I.R.C.C.S. POLICLINICO SAN DONATO

Sistema Sanitario Regione Lombardia

GRUPPO OSPEDALIERO SAN DONATO

ECMO PROGRAM IN 2015:

Bucharest 12/2015

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Clinical Researcher

IRCCS Policlinico San Donato

ECMO:
ExtraCorporeal Membrane Oxygenation definitions

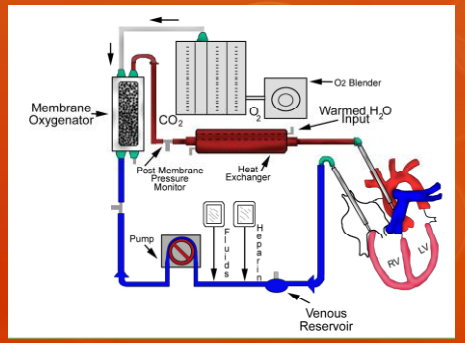
"Cardiopulmonary bypass circuit for temporary life support"

- for patients with potentially reversible cardiac and/or respiratory failure
- when no other form of treatment has been or is likely to be successful.

ECMO IS NOT A THERAPY:

IS A "BRIDGE" TO DECISION

- allows to "buy time"
  - for recovery from lung or cardiac disease
  - To optimize medical/surgical options



WHEN ECMO IS USEFULL?
Cardiac Indications

- **ACUTE/CHRONIC HEART FAILURE:**

Post-cardiotomy	•when unable to get pt off cardiopulmonary bypass following cardiac surgery
E-CPR	REFRACTARY CARDIAC ARREST Acute coronary syndrome with cardiogenic shock PULMONARY THROMBO-EMBOLYSM
heart transplant	Decompensated cardiomyopathy primary graft failure Host to donor immune rejection
Severe cardiac failure due to almost any other cause	•Myocarditis •Profound cardiac depression due to drug overdose or sepsis •Peri-partum cardiomyopathy

WHEN ECMO IS USEFULL?
Respiratory Indications

- **ACUTE/CHRONIC LUNG FAILURE**

NEONATES	•Persistent Pulmonary Hypertension •Meconium Aspiration Syndrome •Respiratory Distress Syndrome •Congenital Diaphragmatic Hernia (CHD)
PEDS and CHILDRENS	•Sepsis/pneumonia •ARDS in pneumonia post chemio Therapy •Chronic/acute lung failure in Cystic Fibrosys

ADULTS	•ARDS:
	  •Viral/bacterial Pneumonia
	  •Thoracic Trauma
	•Primary graft failure following lung transplantation.

AND WHEN IT IS NOT? Contraindications

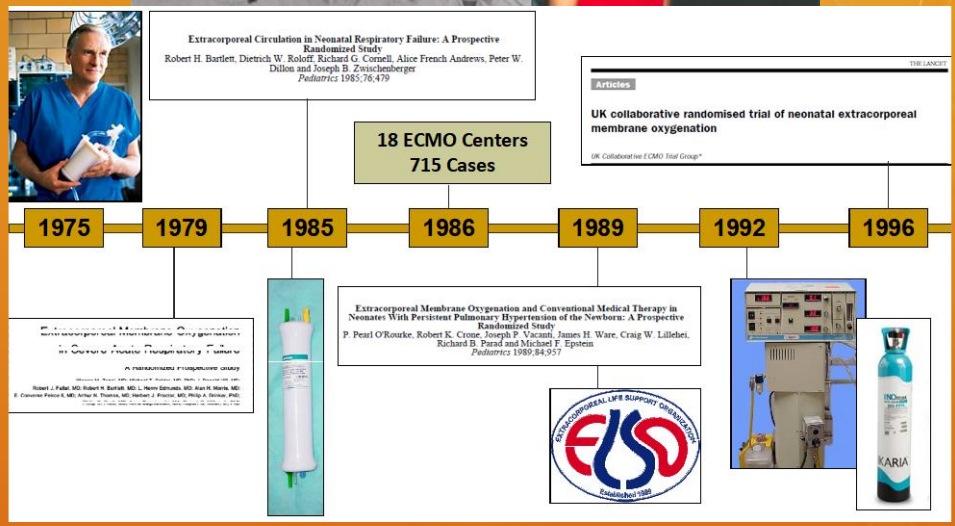
- considerations must be weighed before planning an ECMO implant:
  - ACUTE ORGAN (heart and/or lungs) FAILURE irreversible (A)
  - Chronic end stage organ failure (kidney, liver, metabolic syndrome) (A)
  - Lethal congenital anomalies (A)
  - Gestational age<34 weeks (R)
  - NO other option after ECMO (BRIDGE TO BRIDGE/TX)? (A)
  - PRE-ECMO clinical consideration:
    - Active (disseminated) malignancy (A)
    - Contraindications to anticoagulation therapies (A)
    - Known severe brain injury (Severe irreversible brain damage, Grade III or IV Intra Ventricular Hemorrhage) (A)
    - Graft vs. host disease (post organ transplantation) (A)
    - Unwitnessed cardiac arrest or cardiac arrest of prolonged duration without effective CPR (ET CO^2<18) (A)

AND WHEN IT IS NOT? Contraindications

- Technical contraindications
  - aortic disease (dissection, coartaction, severe vasculopathy) (A)
  - AOV regurgitation (blood "goes back" in to the left ventricle impairing heart recovery) (A)
  - Mechanical prosthetic valve (valve thrombosis, aortic root thrombosis despite aggressive anticoagulation therapy) (A/R)
  - weight in neonates less then 1.6 kg (vessels cannulation) (A)

- **Advanced age and palliated CHD questionable contraindication (R). Evaluation on:**
  - **QOL pre-acute events**
  - **Life expectancy**

ECMO: a story of fluctuating fortune…



- first used successfully for neonates with respiratory failure in 1975.
- In '70 mainly as respiratory support; most cases were neonates and peds.
- In mid '80 ECMO lost its appeal:

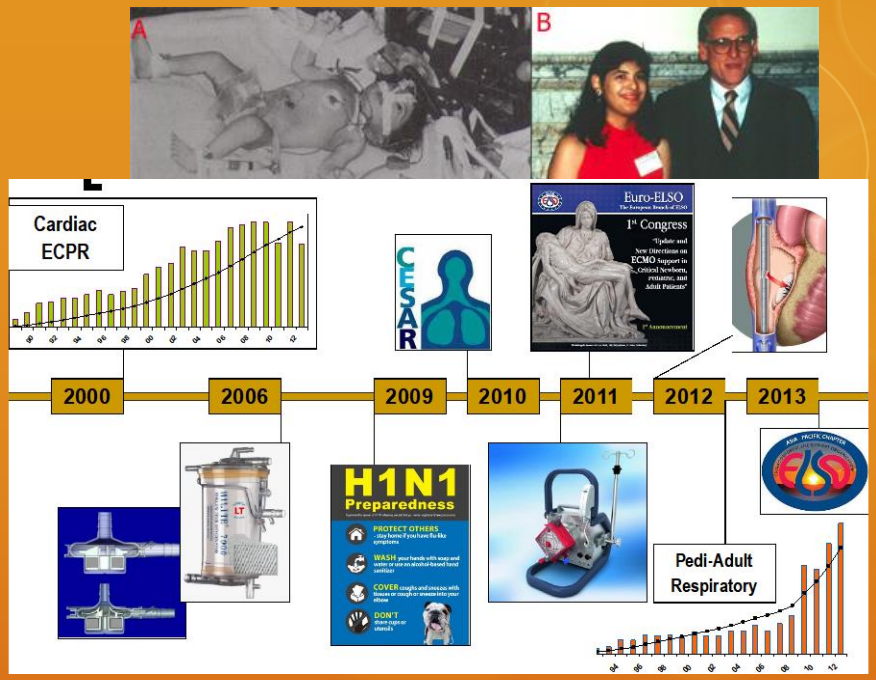
In cardiac-circulatory support because

- NO CLEAR INDICATION AND CONTRAINDICATION, NO CLEAR TIMING
- Mainly used in Transplant Center (difficulties in transportation) or exclusively as a bridge to recover end-stage Pts
- unsatisfactory survival rates in HF

In respiratory support because

- Conventional treatment in ARDS improved (HFOV, NO, new ventilatory setting)

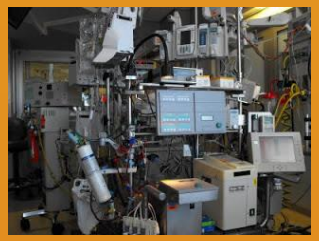
ECMO: a story of fluctuating fortune…



- In mid 2000 ECMO got a new lighting era, particularly as cardio-circulatory support in HEART FAILURE.
  - Pediatric and adult patients started to be successfully treated in increasing numbers.
  - In the US, have been estimated approximately 2800 newborns/Yr could benefit from ECMO (one of every 1309 live births).
  - 2009 "suine Flu": Healthcare systems provided this life-saving technology to some awarded Centers in treatment of respiratory disease.

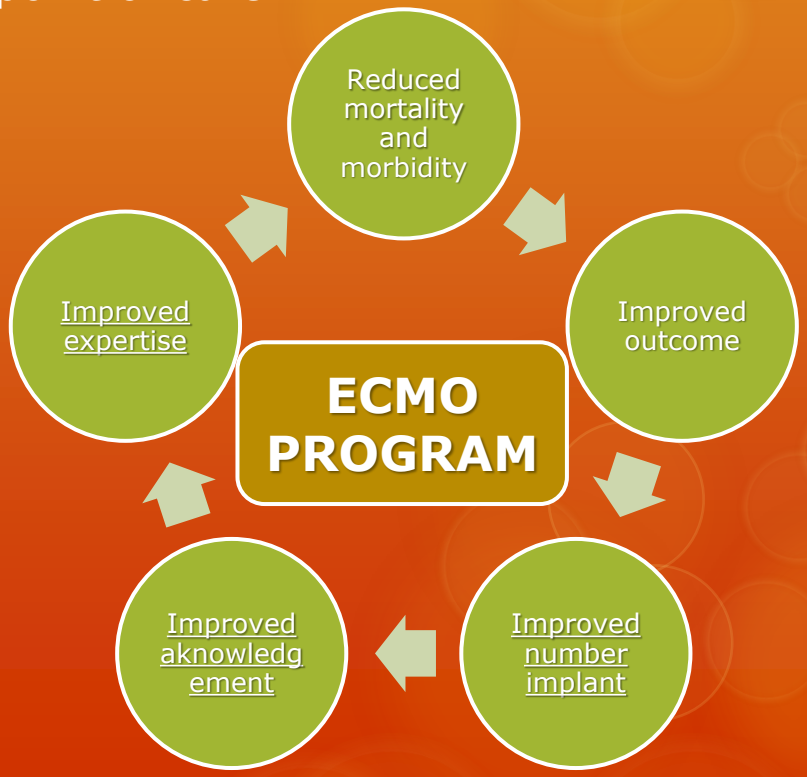
WHAT MOVE TO THIS NEW SCENARIO?

- **NEW DEVICES**



- **NEW PROTOCOLS**
  - Optimized timing, defined indications and contraindication,
  - Improve implant strategy
  - New coagulation management and point of care

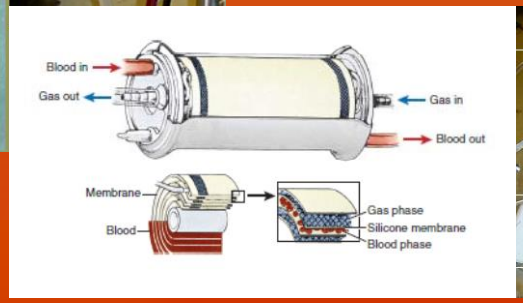
- **NEW TRAINING PROCESS**
  - **ECMO CENTER**
  - **ECMO UNIT**
  - **ECMO TEAM**
  - **ECMO SPECIALIST**



ECMO

NEW DEVICES

THE OLD'S ONES???

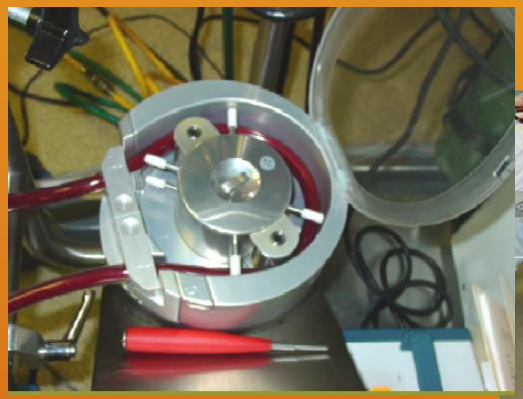


SILICONE MEMBRANE OXYGENATORS:

- High flow resistance (high shear stress and blood tissue damage)
  - Hemolysis
  - Coagulation disorders (PLTs depletion)
- external heat exchanger (high priming volume)
- Difficult to de-air (CO^2 insufflation to wash-out nitrogen)

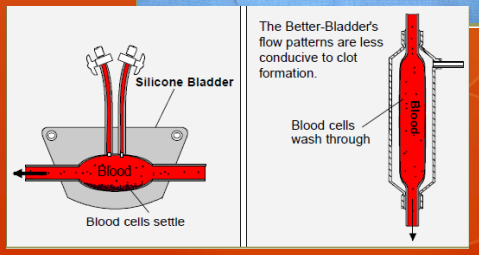
ANACHRONISTIC…OR NOT?

ROLLER PUMPS



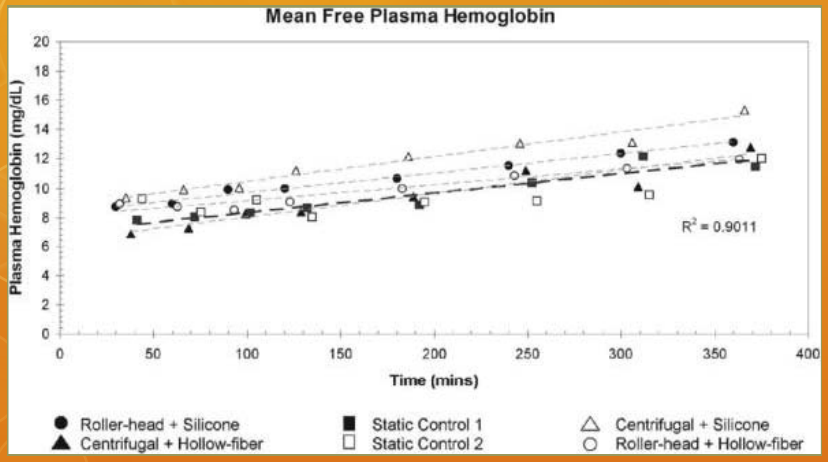
- Compression & displacement
- Inactive drainage
- Raceway durability
- Occlusion

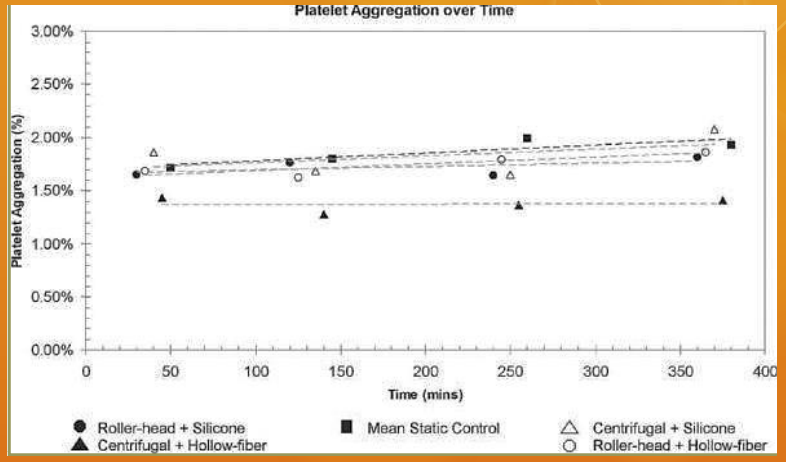
DREAINAGE RESERVOIR (BLADDER)



- Mechanical switch vs. pressure
- Communicates with pump
- Safeguard against cavitation

Nothing good, but…what's worst?





Centrifugal	Roller
Smaller circuit volume	Large circuit volume
No raceway	Raceway durability
More compact	Drainage reservoir needed
Active drainage	Hemolysis
Hemolysis	
Preload / Afterload sensitive	

- **Silicone oxygenator, rather than pump type, seems to be associated to**
  - **increased hemolytic damage**
  - **Induced platelet adhesion and aggregation**

Meyer, A. et al. Hemolytic and thrombocytopenic characteristics of extracorporeal membrane oxygenation systems at simulated flow rate for neonates. *Pediatr Crit Care* 2012;13,4: e255.

New devices

Artificial Organs

Pediatric and Neonatal Extracorporeal Life Support Technology Component Utilization: Are US Clinicians Implementing New Technology?

*Deborah Reed-Thurston, †Feng Qiu, †Akif Ündar, *Kim Kopenhaver Haidet, and *Jeffrey Shenberger

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- 125 US ECLS centers identified by ELSO in November 2010.
  - 42% of 95 respondent changed their oxygenator of choice in the past 3 years,
  - 30% both the oxygenator and pump.
  - 46% of respondents cited "clinical preference/experience" as primary reason.
  - others "FDA approval" or "research results."
- Unclear whether these changes were made by clinical evidence of patient benefit or simply due to current trends.

New devices

Technology provides new generation ECMO Systems:

- customized and pre-assembled
- Easy to set and prime
- High performance gas ex-change
- Optimized fluido-dynamics profile
  - Low emolitic pump (centrifugal devices, MAGLEV or ceramic single bearing technology)
  - Low trans-membrane gradient oxygenators

- Smaller and lighter (mobile devices with AMBULANCE and AVIO-TRANSPORTATION CERTIFICATION)

- Up to 30 days certification (upon Company policy)

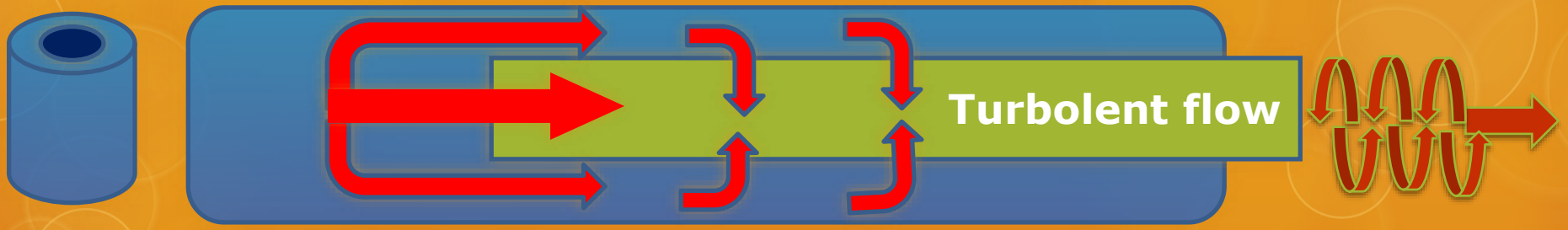
New ECMO system: what is made of?

- **HARDWARE all-in-one**
  - Console-pump drive
  - Heat-exchanger
  - Gas line
  - On-line parameters (perfusion and ventilation adequacy)

- **DISPOSABLE all-in-one**
  - Pumps
    - **centrifugal**
  - Oxygenators
    - **PMP**
  - Tubes
    - **coated**
  - Cannulas
    - Hi-flow, small size

Cannula: chose the right size…

Size matters...



Poisseulle's Law

$$\text{Flow } \alpha \quad \frac{\text{Radius}^4 \times \text{Pressure}}{\text{Length}}$$

In other words **short** and **fat** is best

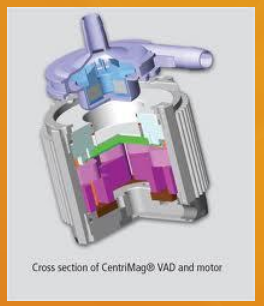
...but wall thickness too!!!

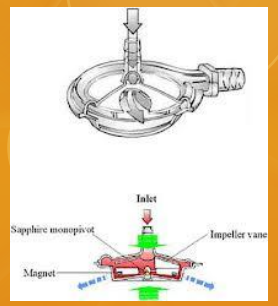
Cannula Design

- Integrated connectors
- Side holes
  - Number
  - Size
  - Configuration
  - VA vrs VV
- Coating
- certification

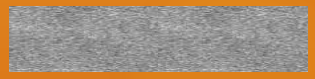
Mandatory feature in ECMO equipement:

- LOW shear stress/HI washout Centrifugal pump
  - Magnetical Levitation
  - Single ceramic/rubin bearing
  - Low hemolytic rate, low thrombogenicity

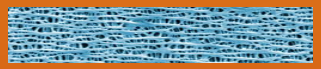




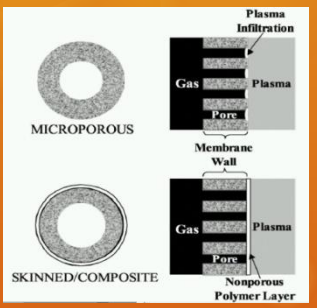
- poly-4-methyl-1-pentene diffusion plasma-tight membrane
  - Same advantages as the hollow-fiber design
  - thin nonporous polymer layer protecting the polymethylpentene fibers.



