Harlequin Problem of ECMO

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Cardio-respiratory Therapies Improving OrgaN Support

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Bond University Bringing Ambition to Life

Critical Care Research Group

ICET LAB

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Conflicts of interest

None relevant

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THE ECLS HOTPOT
VV
VA
VVA
VAV

Objectives

- Appreciate spectrum of cardiorespiratory failure and ECLS therapies
- Understand mechanisms behind harlequin syndrome
- Discuss techniques to recognize and disrupt upper body hypoxia on VA ECMO

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Spectrum of cardiorespiratory failure

- Predominant respiratory failure

- Predominant cardiac failure

- Combined cardiorespiratory failure
  - cardiac >>respiratory
  - respiratory >> cardiac

Conventional therapy

- Mechanical ventilation +/- adjuncts

- Vasoactive agents and IABC

- Renal replacement

- Other supportive ICU care

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Conventional therapies can fail

Expanding use of ECLS

- Extracorporeal respiratory support
- Mechanical circulatory support (MCS)
- Advanced ECLS providing both respiratory and circulatory support

Extracorporeal respiratory support

- More straight forward
- VV ECMO or ECCO2R
- Cardiac function often improves after VV ECMO
- Small group needs additional MCS

MCS far more complex

- Its all about choosing the

    Right perfusion strategy

    Right time

    Right patient

The Grey Scale of MCS

- Acute Heart Failure
  - IABP
  - VA ECMO
  - Temporary LVAD/ BiVAD +/-oxygenator
  - Percutaneous VAD's
- Chronic Heart Failure
  - LVAD/ RVAD
  - Total Artificial Heart

REVIEW

CrossMark

Mechanical circulatory support in the new era: an overview

Kiran Shekar[1,2*], Shaun D. Gregory[1,2] and John F. Fraser[1,2]

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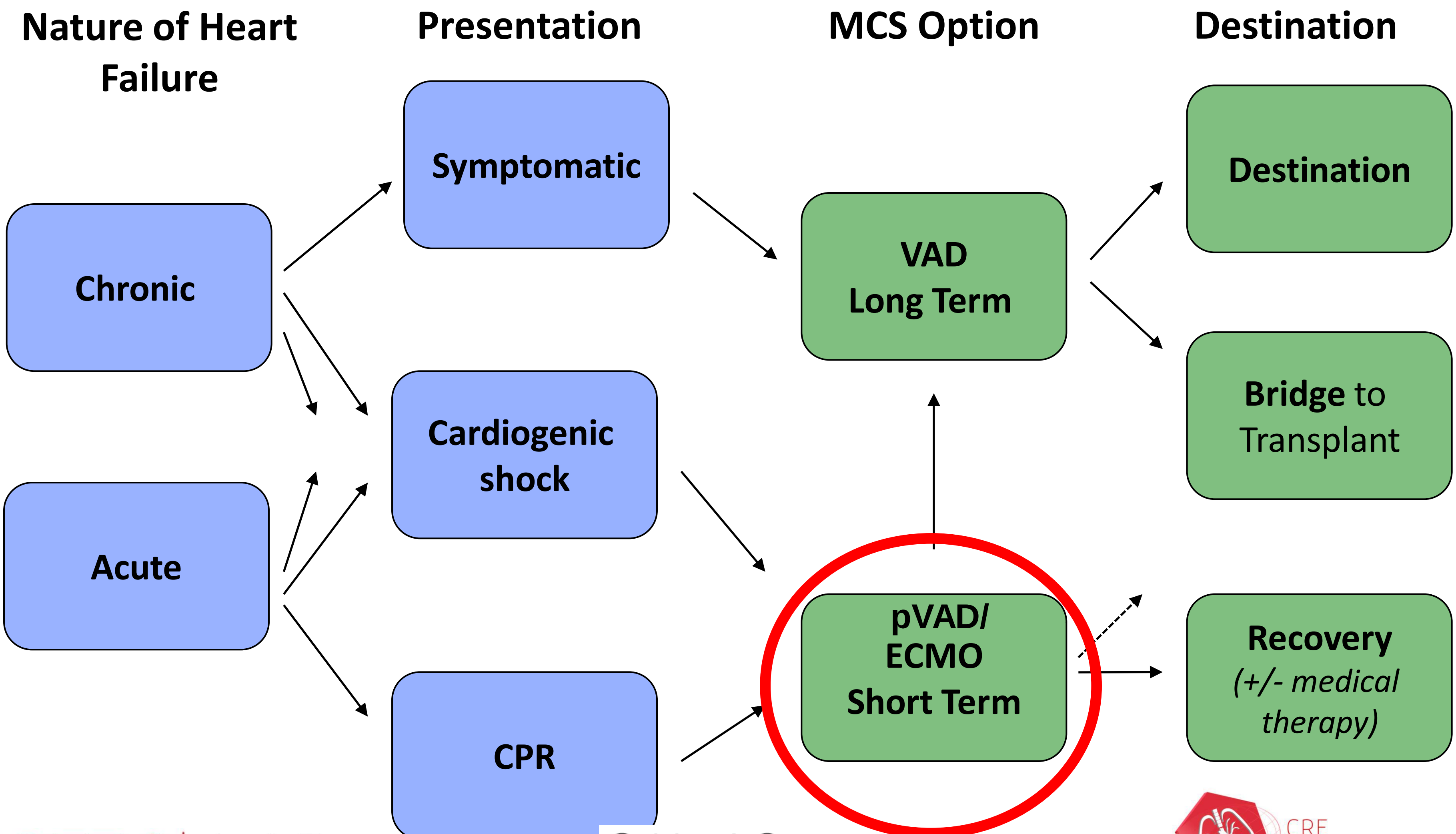
Adult MCS Pathways



