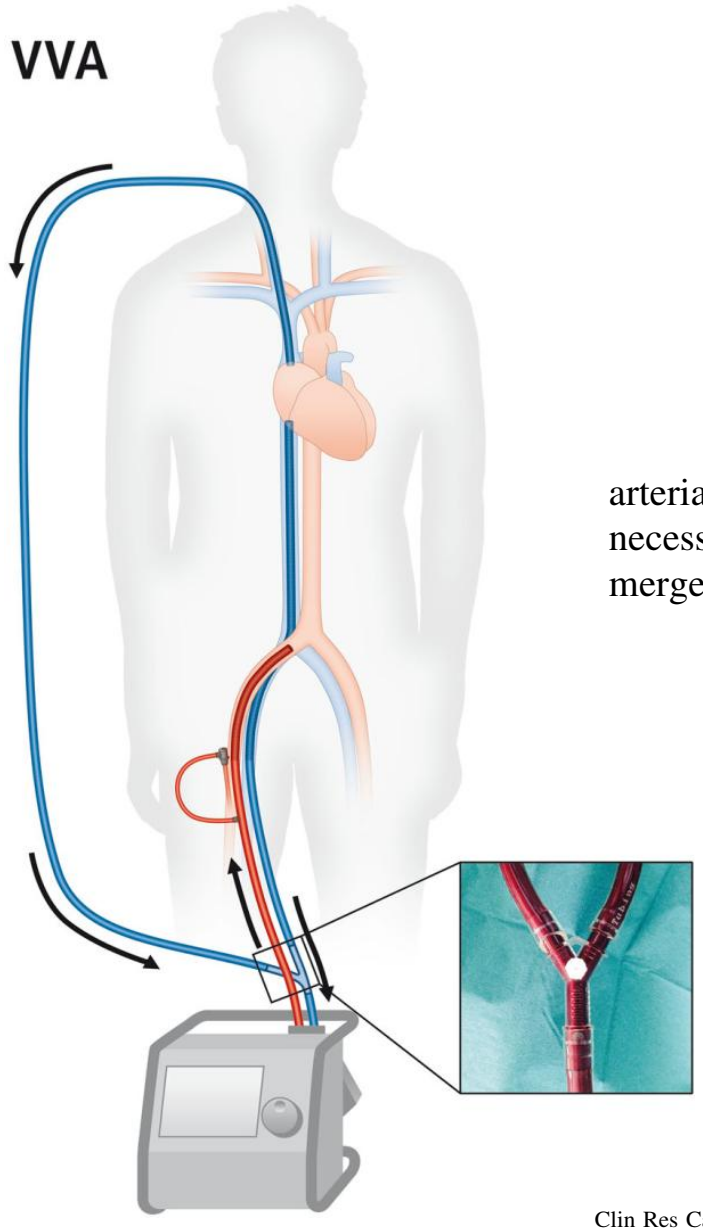
VVA configuration



Veno-veno-arterial ECMO (VVA). When unloading by veno-arterial ECMO is not sufficient, a second draining cannula may be necessary. The draining flows from the two venous cannulas are merged outside the body using a Y-connector (*inset*)

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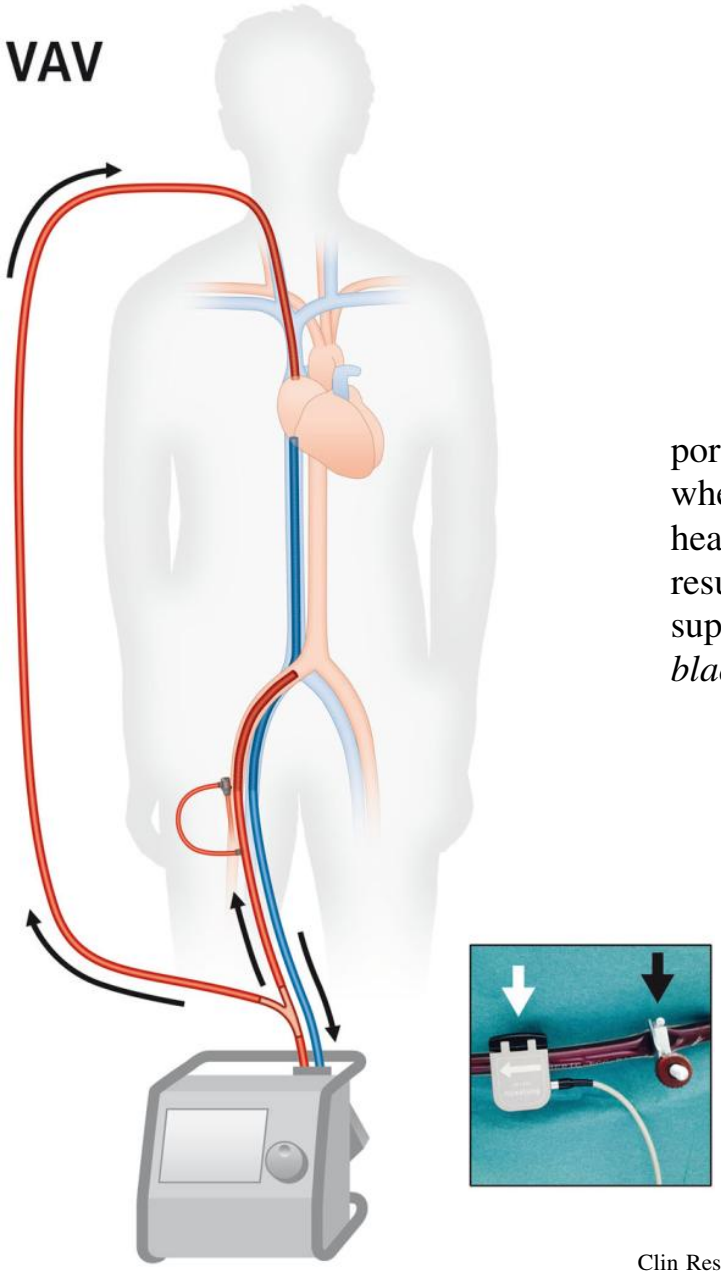
VAV configuration



Veno-arterio-venous ECMO (VAV). When circulatory support with veno-arterial ECMO is complicated by respiratory failure or when respiratory support by veno-venous ECMO is complicated by heart failure, a third cannula may be necessary. Both approaches result in one draining and two supplying cannulae. Flow through the supplying cannulae is balanced using an adjustable clamp (*inset*, *black arrow*) and a separate flow sensor (*inset*, *white arrow*)

