ECMO for lung transplant

Tim Pennel

GROOTE SCHUUR HOSPITAL
HEART AND LUNG TRANSPLANT UNIT

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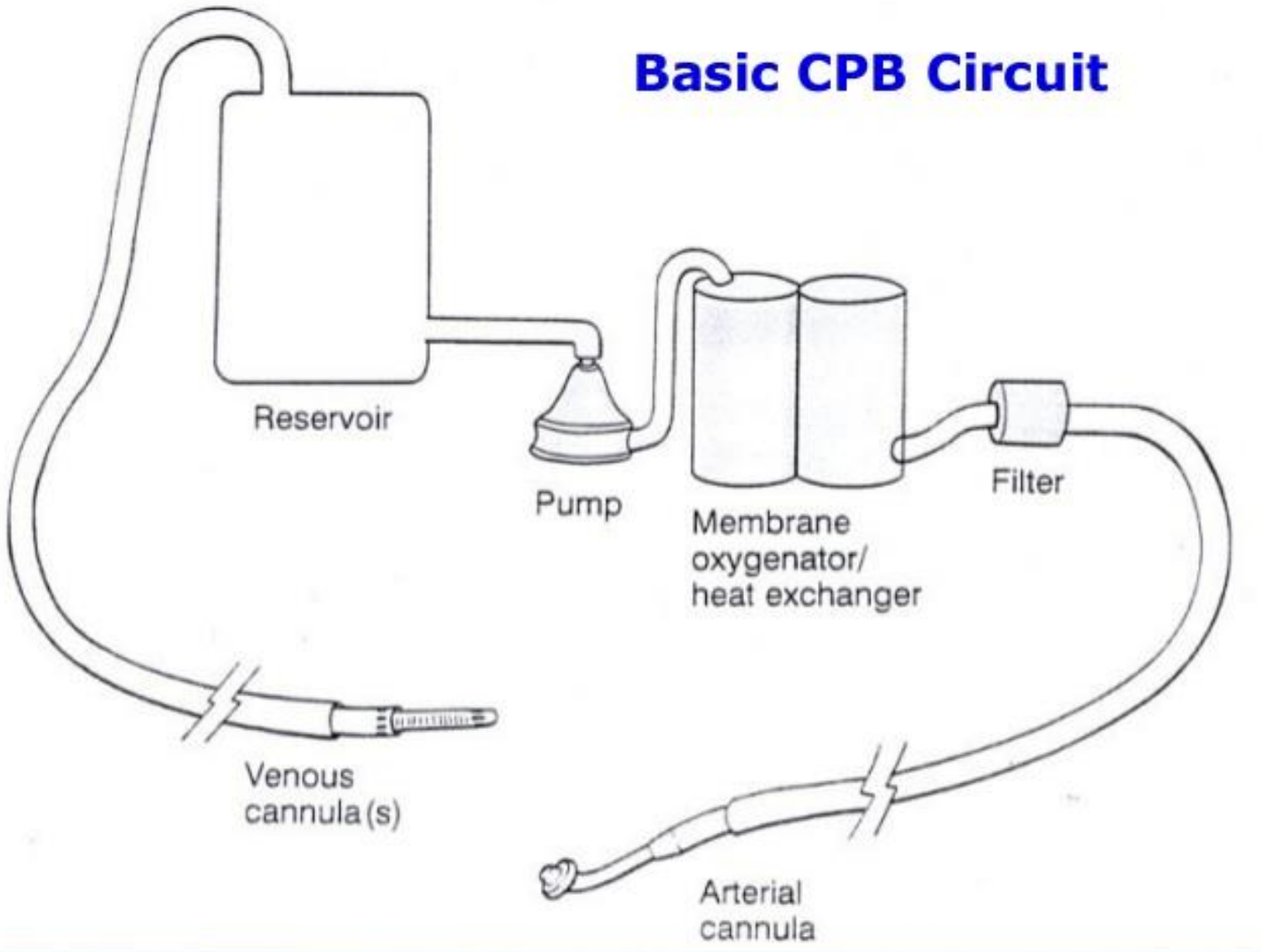
Extracorporeal Membrane Oxygenation

ECMO/ECLS ≠ Treatment

Supportive not disease modifying

Cardiopulmonary Bypass vs ECMO



Post-cardiotomy mechanical circulatory support using a conventional bypass circuit in children

Nirav C. Patel, M. Jothi, Dipesh B. Trivedi, Graham Sabino, Paul Daly, Peter D. Booker, Marco Pozzi*

Department of Cardiac Surgery, Alder Hey Children's Hospital, Eaton Road, Liverpool L12 2AP, UK

European Journal of Cardio-thoracic Surgery 20 (2001) 811–815

What Defines a Contemporary ECMO Circuit?

1. Centrifugal Pump
2. Heparinised Circuit
3. Polymethylpentene Membrane
4. No Reservoir

Run “automated”

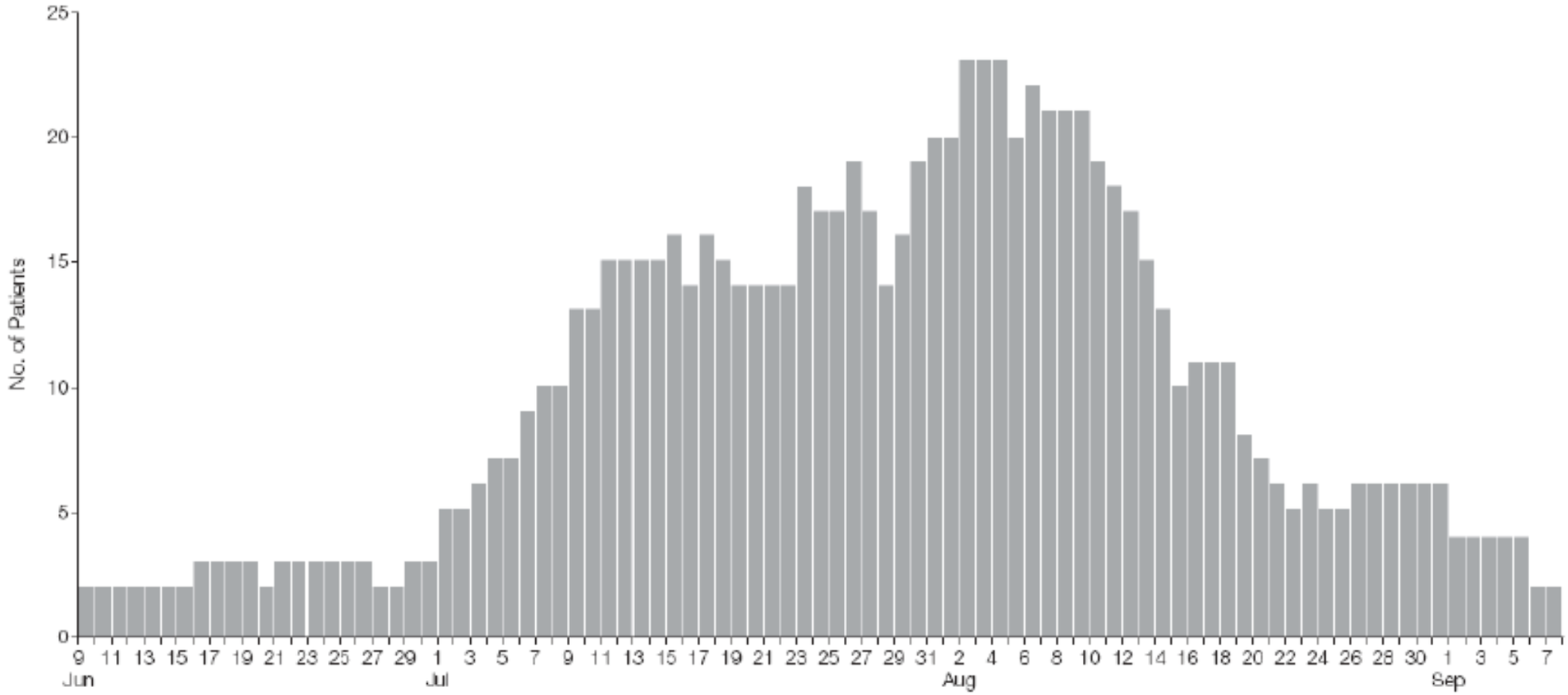
The Role in ECMO in Lung Transplantation

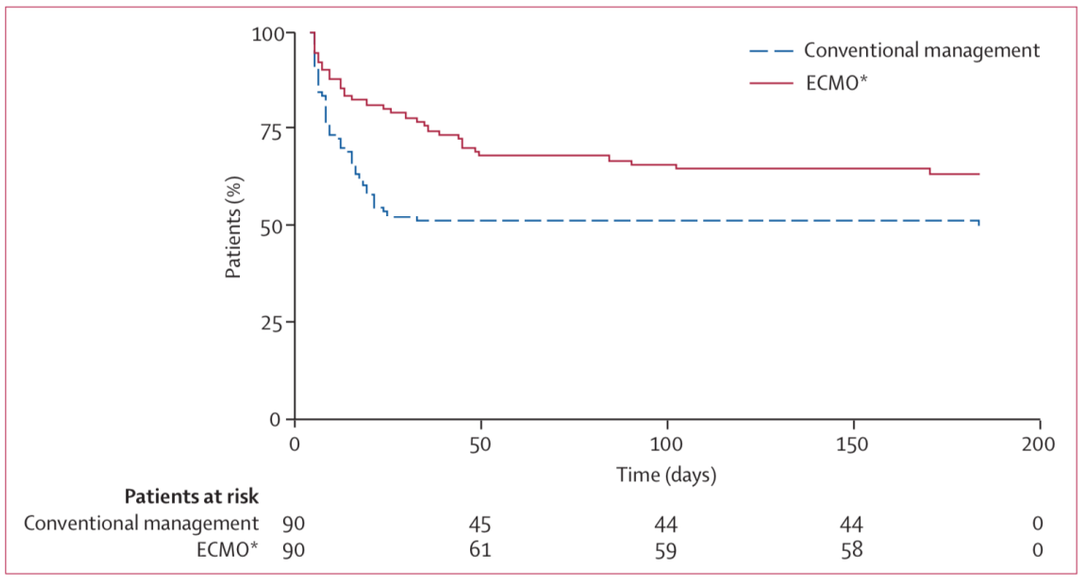
Extracorporeal Membrane Oxygenation for 2009 Influenza A(H1N1) Acute Respiratory Distress Syndrome

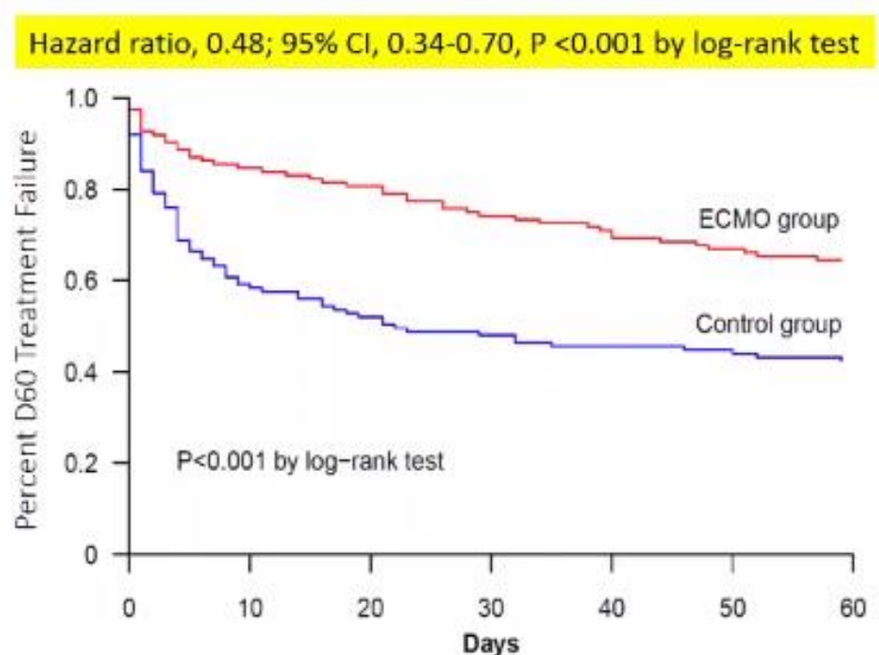
The Australia and New Zealand Extracorporeal Membrane Oxygenation (ANZ ECMO) Influenza Investigators*

JAMA. 2009;302(17)

Figure 2. Histogram of Number of Concurrent Patients Receiving ECMO Across Australia and New Zealand in 2009







Extracorporeal Membrane Oxygenation as "Bridge" to Lung Transplantation: What Remains in Order to Make It Standard of Care?