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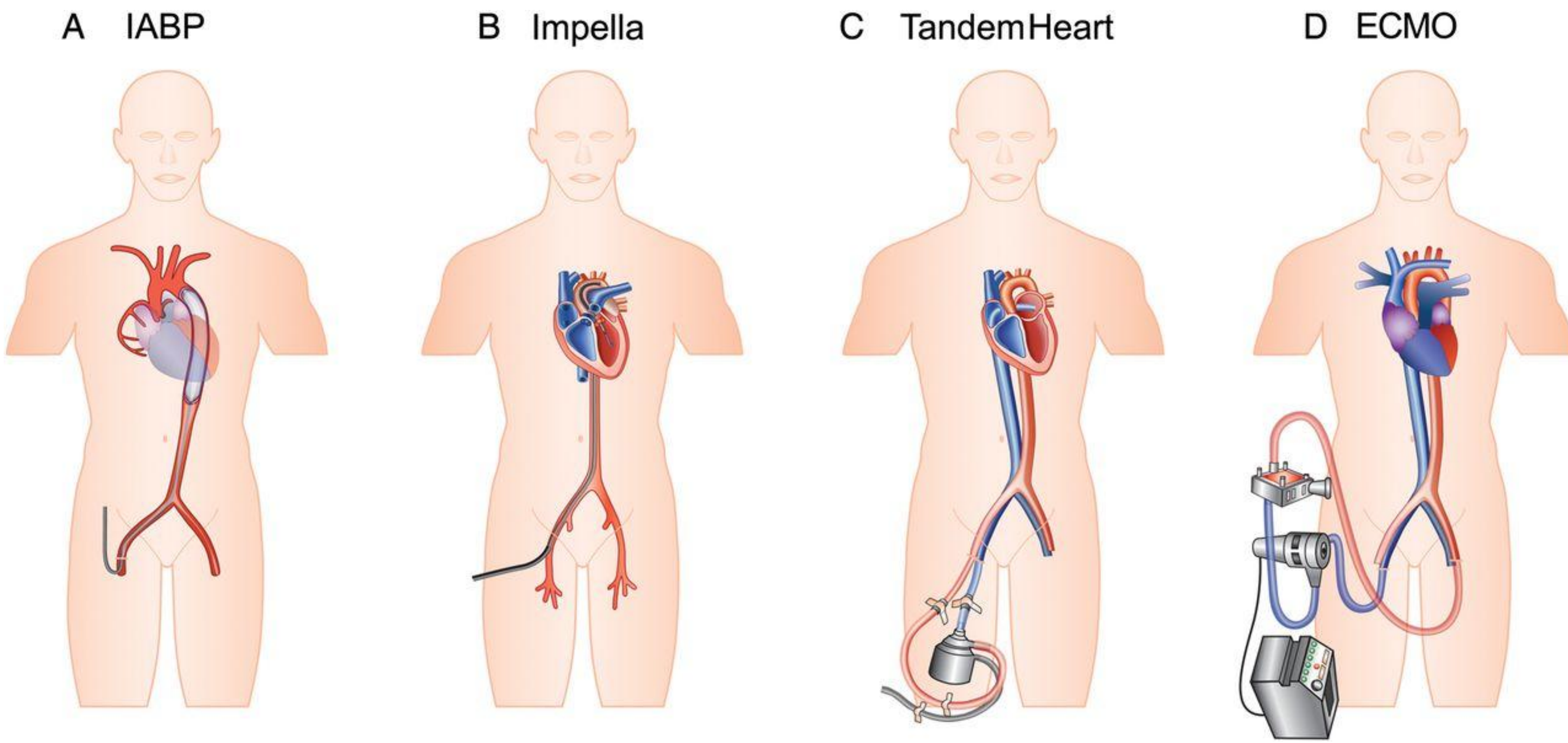
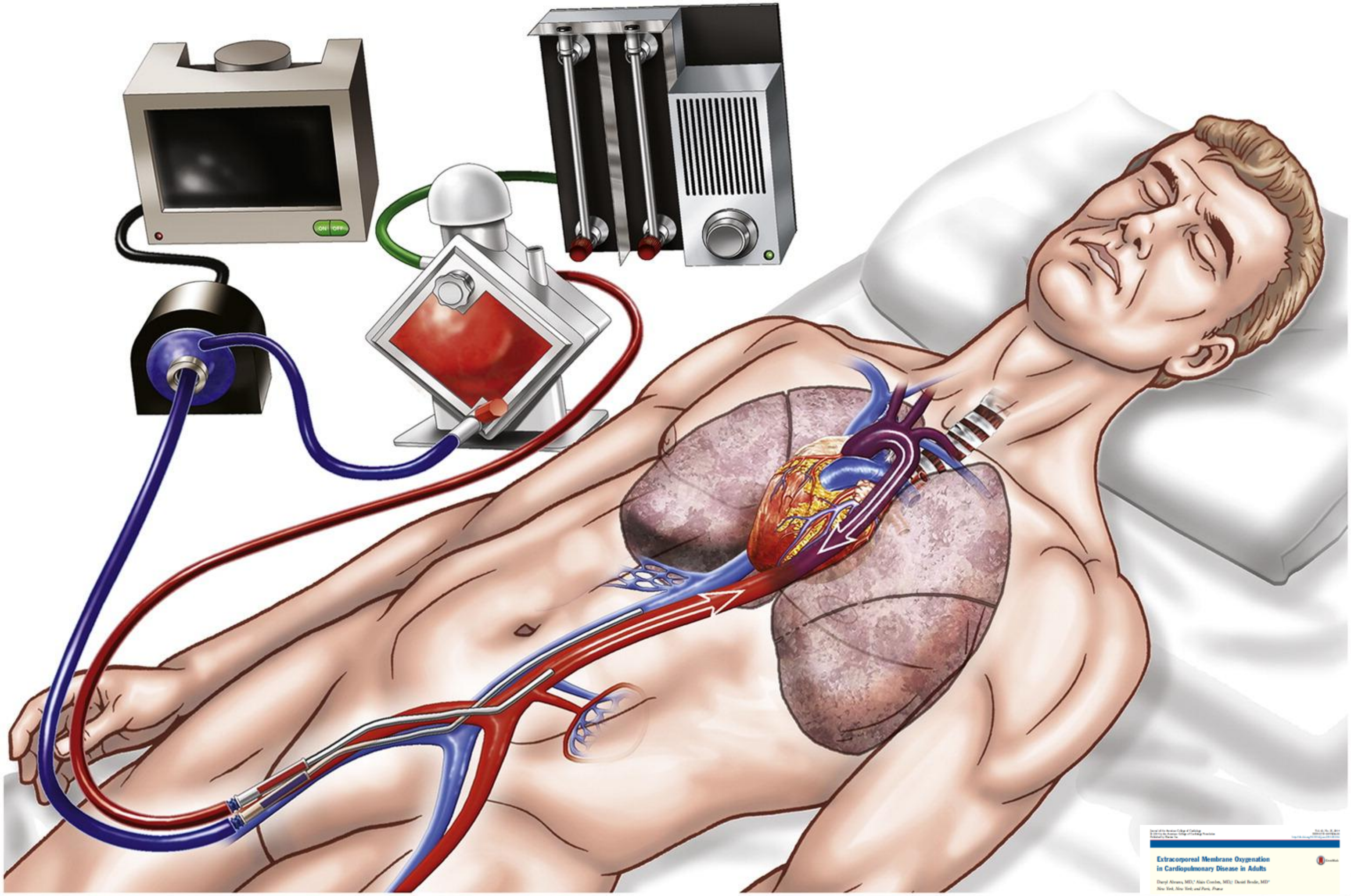
Spectrum of Acute MCS therapies



Is there a perfect MCS strategy

- NO
- All available options have risks/benefits
- Tailored to patient
- Often Incremental
- Fem-Fem VA ECMO a good starting point for most patients

Femoro- femoral VA ECMO



Extracorporeal Membrane Oxygenation in Cardiopulmonary Disease in Adults

Darryl Abrams, MD,* Alain Combes, MD,† Daniel Brodie, MD*
New York, New York; and Paris, France

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VA ECMO use and outcomes

ECLS Registry Report
International Summary
January, 2016

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

	Total Patients	***Survived ECLS***		***Survived to DC or Transfer***	
Neonatal					
Respiratory	28,723	24,155	84%	21,274	74%
Cardiac	6,269	3,885	62%	2,599	41%
ECPR	1,254	806	64%	514	41%
Pediatric					
Respiratory	7,210	4,787	66%	4,155	58%
Cardiac	8,021	5,341	67%	4,067	51%
ECPR	2,788	1,532	55%	1,144	41%
Adult					
Respiratory	9,102	5,989	66%	5,254	58%
Cardiac	7,850	4,394	56%	3,233	41%
ECPR	2,379	948	40%	707	30%
Total	73,596	51,837	70%	42,947	58%

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Myocarditis

Results. Mean VA-ECMO support was 9.9 ± 19 days (range, 2 to 24 days). Cardiac recovery with ECMO weaning was achieved in 43 patients (75.5%), major complications were observed in 40 patients (70.1%), and survival to hospital discharge occurred in 41 patients (71.9%). After hospital discharge (median follow-up, 15 months) there were 2 late deaths. The 5-year actual survival was 65.2% ± 7.9%, with recurrent self-recovering myocarditis observed in 2 patients (at 6 and 12 months from the first AFM event), and 1 heart transplantation.

