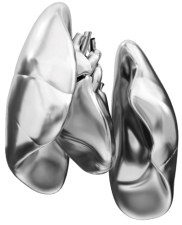


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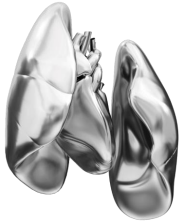
How I Do It: Insertion of Veno-Venous ECMO For Thoracic Surgery Support

Laura Donahoe MD MSc FRCSC
Thoracic and Lung Transplant Surgeon
Toronto General Hospital
University of Toronto



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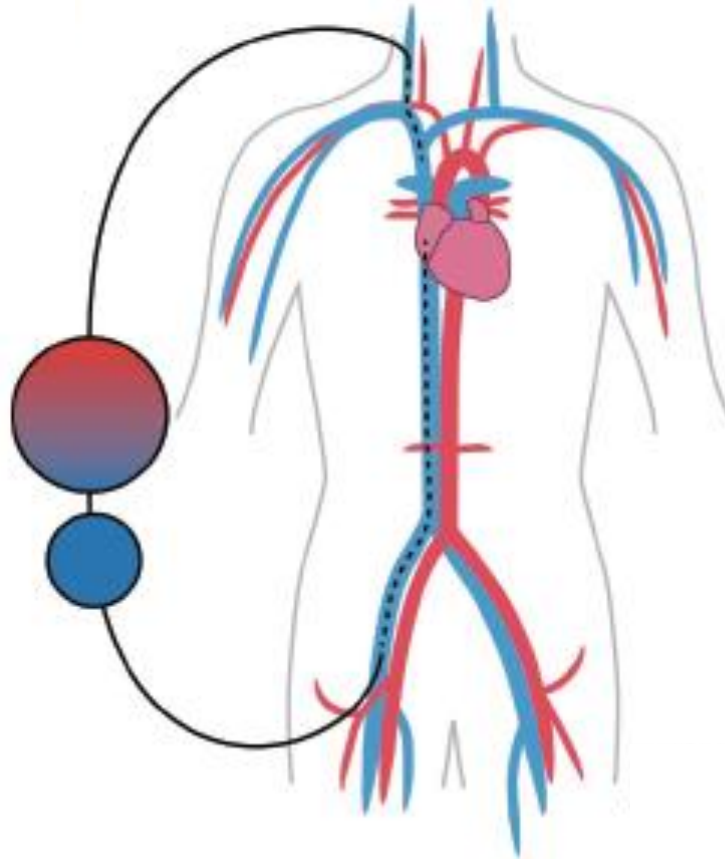
ECLS Configurations

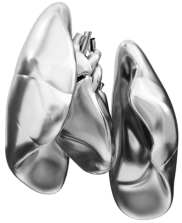


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Veno-Venous

Femoral Vein drainage, Internal Jugular Vein inflow



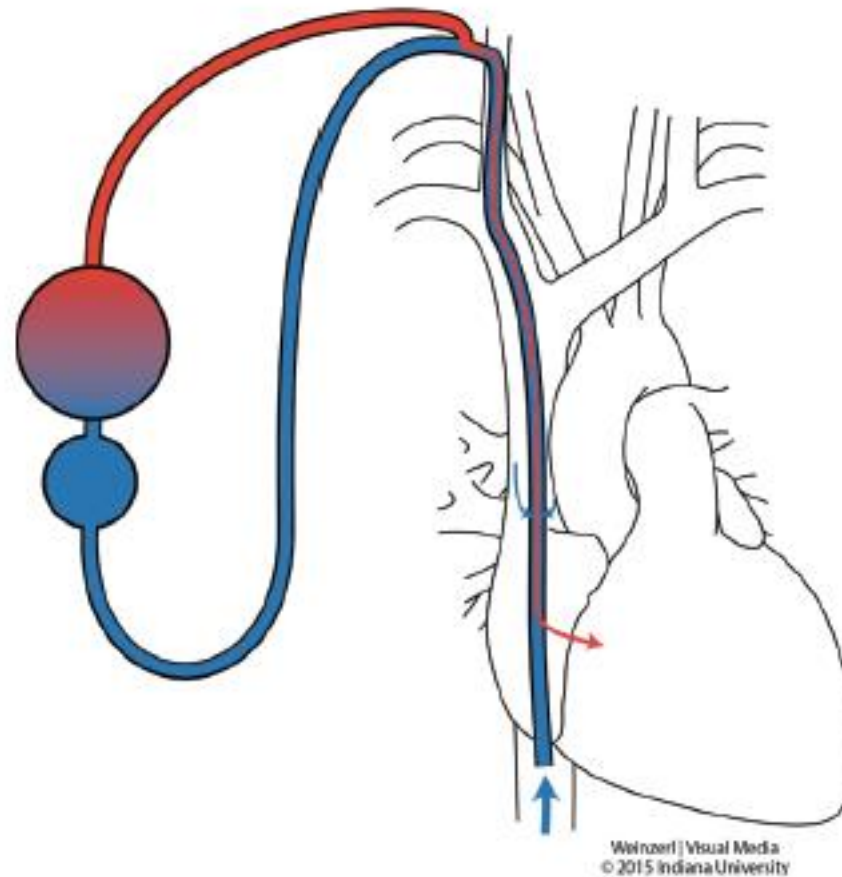


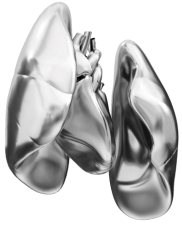
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Veno-Venous

Dual lumen cannula, Internal Jugular Vein

Veno-venous ECMO: double stage single cannular approach



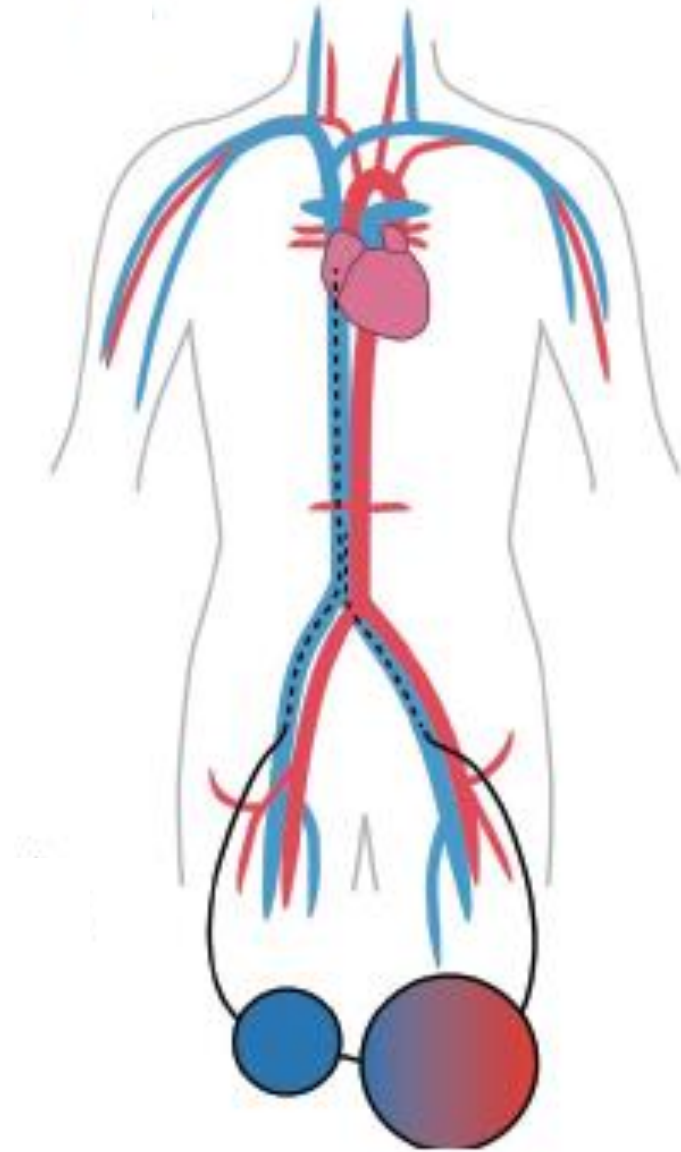


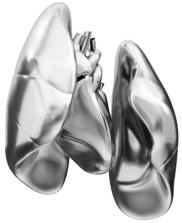
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Veno-Venous