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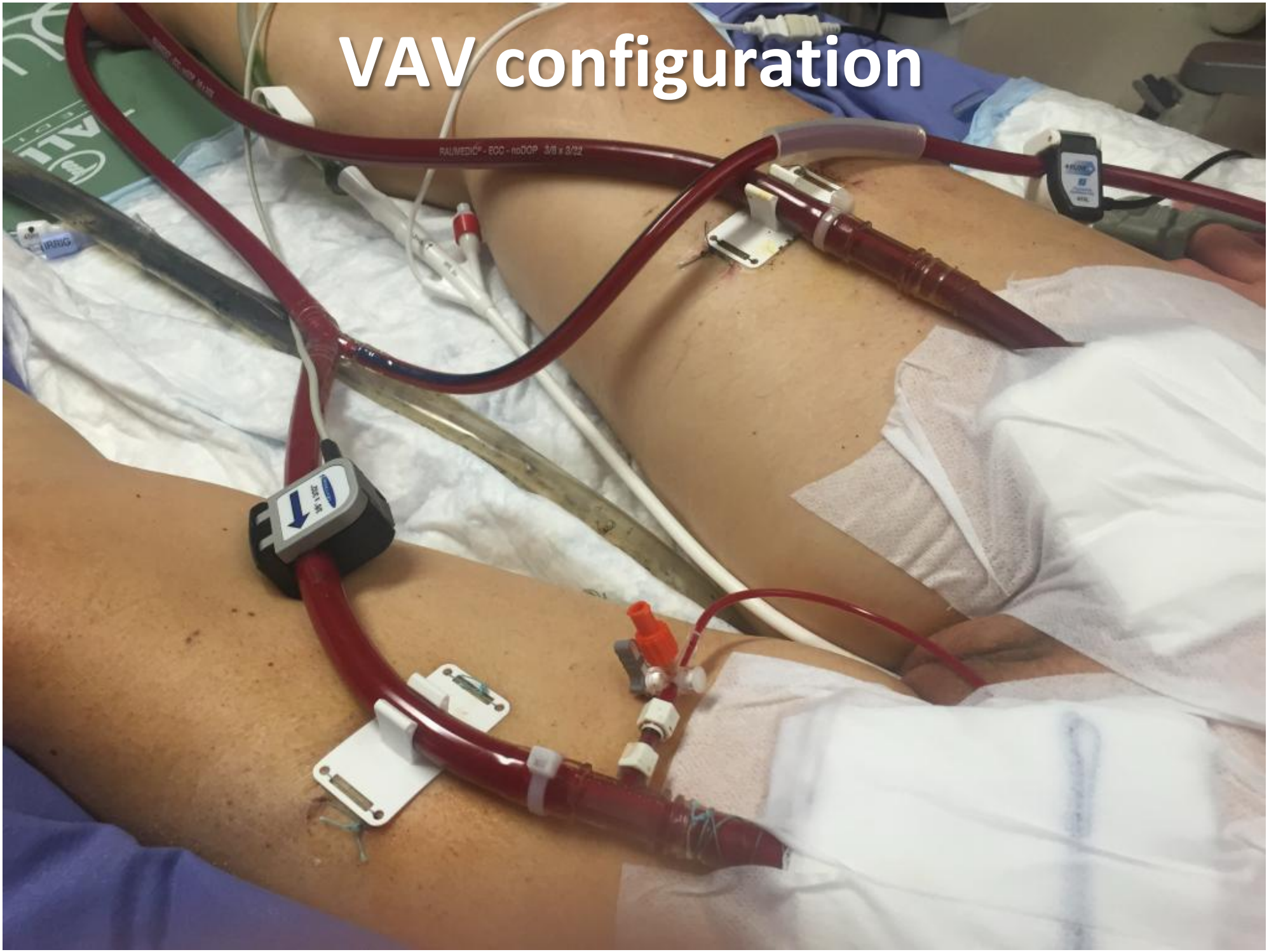
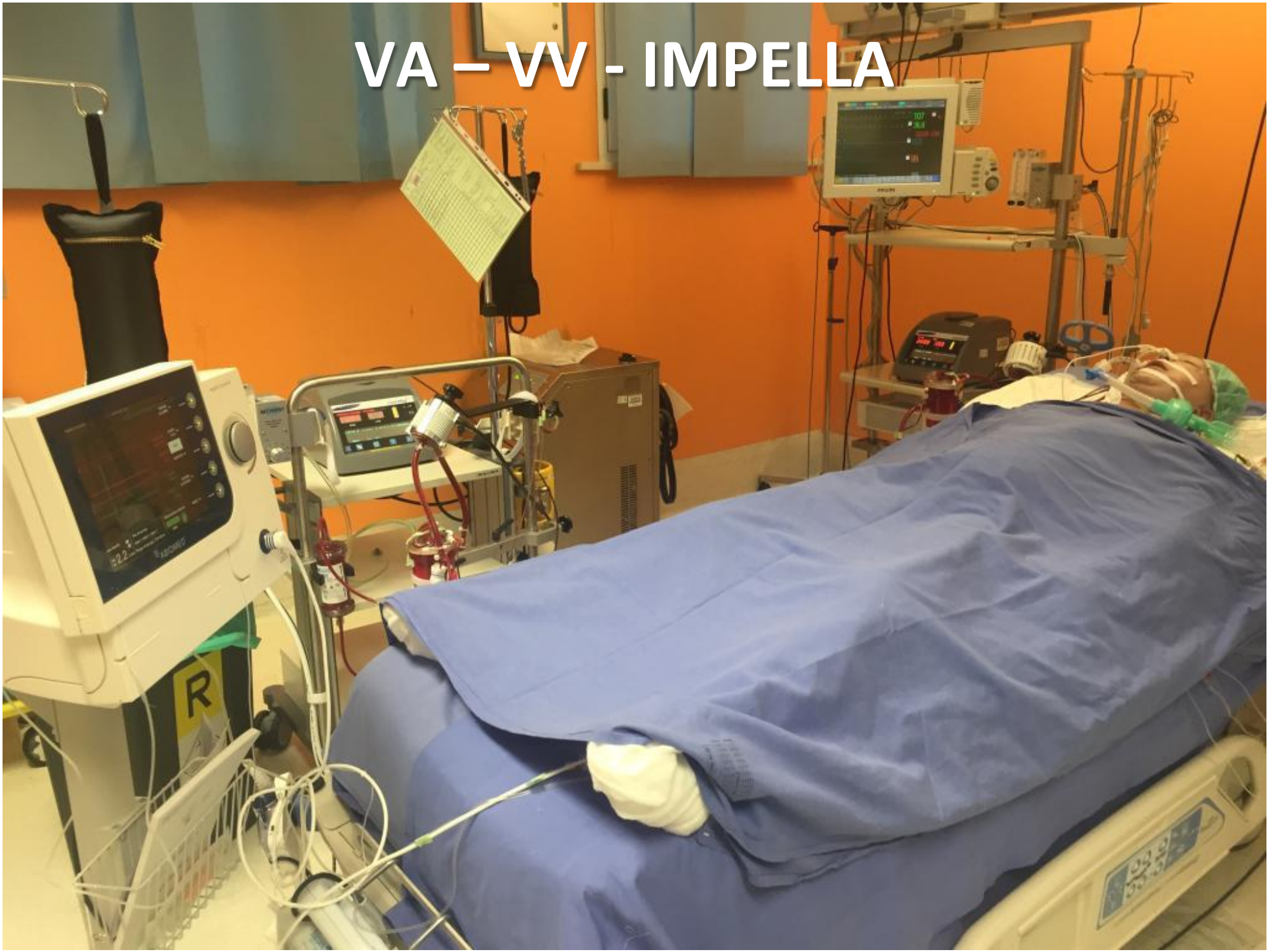
VAV configuration



VA – VV - IMPELLA



Peripheral Femoro-Femoral VA ECMO

Achilles heel

1. Lower Limb Ischemia
2. Harlequin Syndrome
3. **Pulmonary Edema**

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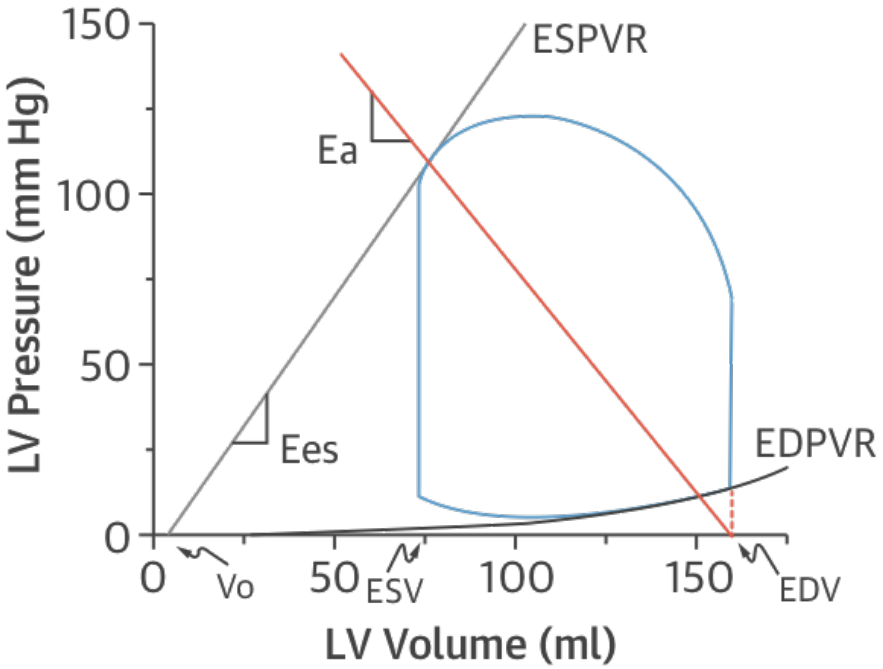
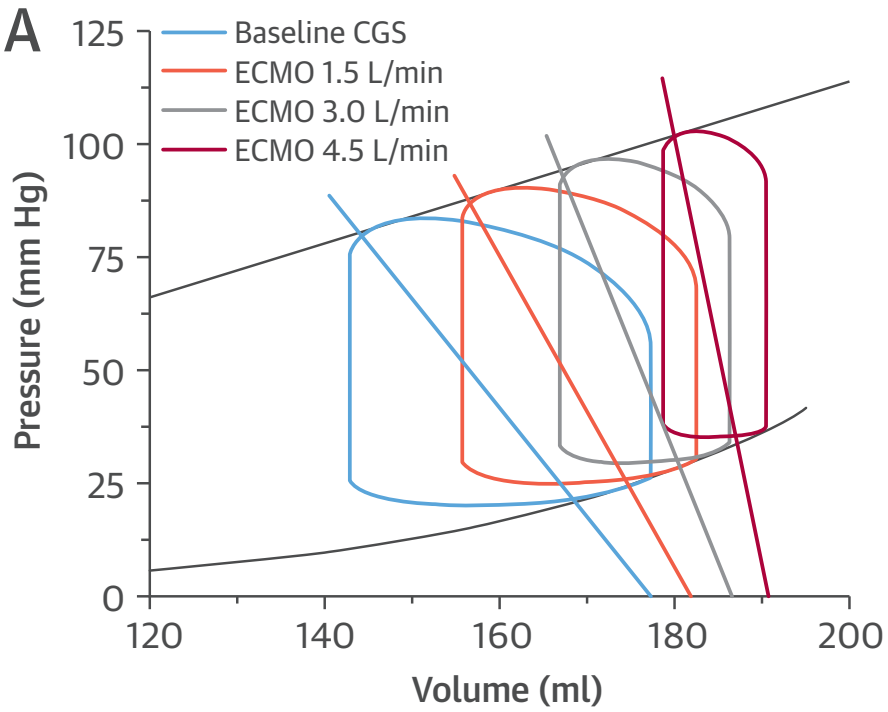
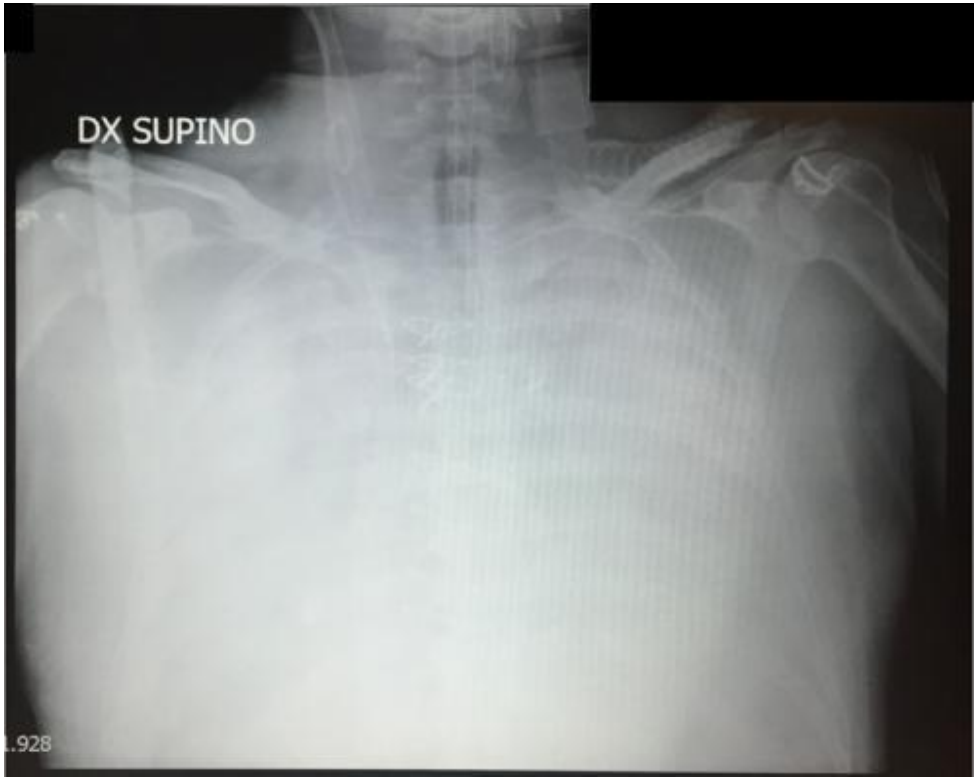
ECMO increases LV afterload