Venoarterial Extracorporeal Membrane Oxygenation for Acute Fulminant Myocarditis in Adult Patients: A 5-Yea Multi-Institutional Experience

(Ann Thorac Surg 2016;101:919–26)

Table 4. Multivariate Analysis

Variable	β	SE	Exp (β)	*p* Value
pH before ECMO implantation	−14.251	7.148	.000	0.046
Lactate normalization, hours from ECMO implantation	0.029	0.012	1.029	0.013
Cardiac recovery	5.288	1.769	197.930	0.003

VA ECMO : major challenges

- Maintaining LV ejection
- Preventing upper body hypoxia
- Distal limb perfusion

Peripheral VA ECMO: considerations

- Only an adjunct to native heart
- ↑LV after load and ↓LV ejection
- Pulmonary reserve and upper body hypoxia

Attempts to ↑ LV ejection worsen upper body hypoxaemia in setting of ↓pulmonary function

Pulmonary reserve and peripheral VA ECMO

- Normal
- Marginal
- Can get worse subsequently : pulmonary edema , haemorrhage , infection etc

Do marginal lungs matter if heart is not ejecting well ?

Cardiac reserve and peripheral VA ECMO

- Can get better or worse
- Consequences depend on pulmonary reserve and LV distension and need for venting

Fem –fem VA ECMO

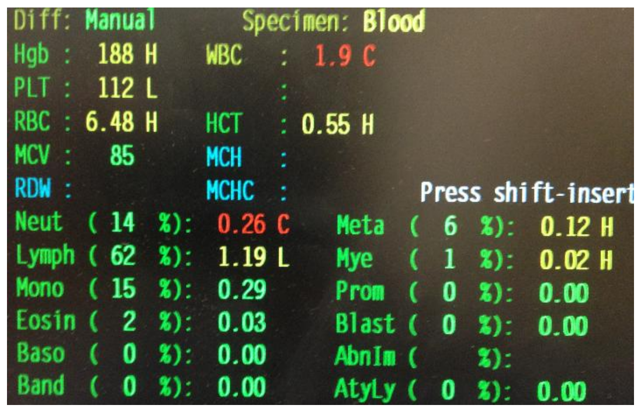
If lungs good ,

Double thumbs up !!

If not,

bit of a problem

16 y old ,pneumonia , septic shock



Day 1 SOFA score = 17

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16 y old ,pneumonia , septic shock

- Presenting in extremis
- Severe cardiac failure , but not critically hypoxic
- Urgent fem-fem VA ECMO
- Over next 2 days heart gets better, lungs get worse -> differential hypoxia
- Changed to VV ECMO
- Weaned off VV ECMO after 44 days

Understanding differential hypoxia

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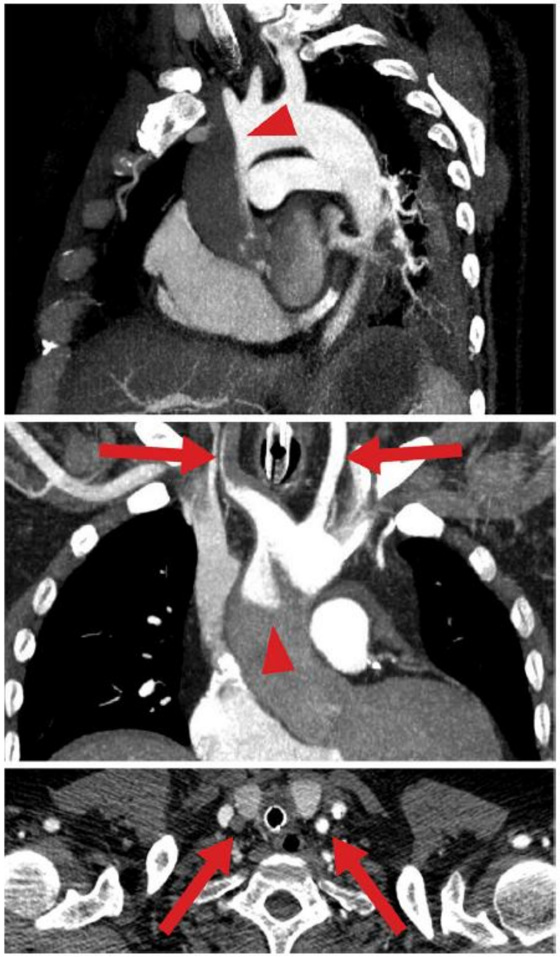
Peripheral VA ECMO and systemic oxygenation



Minimal LV ejection +/- bad lungs = retrograde perfusion from ECMO= less risk of upper body hypoxia

Some LV ejection + bad lungs = upper body hypoxia

Clin Res Cardiol (2016) 105:283–296

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fem–fem VA ECMO and harlequin