Lorenzo Del Sorbo, M.D.
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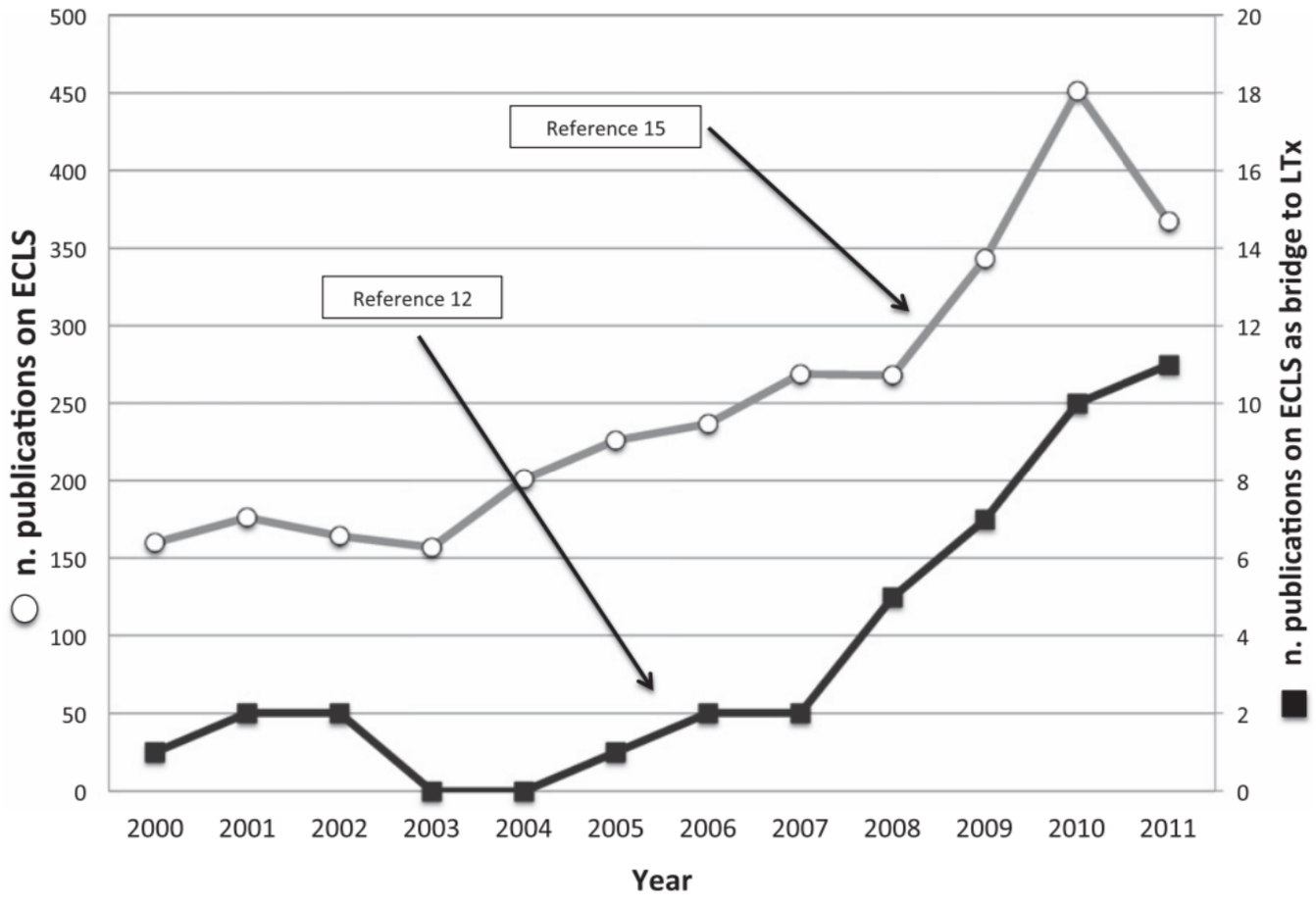
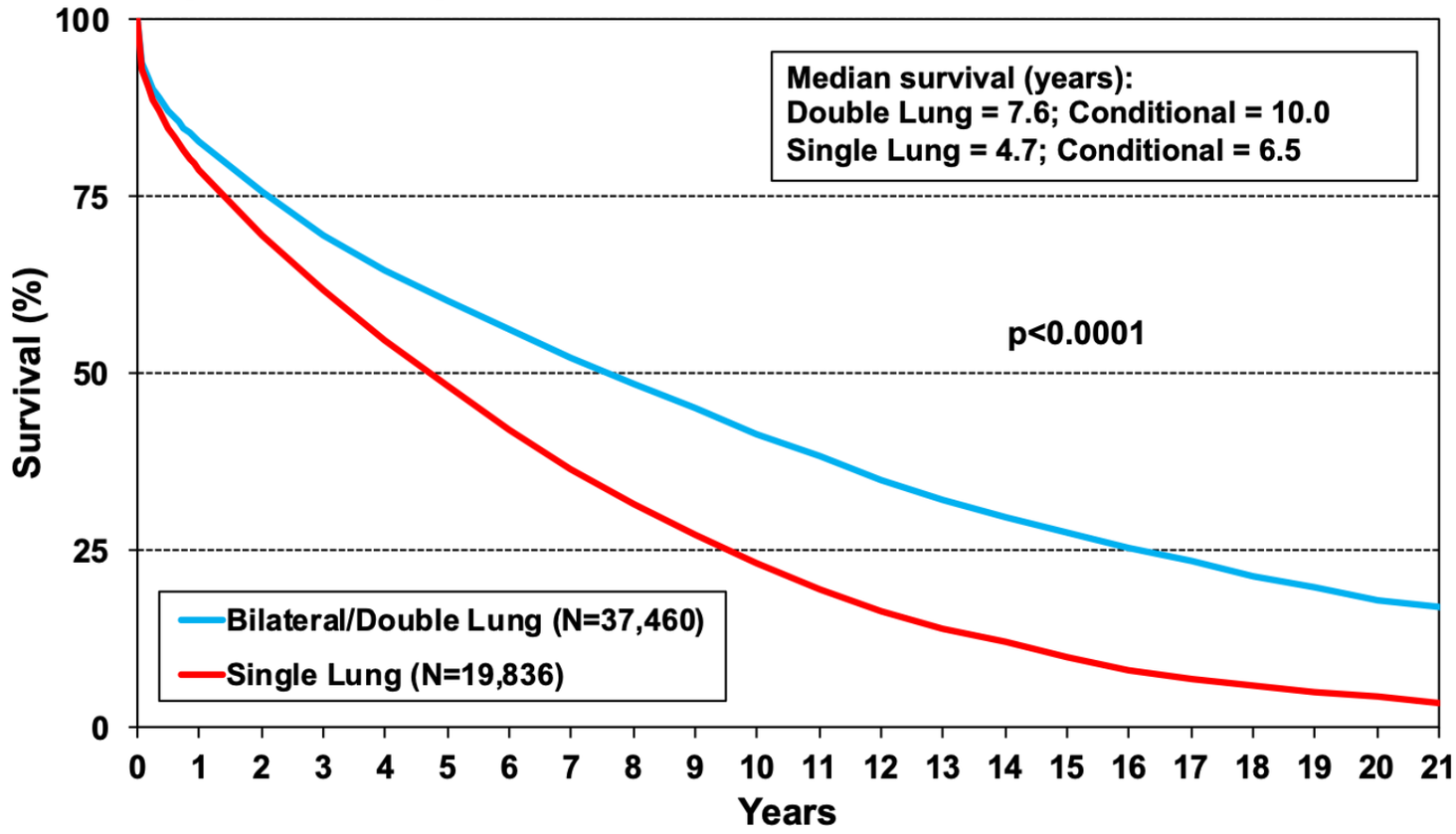


Figure 1. Number of articles on extracorporeal life support (ECLS) (*gray line, left vertical axis*) and ECLS as bridge to LTx (*black line, right vertical axis*), published on PubMed for each year from 2000 until 2011.

Adult Lung Transplants

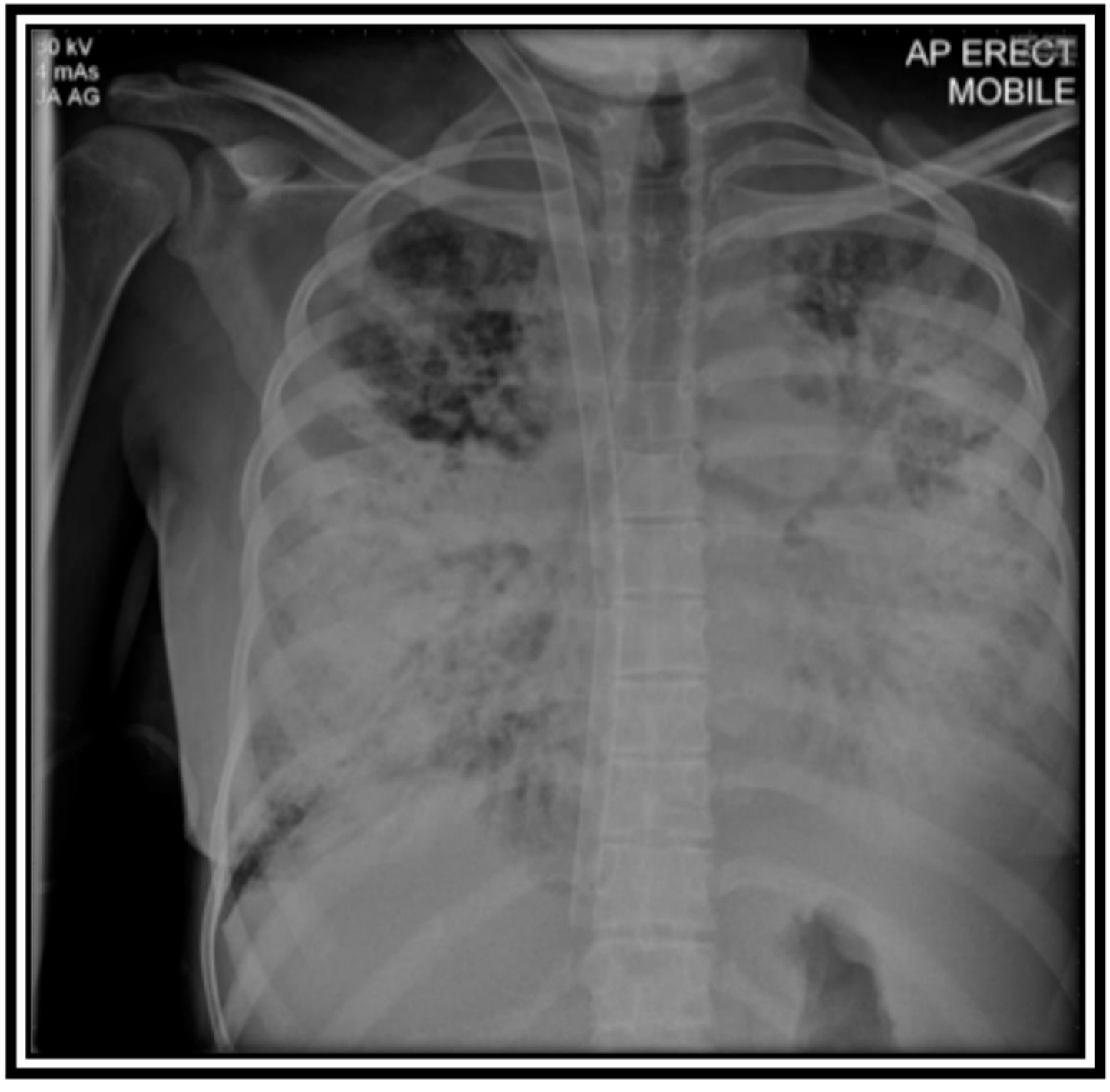
Kaplan-Meier Survival by Procedure Type for Primary Transplant Recipients (Transplants: January 1990 – June 2016)