Femoral Vein drainage

Femoral Vein inflow



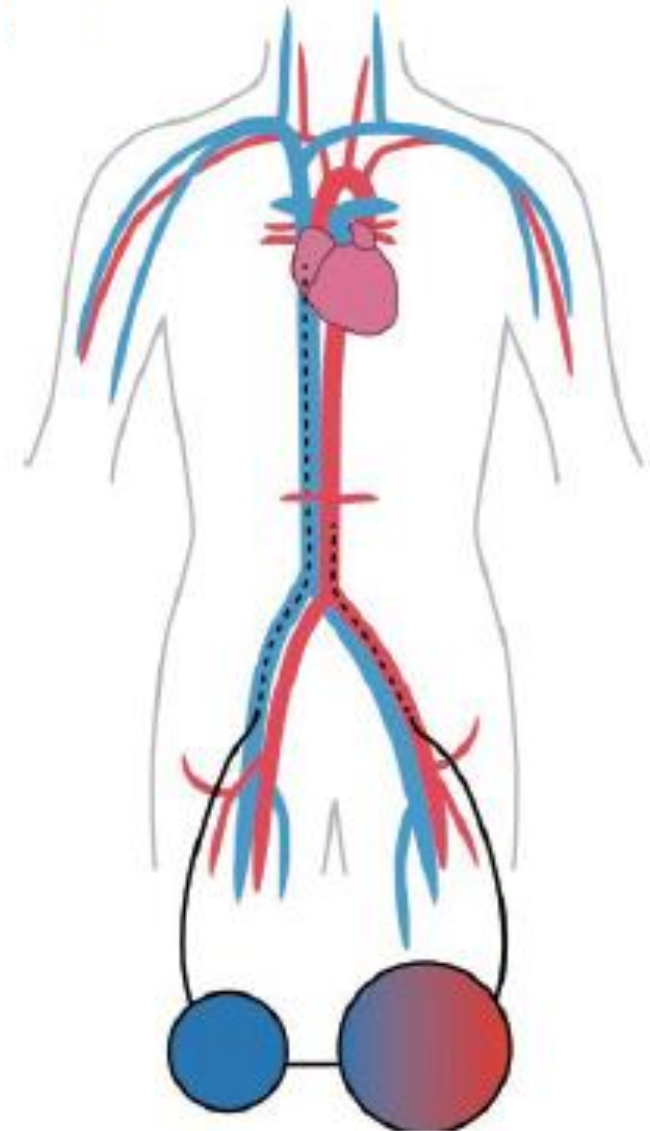


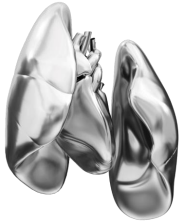
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Veno-Arterial - Peripheral

Femoral Vein drainage

Femoral Artery inflow



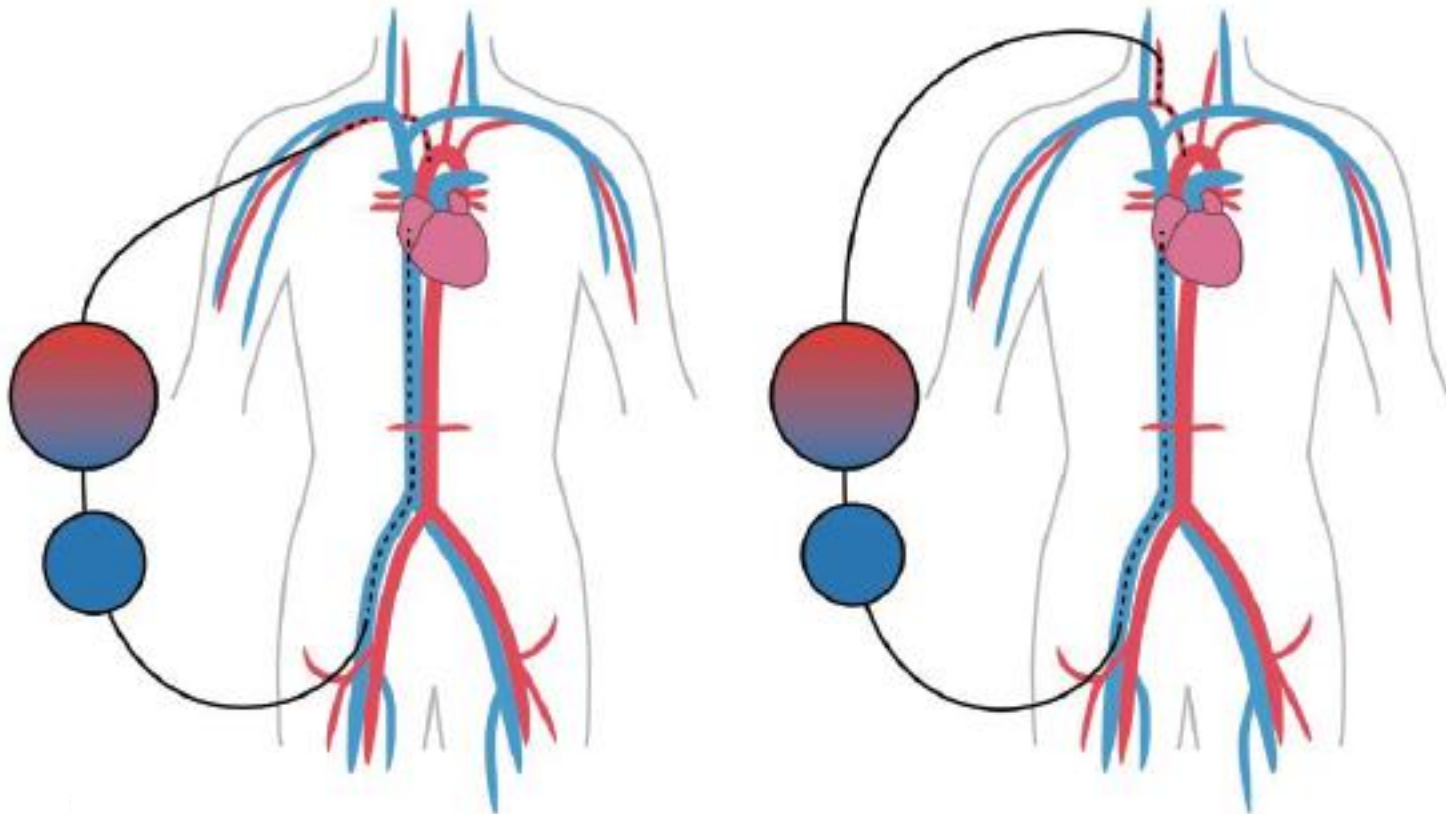


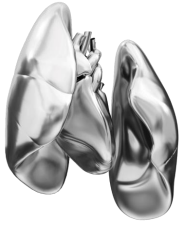
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Veno-Arterial - Peripheral