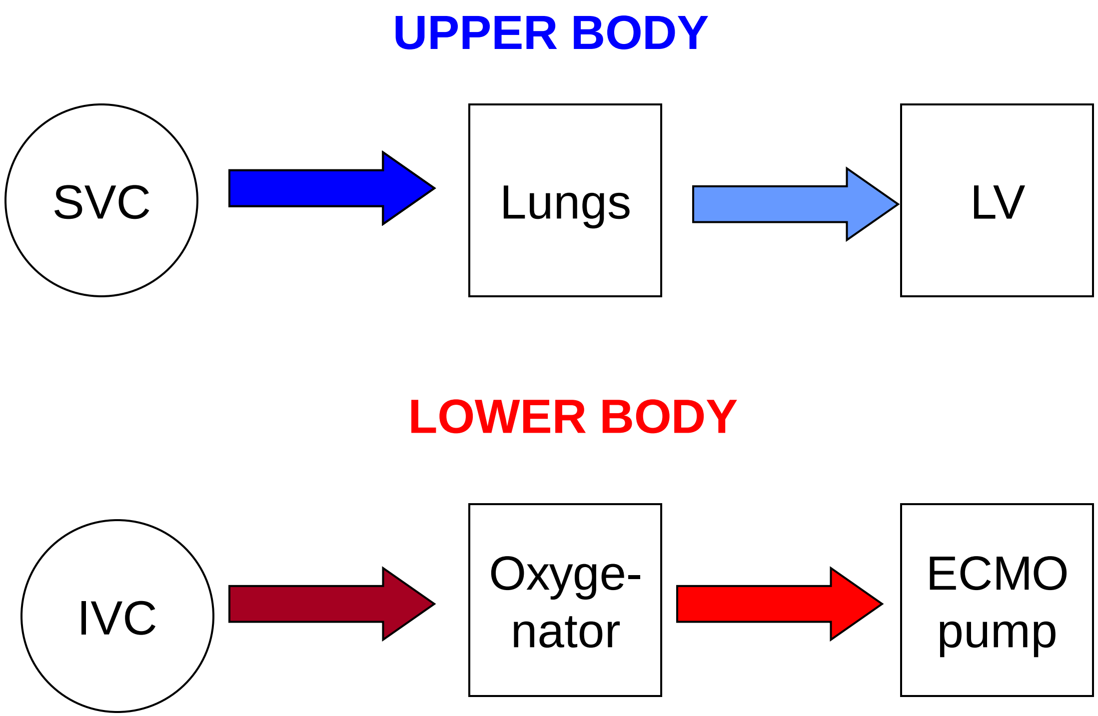
- Differential venous oxygen return

SVC Sao2 <<< IVC Sao2

- Lower body perfused with ECMO and upper body from native cardiac ejection

Two circuits

Two independent circuits



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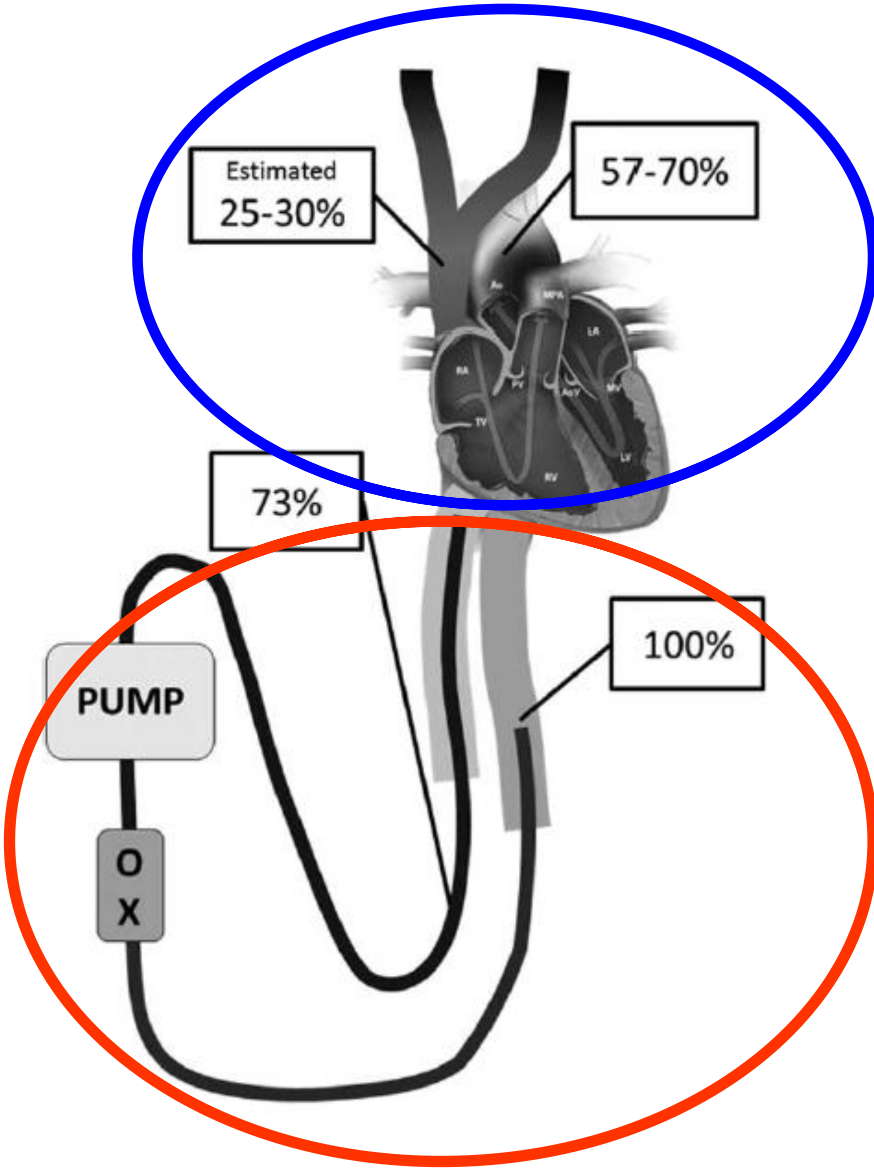

Note drainage cannula in IVC

RA drainage much better and preferred

*†Mattias Lindfors, *‡Björn Frenckner,
§¶Ulrik Sartipy, ¶**Anna Bjällmark,
and *†**Michael Broomé

Artificial Organs 2016, 00(00):00–00

Hou et al. Critical Care (2015) 19:68
DOI 10.1186/s13054-015-0791-2

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Superior vena cava drainage improves upper body oxygenation during veno-arterial extracorporeal membrane oxygenation in sheep

Xiaotong Hou[1,2*], Xiaofang Yang[1,2], Zhongtao Du[1,2], Jialin Xing[1,2], Hui Li[2,3], Chunjing Jiang[1,2], Jinhong Wang[1,2], Zhichen Xing[1,2], Shuanglei Li[1], Xiaokui Li[4], Feng Yang[1,2], Hong Wang[1,2] and Hui Zeng[5,6*]

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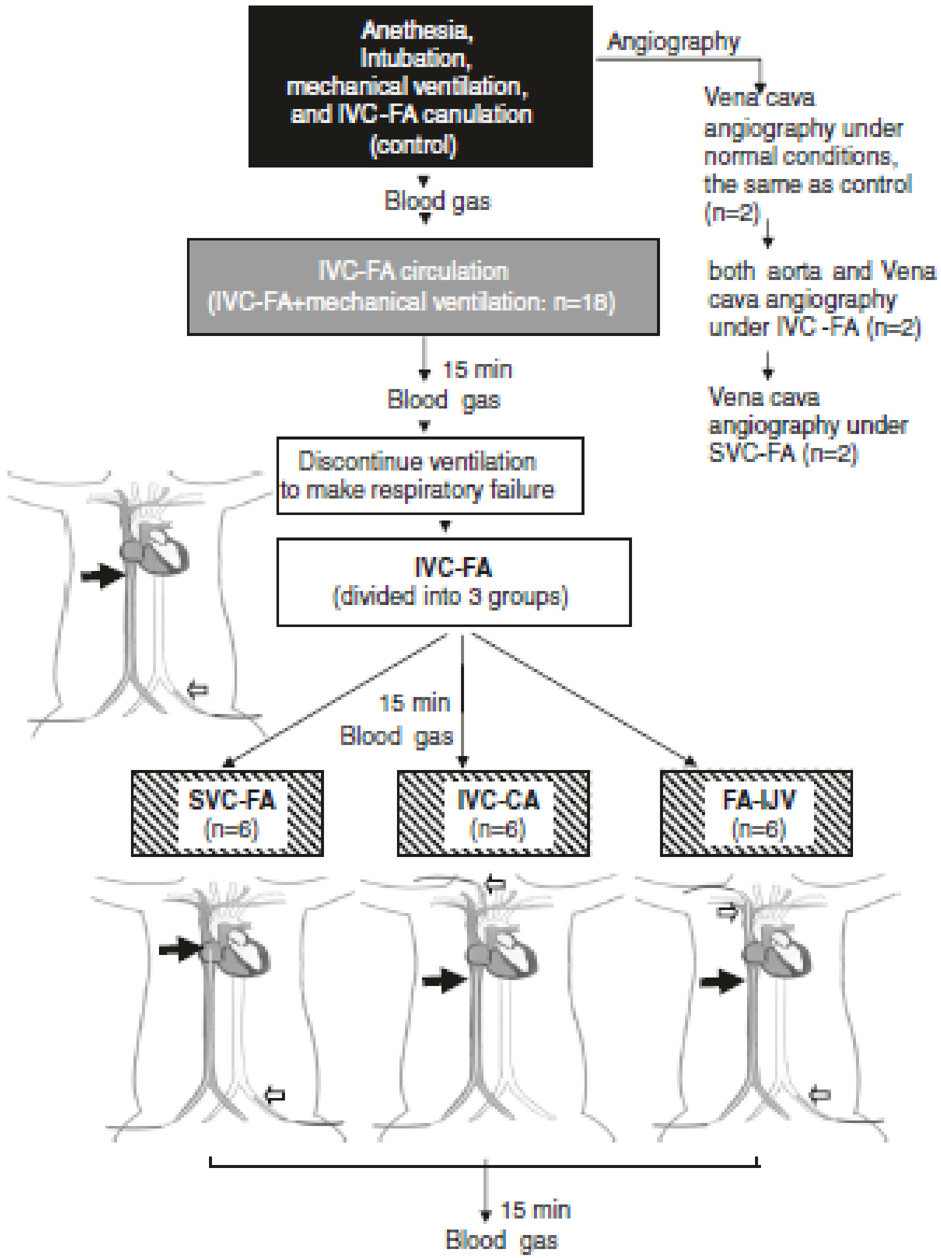