ISHLT 2018
ISHLT • INTERNATIONAL SOCIETY FOR HEART AND LUNG TRANSPLANTATION
JHLT. 2018 Oct; 37(10): 1155-1206

Study	Year	Number of Patients	1-year survival (%)
Hoetzenecker	2018	71	70
Todd	2017	12	100
Toyoda	2013	24	74
Hoopes	2013	31	93
Lafarge	2012	30	66.5
Bittner	2012	27	33
Hammainen	2011	13	92

Awake Ambulatory



Mechanical Ventilation and Extracorporeal Membrane Oxygenation as a Bridging Strategy to Lung Transplantation: Significant Gains in Survival

A. J. Hayanga[1,†], A. L. Du[2,†], K. Joubert[1], M. Tuft[3], R. Baird[1], J. Pilewski[4], M. Morrell[4], J. D'Cunha[1] and N. Shigemura[1,*]

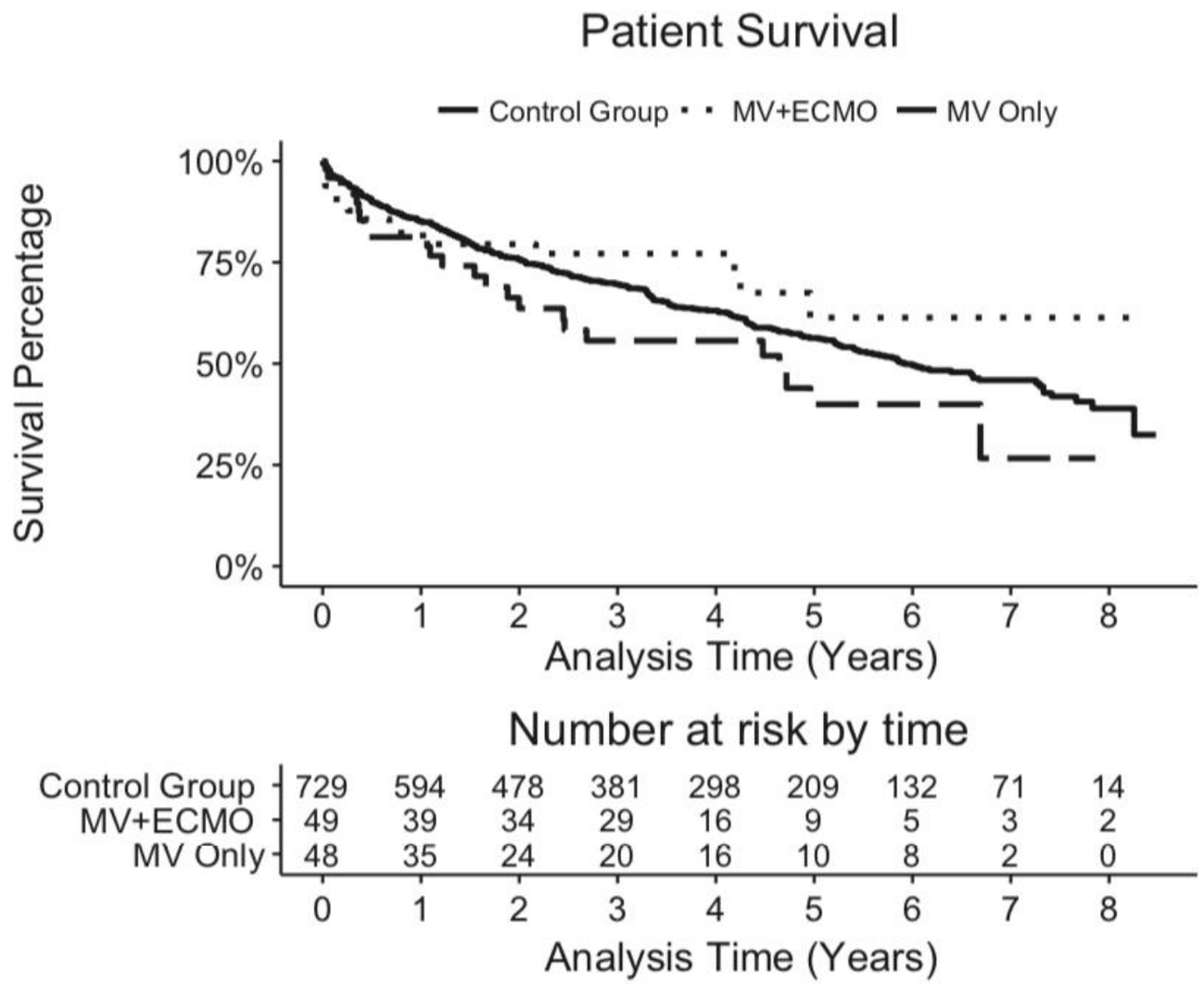
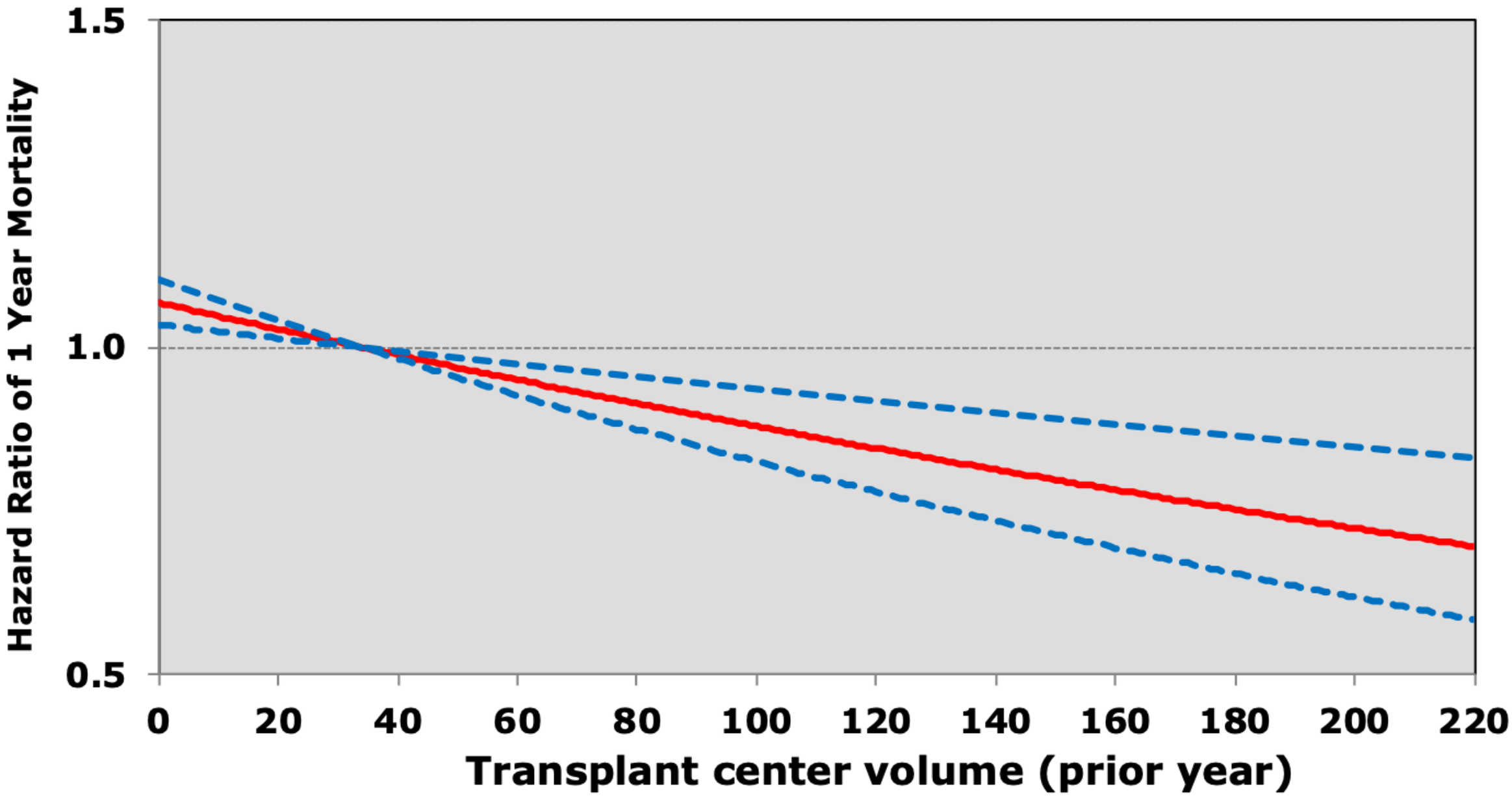


Figure 1: Kaplan-Meier analysis of overall survival after lung transplantation.

Risk factors for 1-year mortality



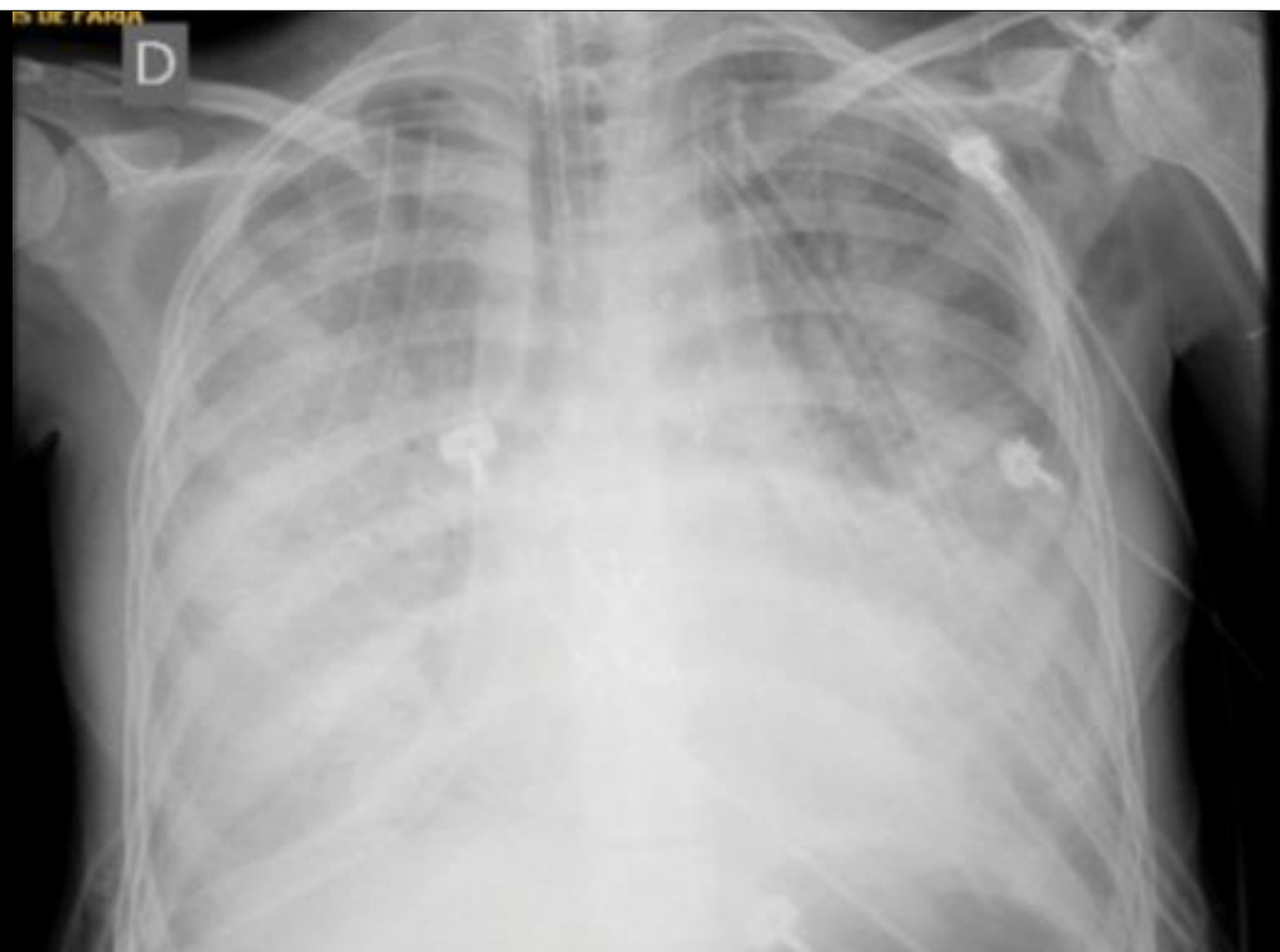
JHLT, 2016.