Femoral Vein drainage

Axillary/Carotid Artery inflow



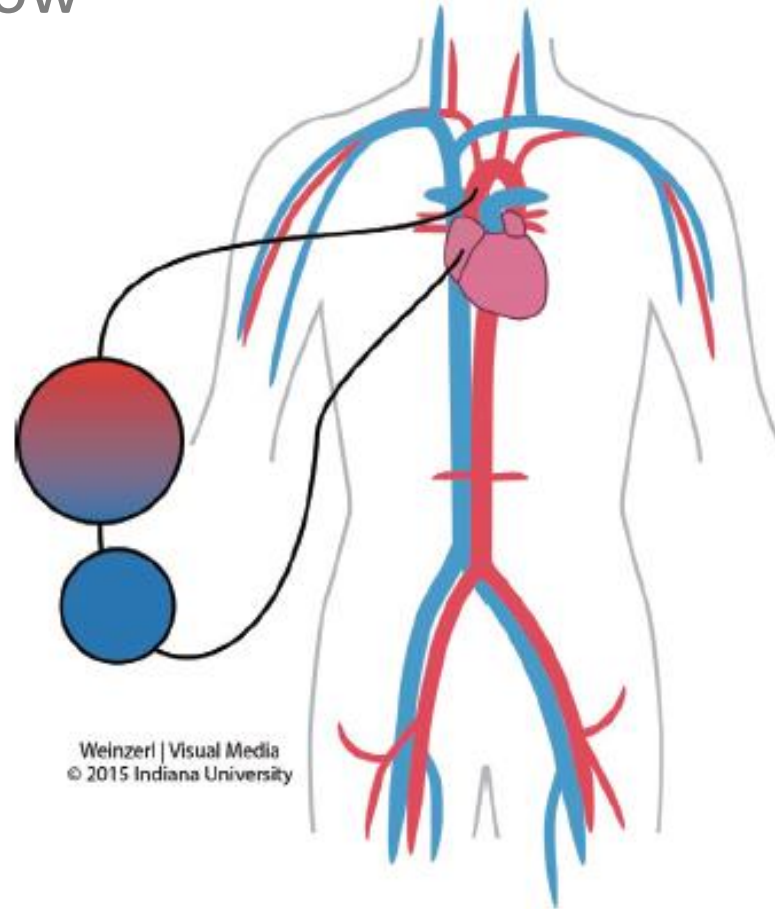


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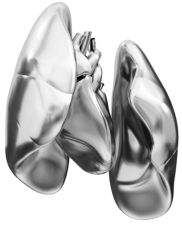
Veno-Arterial - Central

Right Atrium drainage

Aorta inflow

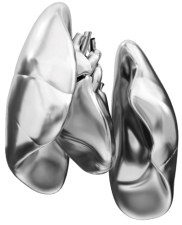


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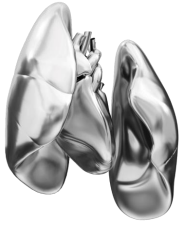
Cannulation



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Cannulation Technique

- ◎ Sterile Technique
- ◎ Ultrasound Guidance
- ◎ Seldinger Technique
 - ◎ Finder needle
 - ◎ Guidewire
 - ◎ Avoid Kinking
 - ◎ Sequential dilators
 - ◎ Cannula insertion



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Cannulation Team

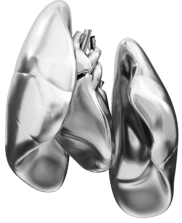
◎ Surgeon

◎ Fellows

◎ Anaesthesiologist/Intensivist

◎ Perfusionist

◎ Nurses



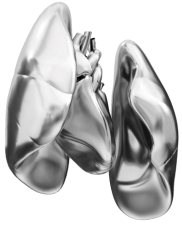
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Cannula Size Choice

- ⦿ Flow desired for patient

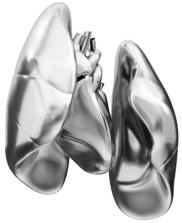
- ⦿ Peripheral – vessel size on ultrasound
 - ⦿ Outer Diameter = $Fr/3$
 - ⦿ Not $> 2/3$ vessel diameter

- ⦿ Central – flow profile and desired flow



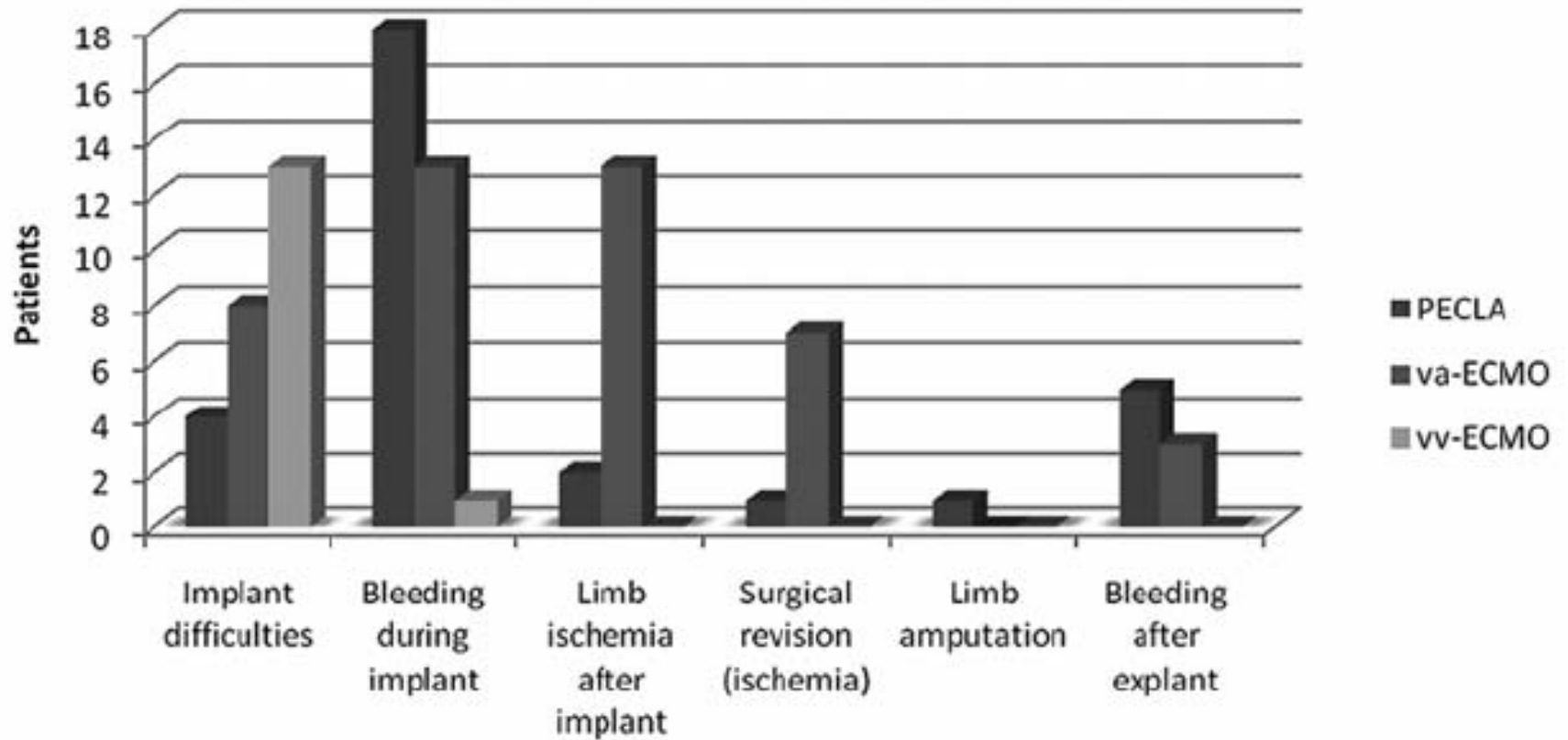
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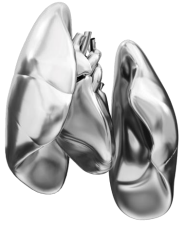
Potential Complications of Cannulation