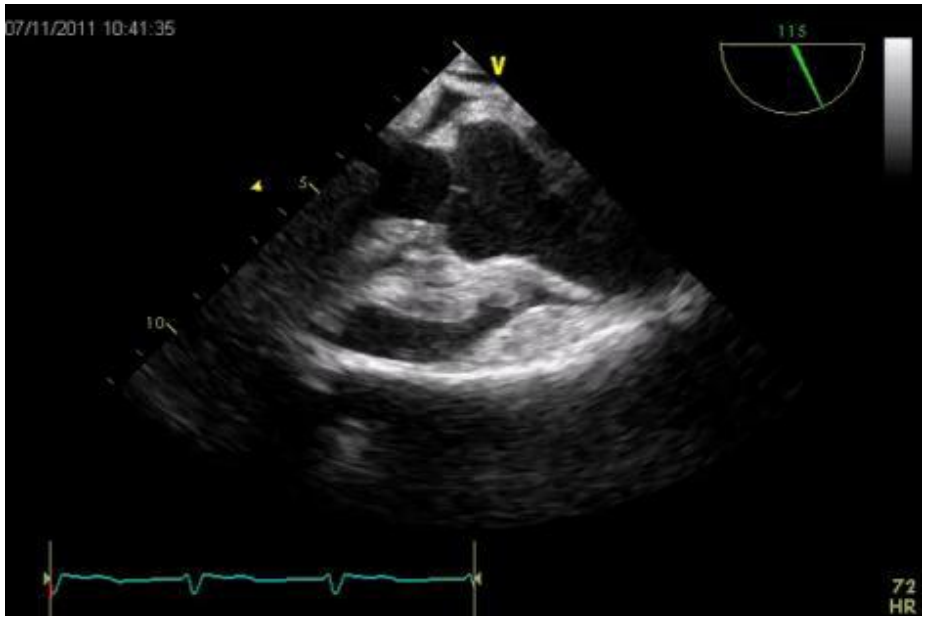


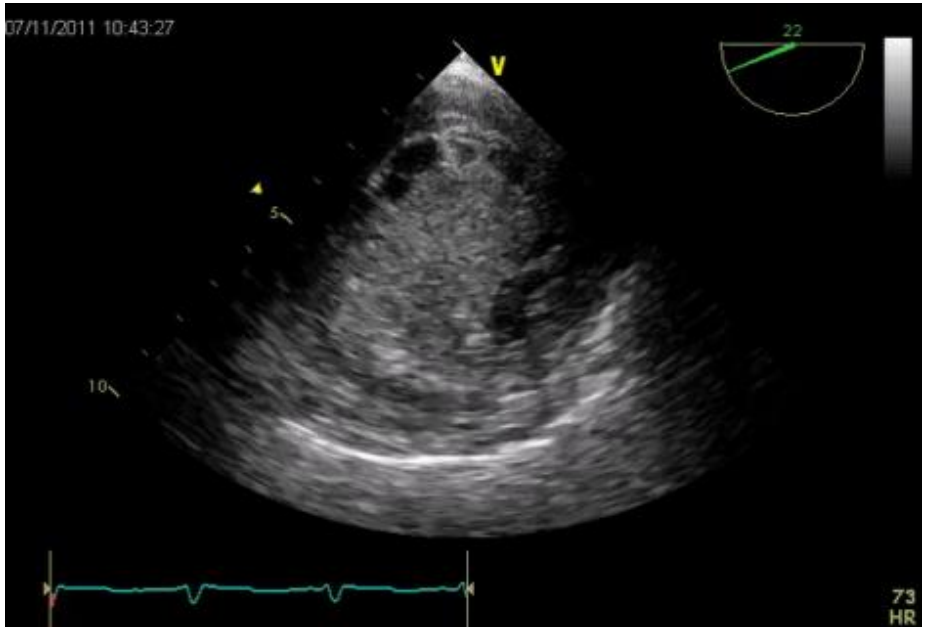


JACC VOL. 66, NO. 23, 2015
DECEMBER 15, 2015:2663–74

Pulmonary edema under peripheral ECMO



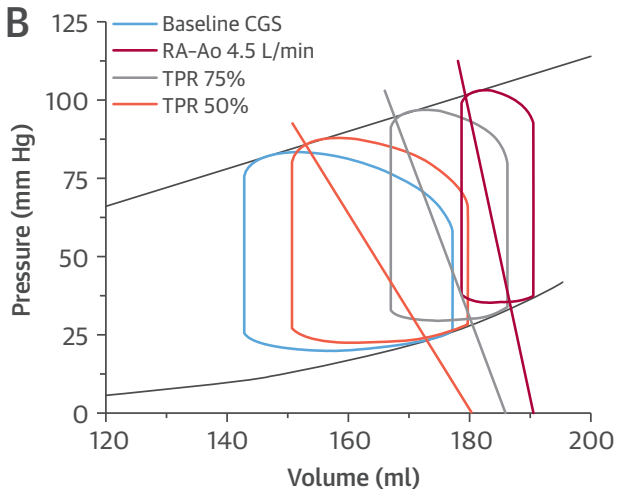


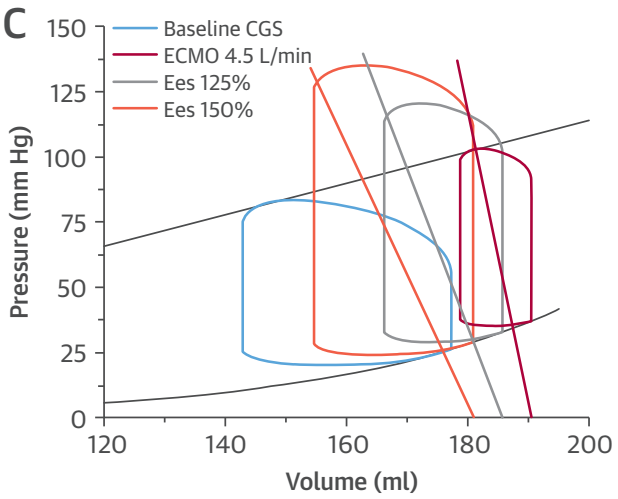


Management of pulmonary edema under peripheral ECMO

Solutions to decrease LVEDP:

- ✓ Inotropes for improving LV ejection
- ✓ Decrease ECMO flow
- ✓ Intra Aortic Balloon Pump
- ✓ Impella®
- ✓ Atrial Septostomy
- ✓ Transeptal LA drainage
- ✓ Switch from femoral to central ECMO (with a LA, PA or LV drainage cannula)