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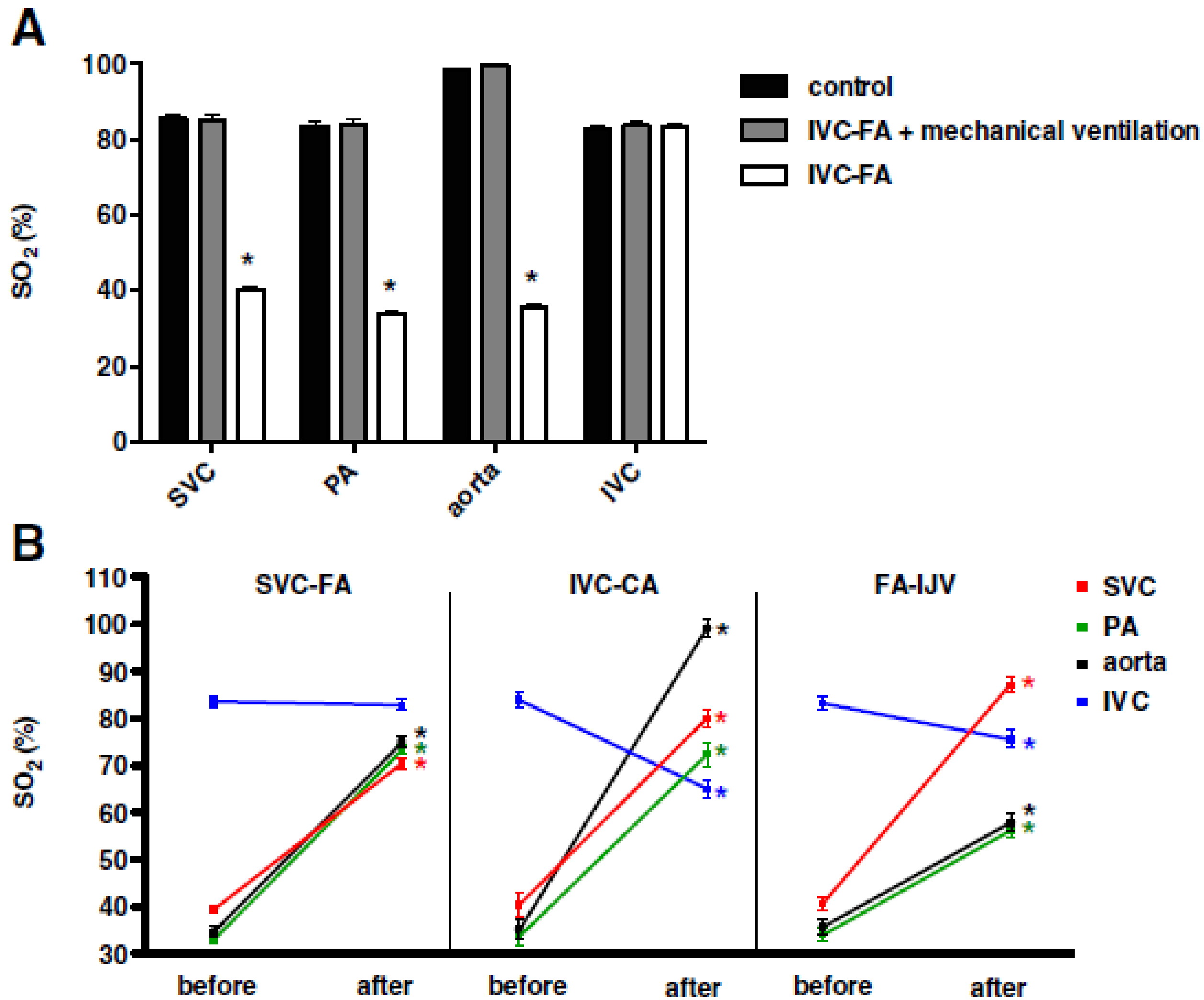

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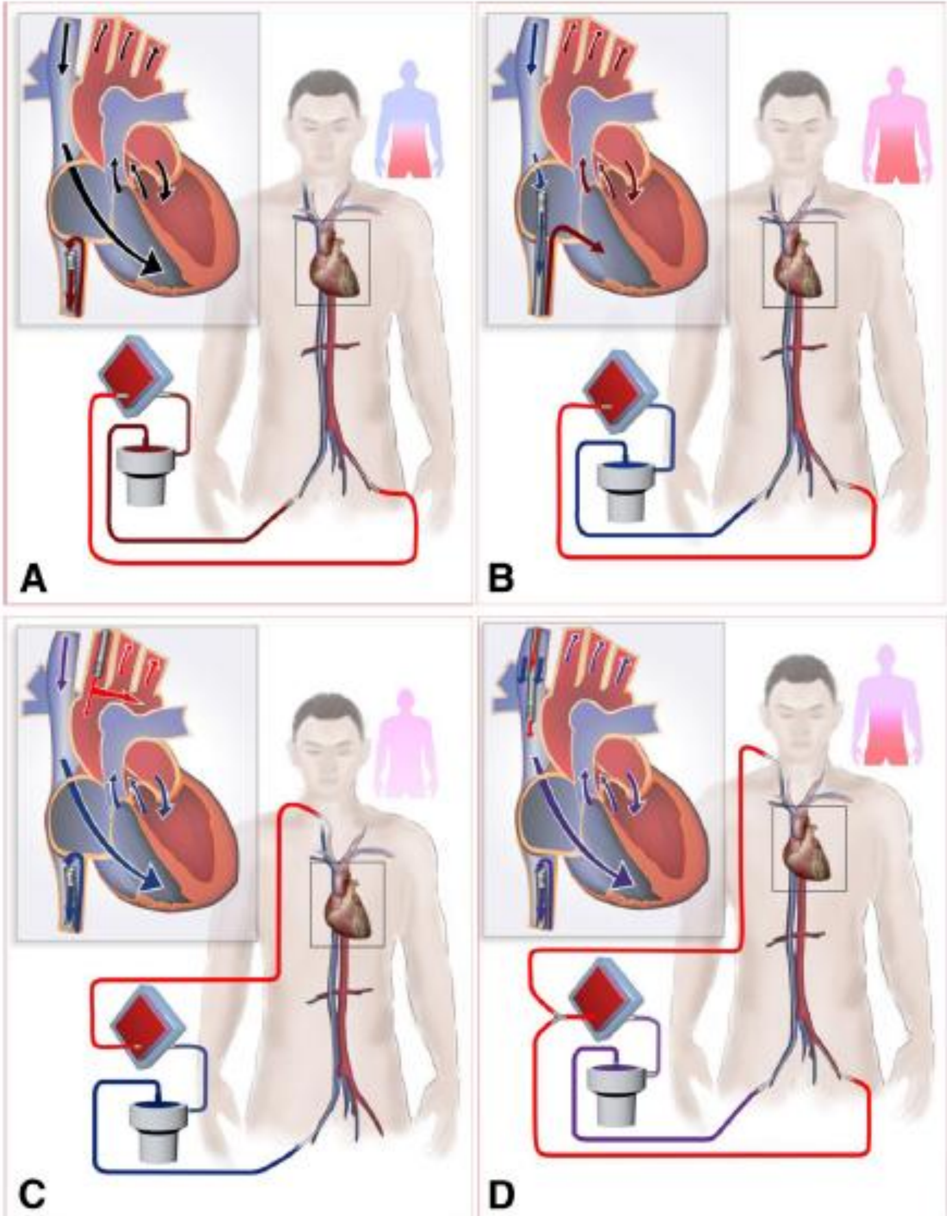
Is IVC-FA really a good option?