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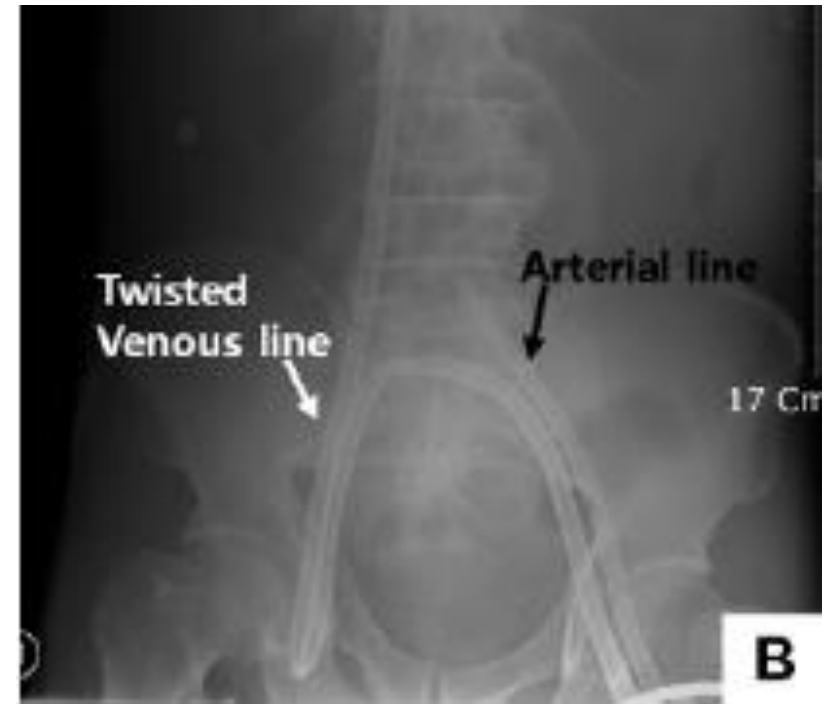
Complications during and after cannulation



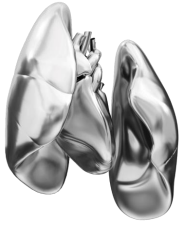


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Kinking of Cannula

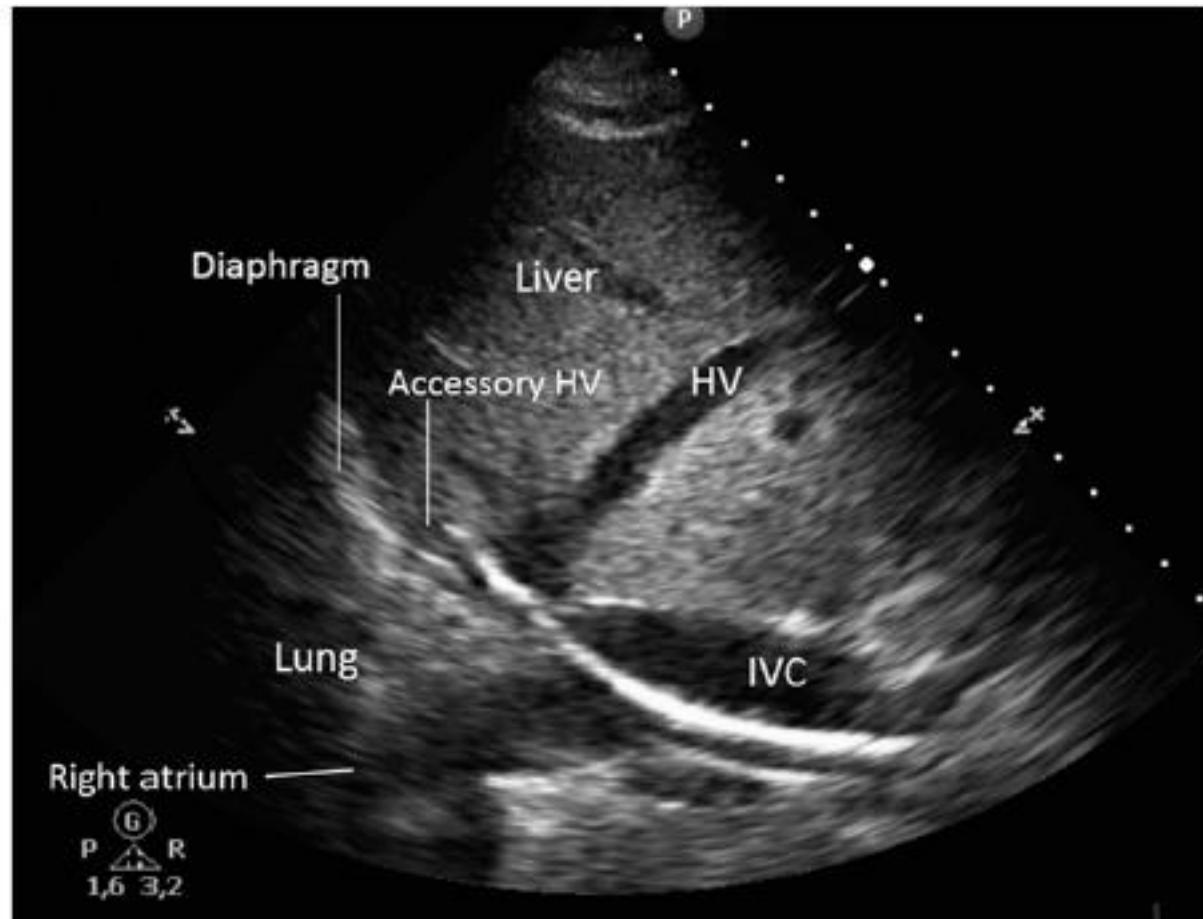


Yie K. A fatal complication during bedside extracorporeal membrane oxygenation: caused by catheter twisting.
Eur J Cardio Thorac Surg. 2010;38:810.



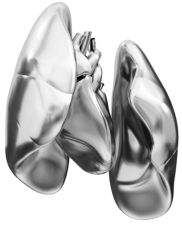
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Malpositioned Cannula



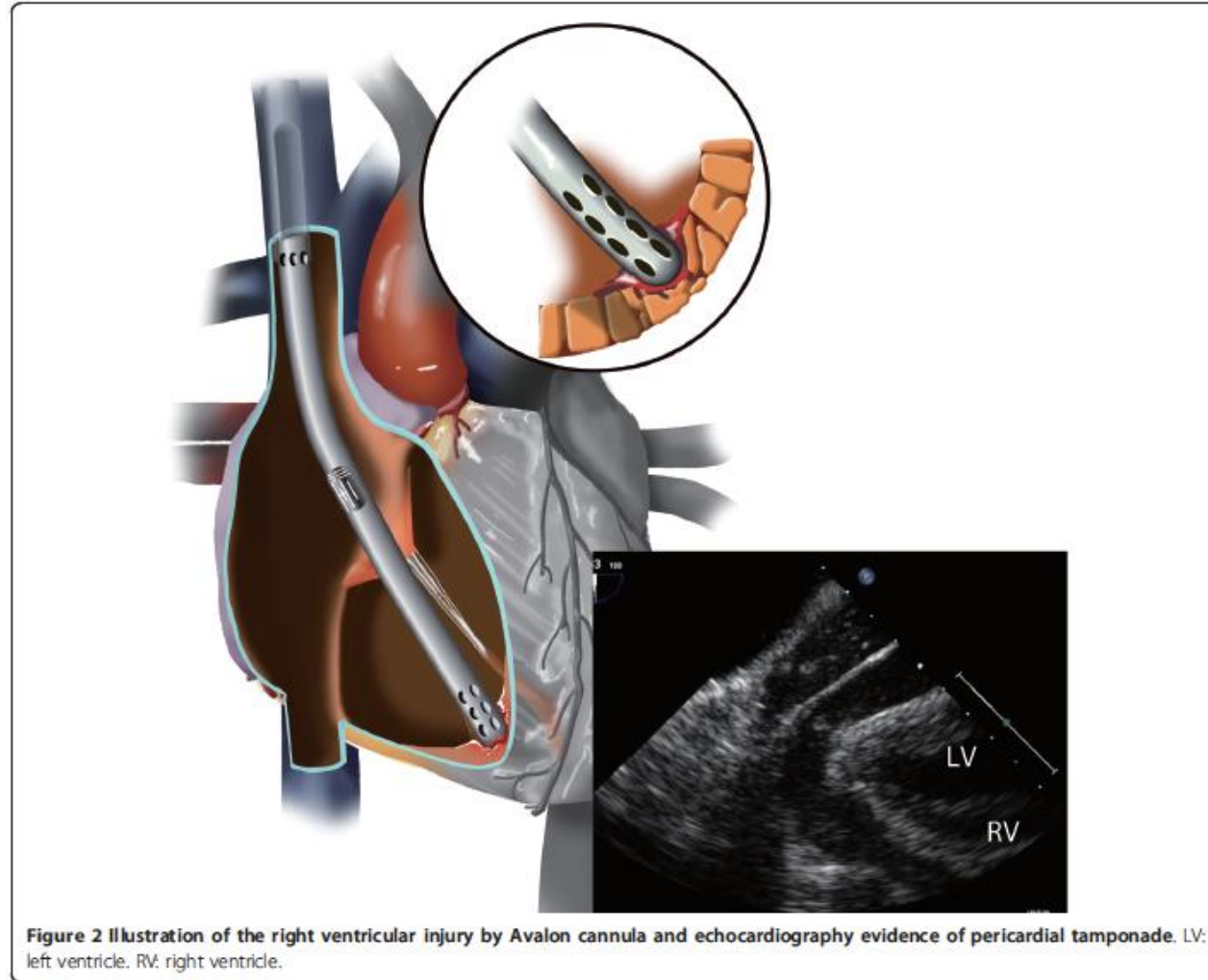
Winiszewski H et al. Malposition of the Extracorporeal Membrane Oxygenation Venous Cannula in an Accessory Hepatic Vein. J Extra Corpor Technol. 2018;50:167-169.