Polymethylpentene
"plasma-tight" fiber



Polypropilene
"standard" fiber



- (2-ethylhexyl) phthalate (DEHP) free.
  - added to PVC tubing providing durability or flexibility;
  - The US FDA and Health Canada recommend limiting DEHP exposure in patient populations such as the male prepubescent and neonate (**INCREASED RISK OF HORMONAL DISORDERS**)

- Heparin-bonded (Bioline) or bio-mimetic (phosporilcoline, PHISIO) TIP TO TIP coating
  - Reduced hemostatic disorders intrinsic pathway dependent
  - Inhibits platelets adhesion/aggregation
  - Reduce SIRS

ECMO TRANSPORTATION: THE «HUB&SPOKE» PROGRAMM

New ECMO system allows transportation

- In-hospital (Cath lab, CT-scan,…)
- Inter-hospital
  - SPOKE to HUB
  - HUB to HUB (VAD/transplantation)

TRANSPORTATION PROGRAM:

- Small, light hand devices
- Certified for avio-transportation
- Long term internal accumulators

ECMO

NEW PROTOCOLS

IMPLANT STRATEGY AND CANNULATION principles

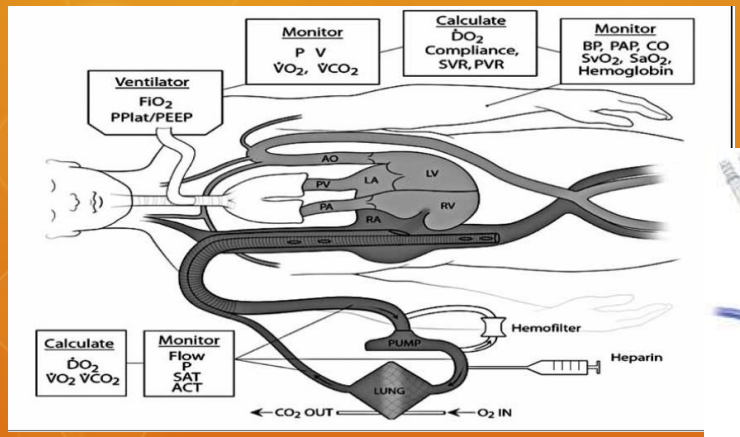
- Depending on the purpose, ECMO can be initiated in a "Veno-Venous" or a "Veno-Arterial" mode:
  - **Veno-venous:** RESPIRATORY ECMO SUPPORT
  - **Veno-arterial:** CIRCULATORY ECMO SUPPORT and RESPIRATORY ECMO SUPPORT

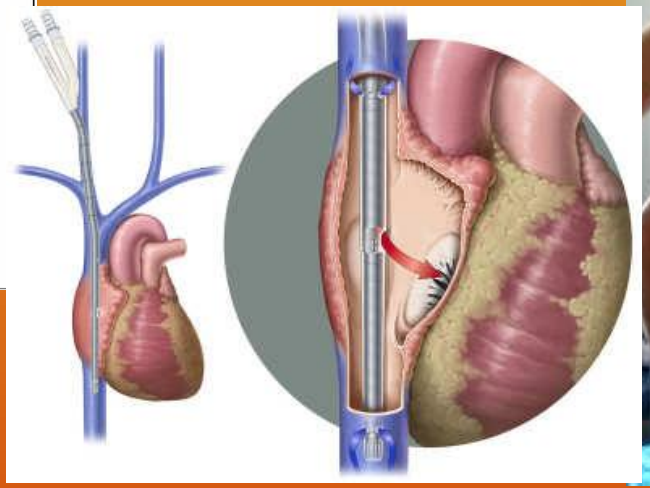
- Depending on the cannulation site, ECMO can be initiated in a CENTRAL or a PERHIPERAL fashion

- According to ongoing clinical modification, ECMO can
  - be converted eachother
  - upgrade to new ***"hybrid configuration"***

Mode	Drainage	Reinfusion
VA	Venous	Arterial
VVA	Venous-Venous	Arterial
VV	Venous	Venous
VVV	Venous-Venous	Venous
VVDL	Venous-Venous Dual-lumen	
Bi-caval	Venous-Venous Dual-lumen Bi-Caval	

- **Veno-Venous (VV)** configuration is namely a **respiratory support:**
  - Provides oxygenation and CO2 removal
  - NO CIRCULATORY SUPPORT





- Blood being drained from venous system and returned to venous system.
- Achieved by peripheral cannulation
  - Fem-Fem
  - Fem-Jug
  - J-J via double lumen cannula

V-V ECMO

ADVANTAGES

- Eliminates potential for ischemic lung injury
- No manipulation or ligation of carotid artery in neonates/pediatrics
- Preserves cardiac pulsatility
- Emboli will travel to pulmonary rather than central or cerebral circulation
- Possible decreased risk of cerebral reperfusion injury

DISADVANTAGES

- No circulatory support
- Maximum oxygen delivery may not be adequate for demand
- Recirculation
- Flow dependent on venous drainage

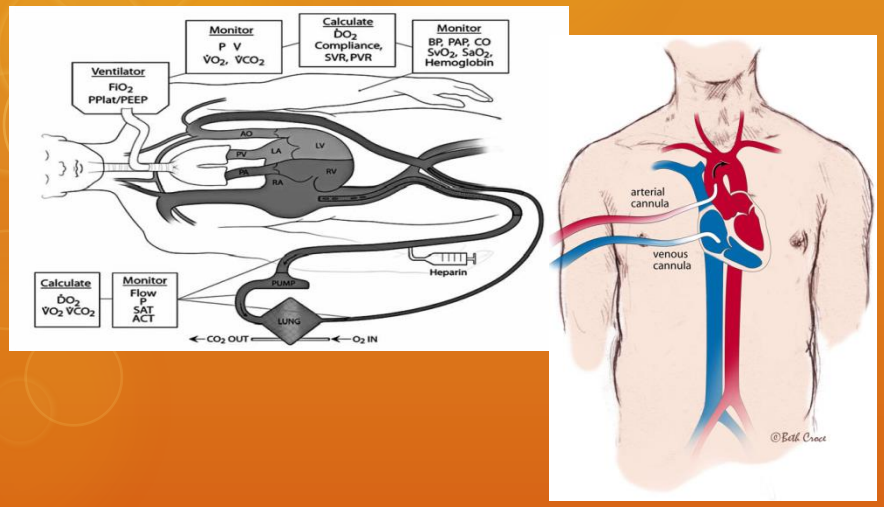
V-V ECMO: RECIRCULATION

- Blood coming from ECMO is drained back to ECMO before been returned to patient
  - Average 30% recirculation with V-V ECMO
  - SaO^2 low as 80-85%

- Clinical signs:
  - decrease in arterial saturation
  - increase pre-membrane saturation

- Factors that increase recirculation:
  - Small distance between drainage and return cannula
  - Axial rotation in DLC ("Coanda effects")
  - Excessive suction in hypovolemic patient
  - Increased cardiac output (INCREASED FLOW "ESCAPING" to the lungs)

- Veno-arterial (VA) configuration could be either a **respiratory as a cardio-circulatory support**



- Blood being drained from the venous system and returned to the arterial system.
- Achieved by either peripheral or central cannulation
  - RA-Ao
  - Fem V-Fem A/Axil A (distal limb perfusion)
  - Jug V-Carot A (in neonates up to 5kg)
- Left cavity vented to improve recovery

V-A ECMO

ADVANTAGES

- Full cardiopulmonary support
- Myocardial rest by unloading the left ventricle
- Improve systolic and diastolic pressure
- Improve end organ and coronary perfusion

DISADVANTAGES

- Myocardial stun
- Lose cardiac pulsatility
- Increased afterload→ LV failure→ increased LA pressure→ pulmonary edema
- Atrial septostomy to off-load the left heart

KEEP IT IN MIND…

CANNULATION SITE: WHICH ONES ARE AVAILABLE?

- Echo/ultrasound pre-cannulation
- Cath lab investigation

V-V or V-A ECMO

CENTRAL ECMO

PERIPHERIC ECMO

- Neck
- Groin
- Subclavian
- Axillary

CONSIDER ANATOMICAL VARIATION:

- Cavo pulmonary connections (V-V)
- Left superior vein cava
- Bovine brachicephalic arterial trunk (V-A)
- HYPOPLASTIC AORTIC ARCH

HOW TO SITE CANNULAS

CENTRAL

- **Generally V-A ECMO**
- **Surgical, open technique**

PHERIPHERAL

- **Percutaneous (Seldinger technique)**
  - **IV catheters first, verify position**
  - **Largest possible cannula, over heavy wire**
- **Semi-Seldinger**
  - **Expose vessel, place wire under direct vision (for infant double lumen)**
- **Cut down**
  - **Direct exposure, distal ligation, cannulation, distal perfusion or collaterals**

CANNULATION SITE

- CENTRAL CANNULATION
  - No cannula sizing problems
  - Antegrade arterial flow
    - RIGHT ATRIUM
    - ASCENDING AORTA
      - Direct for very short term
      - Side vascular graft
    - LEFT ATRIUM/VENTRICLE
      - Left side unloading

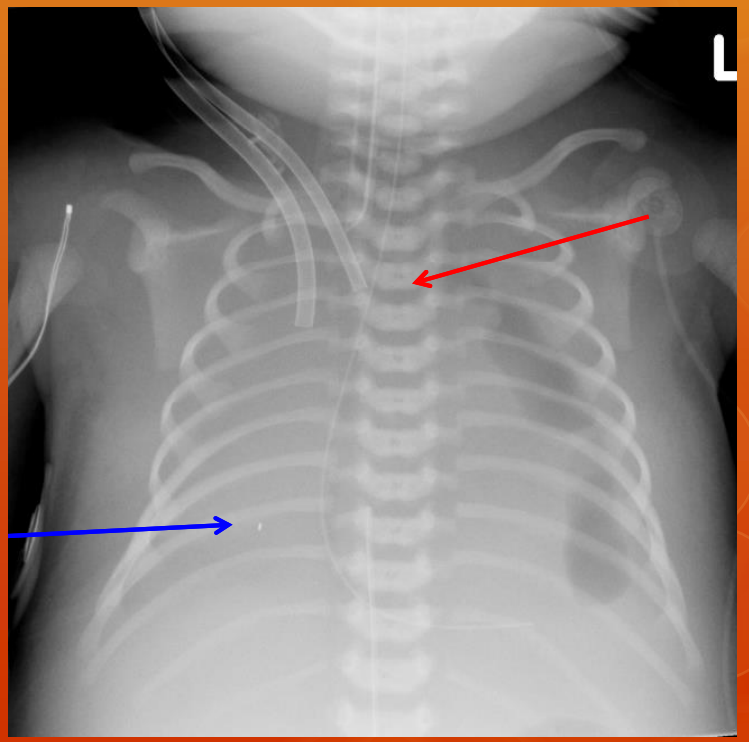
- Main complications
  - BLEEDING
  - INFECTION

V-A ECMO: is it in the right place?

Echo confirmation

Chest X-ray confirmation

- Arterial cannula should be in aortic arch/RCCA junction
- Venous cannula in right atrium



(if possible) KEEP THE THE CHEST CLOSE…

- **TRANSTHORACIC APPROACH**
  - Usually after cardiac surgery
  - Full ECMO support
  - Dedicated cannulas
  - Re-sternotomy to remove cannulas

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Work in progress report - Assisted circulation

Implantation technique of the CentriMag biventricular assist device allowing ambulatory rehabilitation

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Abstract

Non-implantable ventricular assist device plays a major role in emergent or urgent situation where a patient has acutely decompensating hemodynamics. One of its major disadvantages is that the patient needs to be bed-bound after insertion. We have developed a surgical technique that allows ambulatory management of the patients who received non-implantable device with CentriMag.

Keywords: Ventricular assist device; CentriMag; Rehabilitation

- **ADVANTAGES**
  - LESS BLEEDING:
    - Less surgical trauma
    - Less Tissue Factor pathway
    - Less Fybrinolitic response
  - LESS INFECTION RATE
  - ADVANCED REHABILITATION
    - Weaning from mechanical ventilation
    - Feeding
    - Rehabilitation

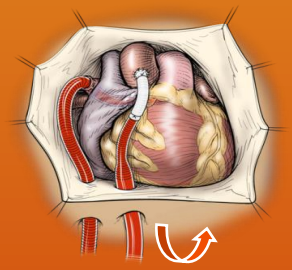


Fig. 1. A patient ambulating with CentriMag BiVAD. BiVAD, biventricular assist device.

PERIPHERAL CANNULATION

- **WIDELY USED (now)**
- Ideal for
  - short term support
  - Emergency (neck, femoral vessel)
- **ADVANTAGES:**
  - Percutaneous approach with Seldinger technique (adults): RAPID TIME
  - Awake/Spontaneous breathing patients
  - No need to open/re-open the chest
  - Easy transportation

Small size cannula

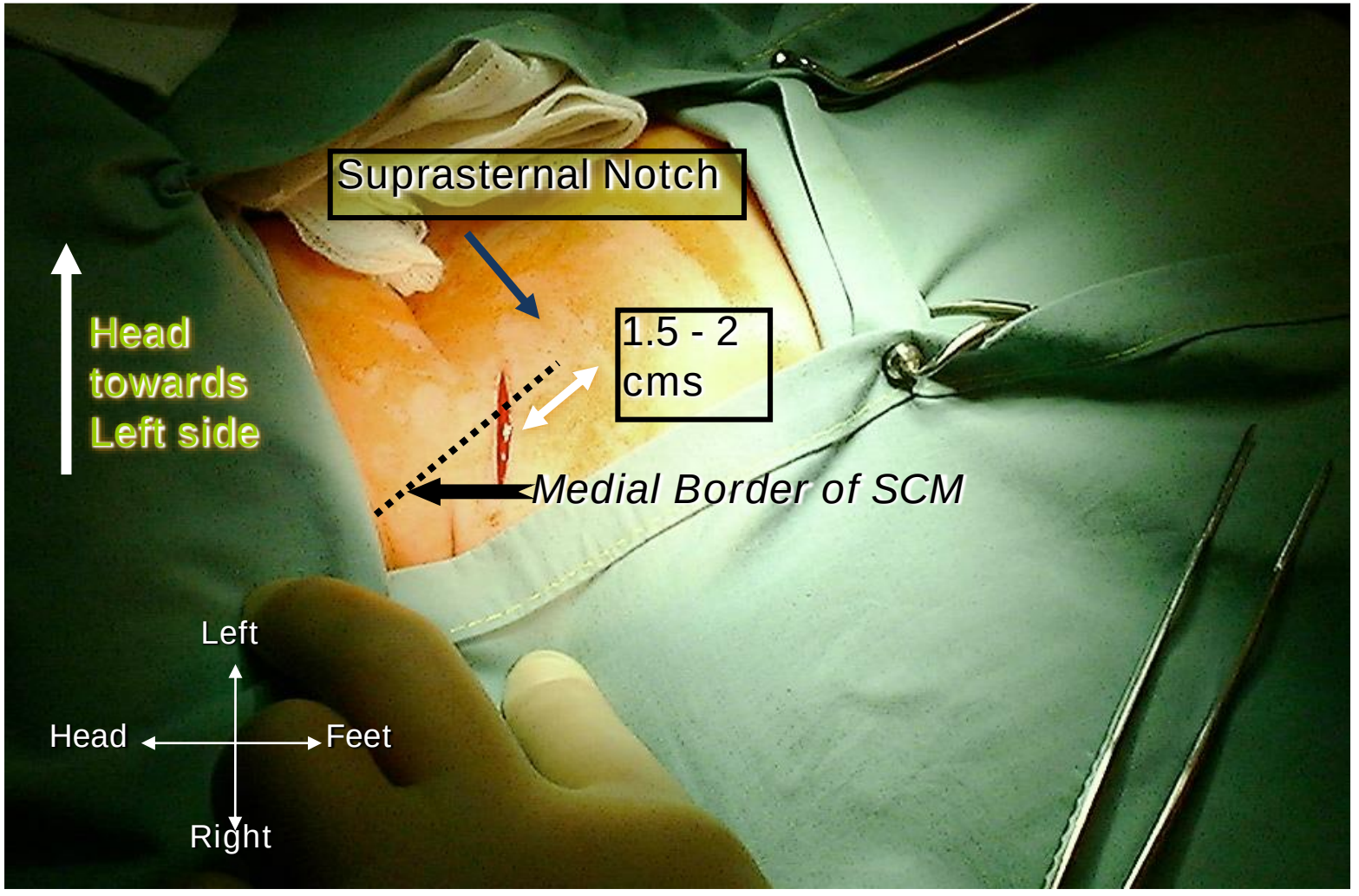
- Jugular vein (15 F)
- Femoral vein (19-21 F)

- Femoral artery (15-17 F)
- Carotid artery (newborns)
- Axillary artery

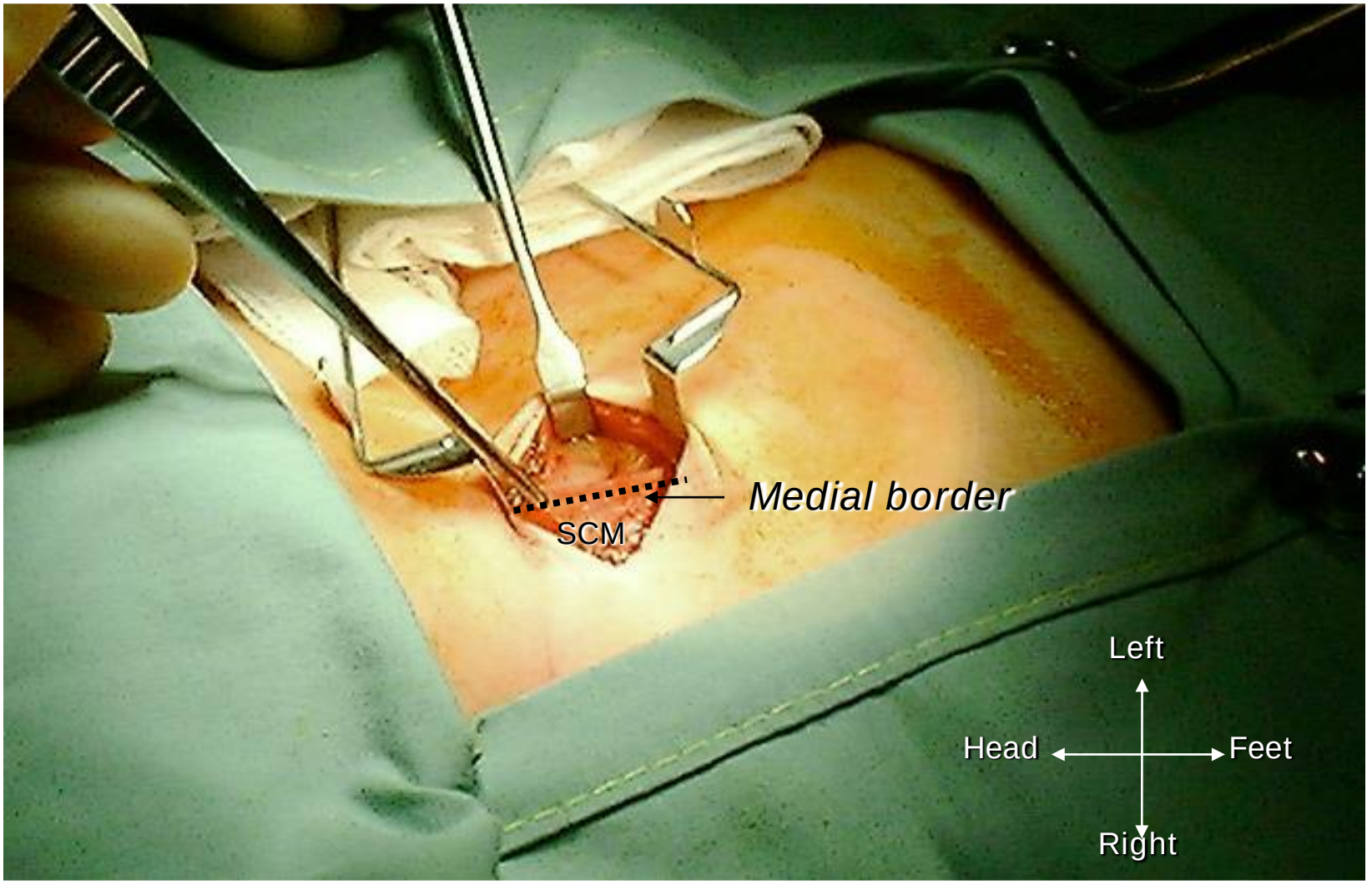
Pediatric VA Cannulation

- R IJ and R carotid artery in children < 10-15kg
- Stroke rate increased in pediatric population with carotid artery cannulation
- Femoral artery and R internal jugular vein for children >15kg
- Reperfusion cannula in lower extremity to prevent ischemia
- Femoral artery & vein + R IJ reinfusion (VA-V) if cerebral hypoxia
- Central cannulation

