Circulatory strategies – VVB and ECMO in Liver Transplantation

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Outline

Disclosure Statement

- VVB in LT
  - Evolution of techniques and current status
  - Current relative indications and issues
- ECMO in LT
  - Indications
  - Approach to initiation and maintenance
  - Outcome studies
    - Case series and Reviews
    - Intraop Salvage
    - Preemptive ECMO
    - ECMO for expansion of donor pool

VVB in LT

Evolution of surgical techniques in LT and Current Status

- Conventional OLT -Resection of recipient retrohepatic cava- complete caval clamp – hemodynamic instability, splanchnic venous congestion
- Use of VVB – more than 30% fall in MAP or 50% fall in cardiac index during a trial clamp of 5 minutes ; outcome results are not uniformly favourable ; some morbidity and high resource utilization
- Piggyback technique with or without portocaval shunt– technically challenging but avoids most of the adverse effects

Surveys of European and North American Transplant Centers have shown a decline in use of VVB from as high as 91% in 1987 to 1-7% of cases in 2019-21

Crouch C et al Clin transplant 2022
Czigany et al J Gastrointest Surg 2019

Conclusion:

- Based on existing data and expert opinion, the panel cannot recommend one cava reconstruction technique over another, rather the surgical approach should be based on surgeon preference and center dependent, with special consideration toward patient circumstances **(Quality of evidence: Low | Grade of Recommendation: Strong)**
- The panel recommends against routine use of vevo-venous bypass (Quality of evidence: Very Low | Grade of Recommendation: Strong) and against the routine use of temporary porto-caval shunt **(Quality of evidence: Very Low | Grade of Recommendation: Strong)**

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Clinical TRANSPLANTATION
WILEY

REVIEW ARTICLE

Which cava anastomotic techniques are optimal regarding immediate and short-term outcomes after liver transplantation: A systematic review of the literature and expert panel recommendations

Tamer M. Shaker[1] | James D. Eason[2] | Brian R. Davidson[3] | Rolf N. Barth[4] | Jacques Pirenne[5,6] | Oscar Imventarza[7] | Michael Spiro[8,10] | Dimitri Aristotle Raptis[9,10] | John Fung[4] | On behalf of the ERS4OLT.org Working Group: Claus Niemann, San Francisco, CA, USA, Joerg-Matthias Pollok, London, UK, Marina Berenguer, Valencia, Spain, Pascale Tinguely, London, UK, Manikandan Kathirvel, London, UK, Nolitha Morare, London, UK.

REVIEW

Venovenous Bypass in Orthotopic Liver Transplantation: Time for a Rethink?

Kalpana Reddy, Susan Mallett, and Tim Peachey

Table 2. Advantages and Disadvantages of VVB

	References
Advantages of VVB	
• Reduces hemodynamic instability during anhepatic phase	1, 3, 30
• Useful in patients with pulmonary hypertension and cardiomyopathy who tolerate anhepatic period poorly	0*
• Has been shown to maintain intraoperative renal function	29†
• Maintains cerebral perfusion pressure in patients with acute fulminant failure by avoiding rapid swings in blood pressure	0*
• Facilitates difficult surgery and reduces blood loss	1
Disadvantages of VVB	
• Does not guarantee normal perfusion of abdominal organs and lower limbs	12
• No evidence that it improves outcome	24, 28
• May worsen postreperfusion syndrome	57, 63
• No evidence that it reduces or prevents the occurrence of postoperative renal failure	29†, 36, 37
• May worsen cerebral edema following reperfusion of the graft	41, 42
• May potentiate bleeding by causing hemolysis, platelet depletion	46-48
• Morbidity and mortality associated with its use	3, 49, 51-56

- None have demonstrated a benefit of VVB over simple occlusion techniques
- Moreover, the use of VVB is not without risk
- For the foreseeable future, the decision as to whether or not to use VVB will depend to a large degree on institutional culture, personal experiences and preferences and professional judgement

ORIGINAL ARTICLE

Comparison of surgical methods in liver transplantation: retrohepatic caval resection with venovenous bypass (VVB) versus piggyback (PB) with VVB versus PB without VVB

Tetsuro Sakai,[1] Takashi Matsusaki,[1] James W. Marsh,[2] Ibtesam A. Hilmi[1] and Raymond M. Planinsic[1]

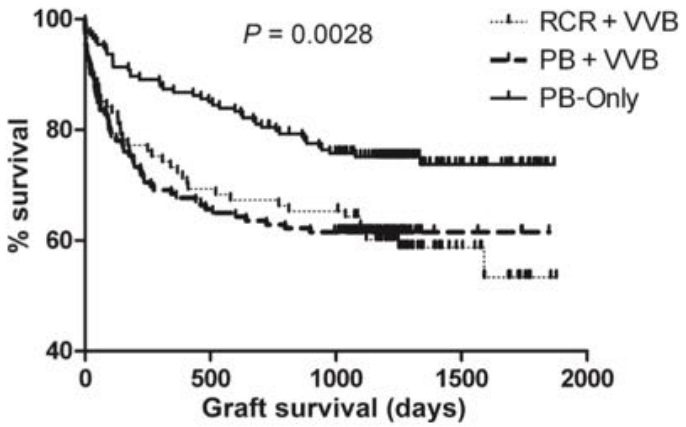
1 Department of Anesthesiology, University of Pittsburgh Medical Center, Pittsburgh, PA, USA
2 Department of Surgery, Thomas E. Starzl Transplantation Institute, University of Pittsburgh, Pittsburgh, PA, USA

Retrospective review 2001-2003

3 different surgical techniques were used for LT (i) the classic retrohepatic caval resection technique with VVB (104) (ii) the PB technique with VVB (148) and (iii) the PB technique without VVB (174)

Table 4. Intraoperative data: duration of the surgery, blood transfusion.