Intraoperative ECMO

PGD

Primary graft dysfunction

- PGD is a form of Acute Lung Injury
- Occurs within the first few days after allograft reperfusion in lung transplant recipients
- The incidence of PGD is 10–30%
- Major cause of mortality within the first post-transplant year

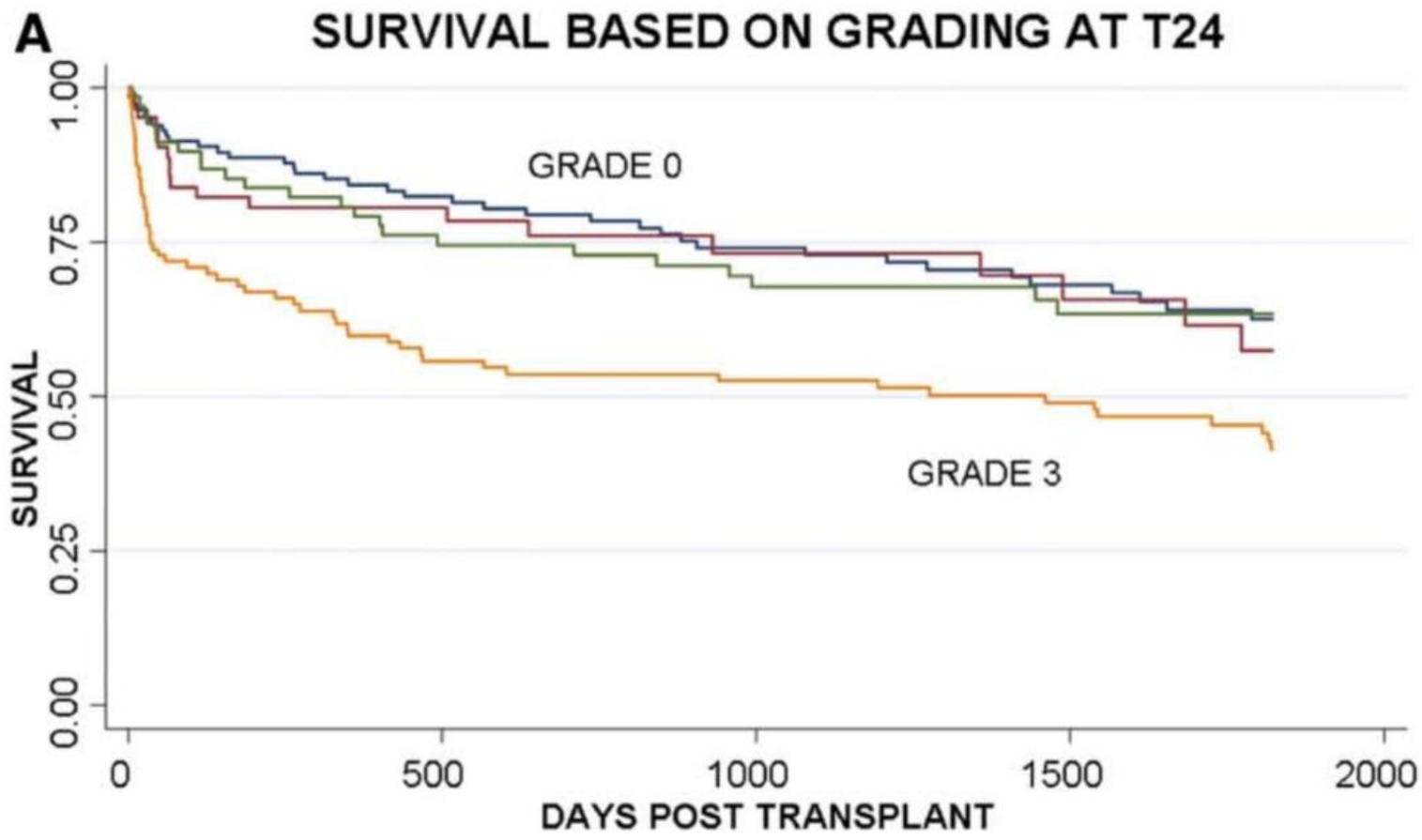


Construct validity of the definition of primary graft dysfunction after lung transplantation

The Journal of Heart and Lung Transplantation

http://www.jhltonline.org

Jason D. Christie, MD, MS,[a,b] Scarlett Bellamy, PhD,[b] Lorraine B. Ware, MD,[c] David Lederer, MD,[d] Denis Hadjiliadis, MD, MHS,[a] James Lee, MD,[a] Nancy Robinson, PhD,[b] A. Russell Localio, PhD,[b] Keith Wille, MD,[e] Vibha Lama, MD,[f] Scott Palmer, MD,[g] Jonathan Orens, MD,[h] Ann Weinacker, MD,[i] Maria Crespo, MD,[j] Ejigaehu Demissie, MSN,[a] Stephen E. Kimmel, MD, MS,[b,k] and Steven M. Kawut, MD, MS[a,b]



Christie et al. J Heart Lung Transplant 2010

Donor

Age

Brain Death

DCD

Smoking

Intra-Op

Controlled Reperfusion

Ventilation

CPB

Single Lung

Lobar

Bleeding

Recipient

Other factors?

PHT

Prolonged Ischaemic time

Mechanical Support for Lung Transplant

Cardiopulmonary Bypass

Protective Ventilation

Controlled reperfusion

Bleeding

Pro Inflammatory

First Lung Syndrome

Courtesy Konrad Hoetzenecker, MD PhD

AKH Vienna

Intraoperative Phases for MCS

1. Anaesthetic Indution
2. One Lung Ventilation
3. PA Clamping
4. Reperfusion Phase
5. Second Lung Implantation

No Support vs CPB

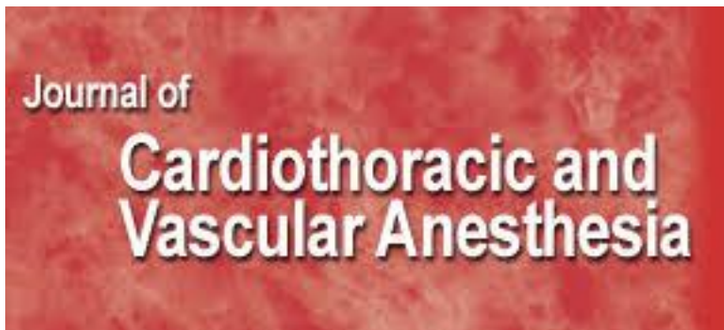
Pro: Lung Transplantation Should Be Routinely Performed With Cardiopulmonary Bypass

Nandor Marczin, MD, PhD, David Royston, MB, and Magdi Yacoub, FRS

Con: Lung Transplantation Should Not Be Routinely Performed With Cardiopulmonary Bypass

Karen McRae, MDCM, FRCPC

Journal of Cardiothoracic and Vascular Anesthesia (2000)



Artificial Organs

Replacing Cardiopulmonary Bypass with Extracorporeal Membrane Oxygenation in Lung Transplantation Operations

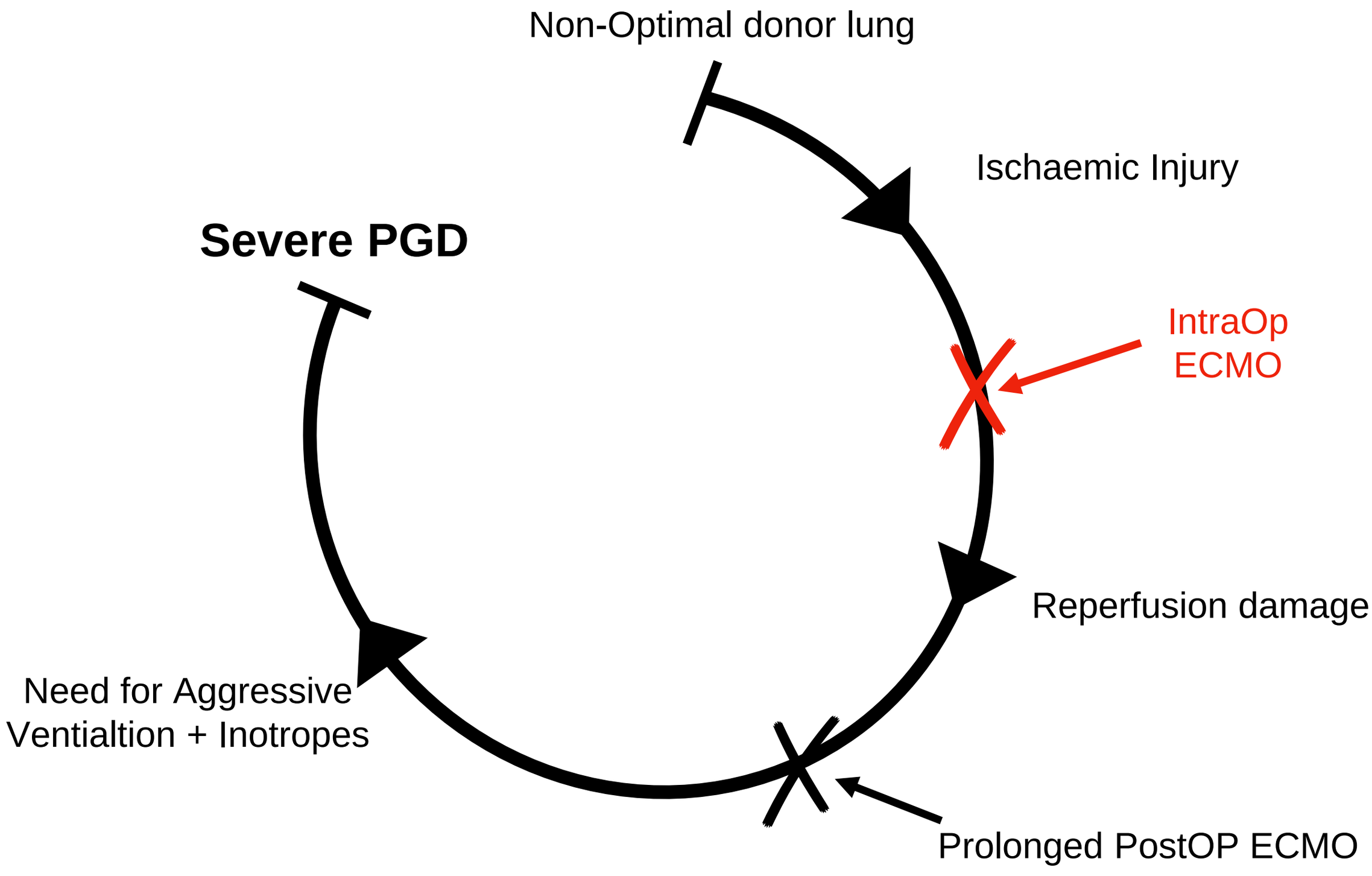
Wen-Je Ko, Yih-Sharng Chen, and Yung-Chie Lee