CGS = cardiogenic shock
RA-Ao = ECMO
TFR = total peripheral resistance
Ees = end-systolic elastance

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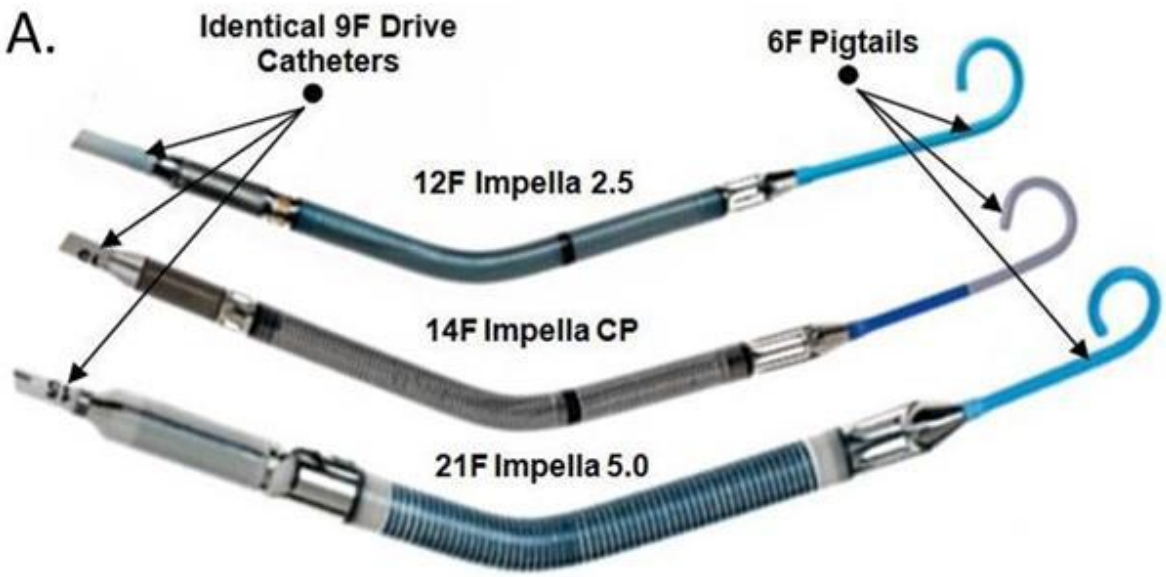
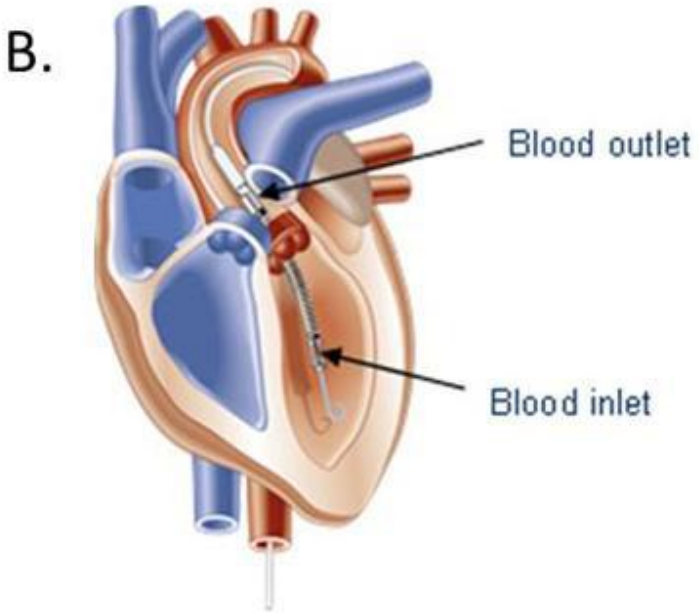
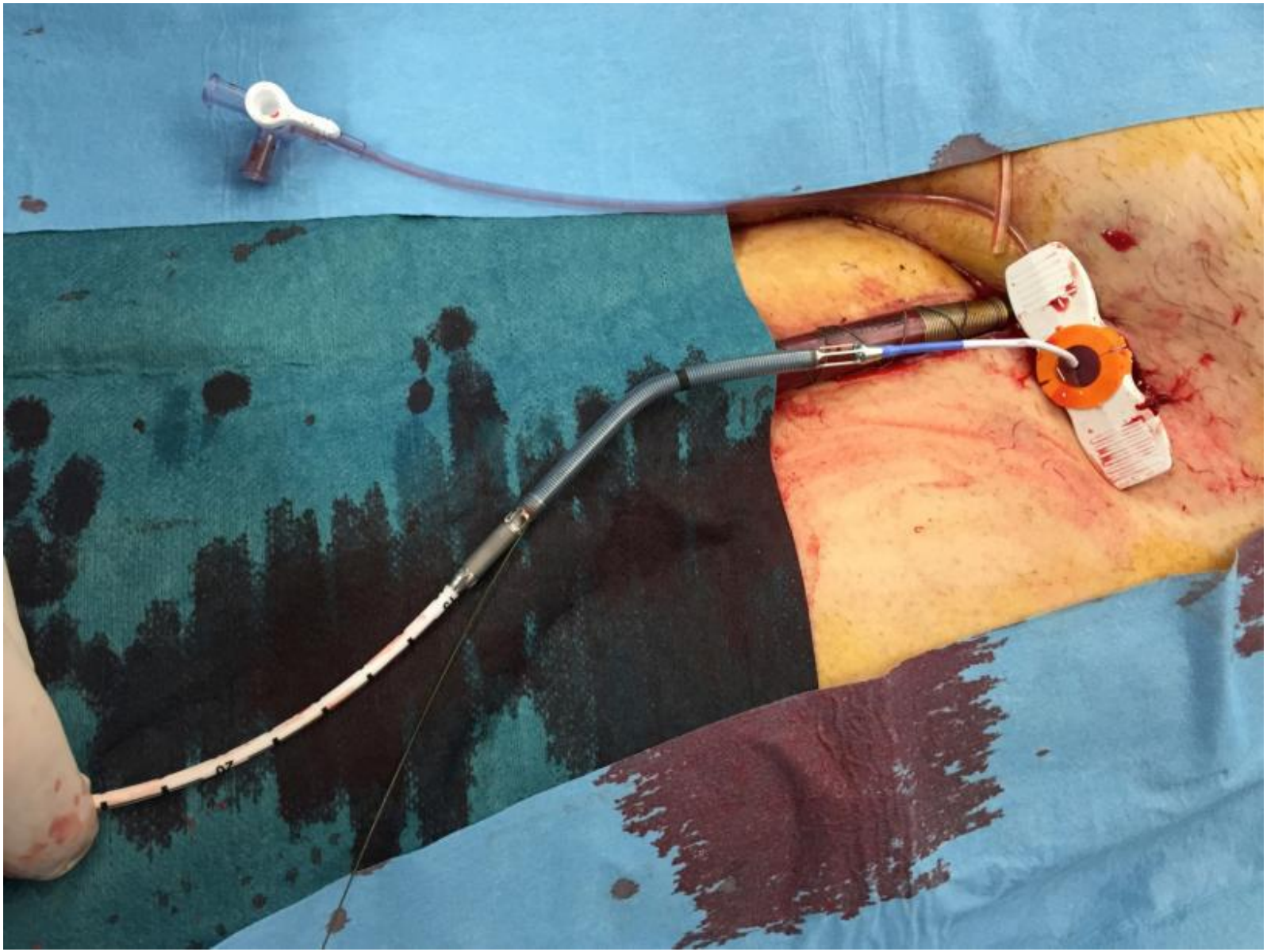
Management of pulmonary edema under peripheral ECMO