Neck Incision



Exposure



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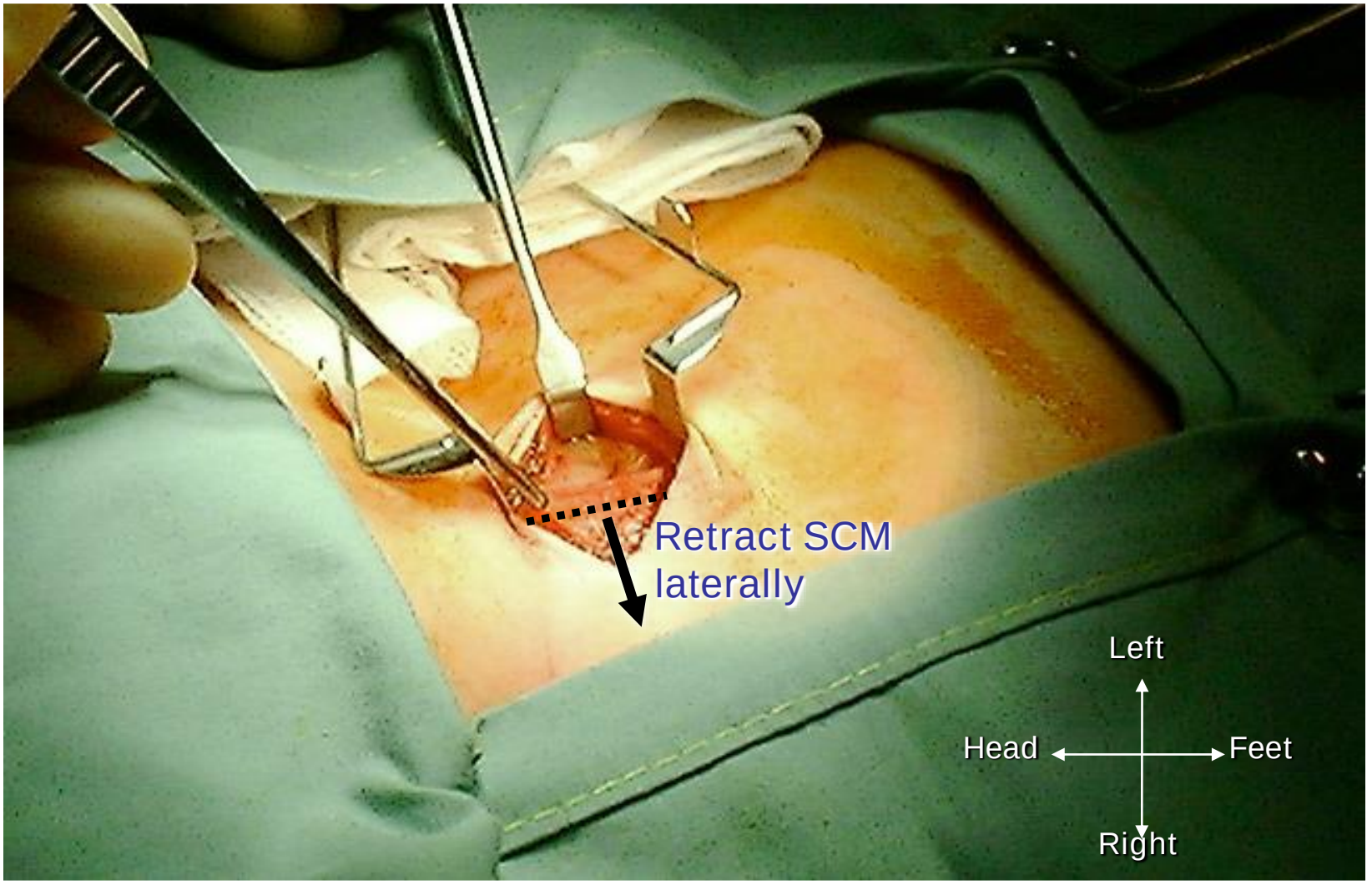
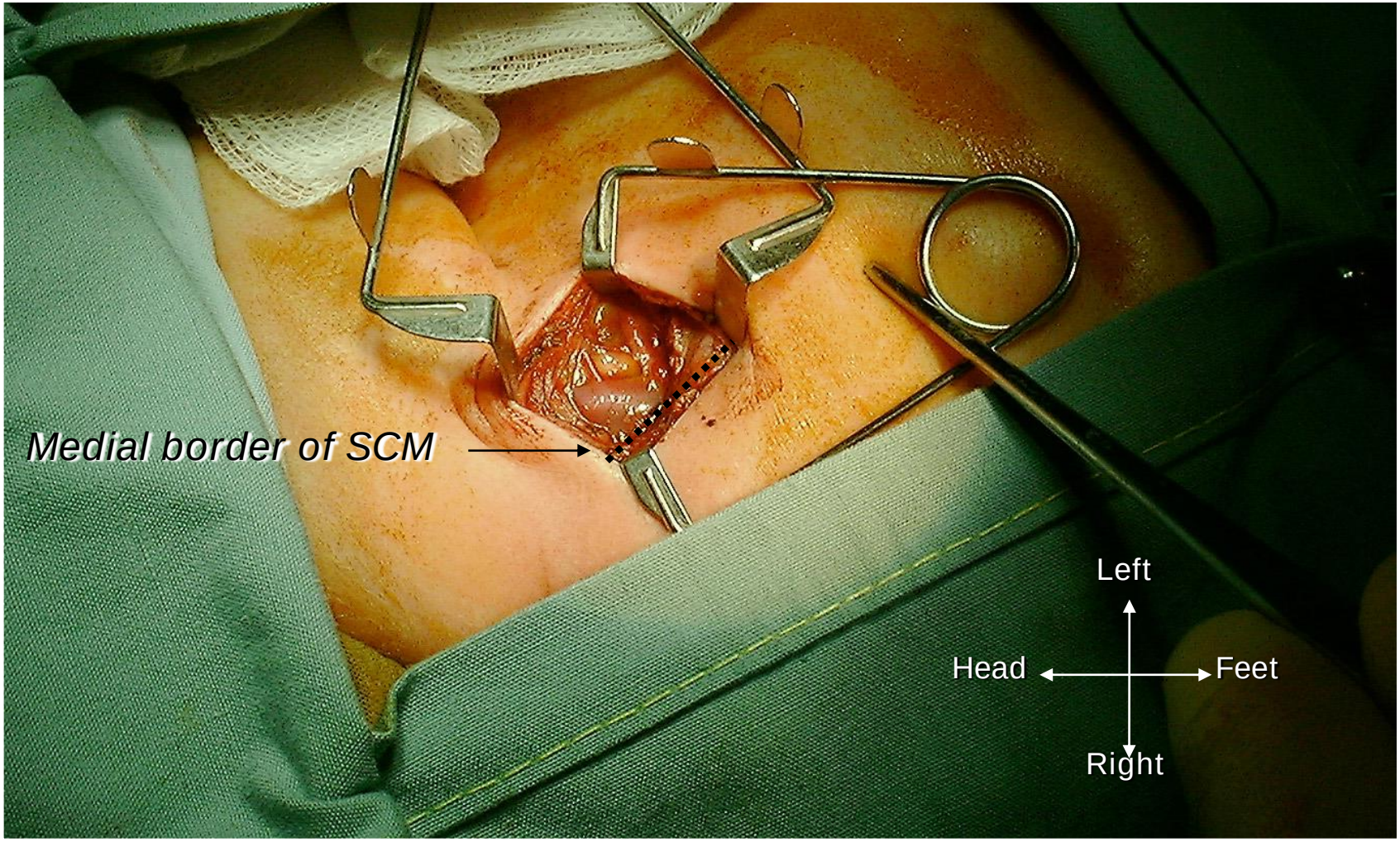
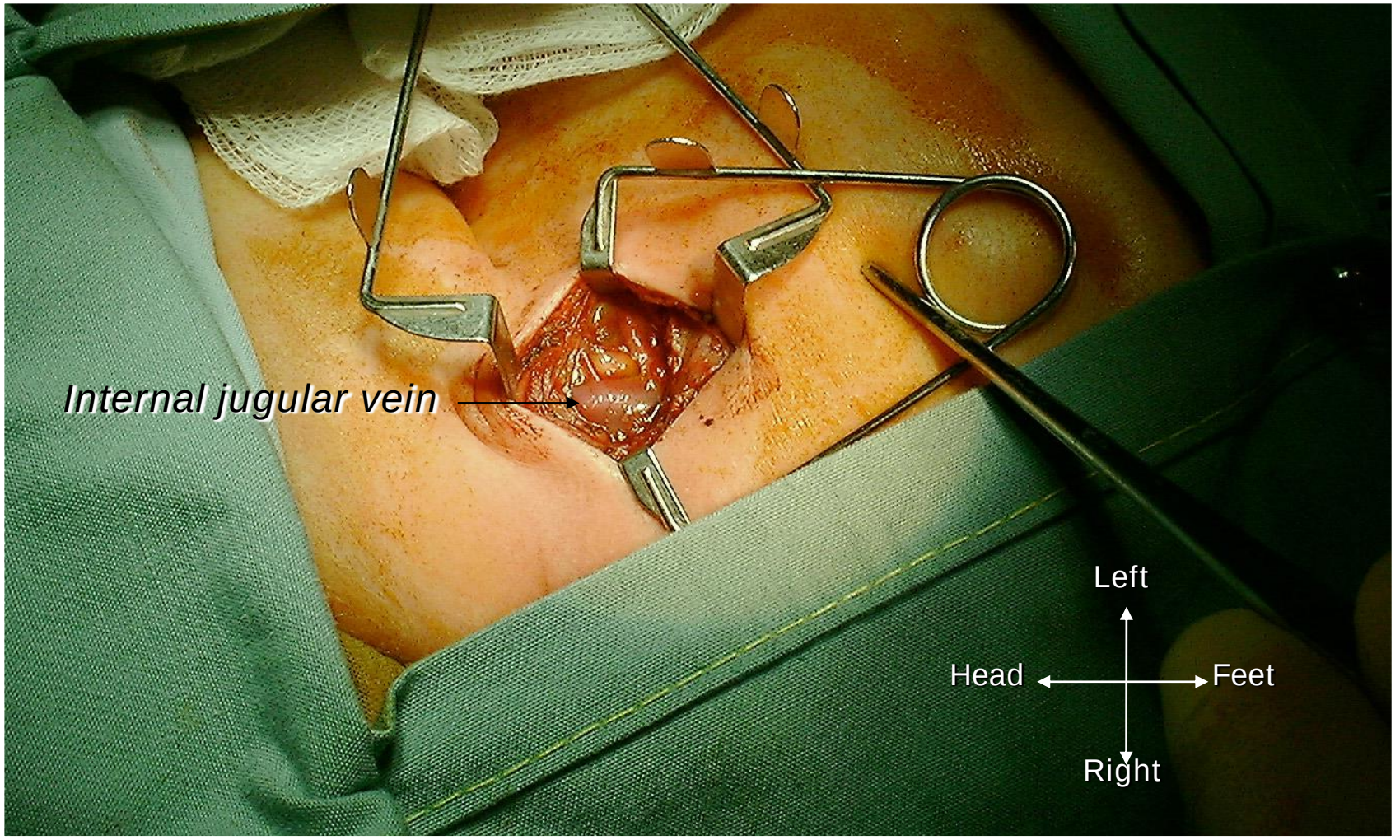