Department of Surgery, National Taiwan University Hospital, Taipei, Taiwan

Artificial Organs 2001

In conclusion, the heparin-bound femoral ECMO rather than CPB should be used for LTx operations unless concomitant cardiac repair is planned

PGD - Vicious Cycle



Journal of Cardiothoracic and Vascular Anesthesia

Con: Extracorporeal Membrane Oxygenation Should Not Routinely Replace Cardiopulmonary Bypass As the Preferred Method of Support During Lung Transplantation

Michael Zhen-Yu Tong, MD, MBA

Department of Cardiothoracic Surgery, Heart and Vascular Institute, Cleveland Clinic, Cleveland, OH

Pro: Veno-arterial Extracorporeal Membrane Oxygenation (ECMO) Should Be Used Routinely for Bilateral Lung Transplantation

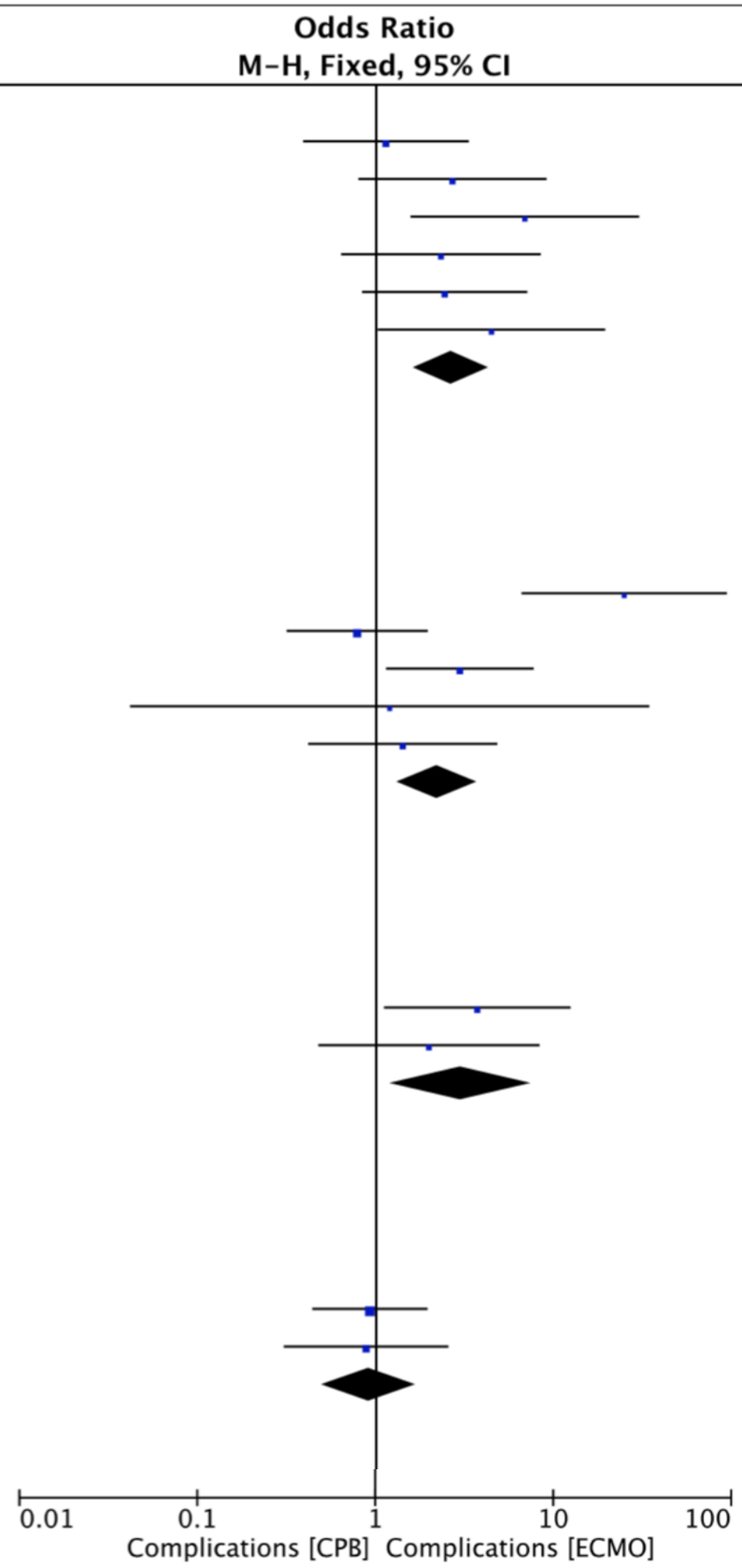
Soheyla Nazarnia, MD, Kathirvel Subramaniam, MD, MPH[1]

Department of Anesthesiology, University of Pittsburgh Medical Center, Pittsburgh, PA

Gen Thorac Cardiovasc Surg (2018) 66:38–47 DOI 10.1007/s11748-017-0836-3

Extracorporeal membrane oxygenation versus cardiopulmonary bypass during lung transplantation: a meta-analysis

Study or Subgroup	Weight	Odds Ratio M-H, Fixed, 95% CI
1.1.1 Bleeding		
Aigner 2007	5.9%	1.12 [0.43, 2.89]
Bermudez 2014	4.0%	2.40 [0.81, 7.06]
Biscotti 2014	1.7%	5.50 [1.48, 20.41]
Hoechter 2015	3.0%	2.10 [0.67, 6.60]
Ius 2012	4.4%	2.19 [0.85, 5.66]
Machuca 2015	2.2%	3.75 [1.02, 13.82]
Subtotal (95% CI)	**21.2%**	**2.35 [1.53, 3.62]**
Total events		
Heterogeneity: $Chi^2 = 4.52$, df = 5 (P = 0.48); $I^2 = 0\%$		
Test for overall effect: Z = 3.88 (P = 0.0001)		
1.1.2 Primary Graft Dysfunction		
Aigner 2007	0.8%	17.19 [5.29, 55.84]
Bermudez 2014	9.3%	0.80 [0.36, 1.81]
Biscotti 2014	4.9%	2.61 [1.12, 6.09]
Bittner 2007	0.6%	1.17 [0.06, 22.94]
Ius 2012	4.2%	1.36 [0.46, 4.01]
Subtotal (95% CI)	**19.7%**	**2.01 [1.27, 3.19]**
Total events		
Heterogeneity: $Chi^2 = 18.66$, df = 4 (P = 0.0009); $I^2 = 79\%$		
Test for overall effect: Z = 2.97 (P = 0.003)		
1.1.3 Renal Failure Requiring Dialysis		
Bermudez 2014	3.8%	3.19 [1.09, 9.30]
Biscotti 2014	2.7%	1.83 [0.51, 6.51]
Subtotal (95% CI)	**6.5%**	**2.62 [1.16, 5.89]**
Total events		
Heterogeneity: $Chi^2 = 0.44$, df = 1 (P = 0.51); $I^2 = 0\%$		
Test for overall effect: Z = 2.33 (P = 0.02)		
1.1.4 Atrial Fibrillation		
Bermudez 2014	13.4%	0.93 [0.48, 1.80]
Ius 2012	6.8%	0.89 [0.35, 2.29]
Subtotal (95% CI)	**20.2%**	**0.92 [0.53, 1.58]**
Total events		
Heterogeneity: $Chi^2 = 0.01$, df = 1 (P = 0.94); $I^2 = 0\%$		
Test for overall effect: Z = 0.31 (P = 0.75)		

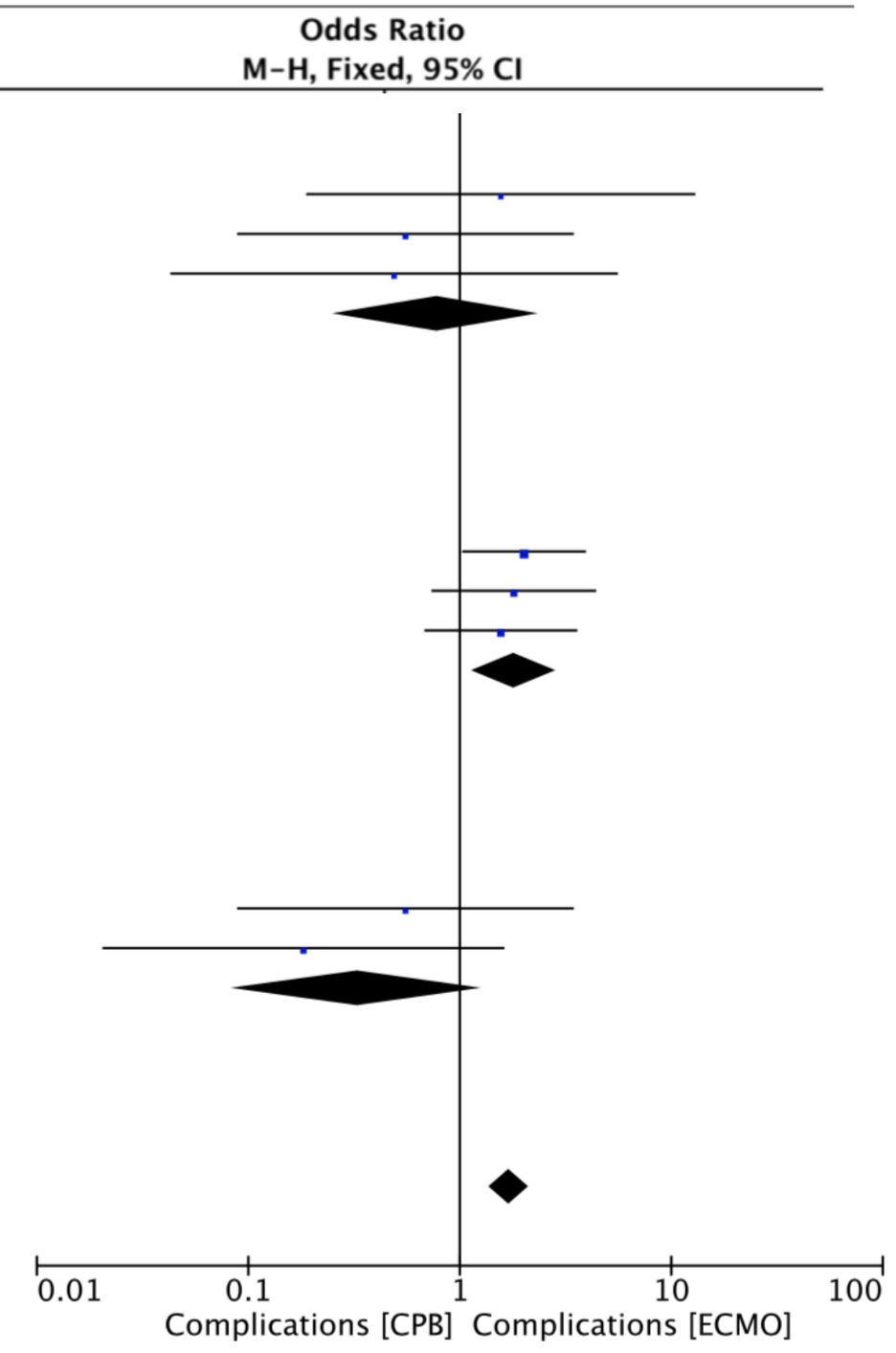


Gen Thorac Cardiovasc Surg (2018) 66:38–47 DOI 10.1007/s11748-017-0836-3

Extracorporeal membrane oxygenation versus cardiopulmonary bypass during lung transplantation: a meta-analysis