IMPELLA

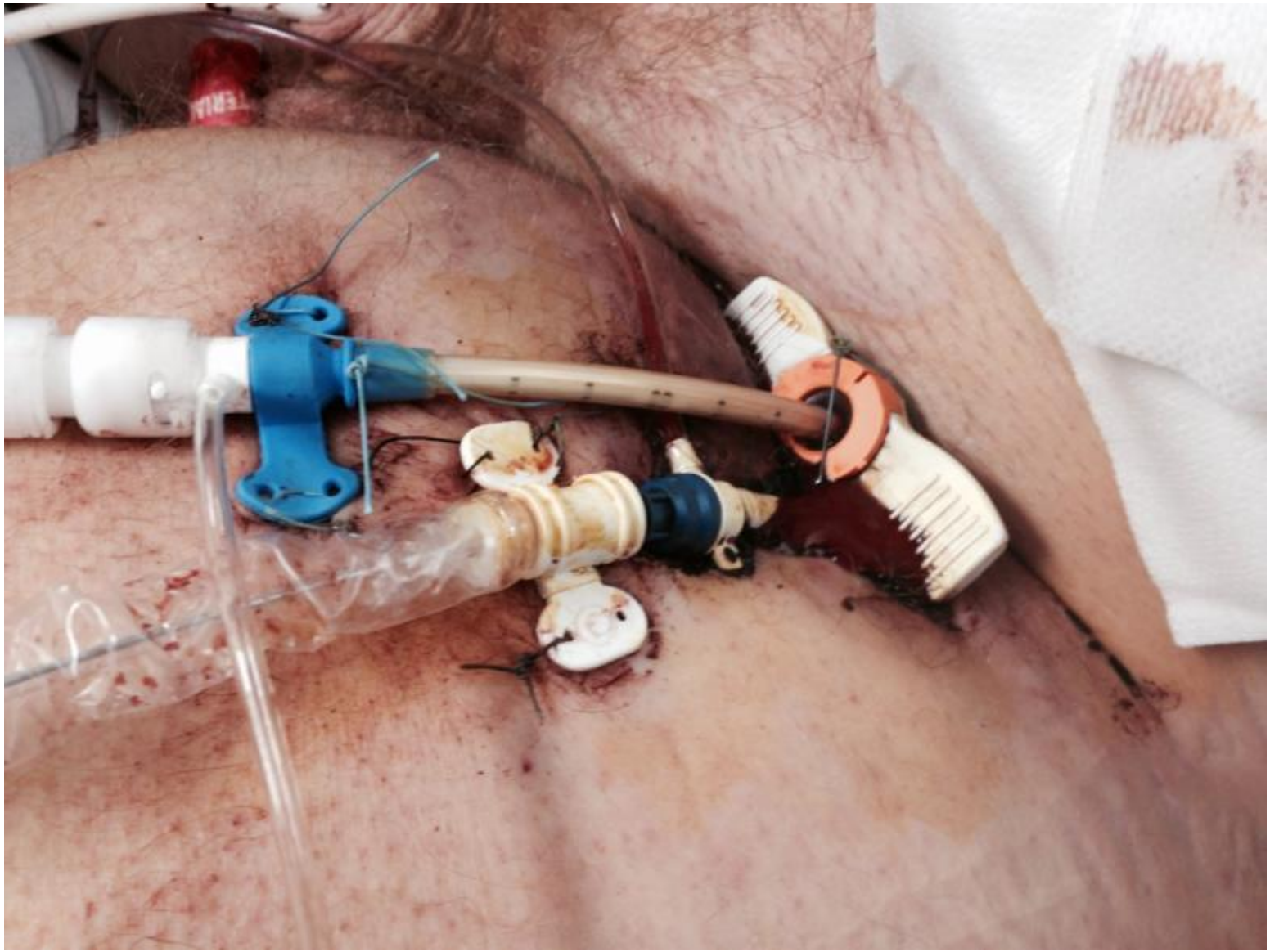




Tips and Tricks…

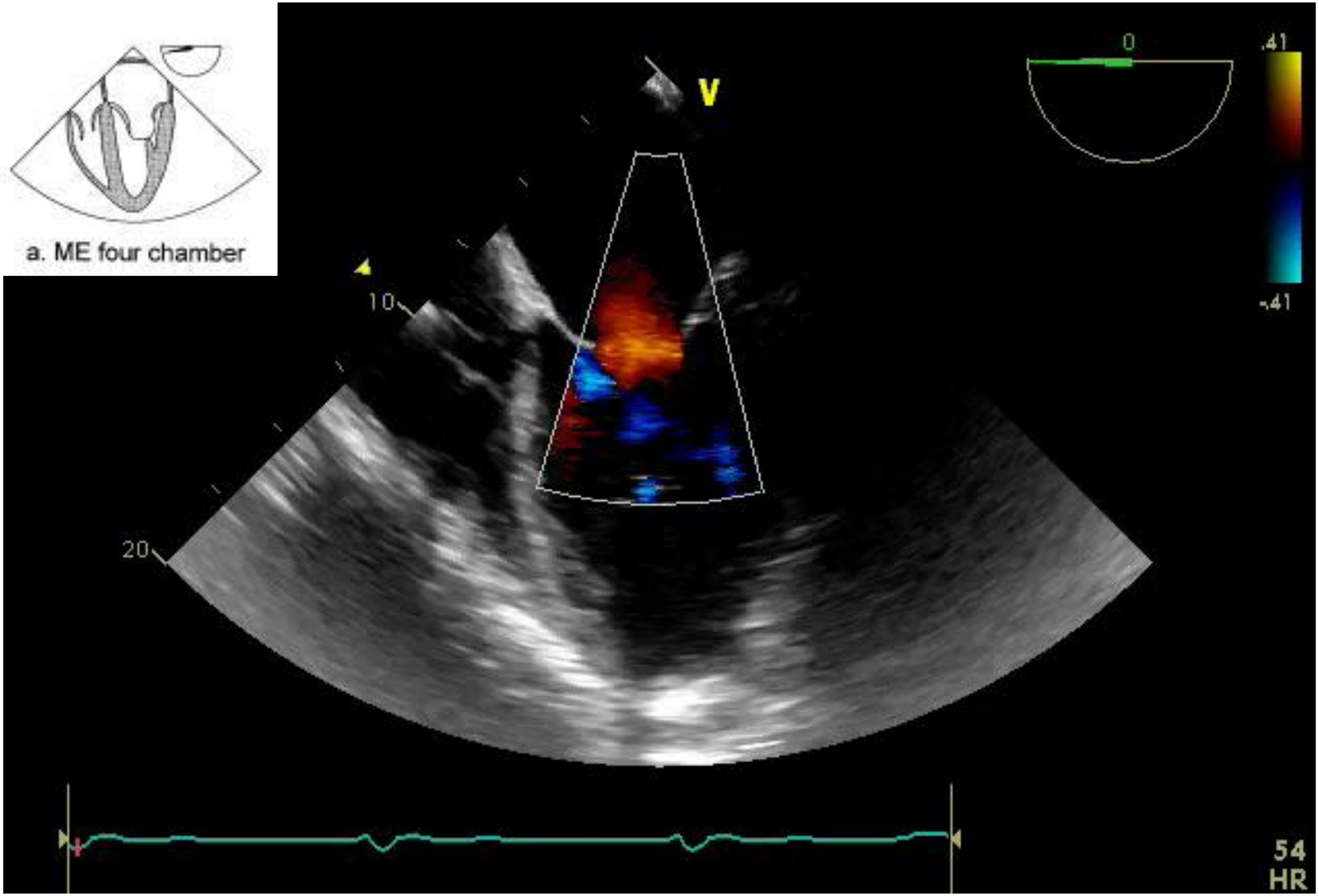


Tips and Tricks…

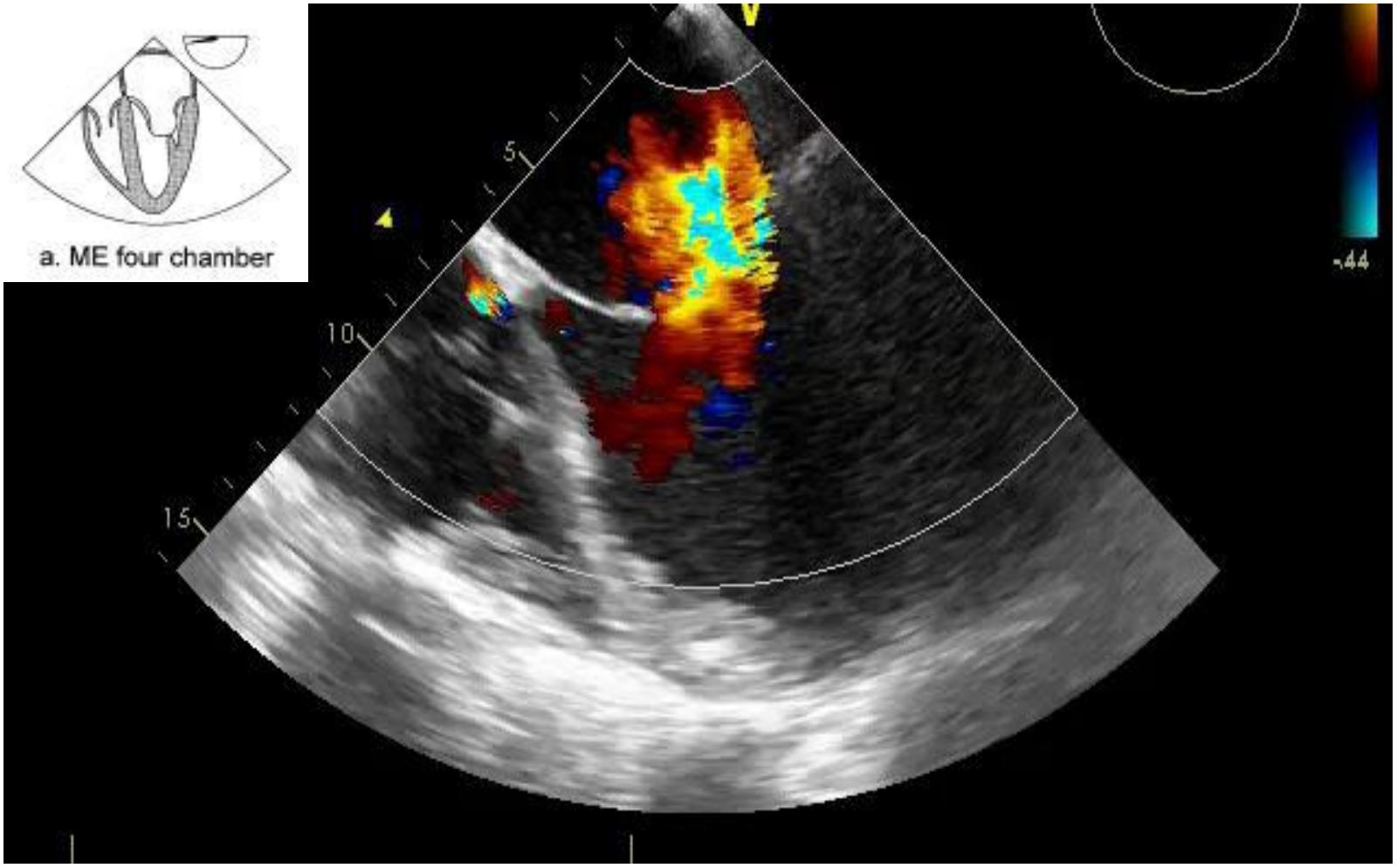


What makes cannulation difficult?