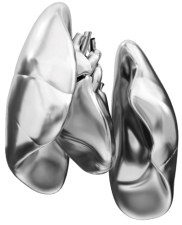


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Cardiac Injury

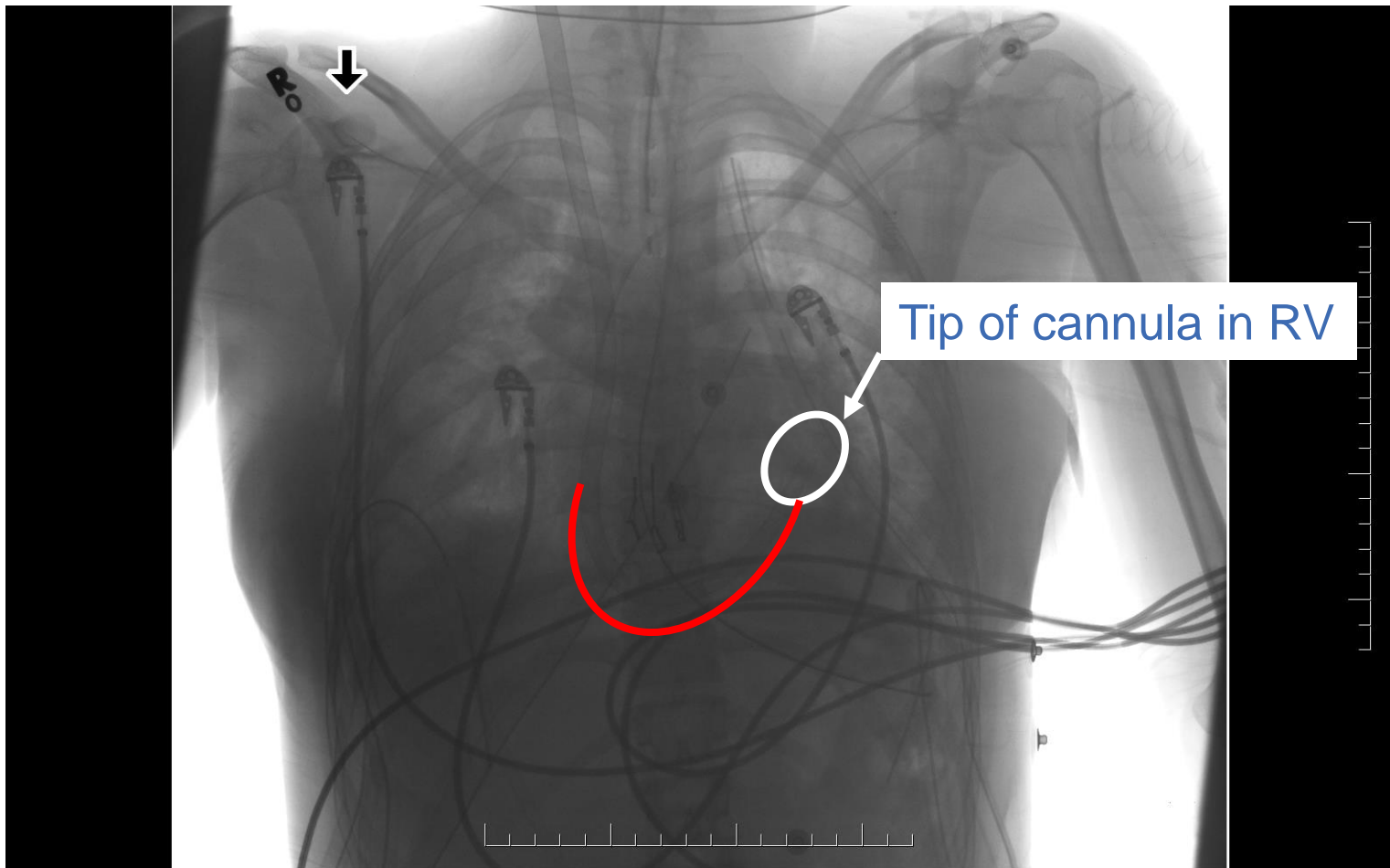


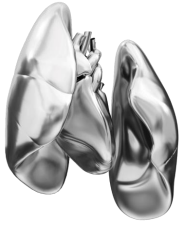
Hirose H et al. Right ventricular rupture and tamponade caused by malposition of the Avalon cannula for venovenous extracorporeal membrane oxygenation. J Cardiothorac Surg. 2012;7:36.



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Cardiac Injury

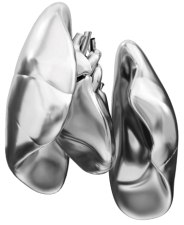




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Iliac Injury/Retroperitoneal Bleeding

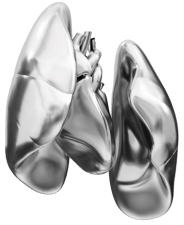




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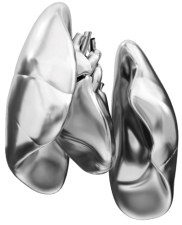
Limb Ischemia