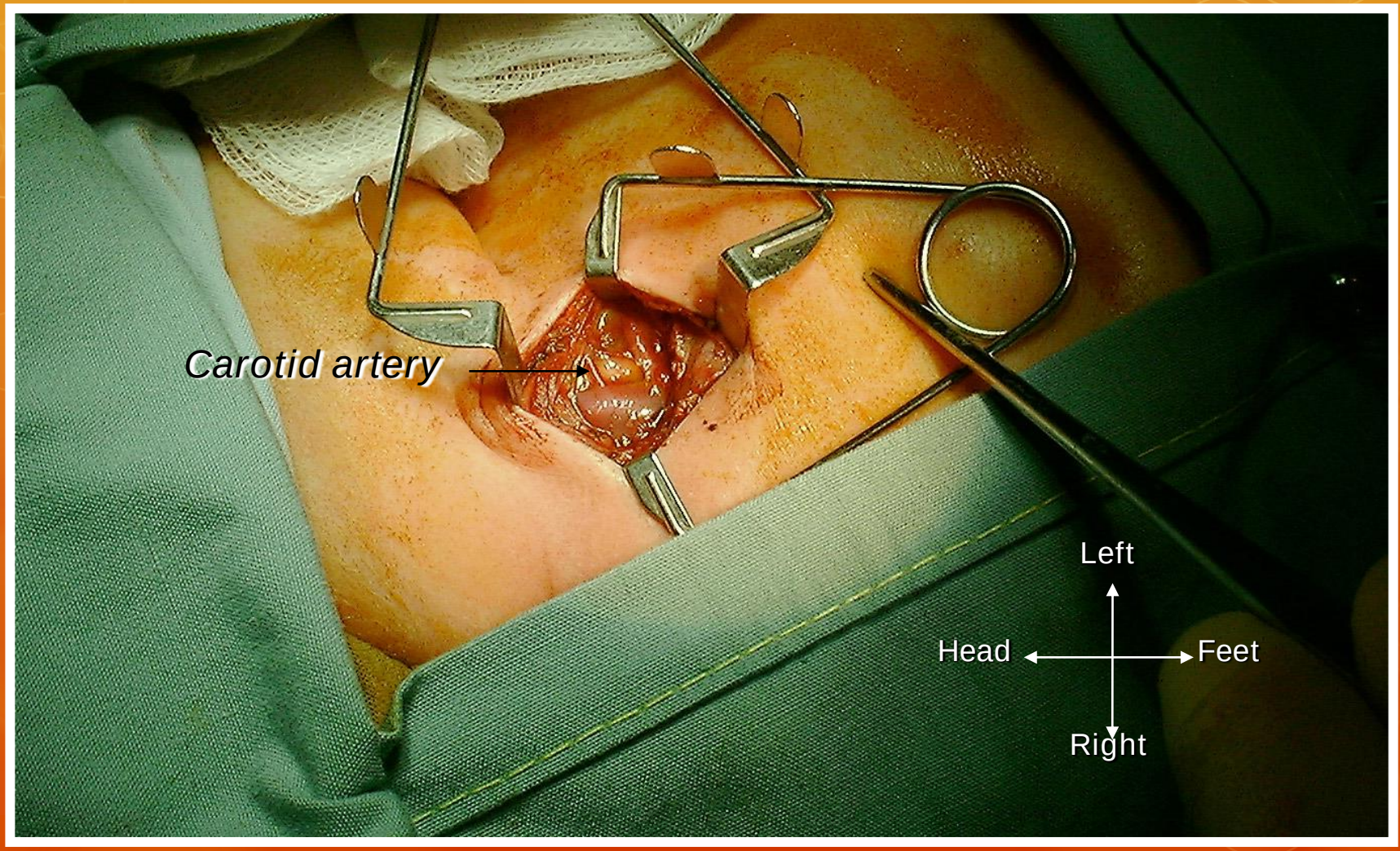
Carotid Sheath



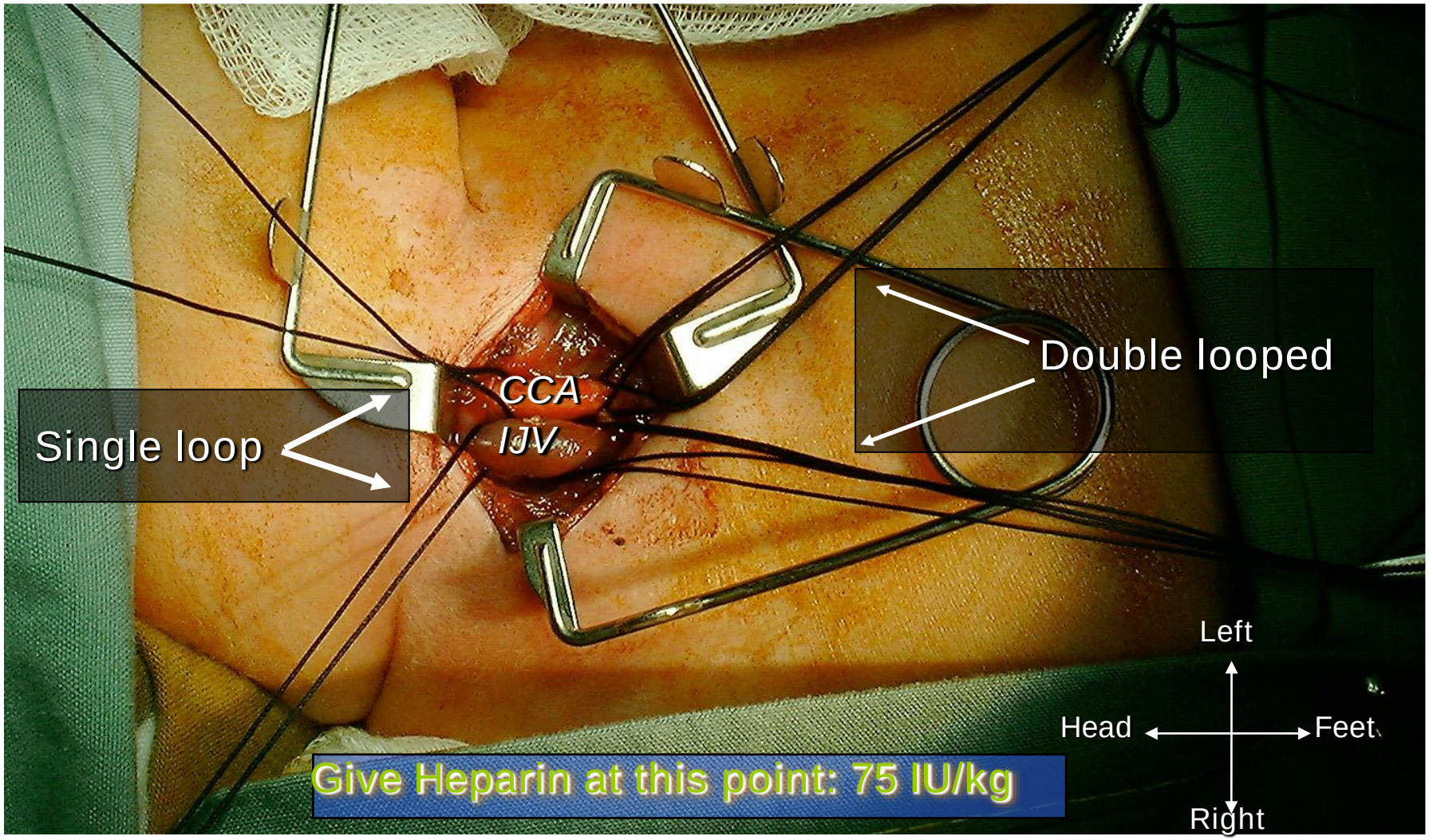
Carotid Sheath



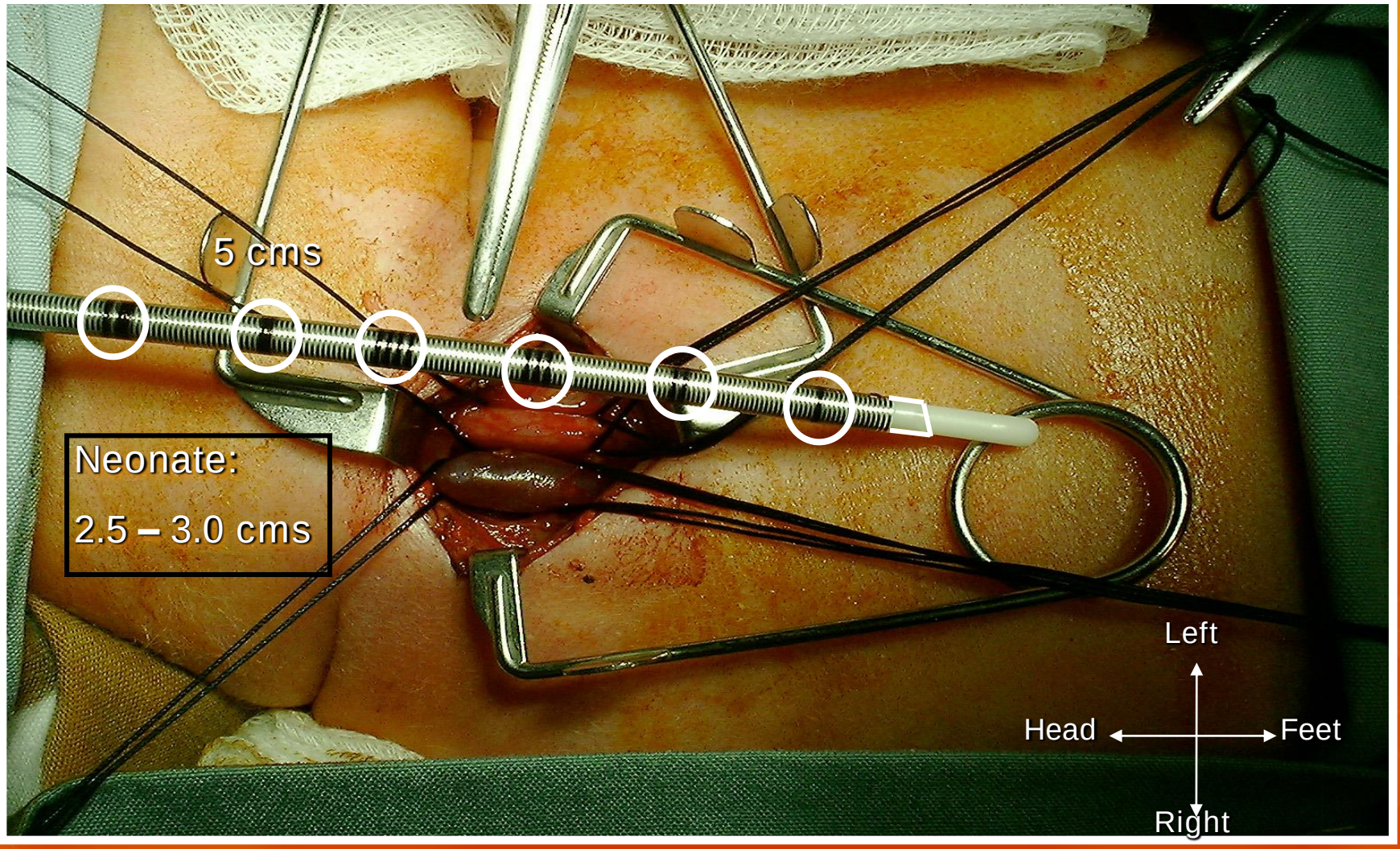
Carotid Sheath



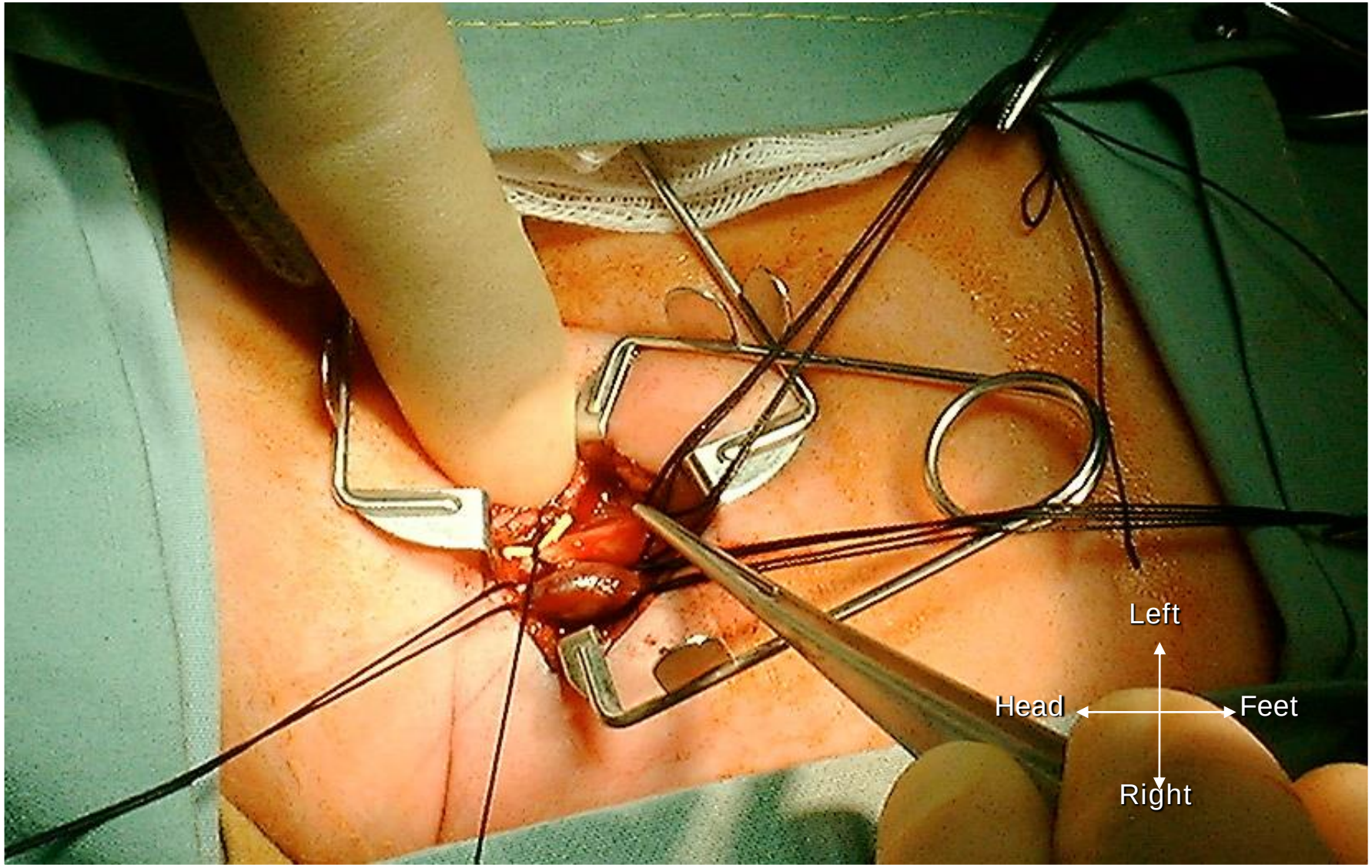
Encircling of the Vessels



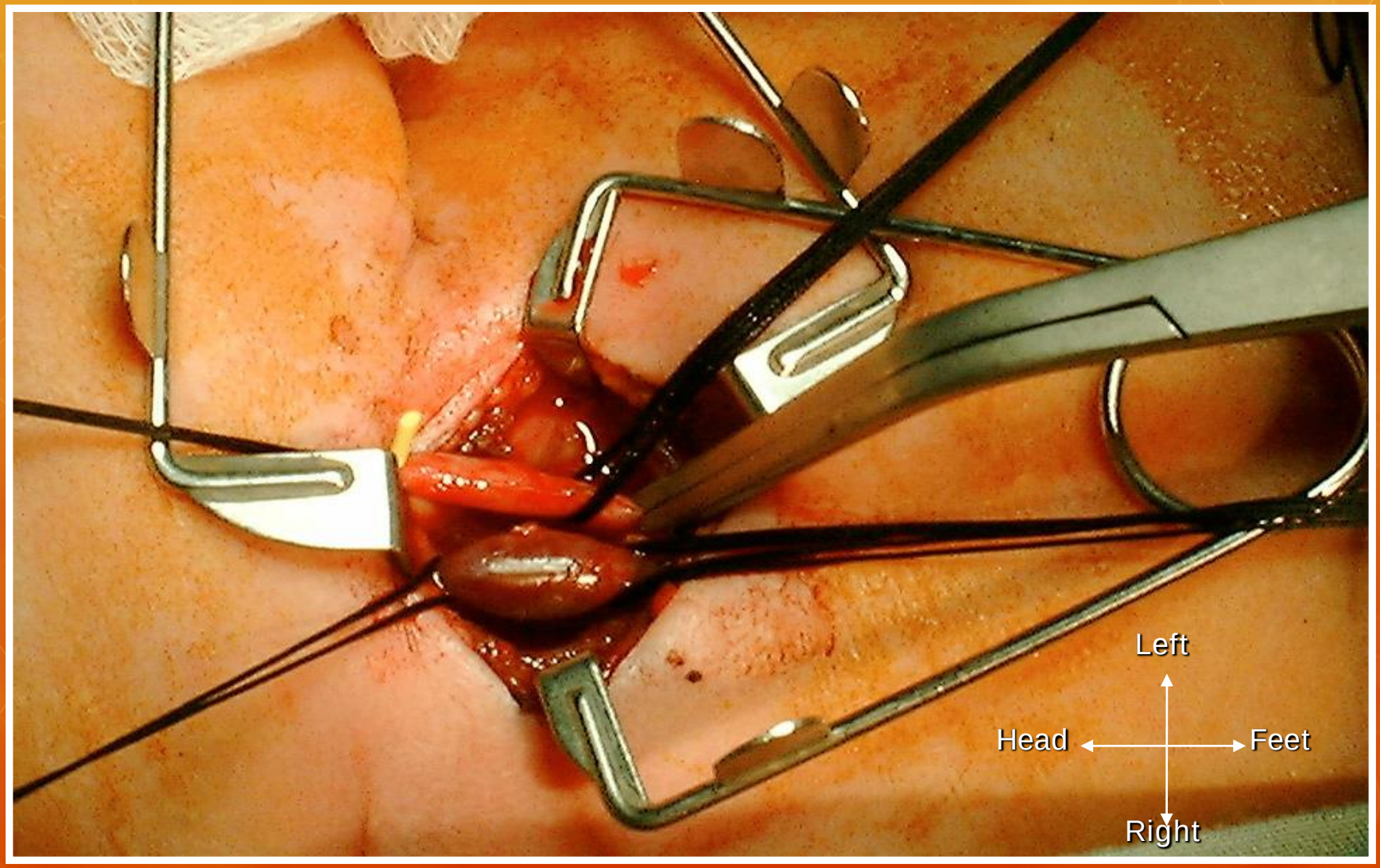
Arterial Cannula Sizing



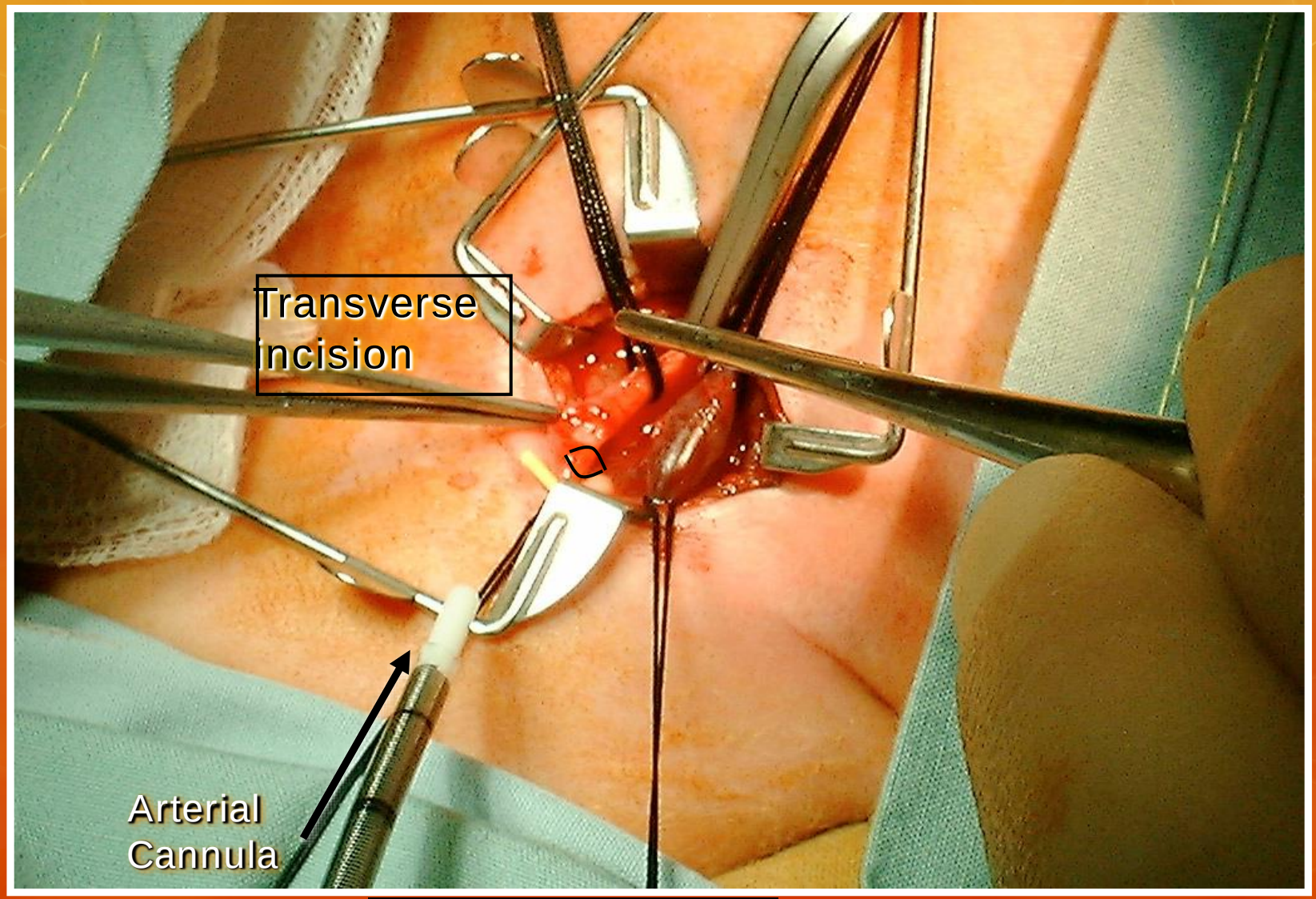
Distal Ligation of the Carotid



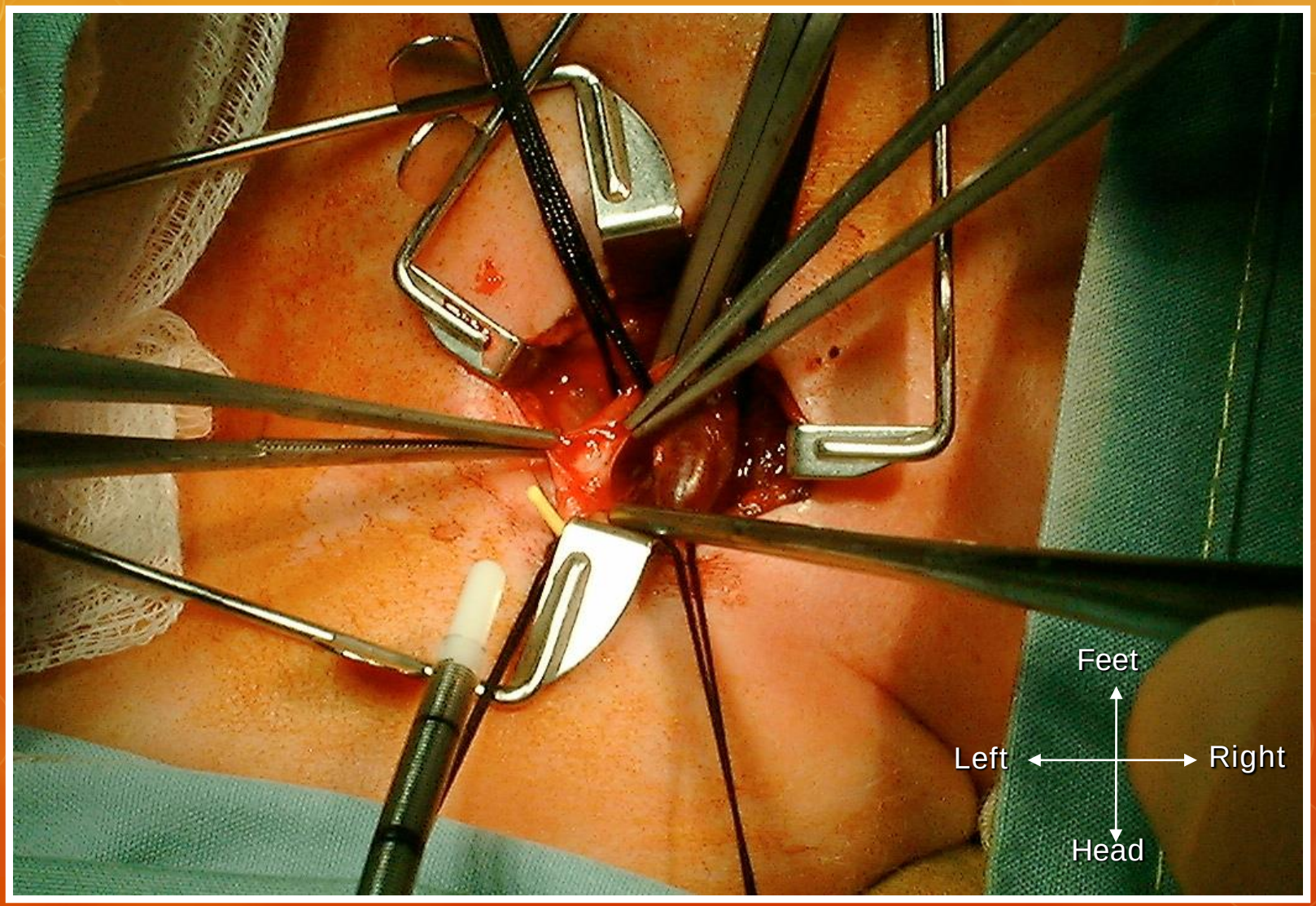
Cross-Clamping the Carotid



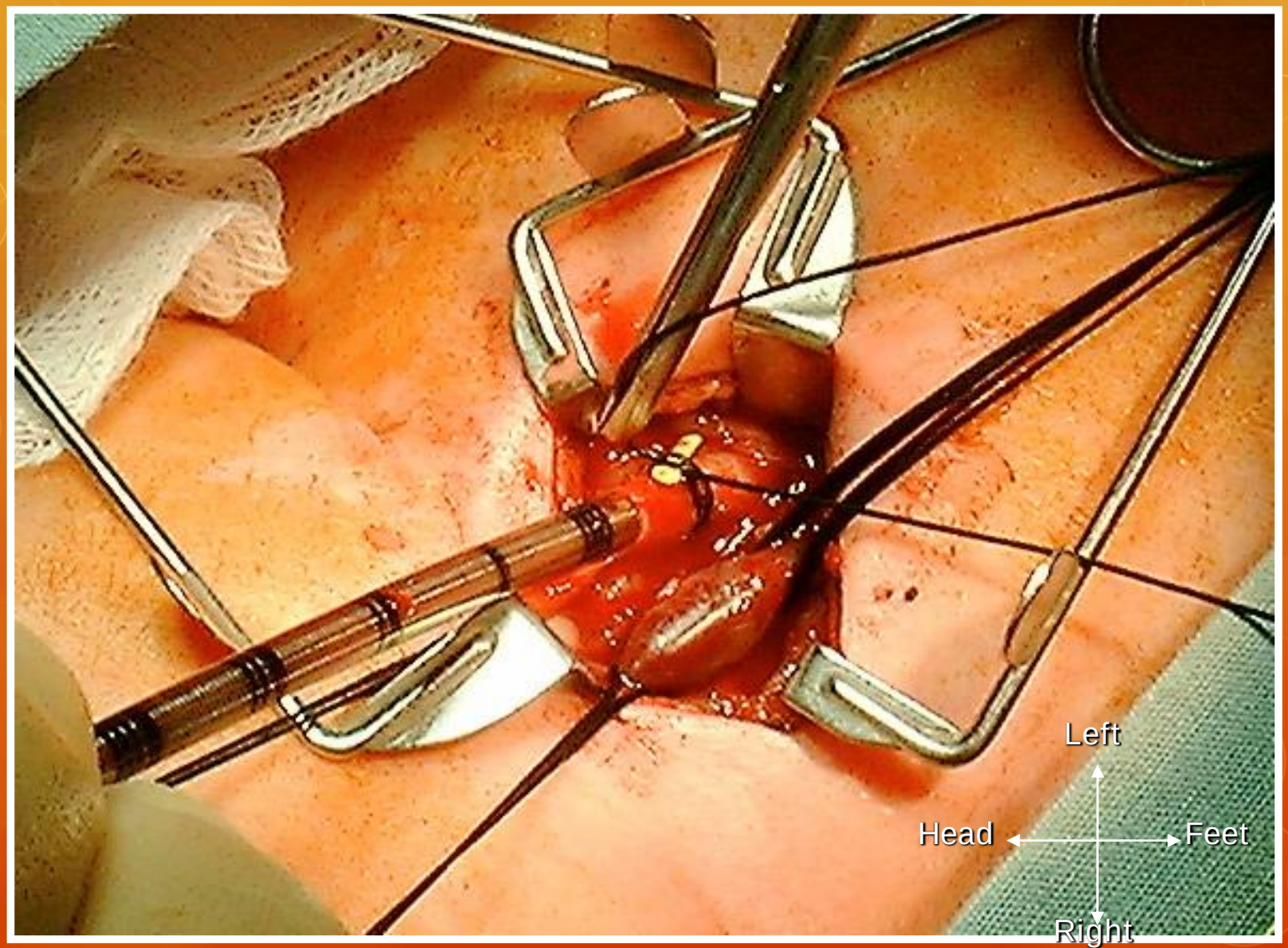
Carotid Arteriotomy



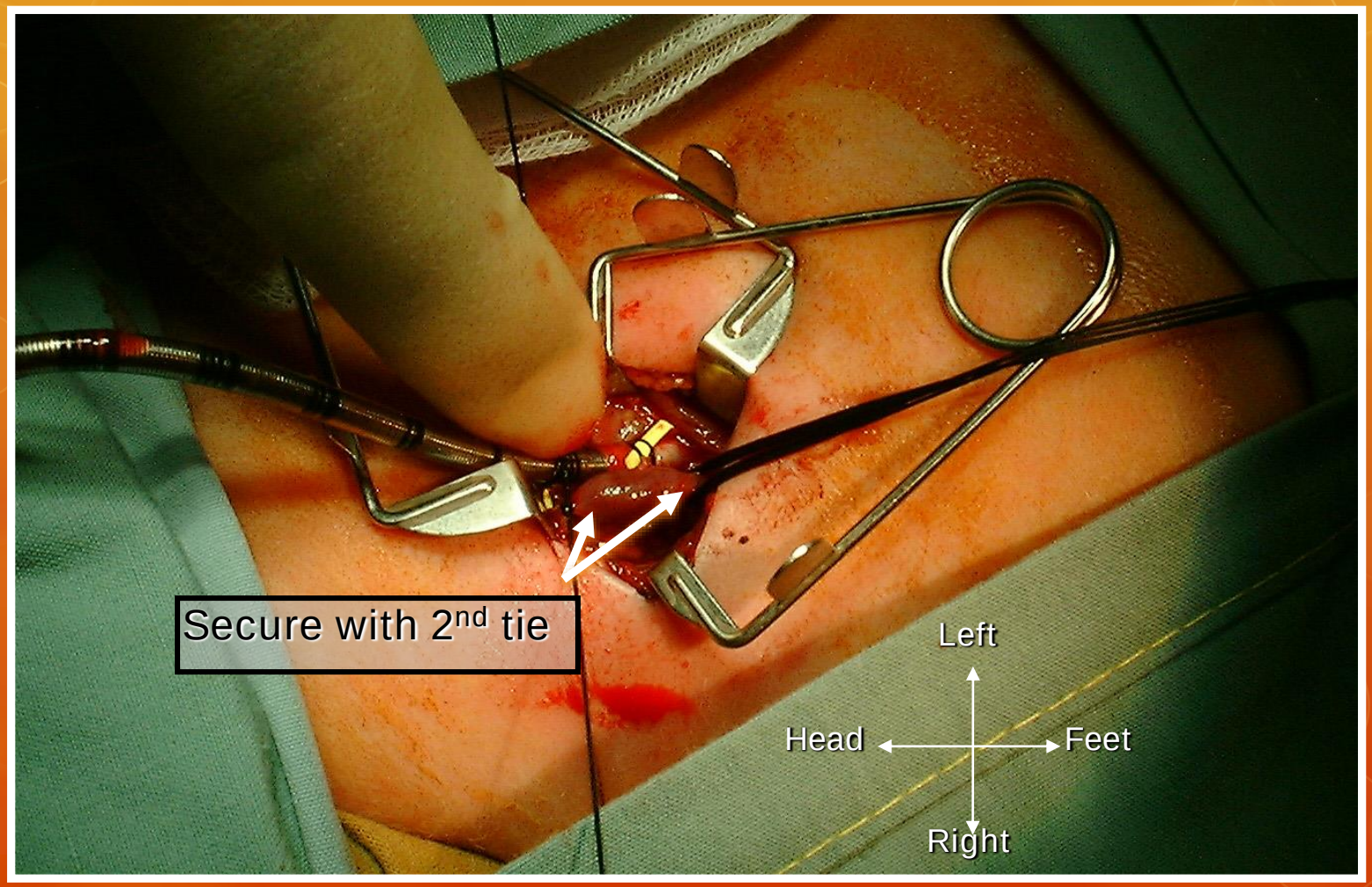
Arterial Cannulation



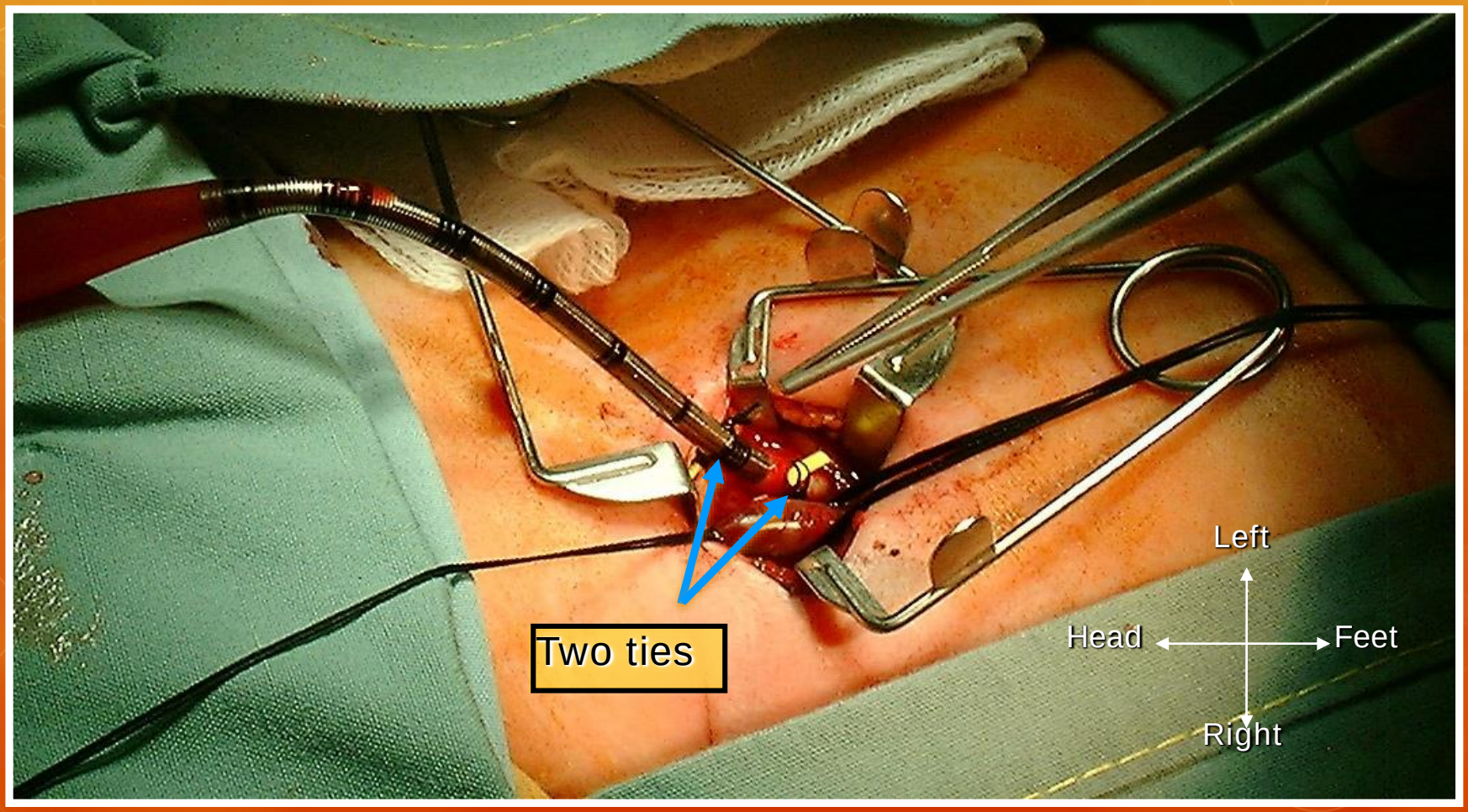
Securing the Cannula



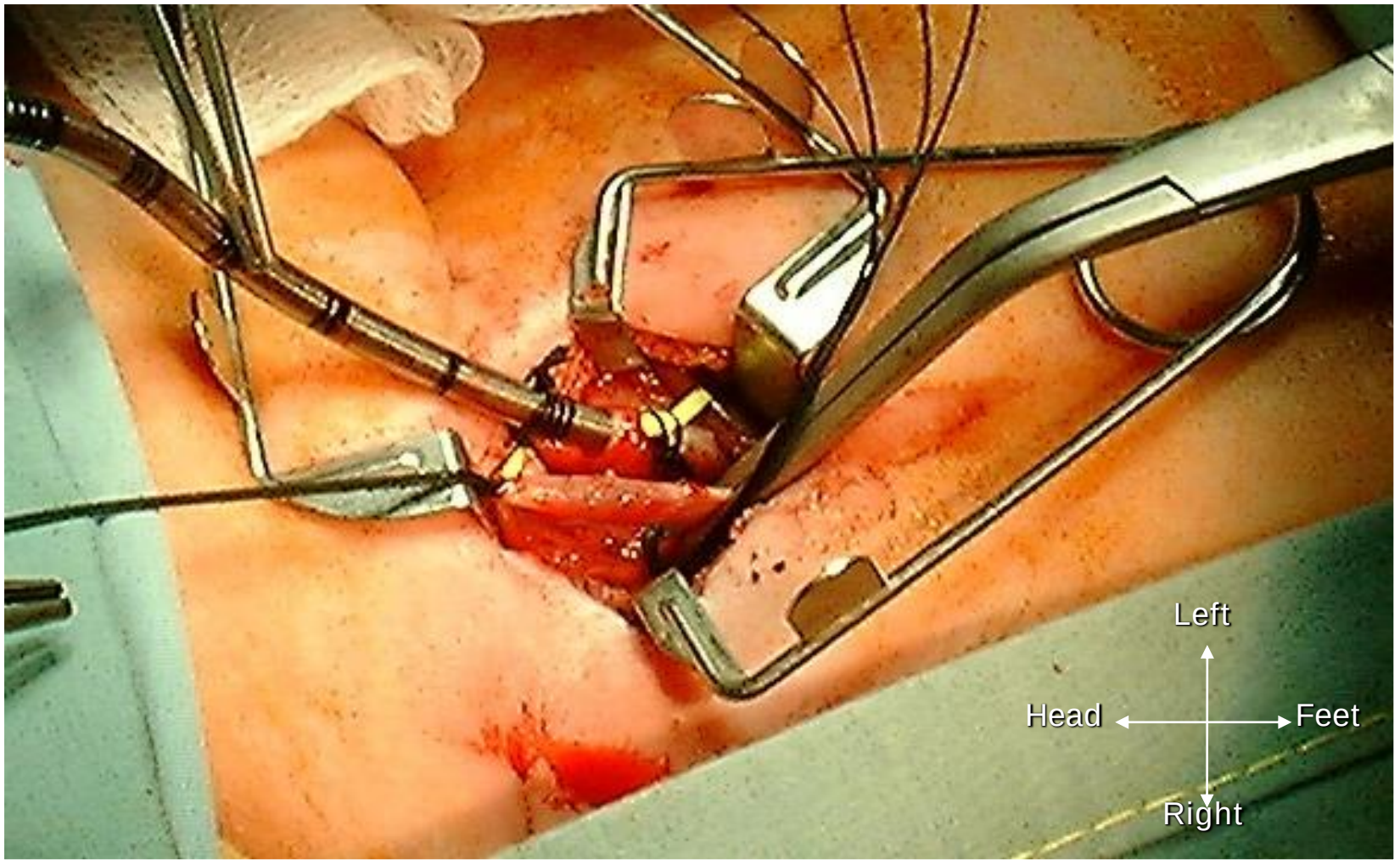
Securing the Cannula Distally



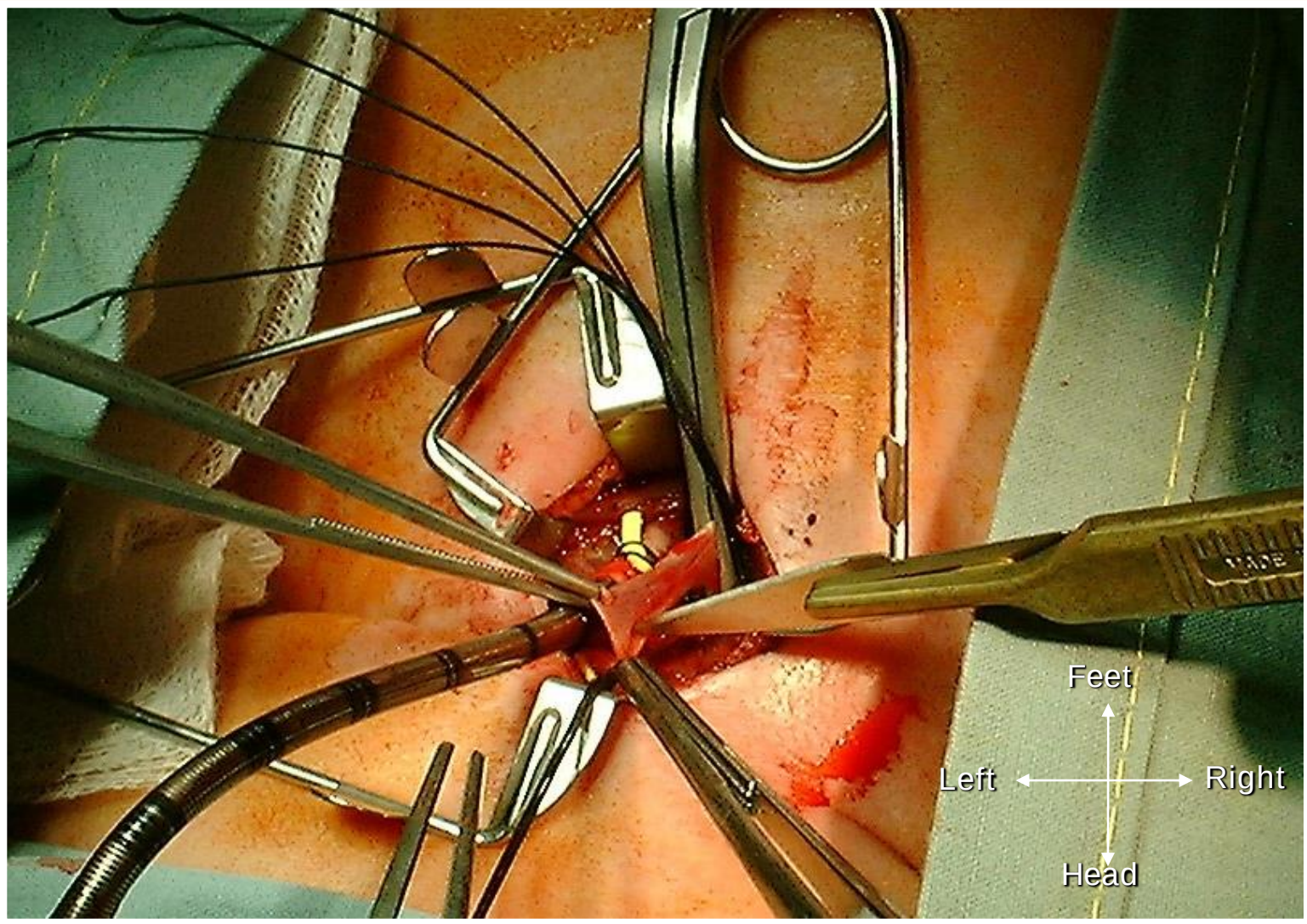
The Secured Arterial Cannula



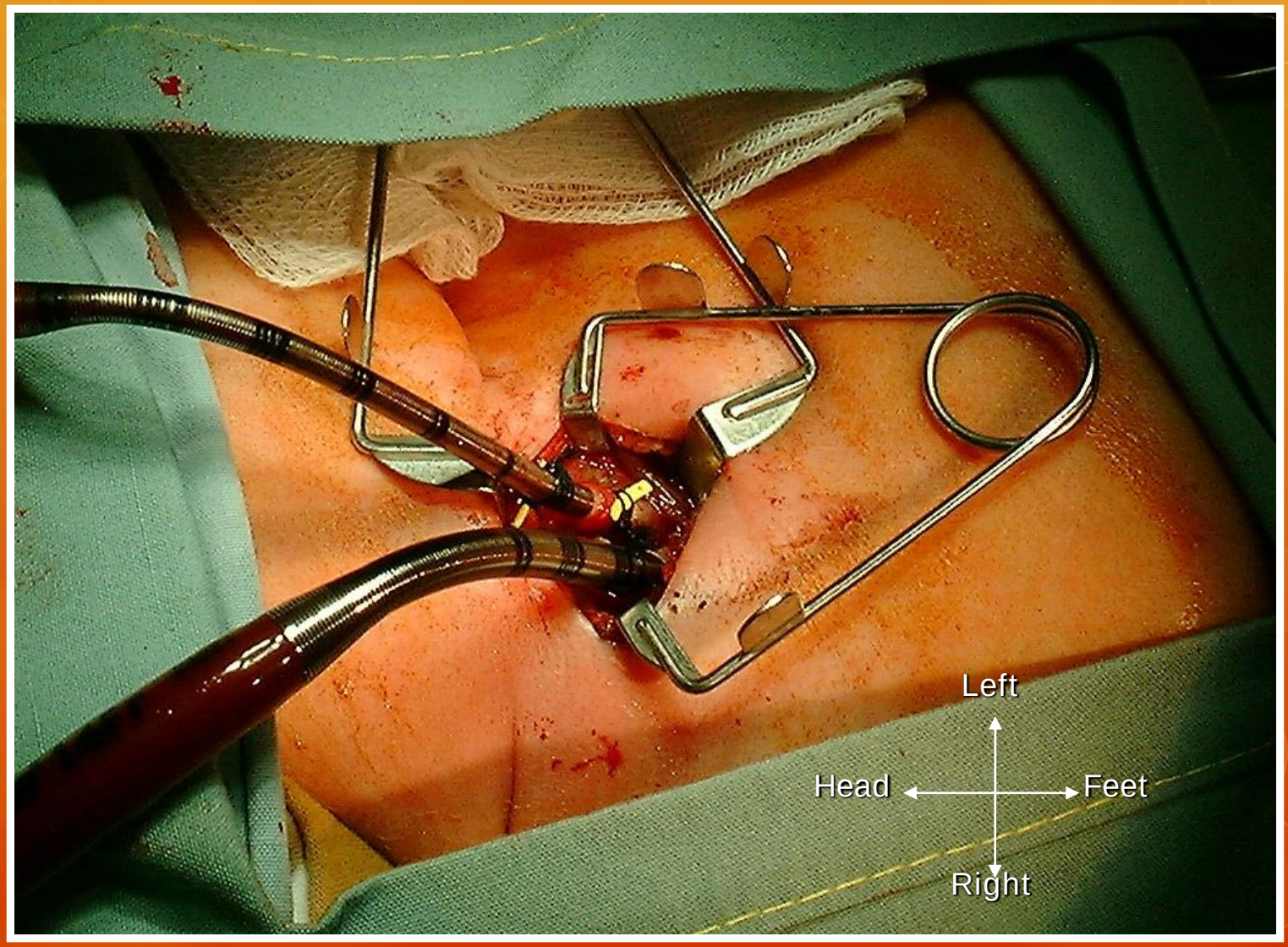
Venous Cross Clamp



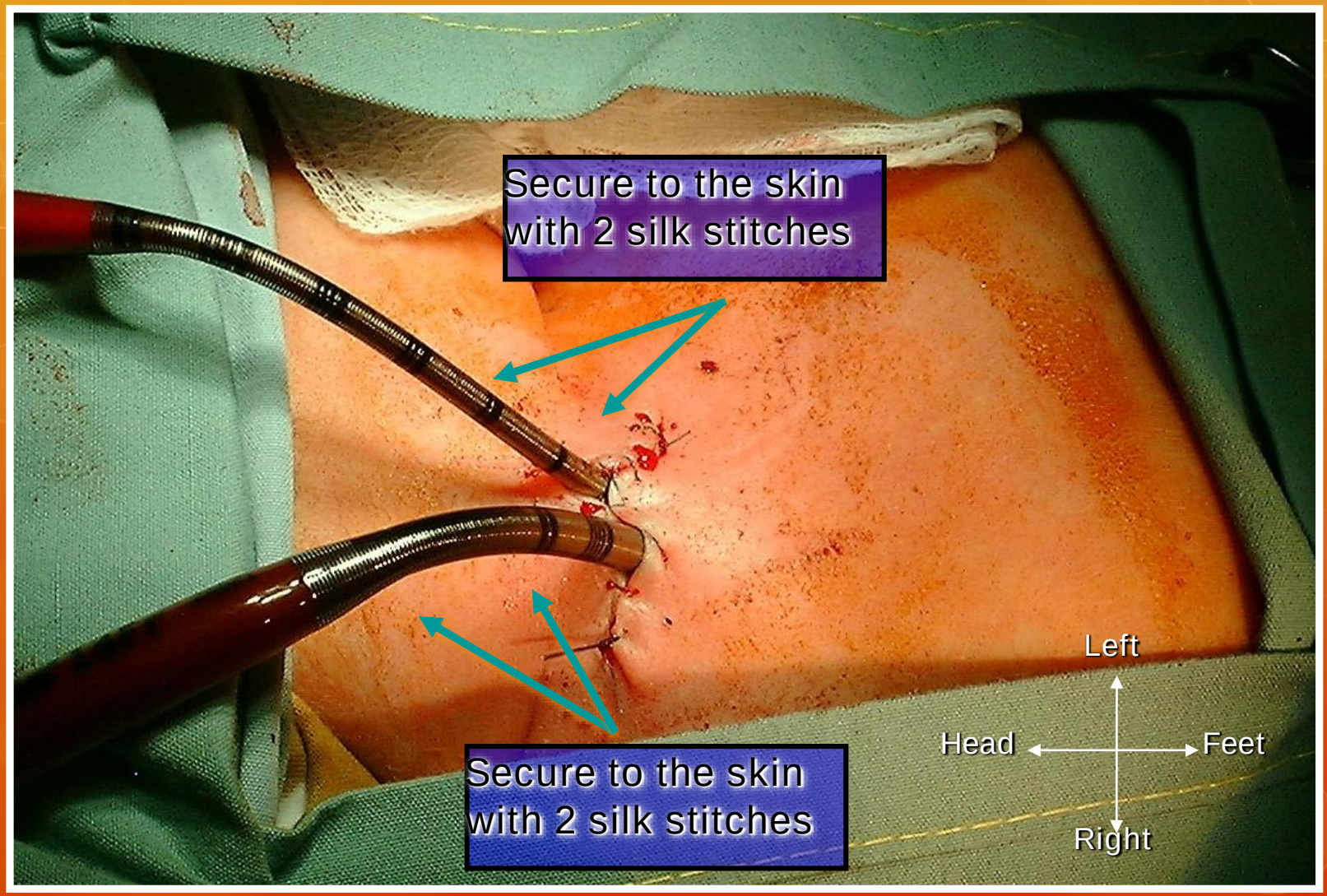
Jugular Venotomy



Venous Line Secured

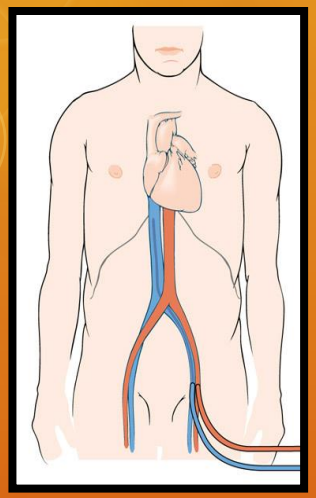


Skin Closure



Baby on VA ECMO

V-A ECMO Femoral cannulation



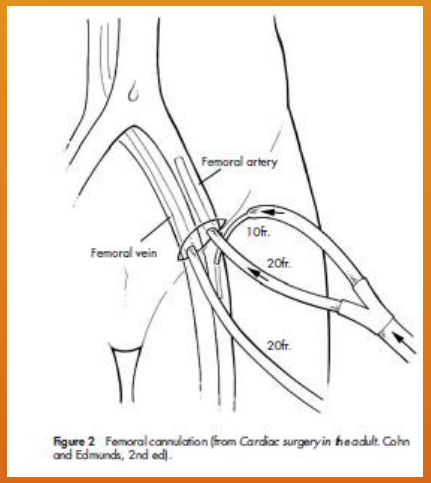
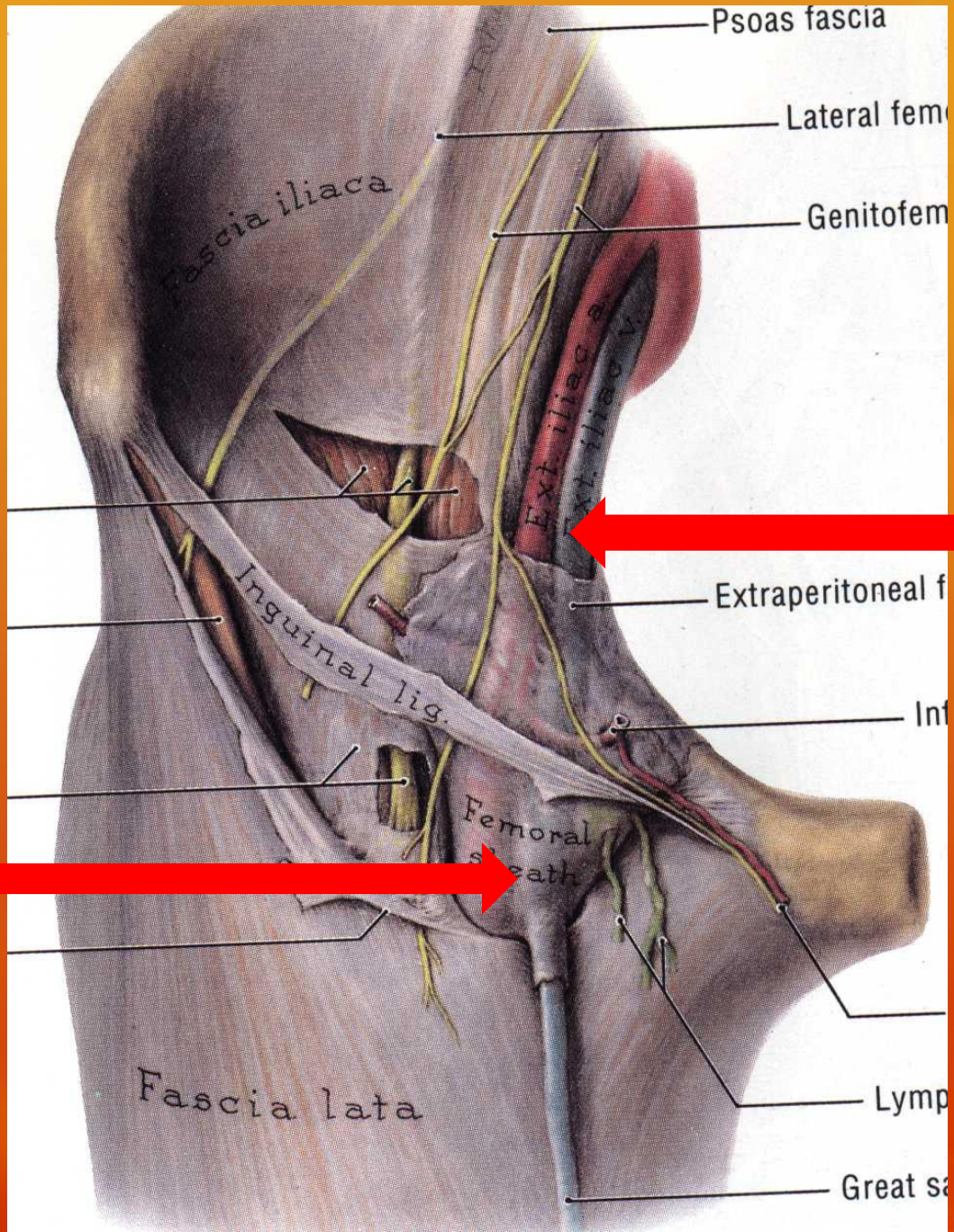


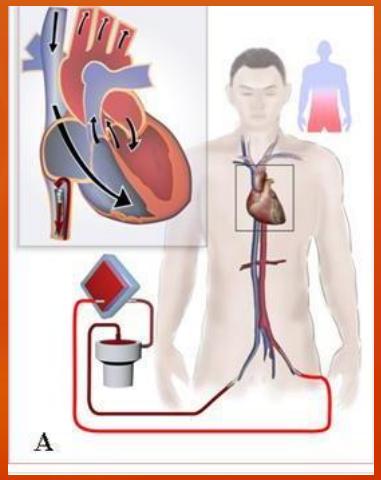
Figure 2 Femoral cannulation (from Cardiac surgery in the adult. Cohn and Edmunds, 2nd ed).

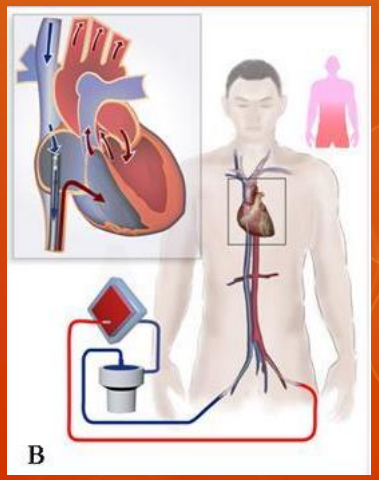
- >15kg
  - Percutaneous (seldinger/semi-seldinger)
  - Open cut down technique
- Ideal positioning
  - venous cannula at level of diaphragm
  - Arterial cannula below renal artery


Psoas fascia
Lateral fem
Genitofem
Fascia iliaca
Ext. iliac a.
Ext. iliac v.
Not Here
Extraperitoneal f
Inguinal lig.
Inf
Femoral
Puncture here
Fascia lata
Lymp
Great sa

V-A ECMO Femoral cannulation: the Arlequin Syndrome

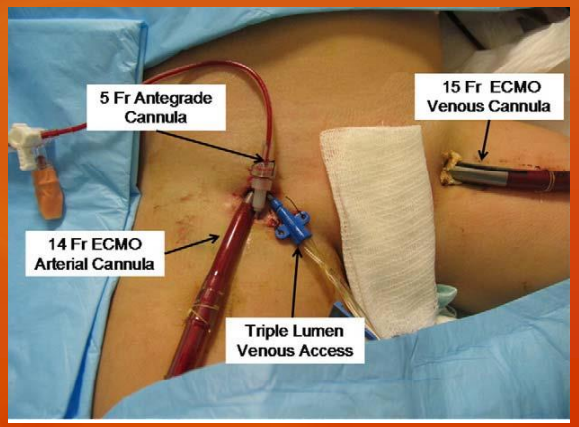
- Effective for cardiac failure
- Ineffective for respiratory failure
  - Fails to perfuse aortic arch if LV is ejecting
  - Poorly oxygenated blood delivered to brain and coronaries (Arlequin Syndrome)
- **VA-V ECMO**
  - **Addition of arterialized IJ cannula improved oxygenation to coronaries and brain**

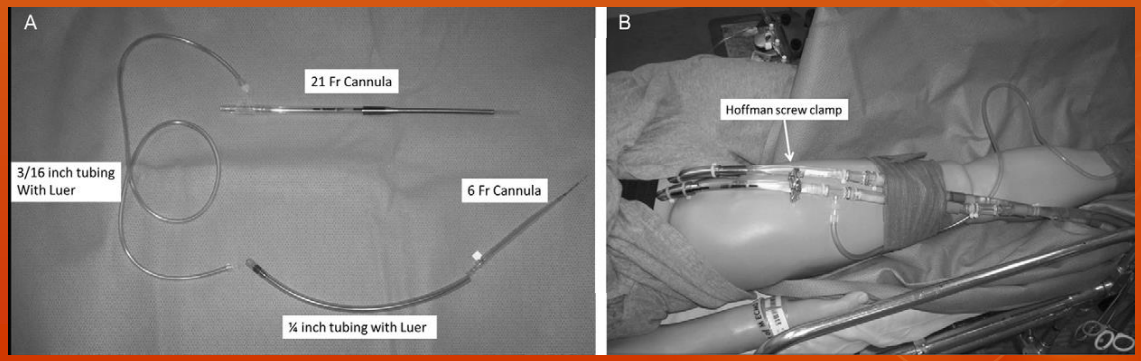




Arterial reperfusion cannula in leg to avoid limb ischemia

- Limb ischemia rate 20-50% with femoral artery cannulation