Table 1 The difference of oxygen saturation between IVC-FA and other approaches of cannulation

	SVC-FA	IVC-CA	FA-IJV
SVC	30.9 ± 0.5	39.6 ± 1.7*	46.4 ± 1.4*
PA	40.2 ± 1.4	38.3 ± 1.2	22.0 ± 0.4$^{*\#}$
Aorta	40.3 ± 0.9	63.9 ± 1.3*	22.1 ± 0.6*§
IVC	−1.3 ± 0.9	−18.8 ± 1.8*	−7.6 ± 0.7$^{*\#}$


A
B
C
D

Retrograde flow on IVC-FA VAECMO

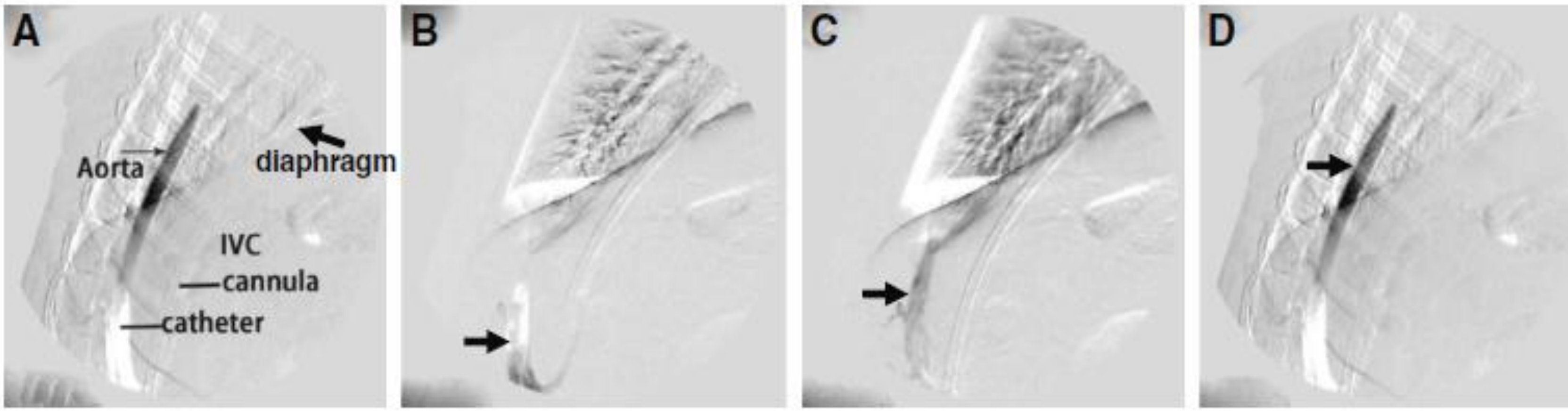
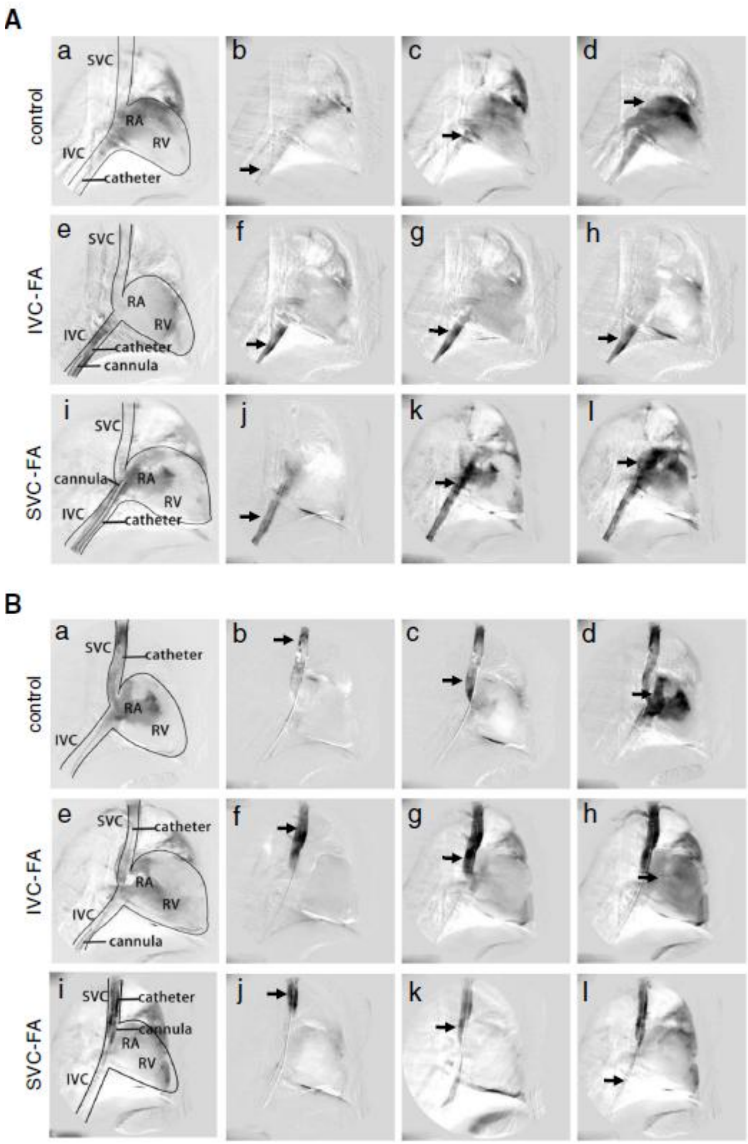


Figure 3 Aorta angiography in IVC-FA. (a) The diagram of aorta angiography. **(b)** Representative photos in the early stage of angiography. **(c)** Representative photos in the intermediate stage of angiography. **(d)** Representative photos in the late stage of angiography. The black arrow shows the contrast medium, which could only reach the diaphragm level. IVC-FA: inferior vena cava through the femoral vein and a return cannula was inserted into the femoral artery.

SVC-FA vs. IVC -FA



IVC-FA : contrast from IVC doesn't reach RA

SVC –FA: contrast from SVC doesn't reach RA

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Harlequin avoidable

- Optimal RA drainage from start
- Careful monitoring
- Optimal medical management
- Timely change of ECLS configurations

Monitoring for differential hypoxia

- Spo2/Pao2 both radial arteries, esp. R radial
- Neuro monitoring , NIRS, Bto2
- Jugular oximetry
- PA catheter -> SVO2
- Pre oxygenator sao2/pao2 poor predictors

Disrupting differential hypoxia

Medical measures

- Optimise mechanical ventilation , add inhaled nitric oxide /prostacyclin
- Minimise O_2 consumption : sedation, paralysis, hypothermia
- Haemoglobin ~100
- Reduce inotropy if possible
- Modulate HR if native CO relatively high
- ↑ECMO blood flows transiently

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Harlequin :problem or positive sign ?