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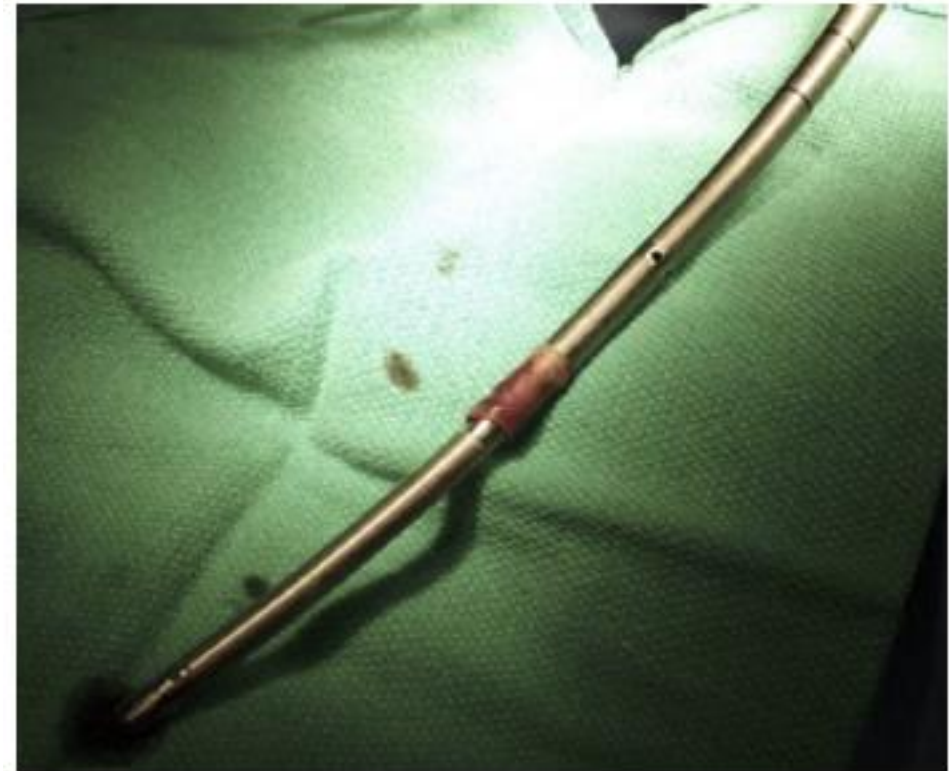


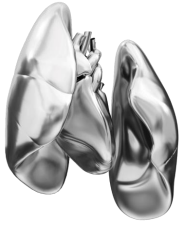
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Vascular Injury

Avulsion of Internal Jugular Vein

- ◎ 31Fr Avalon
- ◎ Dilated up to 22Fr
- ◎ Hemodynamic collapse during cannulation
- ◎ “Gentle force”
- ◎ TEE Guidance
- ◎ Patient stable, ready for decannulation 3 days later
- ◎ Resistance on pulling
- ◎ Open dissection of IJ
- ◎ Vessel repaired

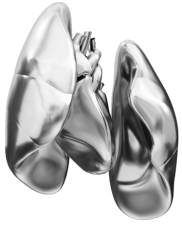




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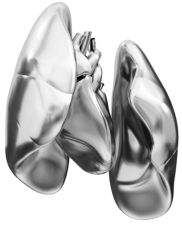
Others

- Airway Injury
- Materials Use
- Site Bleeding



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Avoiding Complications



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Ultrasound Guidance

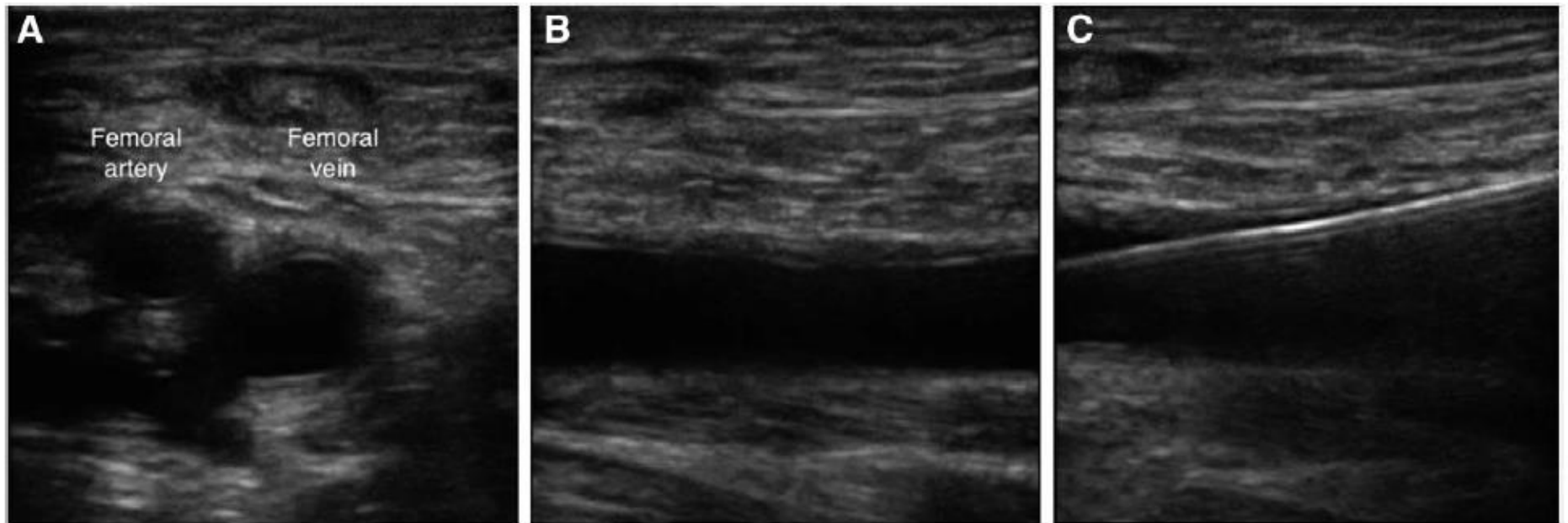
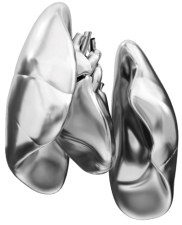


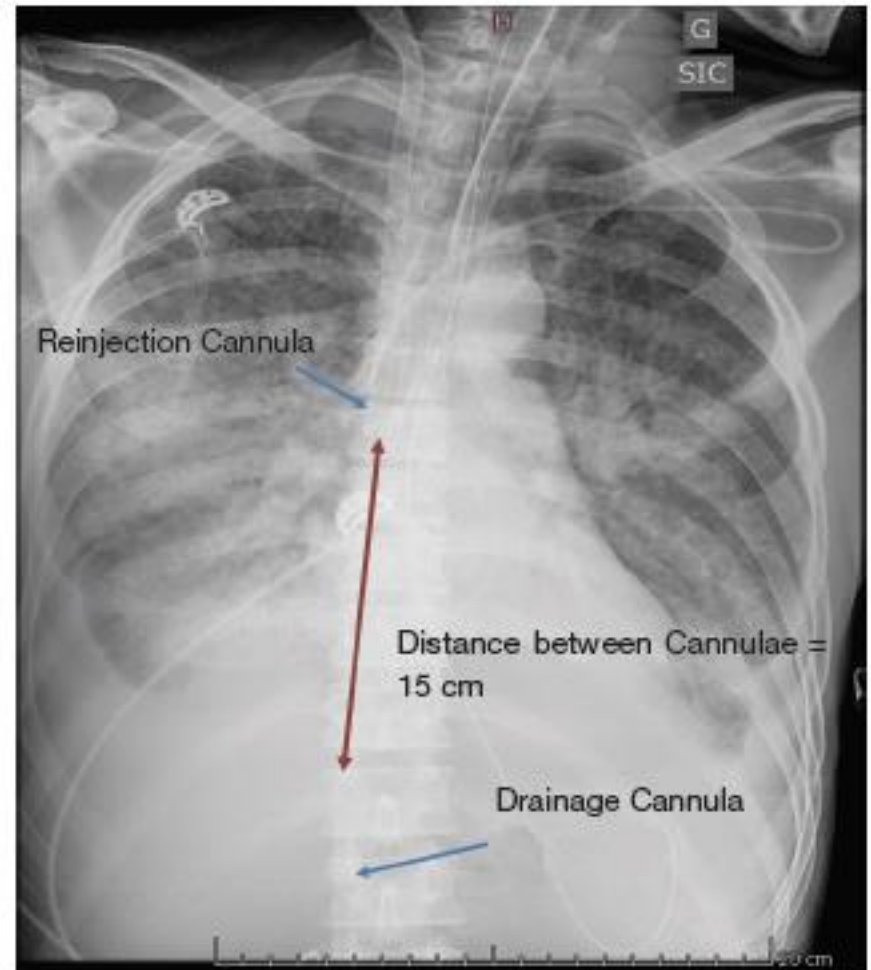
Figure 1. Ultrasound images of femoral vessels: (A) out-of-plane ultrasound of femoral vessels; (B) in-plane ultrasound of femoral vein; (C) in-plane ultrasound demonstrating guidewire within femoral vein.