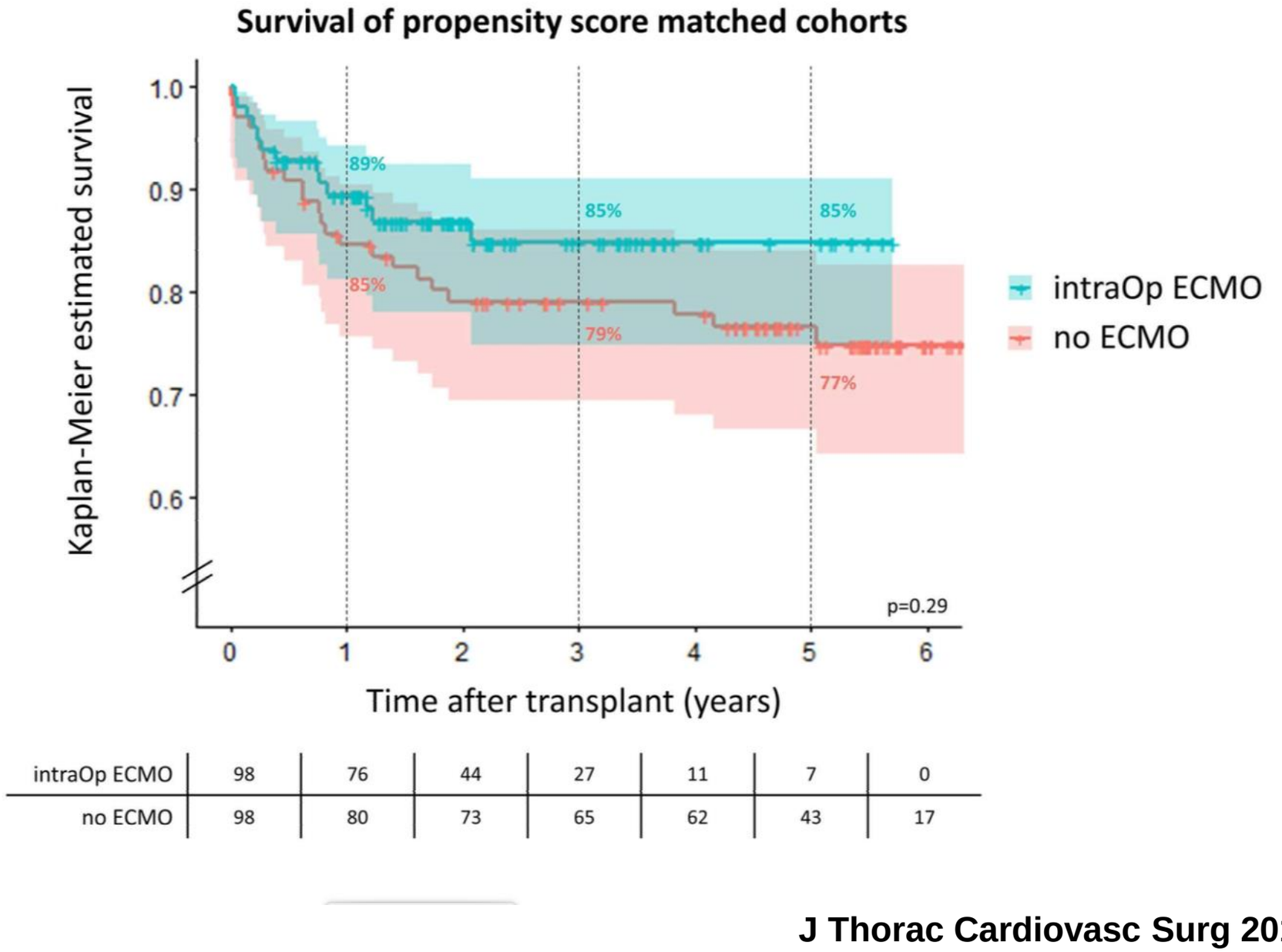
Dimitrios E. Magouliotis[1] · Vasiliki S. Tasiopoulou[2] · Alexis A. Svokos[3] · Konstantina A. Svokos[4] · Dimitris Zacharoulis[1]

Study or Subgroup	Weight	Odds Ratio M-H, Fixed, 95% CI
1.1.5 Stroke / C.V.A.		
Bermudez 2014	1.2%	1.56 [0.19, 13.00]
Biscotti 2014	2.3%	0.55 [0.09, 3.46]
Ius 2012	1.5%	0.49 [0.04, 5.59]
Subtotal (95% CI)	**5.0%**	**0.77 [0.25, 2.40]**
Total events		
Heterogeneity: $Chi^2 = 0.69$, df = 2 (P = 0.71); $I^2 = 0\%$		
Test for overall effect: Z = 0.44 (P = 0.66)		
1.1.6 Tracheostomy		
Bermudez 2014	9.4%	2.01 [1.03, 3.95]
Biscotti 2014	5.4%	1.80 [0.73, 4.42]
Ius 2012	6.6%	1.56 [0.68, 3.60]
Subtotal (95% CI)	**21.4%**	**1.82 [1.16, 2.86]**
Total events		
Heterogeneity: $Chi^2 = 0.21$, df = 2 (P = 0.90); $I^2 = 0\%$		
Test for overall effect: Z = 2.60 (P = 0.009)		
1.1.7 Vascular Complications		
Biscotti 2014	2.3%	0.55 [0.09, 3.46]
Ius 2012	3.6%	0.18 [0.02, 1.63]
Subtotal (95% CI)	**6.0%**	**0.33 [0.08, 1.28]**
Total events		
Heterogeneity: $Chi^2 = 0.59$, df = 1 (P = 0.44); $I^2 = 0\%$		
Test for overall effect: Z = 1.61 (P = 0.11)		
Total (95% CI)	**100.0%**	**1.70 [1.37, 2.10]**
Total events		
Heterogeneity: $Chi^2 = 39.86$, df = 22 (P = 0.01); $I^2 = 45\%$		
Test for overall effect: Z = 4.87 (P < 0.00001)		
Test for subgroup differences: $Chi^2 = 16.34$, df = 6 (P = 0.01), $I^2 = 63.3\%$		



Intraoperative extracorporeal membrane oxygenation and the possibility of postoperative prolongation improve survival in bilateral lung transplantation

Konrad Hoetzenecker, MD, PhD,[a] Stefan Schwarz, MD,[a] Moritz Muckenhuber, MD,[a] Alberto Benazzo, MD,[a] Florian Frommlet, PhD,[b] Thomas Schweiger, MD, PhD,[a] Orsolya Bata, MD,[c] Peter Jaksch, MD,[a] Negar Ahmadi, MD,[d] Gabriella Muraközy, MD,[a] Helmut Prosch, MD,[e] Helmut Hager, MD,[f] Georg Roth, MD,[f] György Lang, MD, PhD,[a,g] Shahrokh Taghavi, MD,[a] and Walter Klepetko, MD[a]



J Thorac Cardiovasc Surg 2018;155:2193-206)

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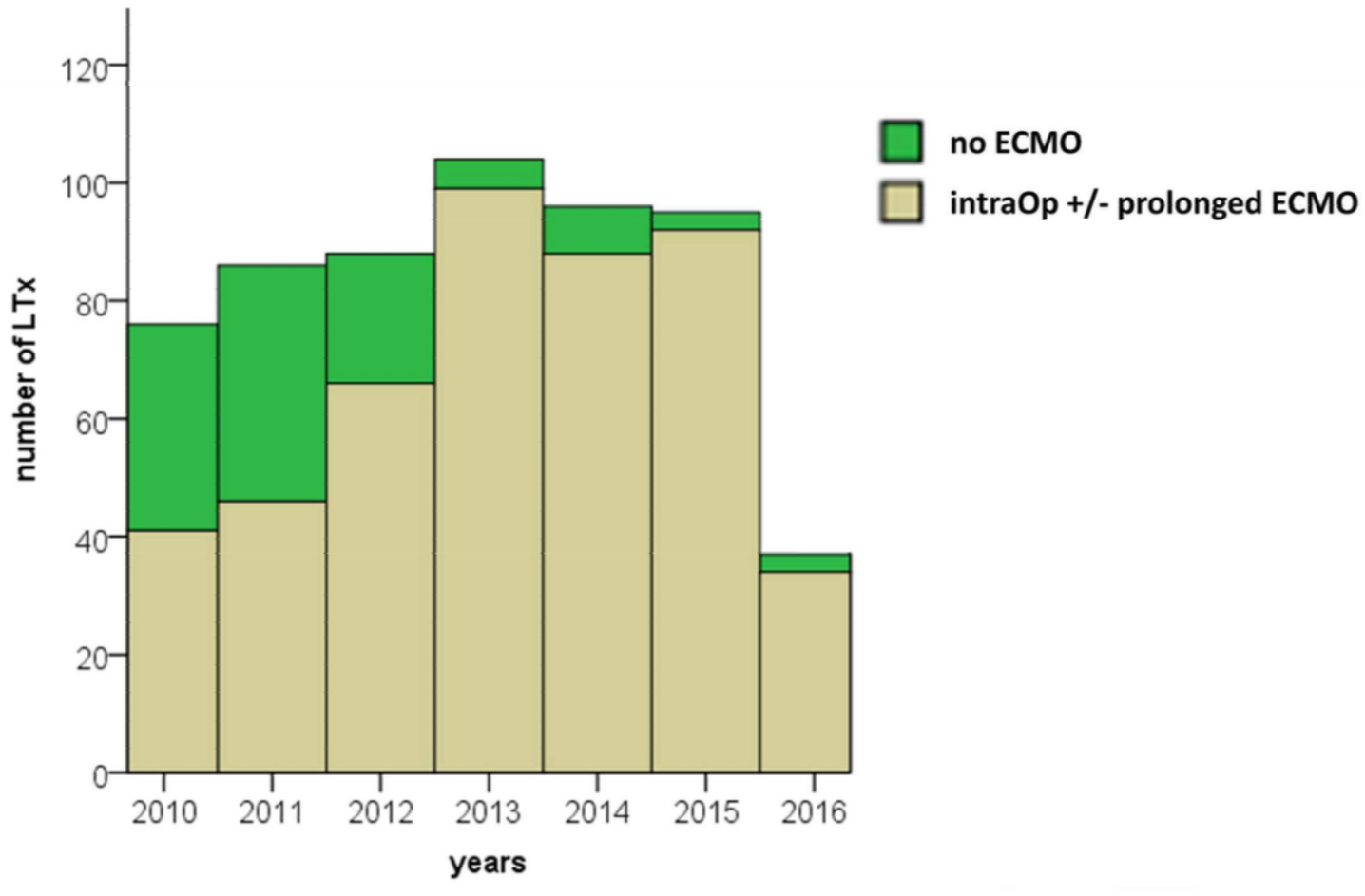