- Bad news is lungs are bad
- Good news is heart is ejecting

Is the heart good enough to wean from VA ECMO

Perfusion strategies

- Change to VV ECMO ± inotropes, IAB/ pVAD
- Advance IVC cannula to RA/SVC
- VAV :Return oxygenated blood to RA
- VVA: additional SVC drainage cannula
- Upper body arterial return: subclavian
- Central VA ECMO
- LVAD/BiVAD configurations with oxygenator in circuit

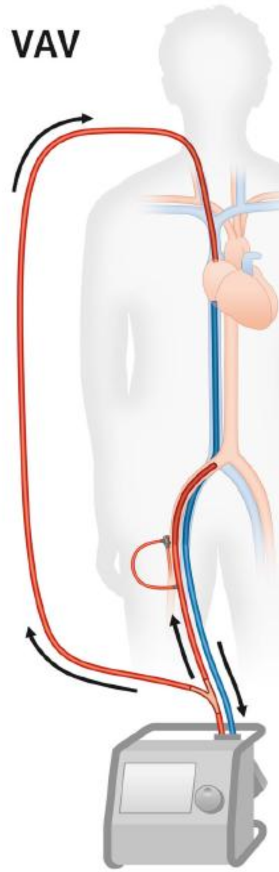
Change to VV

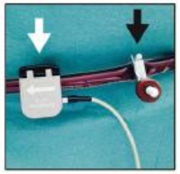
- Tricky as heart not fully recovered
- Turn down for assessment may precipitate upper body hypoxia crisis due to ↑LV ejection
- Much safer to have another venous cannula in before turn down : if heart good change to VV if not to VAV
- If heart not fully recovered –pVAD one short term option

Push IVC cannula into SVC

- Safety concerns
- Dual lumen catheters often limit flows and ↑hemolysis
- Not recommended as first line option

VAV ECMO





Return on left and right side of circulation

Increases respiratory support

Decreases cardiac support

Modulating return flows on both sides can be tricky

L. Christian Napp[1] · Christian Kühn[2] · Marius M. Hoeper[3] · Jens Vogel-Claussen[4] · Axel Haverich[2] · Andreas Schäfer[1] · Johann Bauersachs[1]

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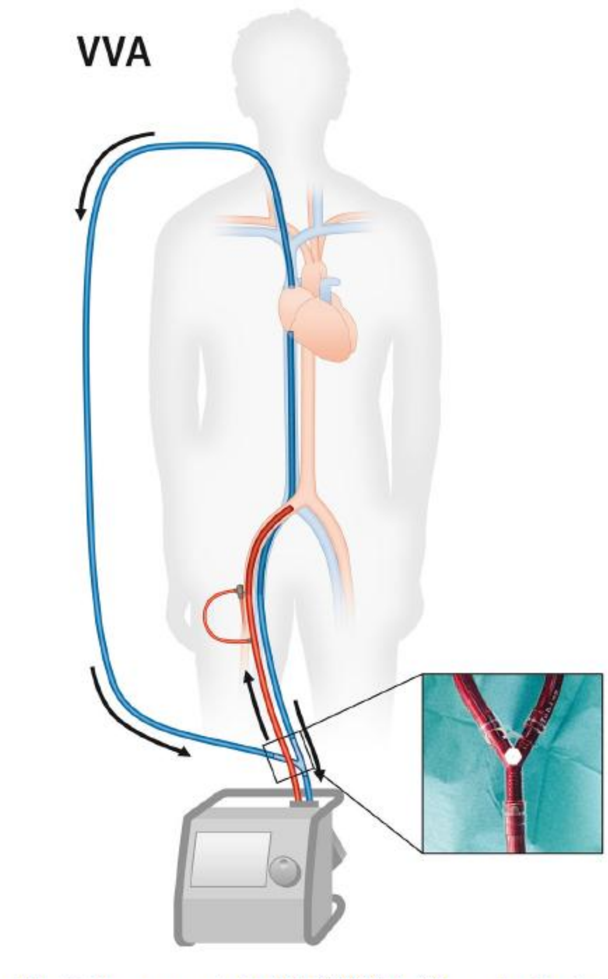
VVA ECMO



Better RV unloading

Draining hypoxic SVC blood for oxygenation

Dual lumen cannula an option but flows limited

L. Christian Napp[1] · Christian Kühn[2] · Marius M. Hoeper[3] · Jens Vogel-Clausen[4] · Axel Haverich[2] · Andreas Schäfer[1] · Johann Bauersachs[1]

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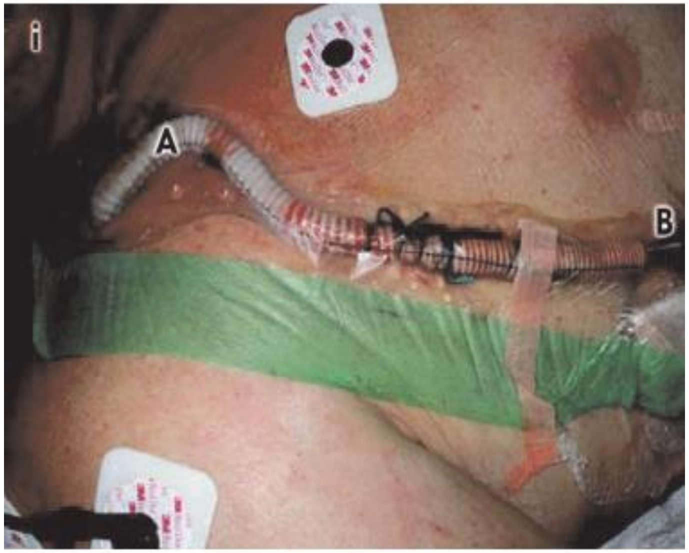
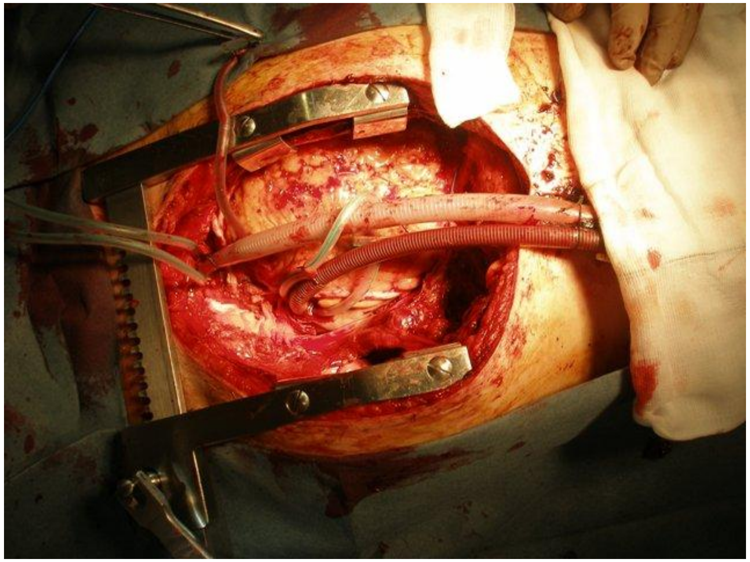
Subclavian /axillary/carotid return