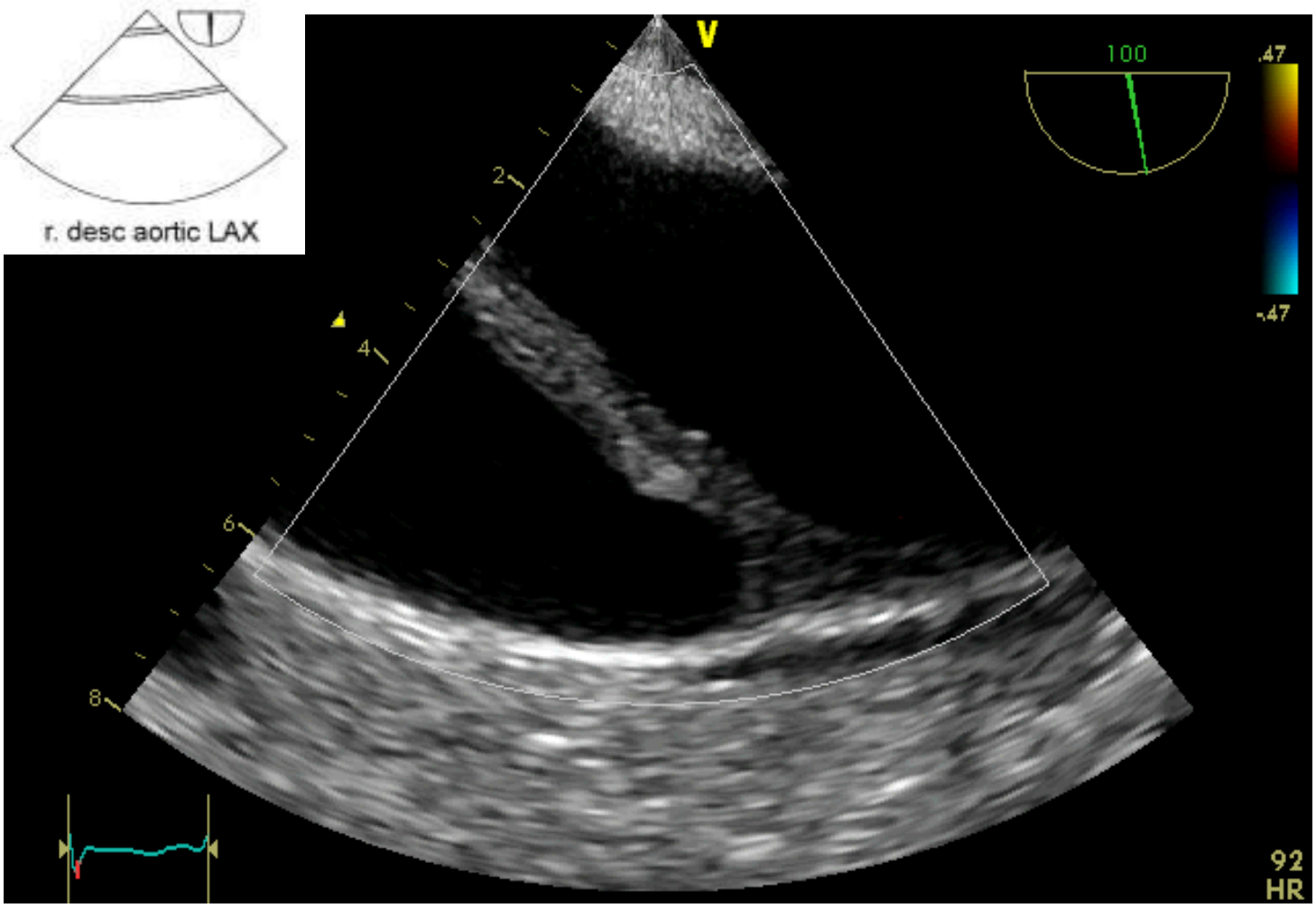
Severe Aortic Regurgitation



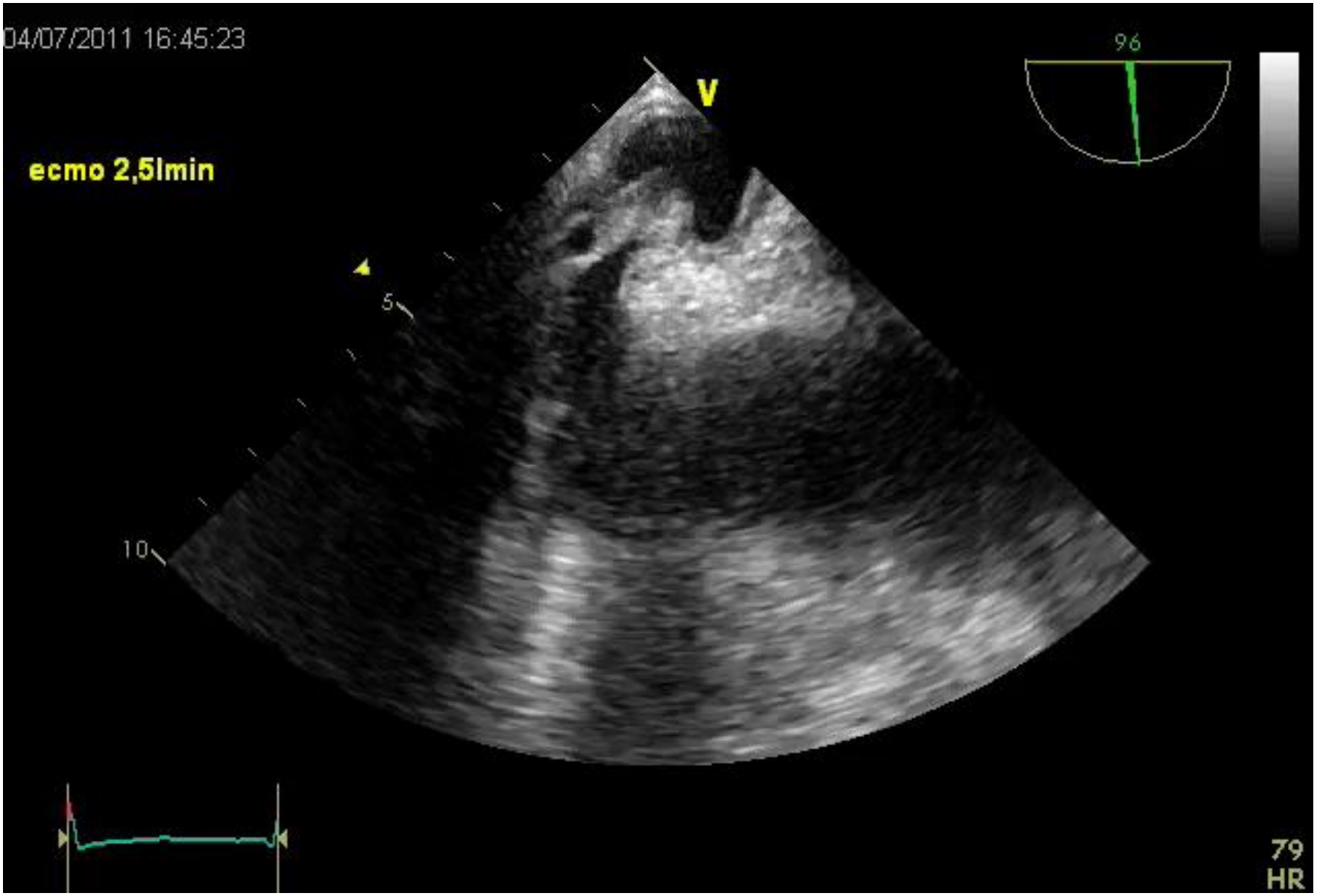
Mitral Valve Regurgitation



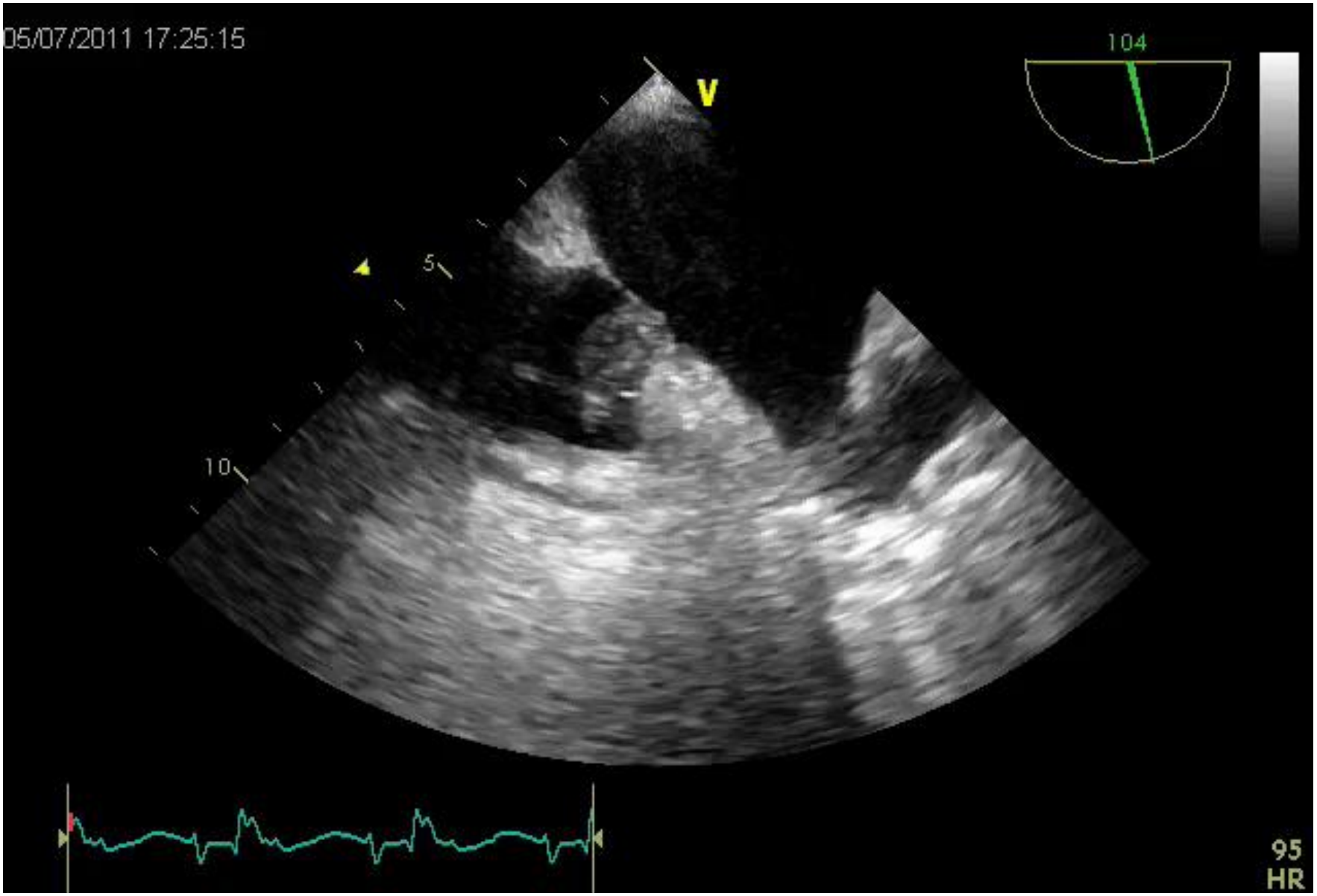
Aortic Dissection



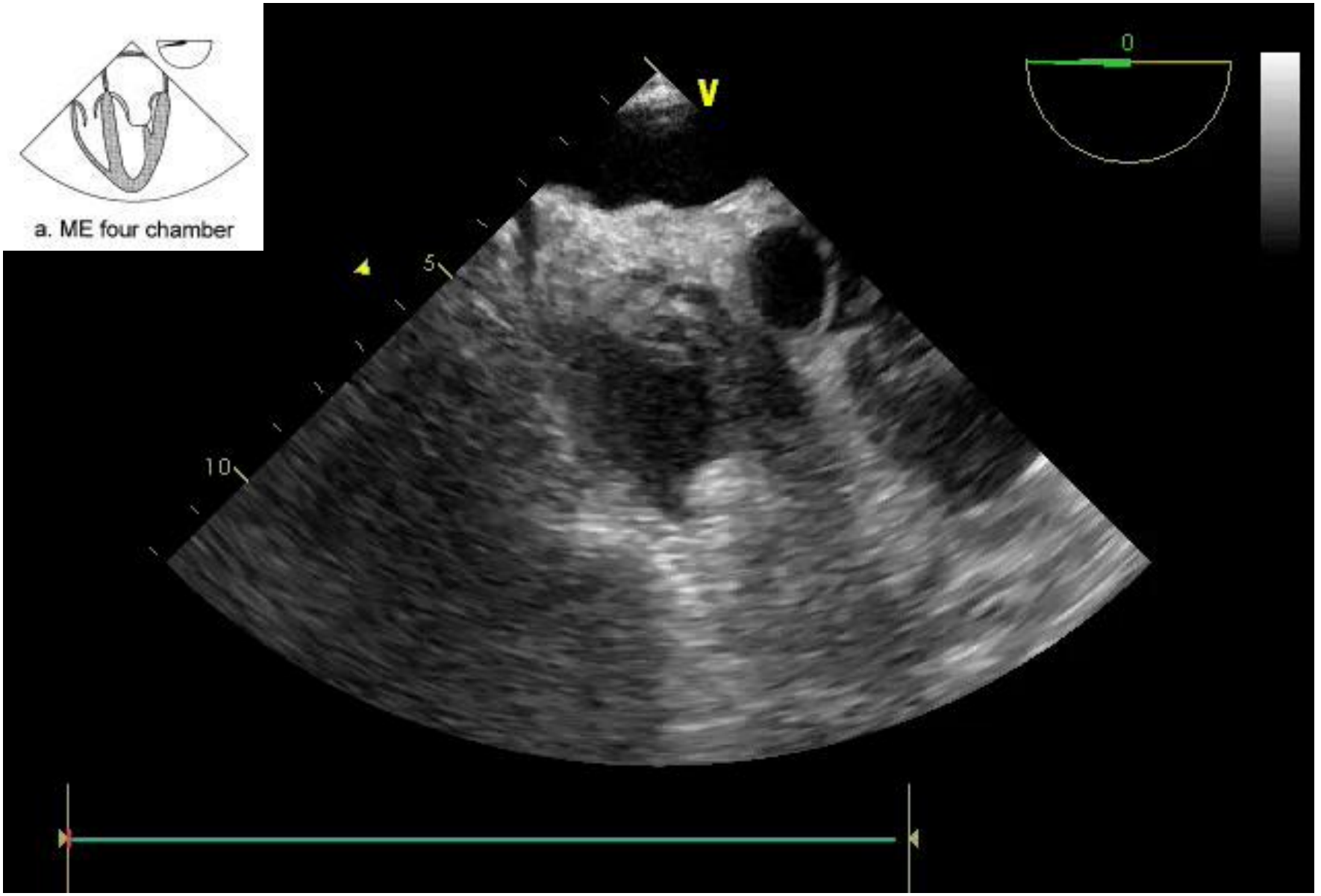
Cannula Malposition



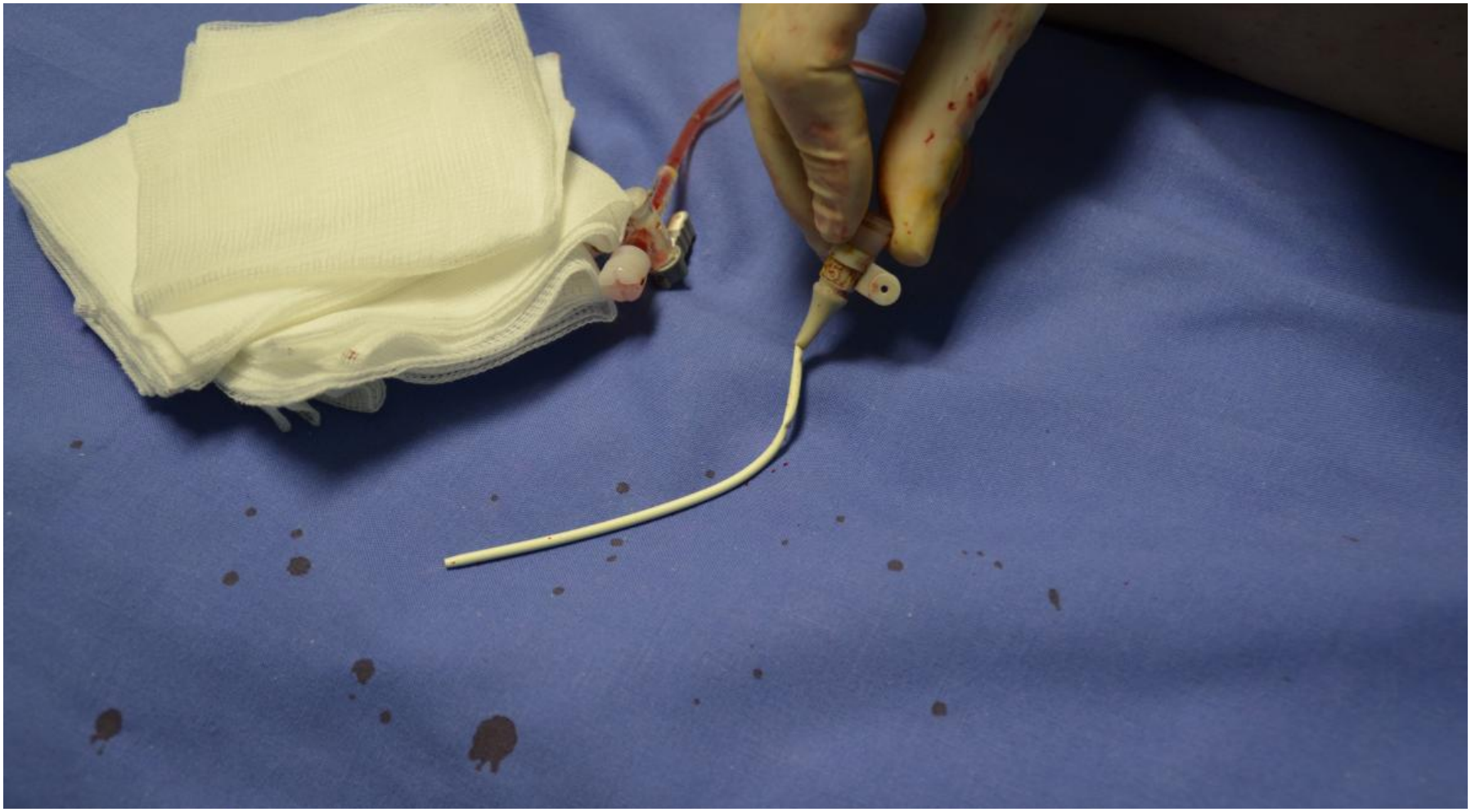