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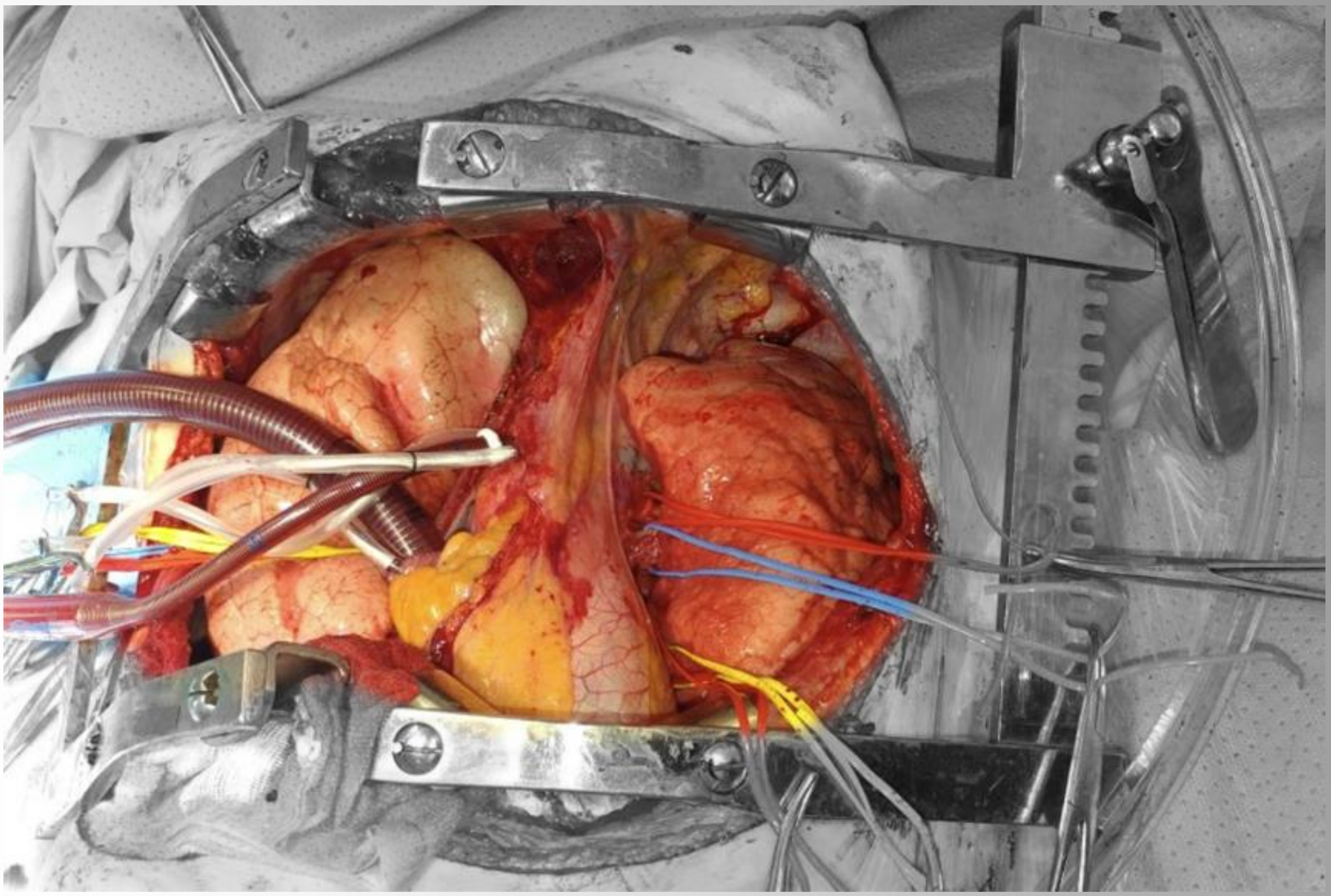


On completion of second implant VA ECMO weaned

Circulated on itself and assessed for PGD

10 min after chest closed

pO_2/FiO_2 < 100

mPAP/mSAP >2/3

Haemodynamic instability

Worsening in ABG

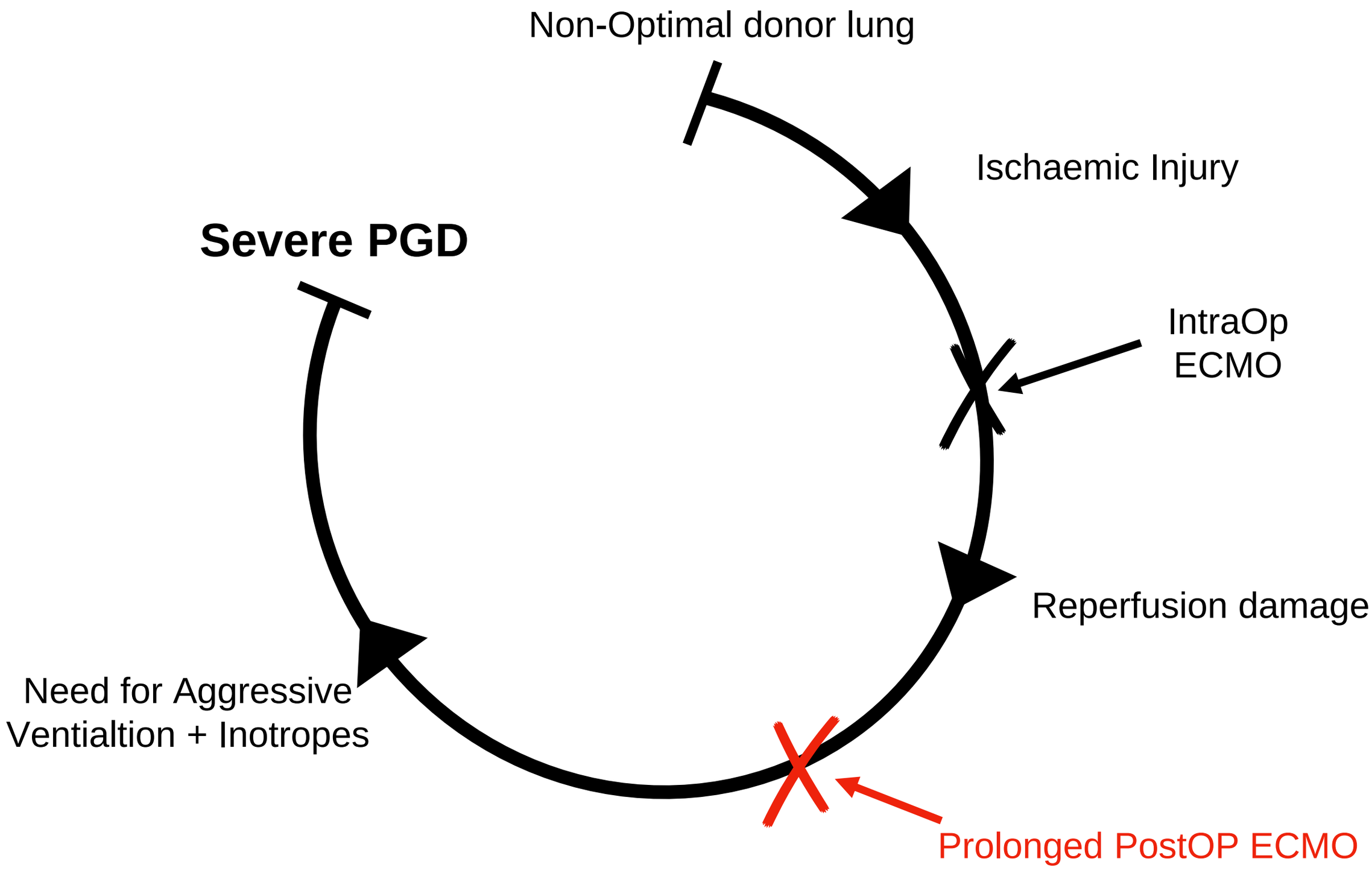
↓

Prolonged ECMO

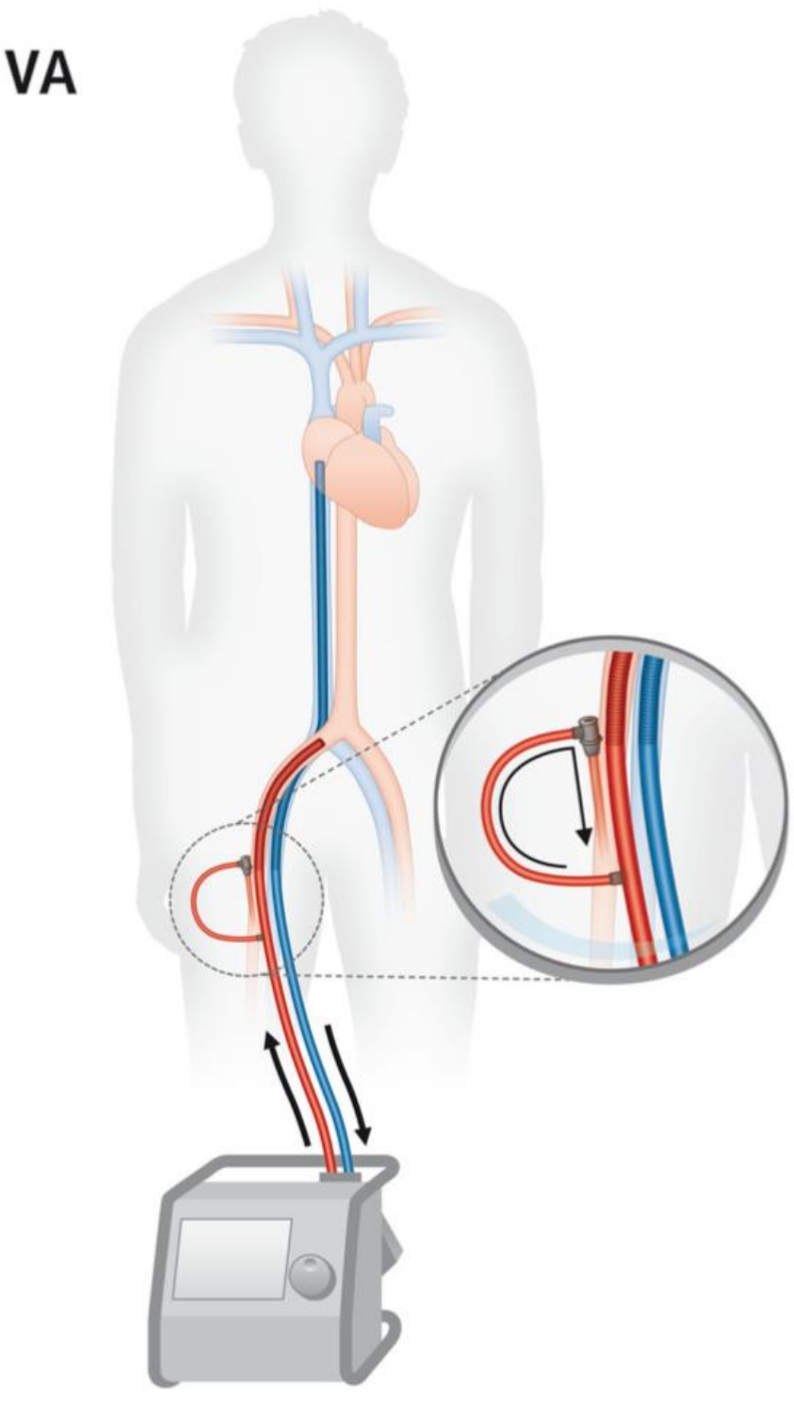
Mandatory Prolongation (Lobar and PHT)