- Options for reperfusion cannula
  - Antegrade cannulation of superficial femoral artery
  - Common femoral artery cannulated in retrograde direction
  - Ipsilateral posterior tibial artery cannulation





NIRS to prevent lower limb ischemia

Artif Organs. 2012 Aug;36(8):659-67. doi: 10.1111/j.1525-1594.2012.01496.x. Epub 2012 Jul 23.

Cerebral and lower limb near-infrared spectroscopy in adults on extracorporeal membrane oxygenation.

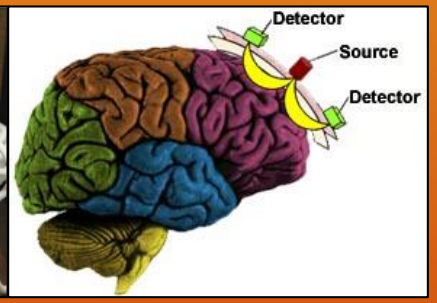
Wong JK, Smith TN, Pitcher HT, Hirose H, Cavarocchi NC.

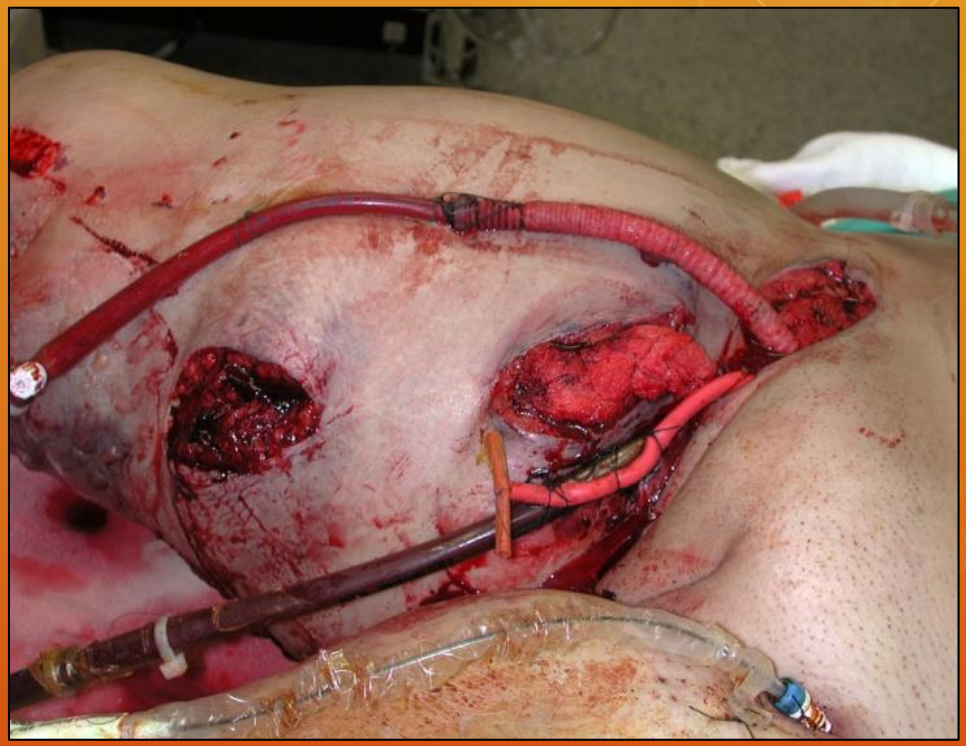
Department of Surgery, Division of Cardiothoracic Surgery and Critical Care, Thomas Jefferson University Hospital, 1025 Walnut Street, Philadelphia, PA 19107, USA.

Abstract

Percutaneous femoral venoarterial (VA) or jugular venovenous (VV) extracorporeal membrane oxygenation (ECMO) can result in delivery of hypoxic blood to the brain, coronaries, and upper extremities. Additionally, VA-ECMO by percutaneous femoral artery cannulation may compromise perfusion to the lower limbs. Use of near-infrared spectroscopy (NIRS) detects regional ischemia and warns of impending hypoxic damage. We report the first known series with standardized monitoring of this parameter in adults on ECMO. This is an institutional review board-approved single institution retrospective review of patients with NIRS monitoring on ECMO from July 2010 until June 2011. Patients were analyzed for drops in NIRS tracings below 40 or >25% from baseline. VA-ECMO and VV-ECMO were initiated by percutaneous cannulation of the femoral vessels and the internal jugular vein, respectively. Sensors were placed on the patients' foreheads and on the lower limbs. NIRS tracings were recorded, analyzed, and correlated with clinical events. Twenty patients were analyzed (median age: 47.5 years): 17 patients were placed on VA-ECMO, and three patients on VV-ECMO. The median duration on ECMO was 7 days (range 2-26). One hundred percent of patients had a significant drop in bilateral cerebral oximetry tracings resulting in hemodynamic interventions, which involved increasing pressure, oxygenation, and/or ECMO flow. In 16 patients (80%), these interventions corrected the underlying ischemia. Four patients (20%) required further diagnostic intervention for persistent decreased bilateral and/or unilateral cerebral oximetry tracings, and were found to have a cerebrovascular accident (CVA). Six (30%) patients had persistent unilateral lower limb oximetry events, which resolved upon placement or replacement of a distal perfusion cannula. No patient was found to have either lower limb ischemia or a CVA with normal NIRS tracings. Use of NIRS with ECMO is important in detecting ischemic cerebral and peripheral vascular events. This allows for potential correction of the underlying process, thus preventing permanent ischemic damage.

PMID: 22817780 [PubMed - in process]





- Patients analyzed for drop in NIRS tracings below 40 or < 25% from baseline
- 30% persistent unilateral lower limb oximetry events

No lower limb ischemia with normal NIRS tracings

Posterior tibial artery approach

Central VS. peripheral cannulation

Thorac Cardiovasc Surg. 2010 Dec;58(8):459-62. Epub 2010 Nov 25.

Peripheral versus central cannulation for extracorporeal membrane oxygenation: a comparison of limb ischemia and transfusion requirements.

Kanji HD, Schulze CJ, Oreopoulos A, Lehr EJ, Wang W, MacArthur RM.

Division of Cardiac Surgery, University of Alberta, Edmonton, Canada. hdkanji@gmail.com

Abstract

BACKGROUND: Extracorporeal membrane oxygenation (ECMO) can be instituted centrally, through the right atrium and ascending aorta, or peripherally, most commonly using the femoral artery and vein. We sought to investigate the impact of the mode of cannulation on the incidence of limb ischemia, perfusion and overall morbidity.

METHODS: A retrospective analysis of 50 consecutive patients over 5 years who underwent ECMO by central or peripheral cannulation was performed.

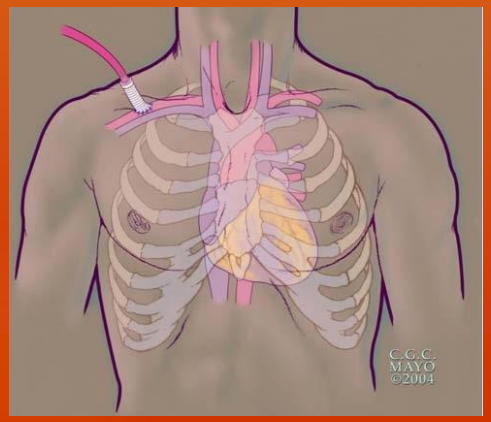
RESULTS: There was no difference in the incidence of limb ischemia and end-organ perfusion when peripheral and central cannulation cohorts were compared. Central cannulation was associated with a higher incidence of bleeding from the cannulation site (64% vs. 18%, P = 0.002), blood product utilization and reoperation (66% vs. 14%, P < 0.0001). 30-day mortality was similar in both cohorts (46% peripheral, 50% central, P = 0.8).