Cannulation not always possible

Differential flows UL oedema

Central VA ECMO



More relevant to paediatrics

Invasive procedure in sick patients

Allows for LV venting if need be

Bleeding risks

LVAD /RVAD/ BiVAD with oxygenator in circuit

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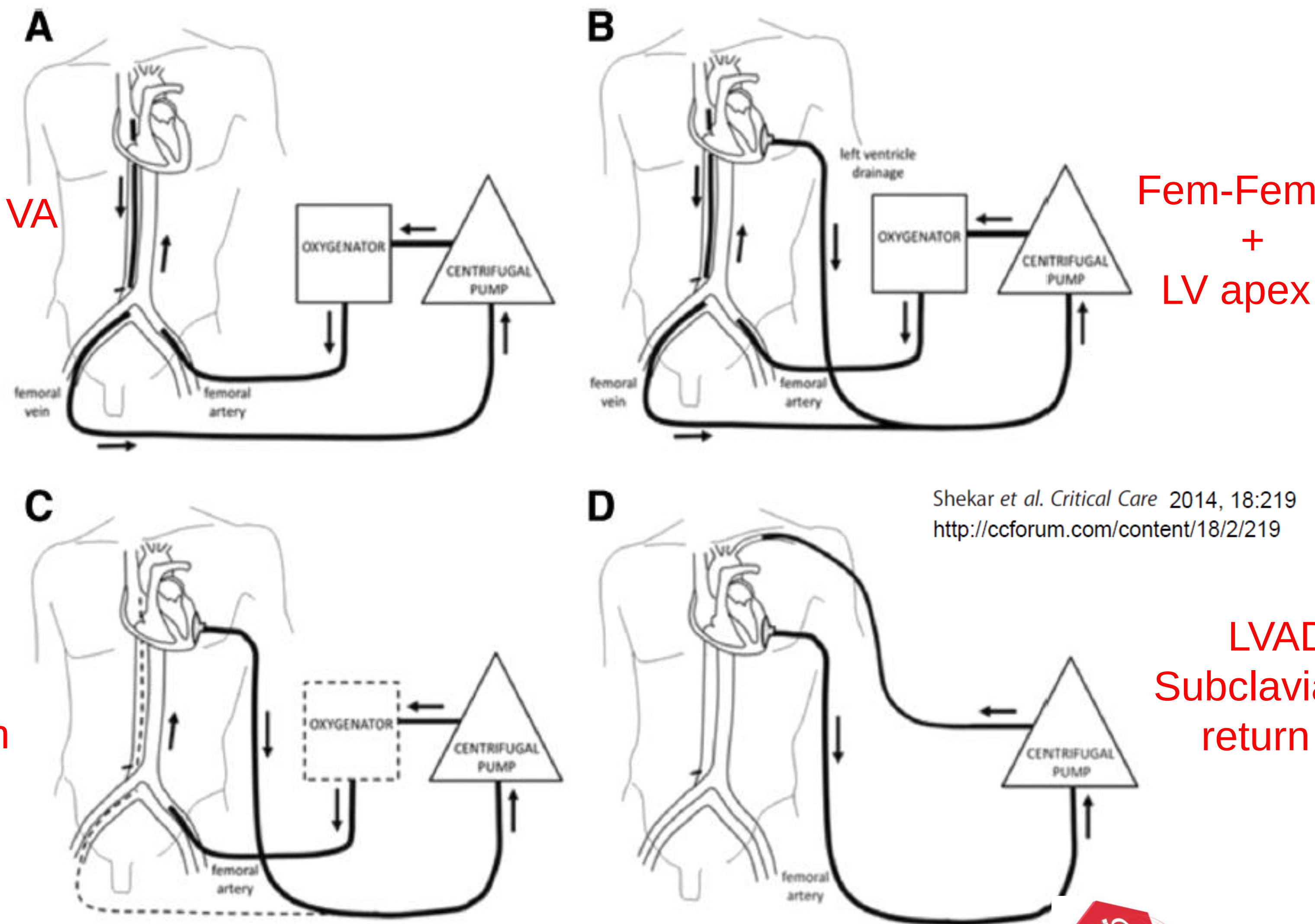
ECMO circuit as temp VAD

Fem –Fem VA

Fem-Fem VA
+
LV apex vent

LVAD
Fem return

LVAD
Subclavian
return



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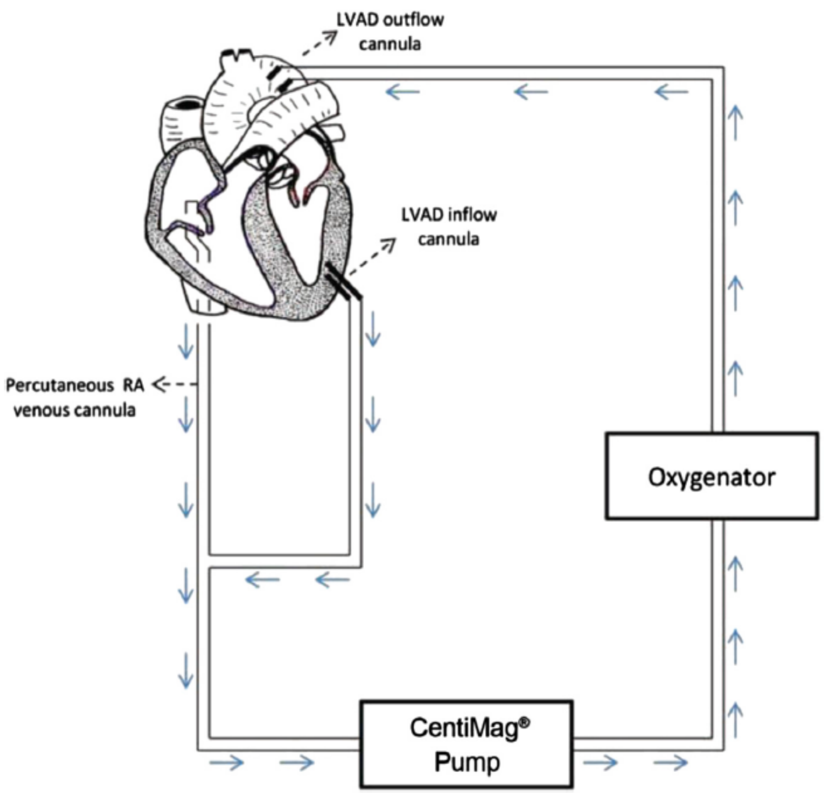
ECMO circuit as temp BiVAD



- 1 pump
- 2 pumps
+/- Oxygentorar

Shekar *et al. Critical Care* 2014, 18:219
http://ccforum.com/content/18/2/219

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Other Alternatives

Combining pVADs (Impella or Tandem Heart) with VV ECMO

- costs
- short term use and arterial complications
- Hemolysis

Summary

- Harlequin syndrome a real problem esp. with fem-fem VA ECMO
- Draining just IVC/SVC suboptimal
- RA drainage and optimal medical management minimizes risks
- Early recognition and timely change of ECLS configurations critical

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A very warm welcome to Brisbane

   

APELSO Gold Coast, Australia, October 2017

The 3rd Conference of

Asia-Pacific Extra-Corporeal Life Support Organization

ECMO ….and Beyond

www.apelso2017.com

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Australia

Audax at Fidelis
Queensland Government

International ECMONet ECMO Network

Australian Government
National Health and Medical Research Council
NHMRC

The Alfred

St Vincents & Mater Health Sydney

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- Aston University
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- St Vincents Hospital
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