Cannula Thrombosis



Cardiac Tamponade



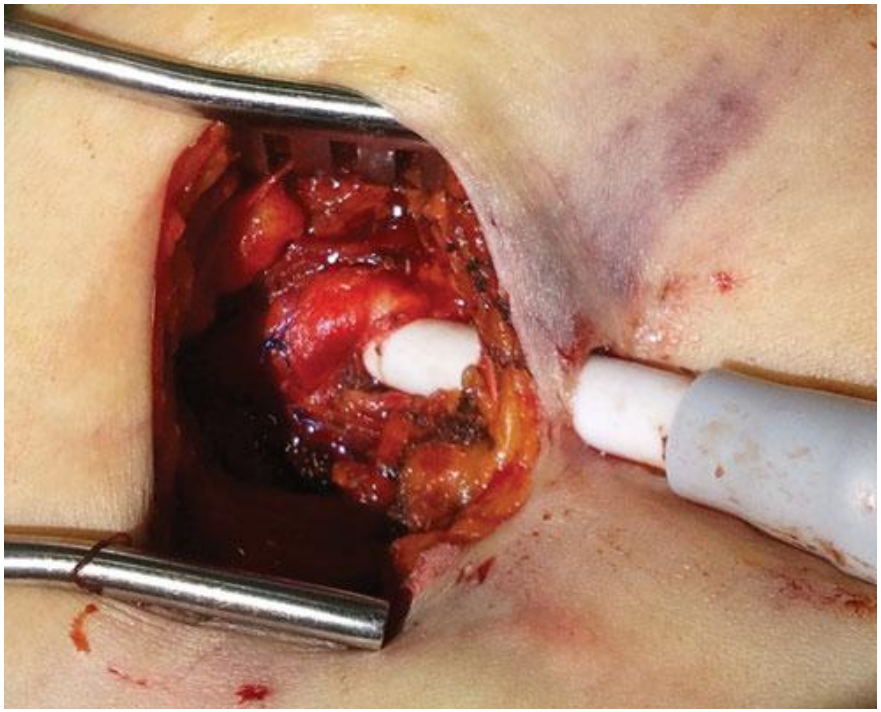
Kinking of distal leg cannula

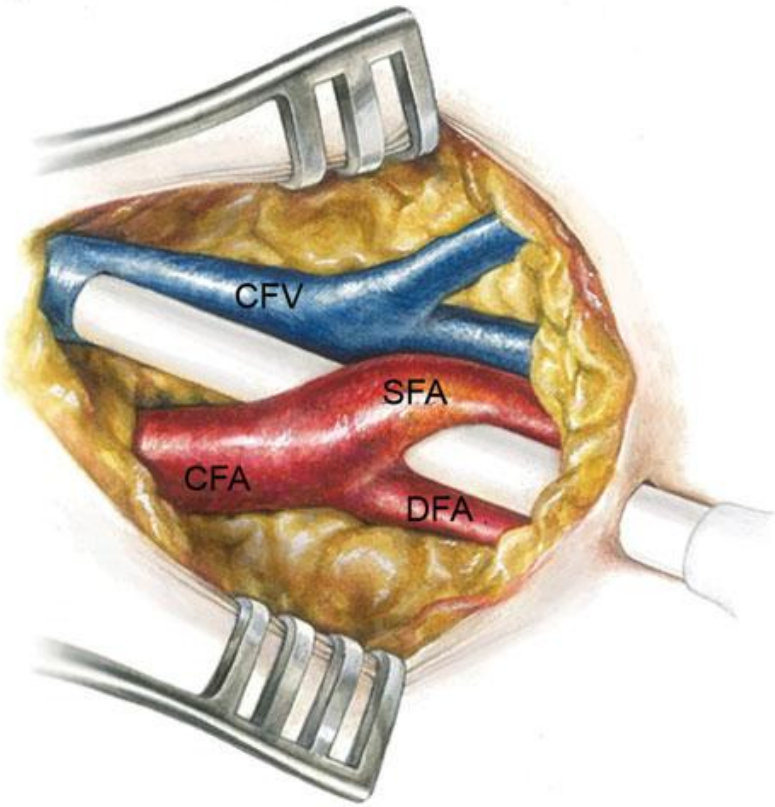


It can also be your fault ….

It can also be your fault ….

Transient Limb Ischemia





Decannulation Procedure

Direct cut down cannulation:

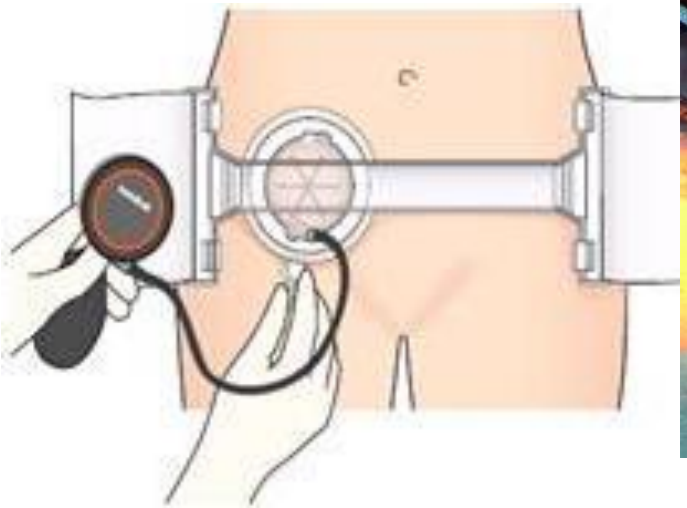
✓ Vascular repair

Percutaneous cannulation and Semi-Seldinger technique:

✓Manual Compression following of a Mechanical Compression System

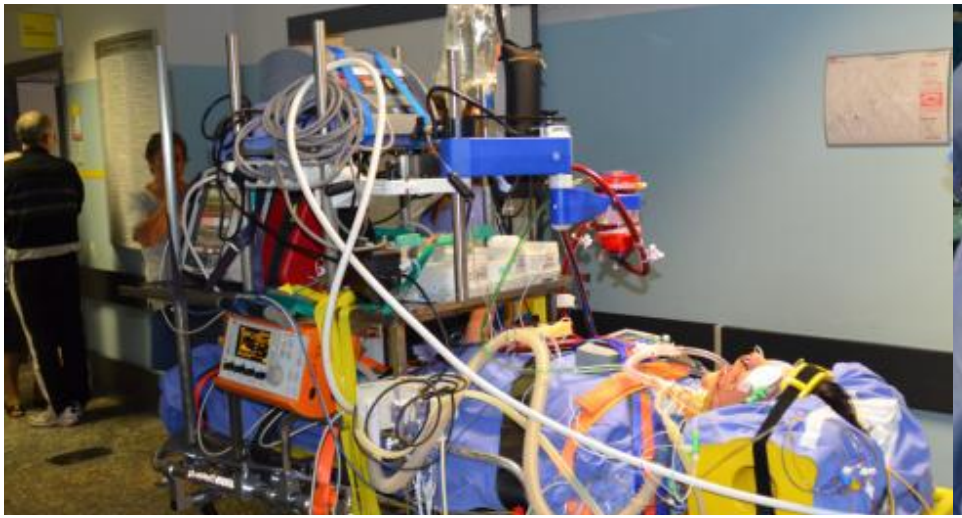
✓Vascular repair

✓Vascular Closure Device





642 ECMO and counting …




THANK YOU