CONCLUSION: Our results suggest that there is comparable tissue perfusion and limb ischemia with both cannulation techniques. Central cannulation is associated with a higher incidence of bleeding, higher transfusion rates, a greater need for reoperation and greater resource utilization. Therefore, peripheral cannulation is safe and may be advantageous in certain clinical scenarios.

- **No difference in incidence of limb ischemia**
- Central cannulation associated higher incidence of
  - **bleeding from cannulation site** (64% vs 18%, p=0.02
  - **transfusion and reoperation** (66% vs 14%, p<0.0001)
- 30-day mortality similar

Subclavian Artery Cannulation

- Alternative site for those with peripheral vascular disease, pelvic trauma, promote ambulation
- Side graft cannulation to avoid arm ischemia
- Complications: hematoma, infection, arm swelling

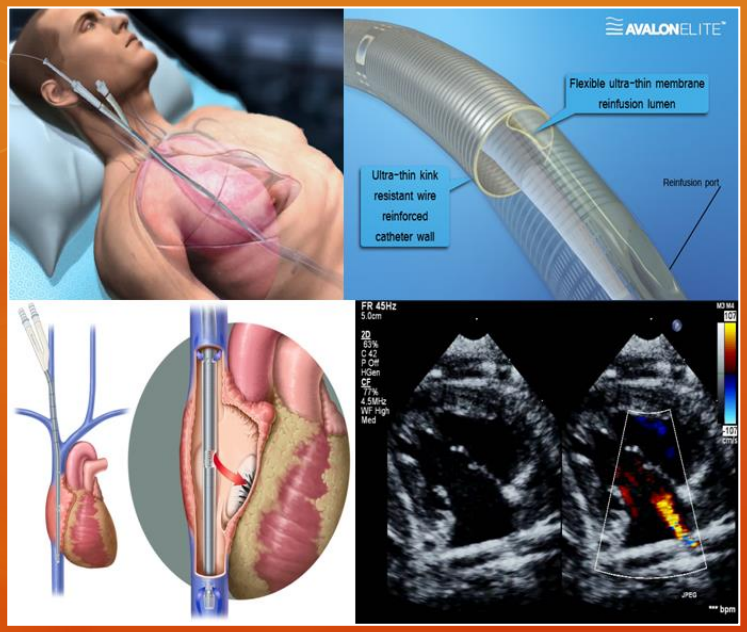


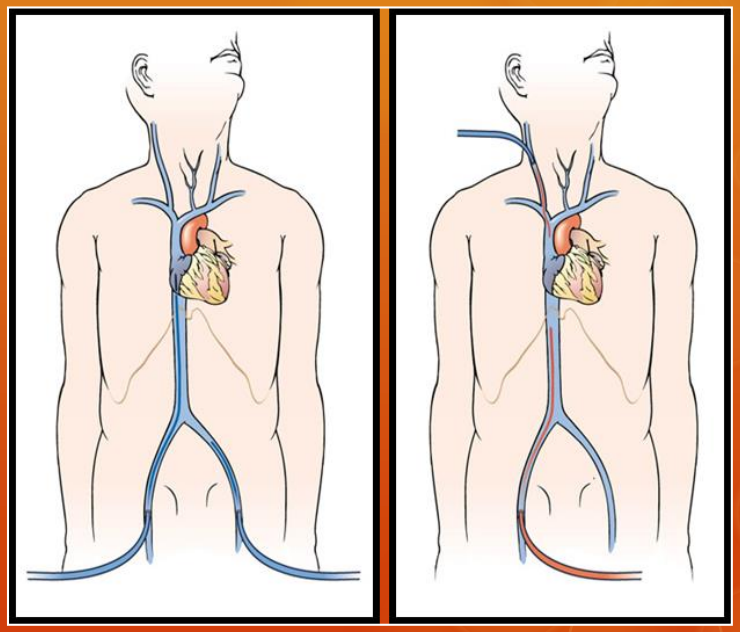
Unloading in Cardiac ECMO

- Venting catheter
  - Need for separate flow measurement (clamp)
  - High (increasing ?) recirculation fraction
- Rashkind/surgical atrioseptectomy
- IABP
- Impella
  - Technical feasible
  - Case report
- Apical – aorta in LVAD

V-V ECMO CANNULATION

- Consider for all children who do not have cardiac disease or refractory pulmonary hypertension
- Wire reinforced & non-wire reinforced double lumen cannulae

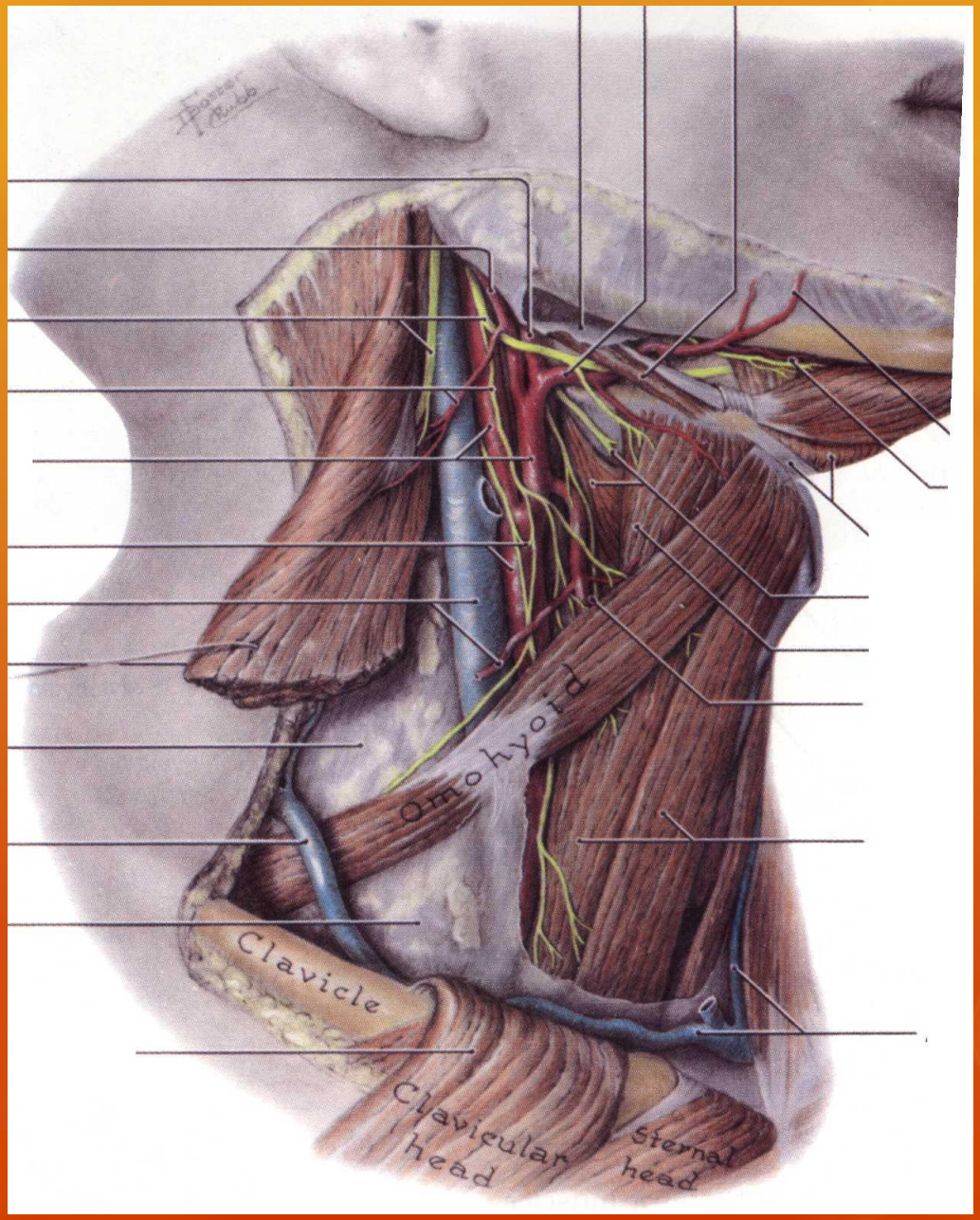




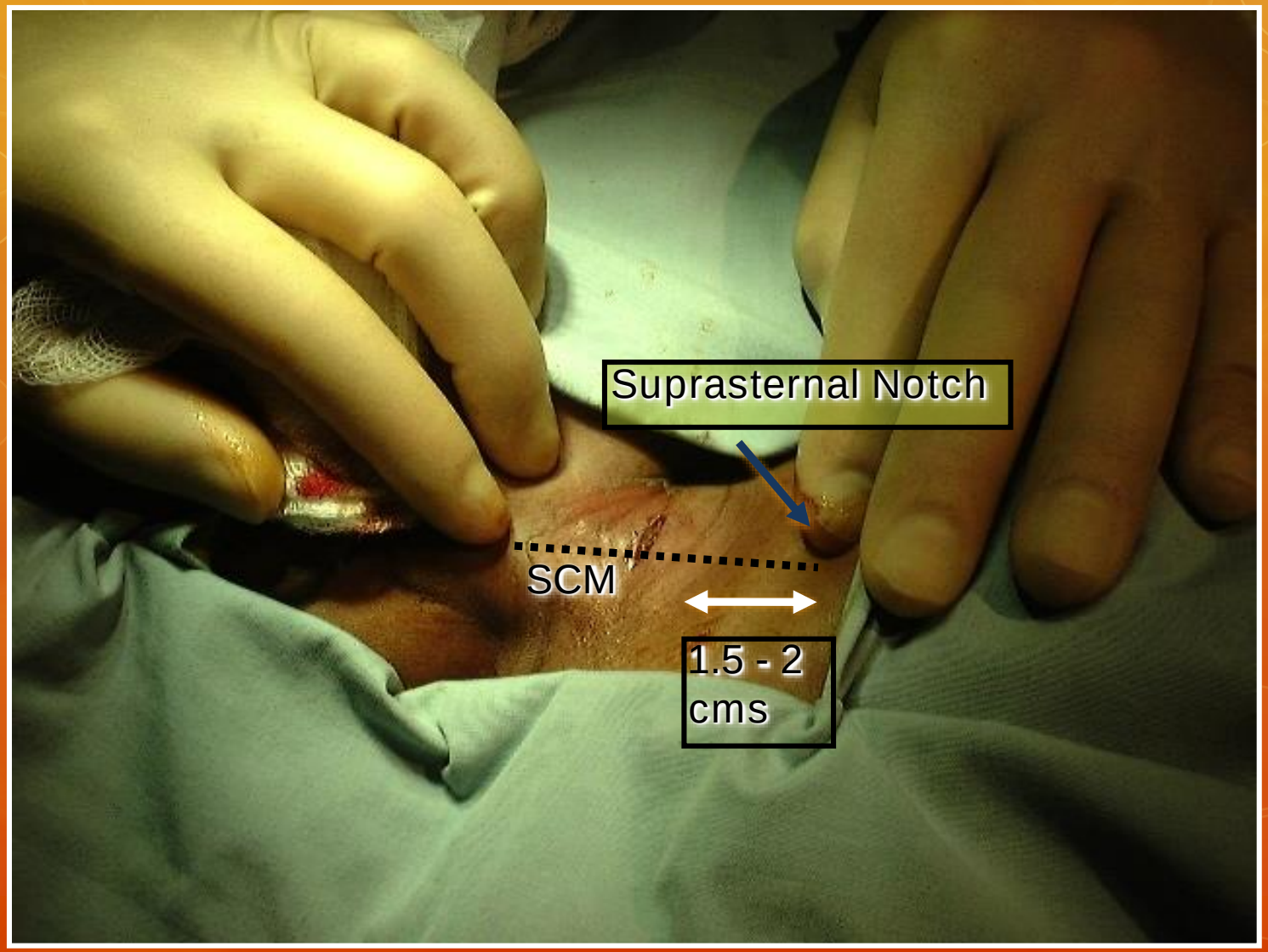
NEONATE V-V CANNULATION

- Double lumen cannula in RIJ
- Femoral vein too small to accommodate cannula

- Non-wire Reinforced DLC
  - Outflow jet directed towards tricuspid valve to reduce recirculation
  - Arterial side up (red lumen) to help direct oxygenated blood towards tricuspid
  - 1cm above diaphragm on CXR