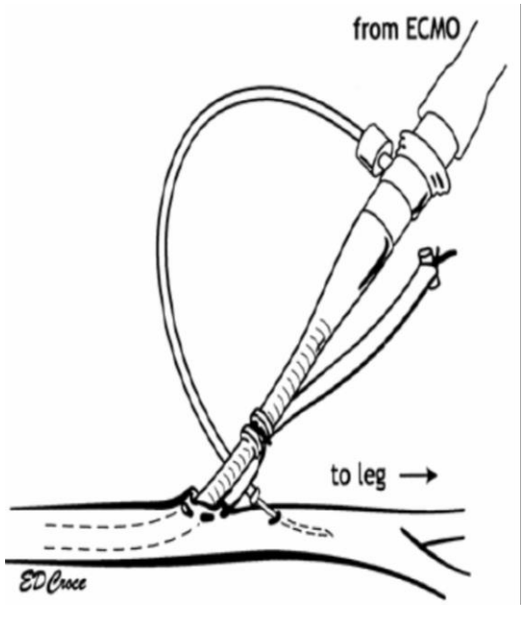
Post-operative ECMO

PGD - Vicious Cycle



Peripheral Cannulation





Banfi et Al ,J Thorac Dis 2016

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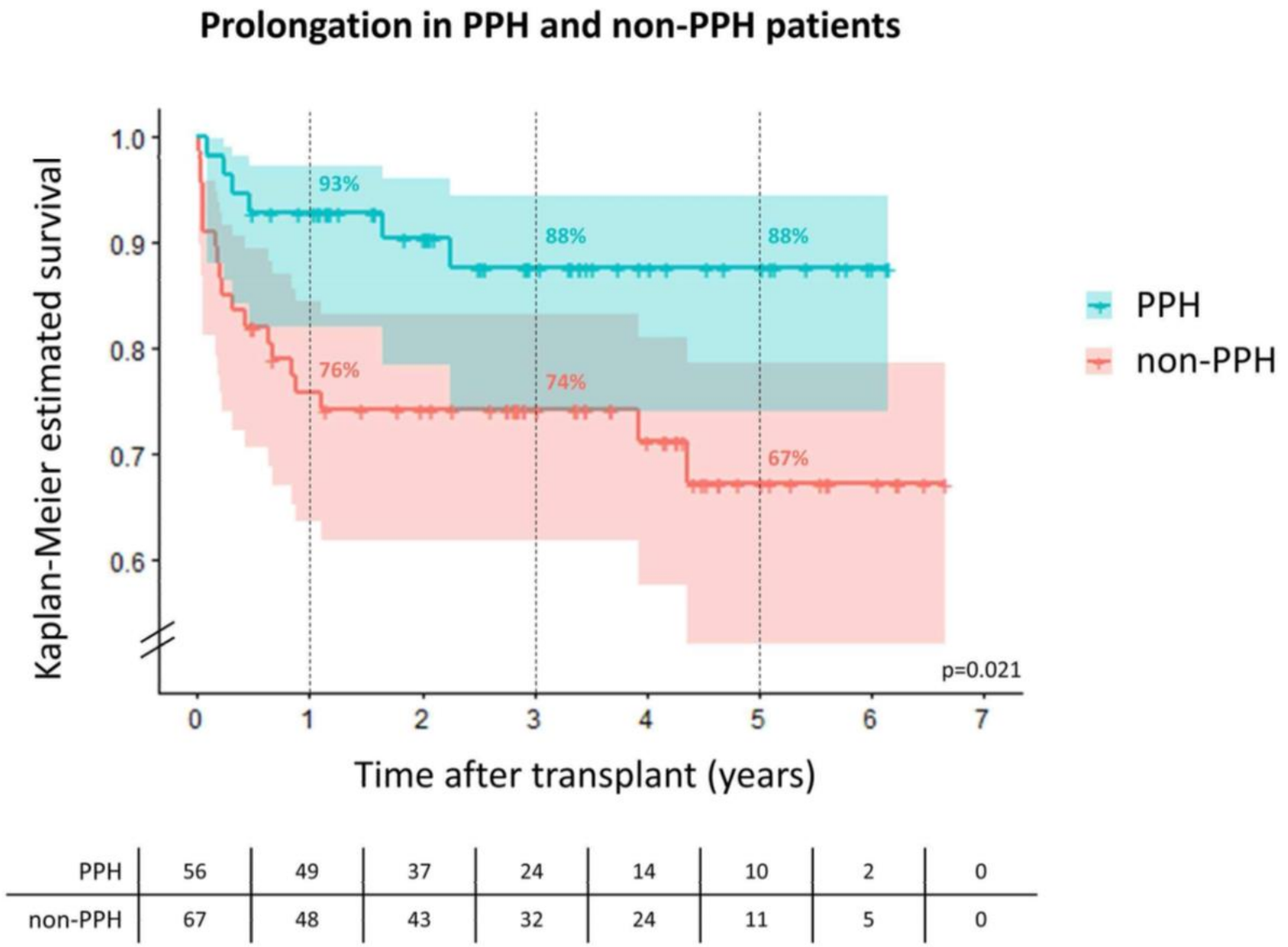

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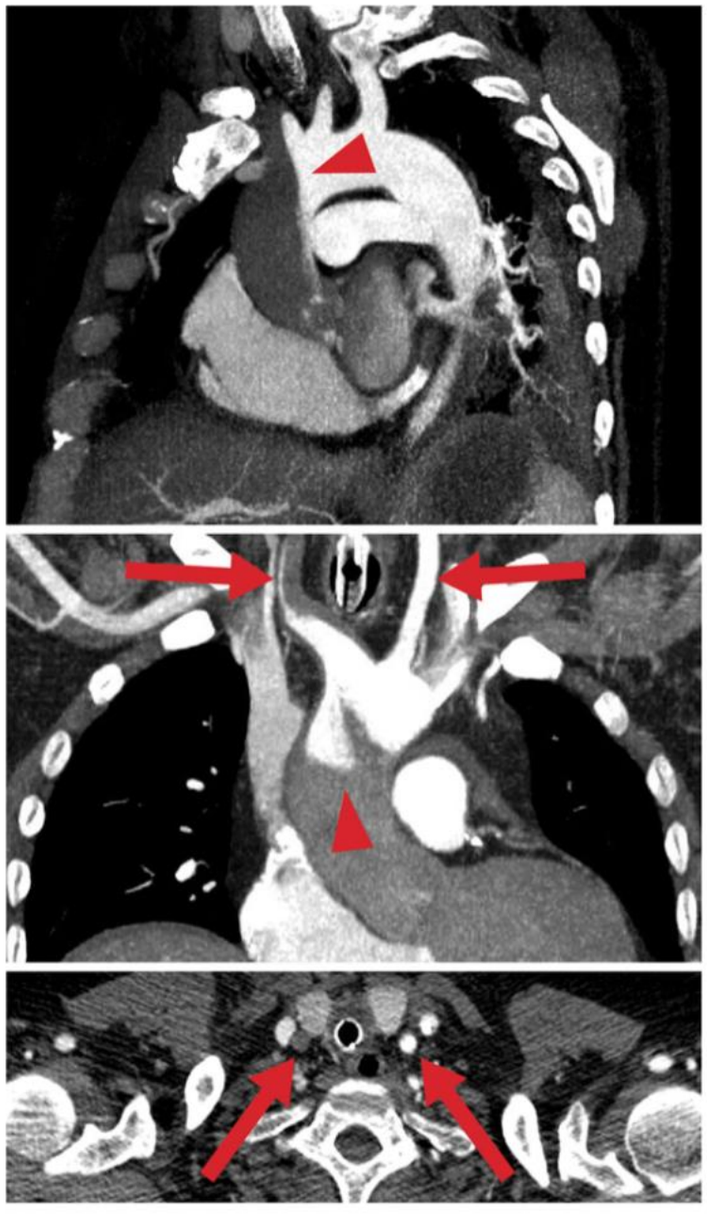
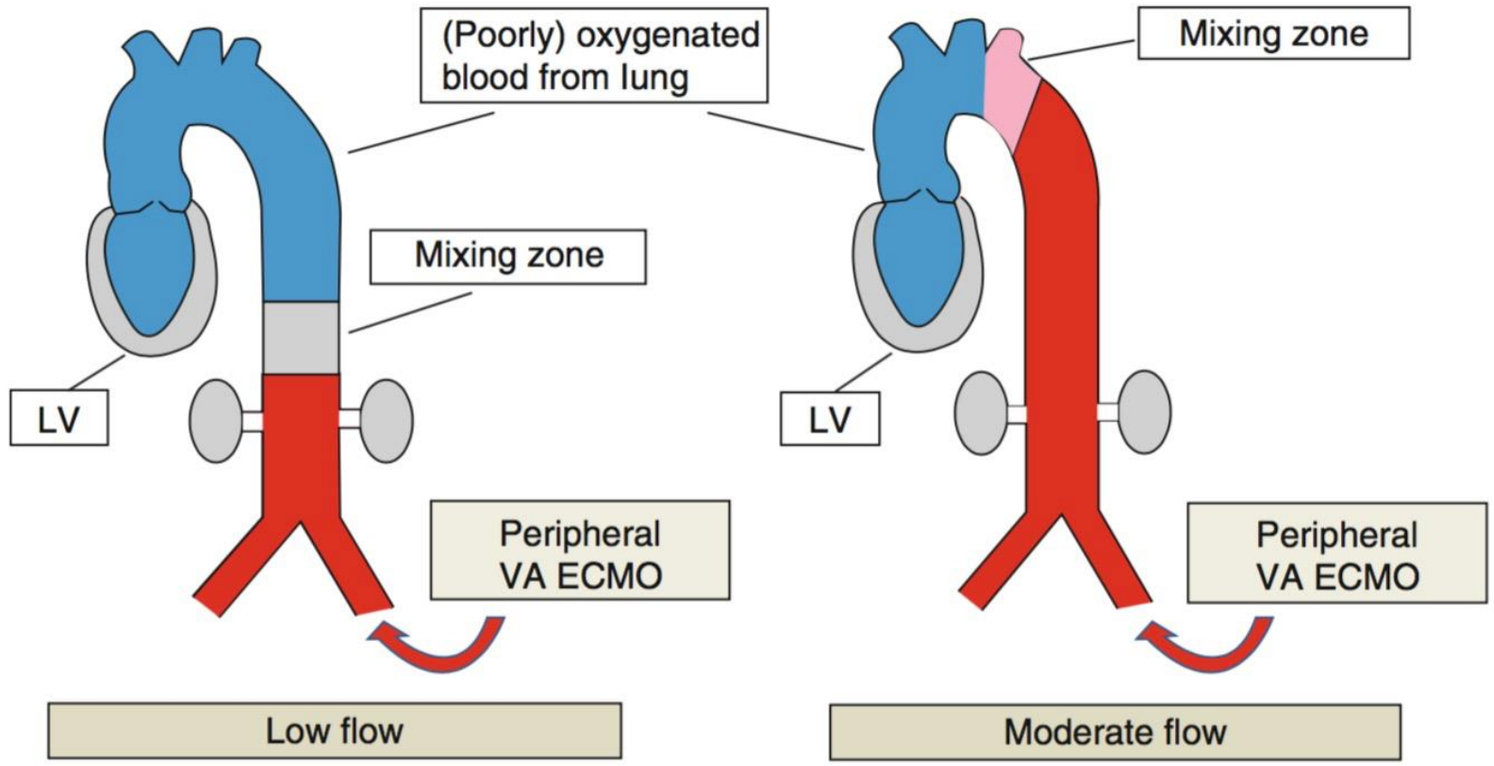
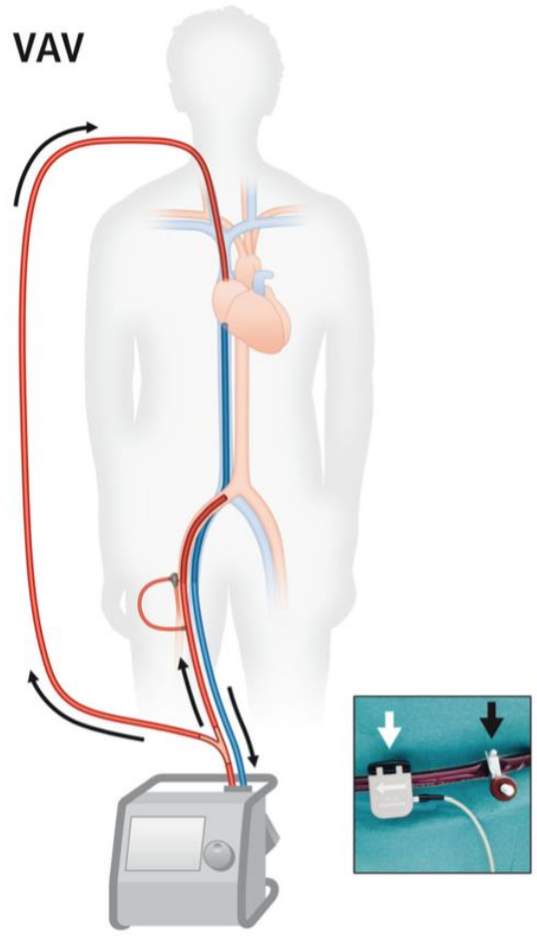


Fig. 4 Watershed phenomenon during veno-arterial ECMO visualized by computed tomography. Antegrade blood flow (low contrast) from the heart competes with retrograde blood flow (high contrast) from the ECMO in the aorta, resulting in a watershed phenomenon (*arrowhead*). Here computed tomography of a patient with pulmonary embolism and reduced cardiac output demonstrates a rather proximal watershed, leading to perfusion of the right carotid artery with "heart blood" (*dark*) and the left carotid artery with "ECMO blood" (*bright*, *arrows*). *Upper panel* sagittal oblique maximum intensity projection (MIP), *middle panel* coronal oblique MIP, *lower panel* transverse plane





Take Home Message

- ECMO and ECMO as BTT is a rapidly progressing space
- ECMO BTT requires an aggressive prehabilitation plan
- BTT therapy should probably not be considered in our donor limited setting

- ECMO has a survival advantage compare to CPB

- Aggressive prolongation of VA ECMO may have a survival advantage
- Prolongation of VA ECMO in PPH should be standard

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