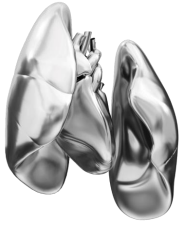


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Fluoroscopy Guidance

- ◎ Guidewire Placement
- ◎ Cannula Placement
- ◎ C-Arm





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TEE Guidance

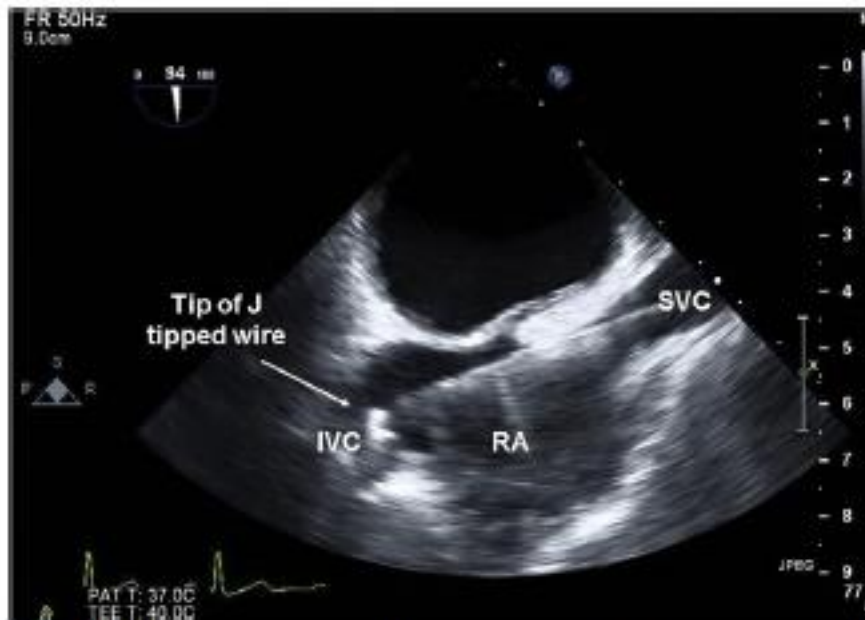


Figure 2 Midesophageal bicaval view showing termination of J-tipped wire in the IVC. RA, Right atrium; SVC, superior vena cava.

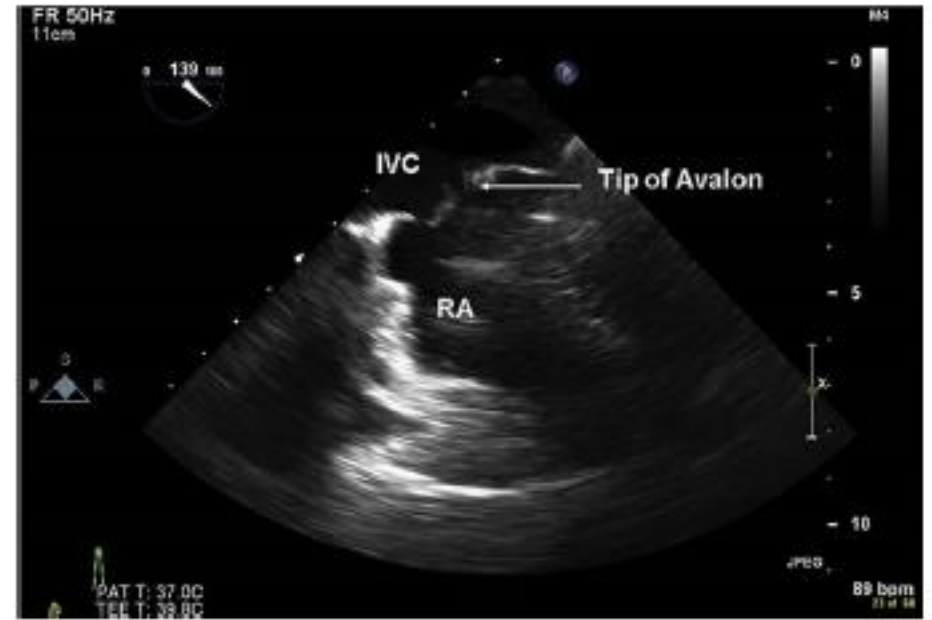
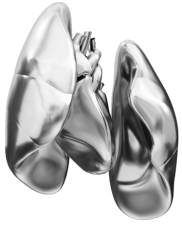


Figure 3 Midesophageal modified bicaval view demonstrating the tip of the Avalon catheter at the cavoatrial junction. RA, Right atrium.



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TEE Guidance

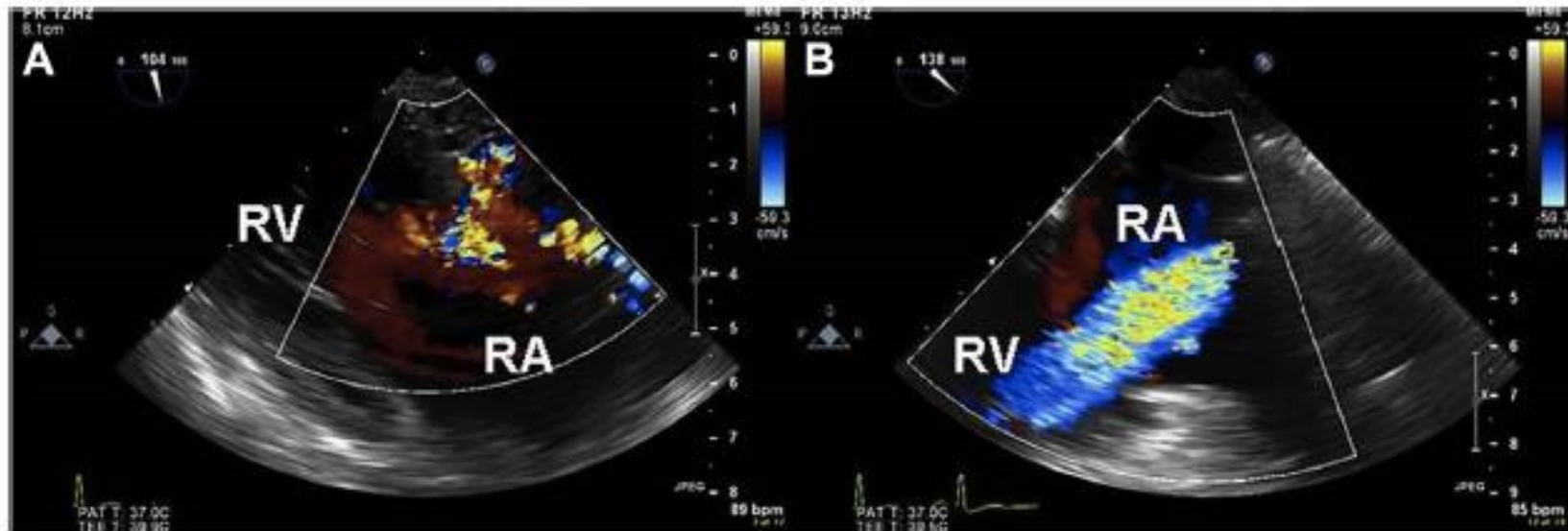


Figure 4 (A) Transgastric RV inflow (*left*) demonstrates turbulent outflow from the Avalon catheter, directed at the posterior leaflet. (B) After repositioning, the midesophageal modified bicaval view (*right*) best shows improvement of laminar flow directed through the tricuspid valve. RA, Right atrium; RV, right ventricle.