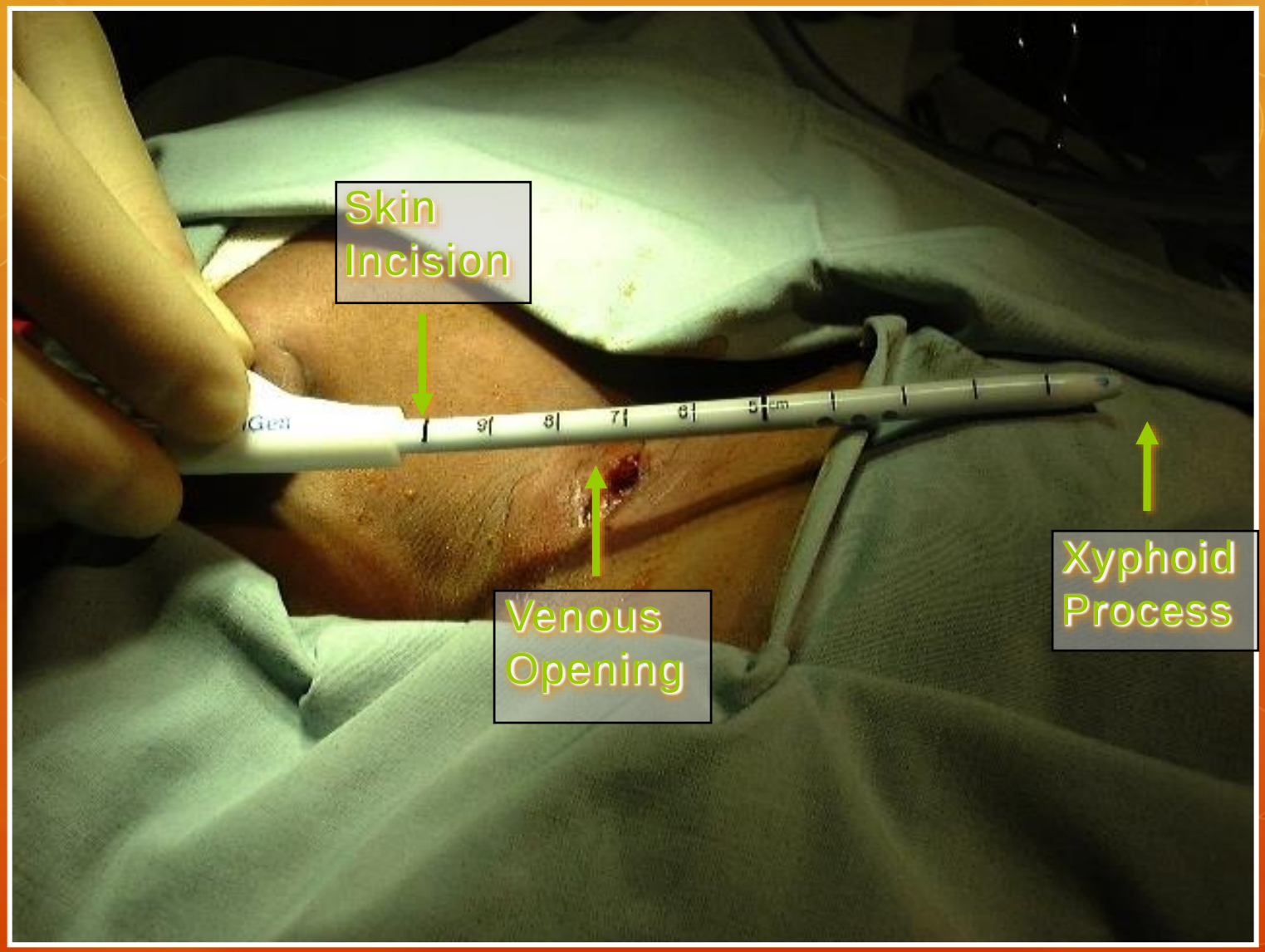

Omohyoid
Clavicle
Clavicular head
Sternal head

V-V Neck Cannulation



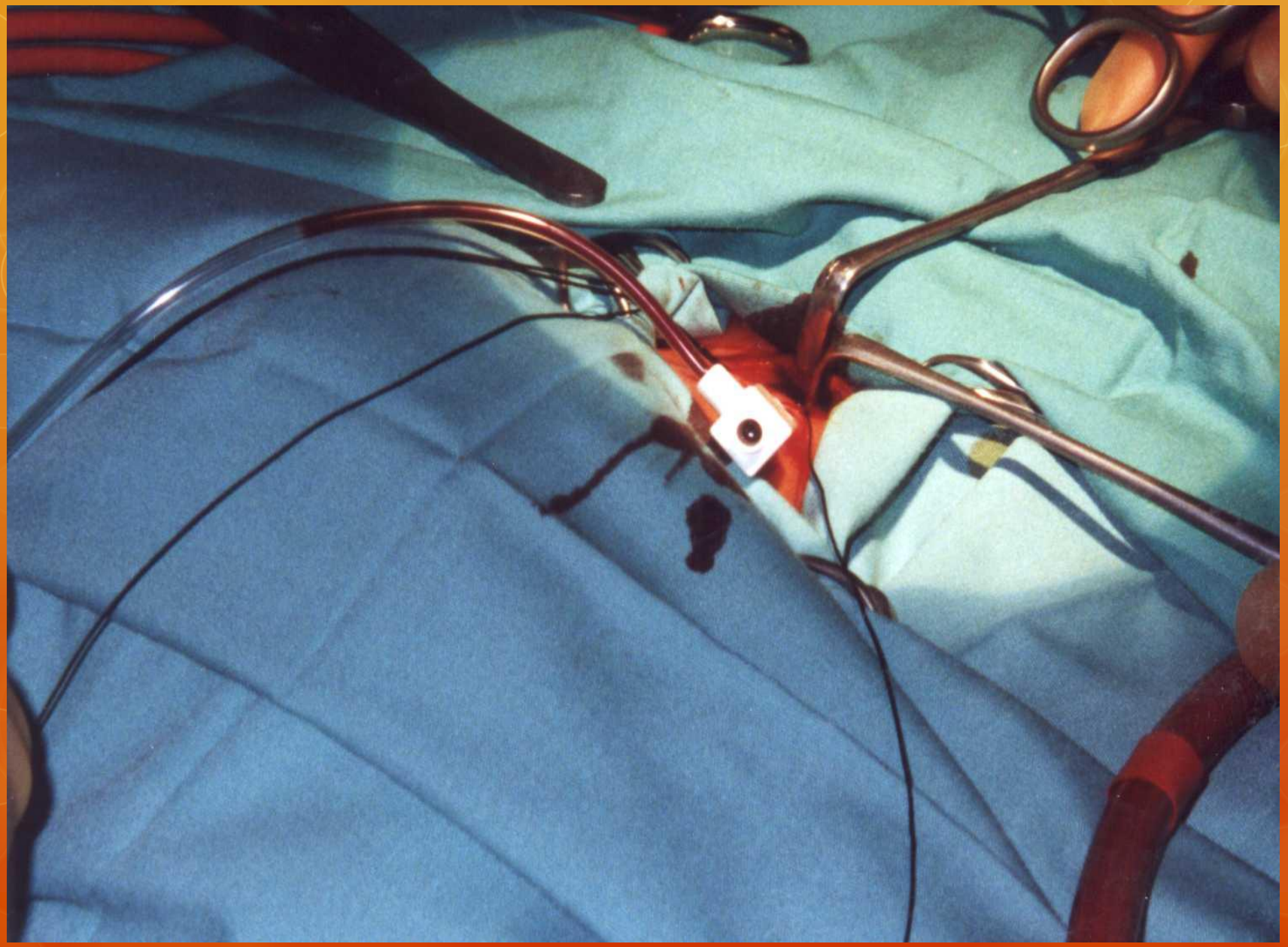
Expose internal jugular vein

Measure length VV cannula

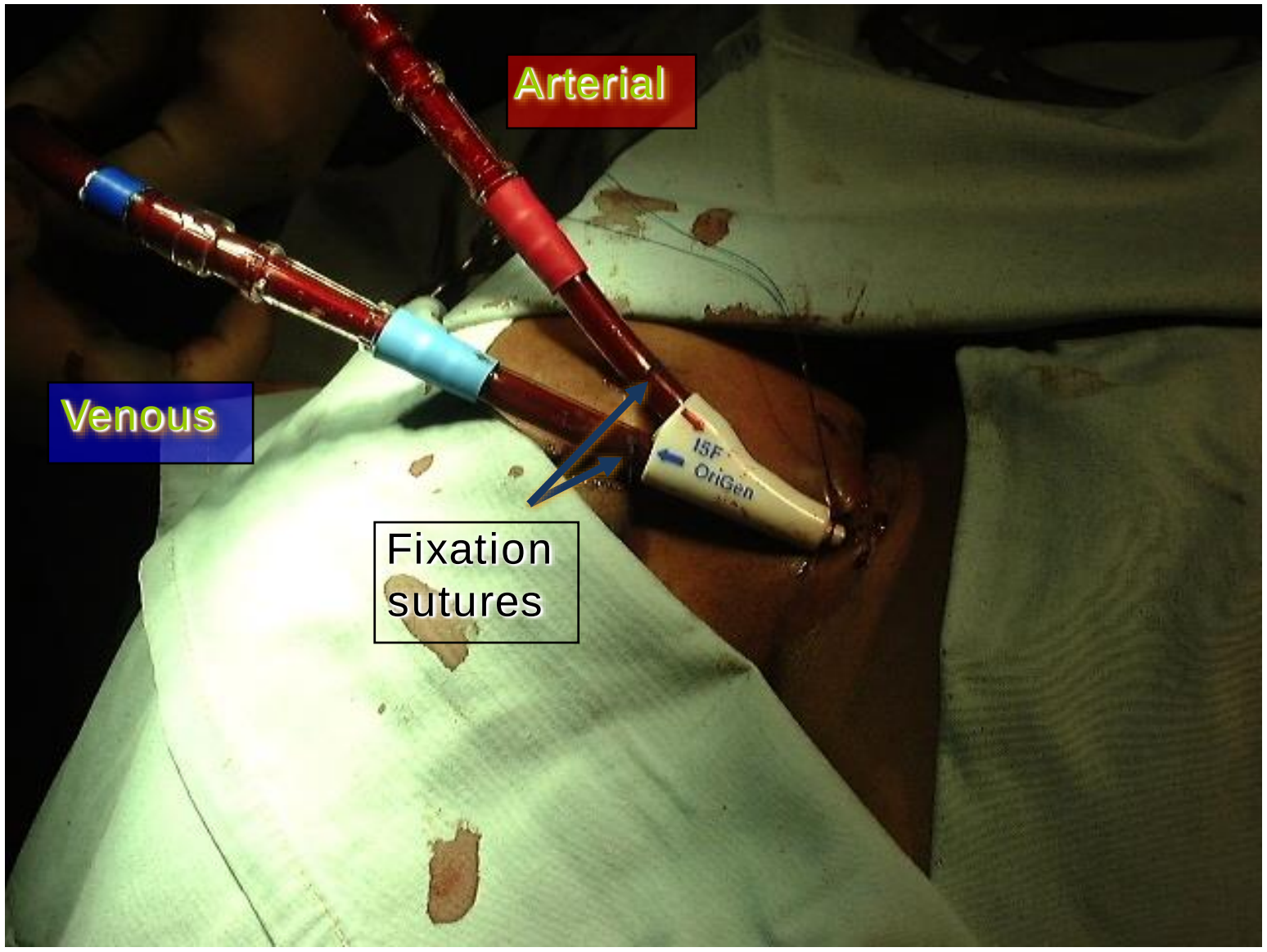


Make puncture incision for cannula

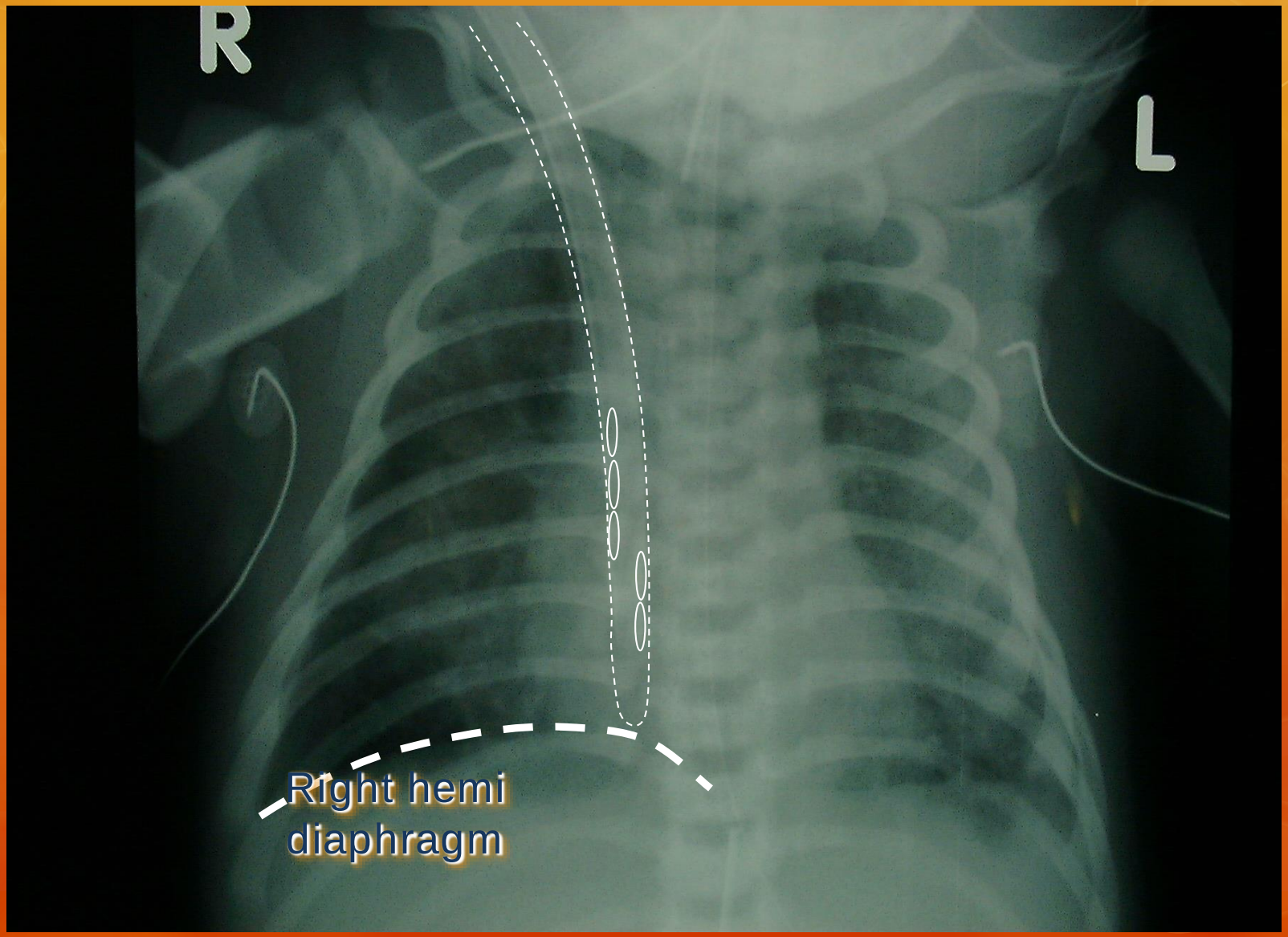
Insert 20 G pink cannula & guide wire




15F
OriGen


Arterial
Venous
Fixation sutures
15F
OriGen

Adequate Cannulae Position - Patient on V-V ECMO



PEDIATRIC V-V CANNULATION

- Double lumen cannula in RIJ preferred
- ■ Alternative femoral vein drainage and R IJ reinfusion

Wire Reinforced Double Lumen VV Cannula

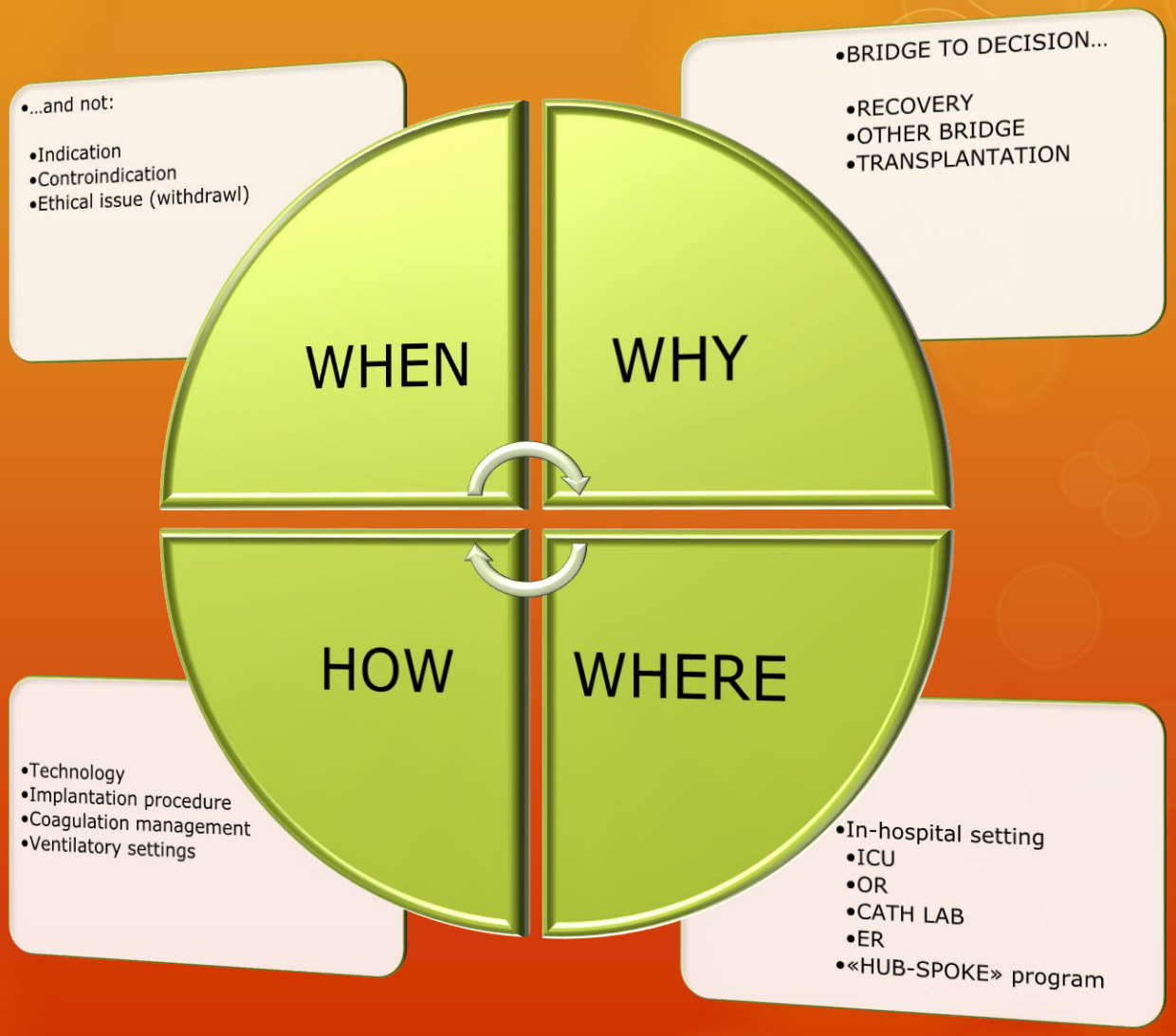
- IJ cannulation
- Should place with image guidance
  - Echocardiogram
  - Fluoroscopy
  - CXR confirmation
- Why place under image guidance?
- Reports of cardiac tamponade & atrial perforation
  - Possibly secondary to cannula characteristics and need for precise location in IVC

ADVANTAGES OF DL VV CANNULA

ANTICOAGULATION AND BEDSIDE POINT OF CARE

- In postcardiotomy: started when no more bleeding from drainage tubes
  - HEPARIN 10-20 U.I./kg/h if no adequate washout of heart cavities
    - AT3 supplementation
  - BIVALIRUDIN 0.3-0.5 MG/KG/HR in all other cases
  - Aspirin 2-5 mg/kg/die
- Coagulation parameters strictly monitored
  - PTT (>65), PT (INR<2.5), Plt's counts (<80000) every 6hr
  - TEG (R>12)/ROTEM (mainly INTEM and FIBTEM) every 8hr

THE ECMO PARADIGM:
how, when, why, where (to do…)



DECISION MAKING PROCESS

- **«how to do»** probably represent the heaviest acknowledgment

BUT…

- **«when and why»** major discriminant in successful outcome:
  - Not all candidates are good candidates,
  - Therapeutic window lies between correct timing (but not prophylactic) and elective weaning (before complication onset)
  - Sometimes weaning means "withdrawl"…(ethical, legal,…)

ECMO OUTCOME IN ELSO REGISTRY
(1989-2010)

	Total	Surv ECLS	Surv to DC
Neonatal			
Respiratory	23 558	19 964 (85%)	17 720 (75%)
Cardiac	3 909	2 338 (60%)	1 515 (39%)
ECPR	537	340 (63%)	203 (38%)
Pediatric			
Respiratory	4 376	2 831 (65%)	2 431 (56%)
Cardiac	4 776	2 995 (63%)	2 250 (47%)
ECPR	1 003	528 (53%)	387 (39%)
Adult			
Respiratory	1 860	1 140 (61%)	968 (52%)
Cardiac	1 131	541 (48%)	379 (34%)
ECPR	408	147 (36%)	109 (27%)
Total	41 558	30 824 (74%)	25 962 (62%)

RCT's in respiratory ECMO

Health Technol Assess. 2010 Jul;14(35):1-46. doi: 10.3310/hta14350.

Randomised controlled trial and parallel economic evaluation of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR).

Peek GJ, Elbourne D, Mugford M, Tiruvoipati R, Wilson A, Allen E, Clemens F, Firmin R, Hardy P, Hibbert C, Jones N, Killer H, Thalanany M, Truesdale A.
Department of Cardiothoracic Surgery, Glenfield Hospital, Leicester, UK.

Abstract

OBJECTIVES: To determine the comparative effectiveness and cost-effectiveness of conventional ventilatory support versus extracorporeal membrane oxygenation (ECMO) for severe adult respiratory failure.

DESIGN: A multicentre, randomised controlled trial with two arms.

SETTING: The ECMO centre at Glenfield Hospital, Leicester, and approved conventional treatment centres and referring hospitals throughout the UK.

PARTICIPANTS: Patients aged 18-65 years with severe, but potentially reversible, respiratory failure, defined as a Murray lung injury score > or = 3.0, or uncompensated hypercapnoea with a pH < 7.20 despite optimal conventional treatment.

INTERVENTIONS: Participants were randomised to conventional management (CM) or to consideration of ECMO.

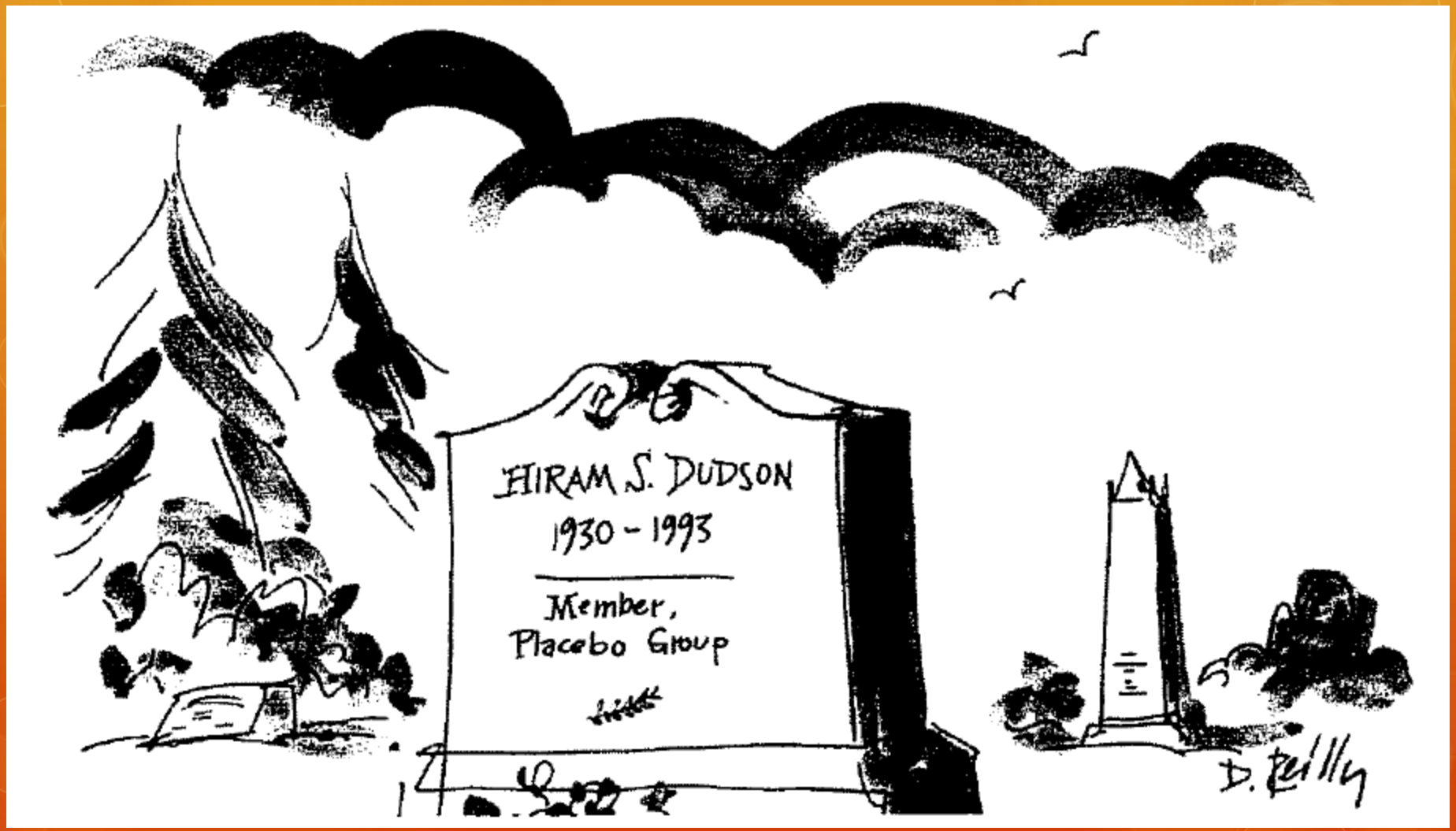
MAIN OUTCOME MEASURES: The primary outcome measure was death or severe disability at 6 months. Secondary outcomes included a range of hospital indices: duration of ventilation, use of high frequency/oscillation/jet ventilation, use of nitric oxide, prone positioning, use of steroids, length of intensive care unit stay, and length of hospital stay - and (for ECMO patients only) mode (venovenous/veno-arterial), duration of ECMO, blood flow and sweep flow.

RESULTS: A total of 180 patients (90 in each arm) were randomised from 68 centres. Three patients in the conventional arm did not give permission to be followed up. Of the 90 patients randomised to the ECMO arm, 68 received that treatment. ECMO was not given to three patients who died prior to transfer, two who died in transit, 16 who improved with conventional treatment given by the ECMO team and one who required amputation and could not therefore be heparinised. Ninety patients entered the CM (control) arm, three patients later withdrew and refused follow-up (meaning that they were alive), leaving 87 patients for whom primary outcome measures were available. CM consisted of any treatment deemed appropriate by the patient's intensivist with the exception of extracorporeal gas exchange. No CM patients received ECMO, although one received a form of experimental extracorporeal arteriovenous carbon dioxide removal support (a clear protocol violation). Fewer patients in the ECMO arm than in the CM arm had died or were severely disabled 6 months after randomisation, [33/90 (36.7%) versus 46/87 (52.9%) respectively]. This equated to one extra survivor for every six patients treated. Only one patient (in the CM arm) was known to be severely disabled at 6 months. Patients allocated to ECMO incurred average total costs of 73,979 pounds compared with 33,435 pounds for those undergoing CM (UK prices, 2005). A lifetime model predicted the cost per quality-adjusted life-year (QALY) of ECMO to be 19,252 pounds (95% confidence interval 7622 pounds to 59,200 pounds) at a discount rate of 3.5%. Lifetime QALYs gained were 10.75 for the ECMO group compared with 7.31 for the conventional group. Costs to patients and their relatives, including out of pocket and time costs, were higher for patients allocated to ECMO.

CONCLUSIONS: Compared with CM, transferring adult patients with severe but potentially reversible respiratory failure to a single centre specialising in the treatment of severe respiratory failure for consideration of ECMO significantly increased survival without severe disability. Use of ECMO in this way is likely to be cost-effective when compared with other technologies currently competing for health resources.

TRIAL REGISTRATION: Current Controlled Trials ISRCTN47279827.

No large RCT's in cardiac ECMO



No one happy to be volunteers in the control group!!!