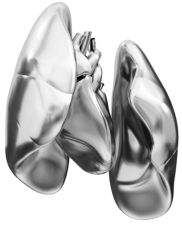


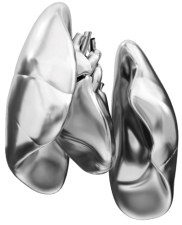
Image Guidance

- Use of ultrasound versus ultrasound and fluoroscopy
- Image all steps of cannulation
 - Wire insertion, dilation, cannula placement

Table 2 Outcome in out-of-hospital cardiac arrest patients who underwent extracorporeal cardiopulmonary resuscitation

| | Overall (n = 73) | Ultrasound- and fluoroscopy-guided cannulation (n = 23) | Ultrasound only-guided cannulation (n = 50) | p value |
|---|-------------------|---|---|---------|
| Complication associated with cannulation | 20 (27) | 2 (8.7) | 18 (36) | 0.022 |
| Bleeding | 6 (8.2) | 1 (4.3) | 5 (10) | 0.66 |
| Vascular injury | 3 (4.1) | 0 (0.0) | 3 (6.0) | 0.55 |
| Change to surgical approach | 4 (5.6) | 0 (0.0) | 4 (8.0) | 0.30 |
| Aberrant placement of cannula | 3 (4.1) | 0 (0.0) | 3 (6.0) | 0.55 |
| Hematoma | 15 (21) | 2 (8.7) | 13 (26) | 0.12 |
| Time from hospital arrival to ECMO start, minutes | 17.0 [13.0, 23.0] | 17.0 [14.0, 22.0] | 17.0 [13.0, 25.0] | 0.92 |
| Time from call to ECMO start, minutes | 46.0 [40.0, 55.0] | 45.0 [38.0, 51.0] | 46.0 [42.0, 56.0] | 0.23 |

ECMO extracorporeal membrane oxygenation. Continuous variables are given as median [interquartile range, from 25th to 75th percentiles]. Categorical variables are given as count (percent)



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Image Guidance

- Introducer can be 10-15cm longer than cannula
- Confirm **Cannula** placement with imaging

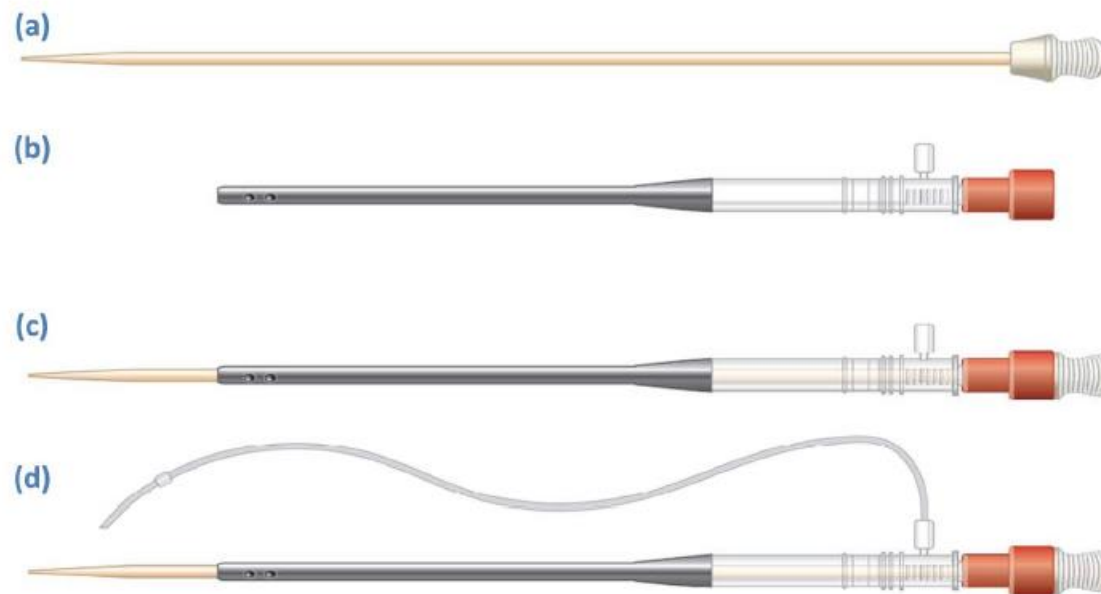
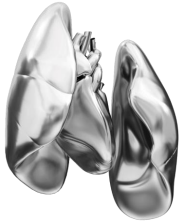


Figure 2. a) Introducer; b) Cannula with side holes, tapered end and side port; c) Assembled cannula for insertion; d) Cannula with Luer lock reperfusion arm.



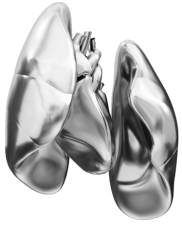
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Open versus Percutaneous

Table 2 ECLS characteristics

| ECLS characteristics | Total | Cut down | Percutaneous | p-Value |
|---|-----------|-----------|--------------|---------|
| No. (%) | 90 (100) | 39 (43) | 51 (57) | |
| Duration ± SD, d | 5.5 ± 2.6 | 5.1 ± 3.0 | 4.3 ± 2.1 | 0.06 |
| CPR implantation, No. (%) | 29 (32) | 12 (31) | 17 (33) | 0.82 |
| Postcardiotomy implantation, No. (%) | 53 (59) | 25 (64) | 28 (55) | 0.40 |
| Location of implantation | | | | |
| ICU | 22 (24) | 4 (10) | 18 (35) | <0.01 |
| Lab | 5 (6) | 2 (5) | 3 (6) | 1.00 |
| OR | 58 (64) | 33 (85) | 25 (49) | <0.01 |
| Trauma room | 1 (1) | 0 (0) | 1 (2) | 1.00 |
| Unknown (in referral center) | 4 (4) | 0 (0) | 4 (8) | 0.03 |
| Distal leg perfusion | 61 (68) | 25 (64) | 36 (71) | 0.36 |
| Distal leg ischemia, No. (%) | 10 (11) | 2 (5) | 8 (16) | 0.18 |
| With distal leg perfusion, No. (%) | 5 (6) | 1 (3) | 4 (8) | 0.38 |
| Surgical revision | | | | |
| Fasciotomy, No. (%) | 4 (4) | 1 (3) | 3 (6) | 0.63 |
| Revision of distal leg perfusion/vascular revision, No. (%) | 6 (7) | 1 (3) | 5 (10) | 0.23 |
| Amputation, No. (%) | 0 (0) | 0 (0) | 0 (0) | n/a |

Abbreviations: CPR, cardiopulmonary resuscitation; ECLS, extracorporeal live support; ICU, intensive care unit; n/a, not applicable; No., number; OR, operative room; SD, standard deviation.



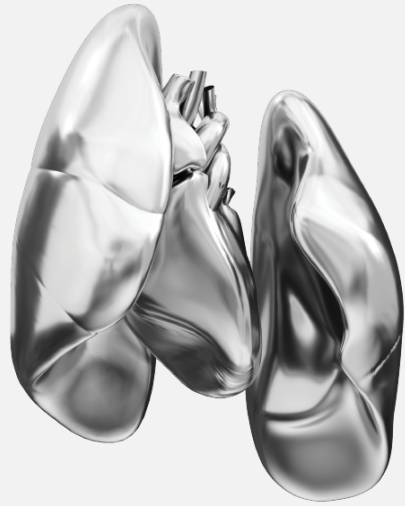
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Conclusions

- ◎ ECMO Cannulation problems can be catastrophic

- ◎ Mandatory steps
 - ◎ Ultrasound guidance for vessel identification and cannulation
 - ◎ Fluoroscopy/TEE for guidewire and cannula placement
 - ◎ Adequate securing of cannula

- ◎ Experienced team



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