Total	RCR + VVB (n = 104)	PB + VVB (n = 148)	PB-Only (n = 174)	ANOVA [Kruskal–Wallis]
Total operation time (h)	8.9 ± 2.2	7.5 ± 1.8*	7.6 ± 1.8*	0.0001
Cold ischemic time (h)	11.8 ± 3.5	11.3 ± 3.1	10.4 ± 3.0*†	0.005
Warm ischemic time (min)	43.4 ± 7.9	30.2 ± 7.0*‡	35.1 ± 10.0*	0.0001
PRBC (units)				
Intraop.	9 (0, 80)	8.5 (0, 91)	7 (0, 40)*†	[0.006]
Periop.	10 (0, 86)	10 (0, 93)	8 (0, 45)*†	[0.002]
FFP (units)				
Intraop.	8 (0, 79)	8 (0, 80)	6 (0, 40)*	[0.005]
Periop.	9 (0, 79)	9 (0, 82)	6 (0, 46)*	[0.005]
Platelet (units)				
Intraop.	11.5 (0, 40)	6 (0, 71)	7 (0, 36)	[0.4]
Periop.	11.5 (0, 48)	12 (0, 77)	8 (0, 42)	[0.5]
Cryo. (units)				
Intraop.	0 (0, 42)	0 (0, 36)	0 (0, 30)	[0.2]
Periop.	0 (0, 42)	0 (0, 54)	0 (0, 30)*	[0.03]
Cell Saver (L)	2.2 (0, 61.0)	1.5 (0, 48.6)	1.1 (0, 16.0)*	[0.007]



	RC R+ VVB (n = 104)	PB + VVB (n = 148)	PB-Only (n = 174)	X^2 test
30-day patient survival (%)	91.3%	93.2%	97.7%	0.05
1-year patient survival (%)	76.0%*	79.7%*	93.1%	0.0001
3-year patient survival (%)	71.2%*	76.4%*	85.1%	0.02

Table 8. Postoperative data.

	RCR + VVB (n = 100)*	PB + VVB (n = 147)*	PB-Only (n = 174)	ANOVA [Kruskal–Wallis]	Chi-square test
ICU stay (days)	5 (2, 128)	6 (2, 105)	4 (2, 70)†	[0.004]	–
Hospital stay (days)	15 (7, 185)	15 (7, 126)	13 (7, 98)	[0.3]	–
Re-intubation	30.0% (30)	26.7% (39)	16.1% (28)¶**	–	0.002
Post/pre creatinine	2.6 ± 1.8	2.5 ± 1.9	1.9 ± 0.9¶**	0.0007	–
Acute renal injury	21.1% (20)†	23.4% (34)‡	17.8% (30)§	–	0.5
Acute renal failure	34.7% (33)†	24.8% (36)‡§	15.4% (26)§¶**	–	0.001
Re-exploration	21.0% (21)	28.1% (41)	17.8% (31)	–	0.08
Hepatic artery thrombosis	2.0% (2)	3.4% (5)	0% (0)	–	0.06

CAVOCAVAL ADULT LIVER TRANSPLANTATION AND RETRANSPLANTATION WITHOUT VENOVENOUS BYPASS AND WITHOUT PORTOCAVAL SHUNTING: A PROSPECTIVE FEASIBILITY STUDY IN ADULT LIVER TRANSPLANTATION

JAN LERUT,[1,6] OLGA CICCARELLI,[1] FRANCINE ROGGEN,[1] PIERRE-FRANÇOIS LATERRE,[2] ETIENNE DANSE,[3] PIERRE GOFFETTE,[3] SOPHIE AUNAC,[4] MARIANNE CARLIER,[4] MARC DE KOCK,[4] LUC VAN OBBERGH,[4] FRANCIS VEYCKEMANS,[4] CLAUDINE GUERRIERI,[5] RAYMOND REDING,[1] AND JEAN-BERNARD OTTE[1]

Transplantation 2003

- Prospective, single-center study- feasibility of adult LT with systematic preservation of IVC and without use of VVB and PCSh, independent of anatomical and general status
- Between November 1993 and November 2000, 202 consecutive grafts were performed in 188 adults
- IVC preservation, avoidance of IVC cross clamping and avoidance of VVB use were possible in 98.9%, 93%, and 99.5% of 183 primary LT and in 89.5%, 84.2%, and 89.5% of 19 re-LT
- VVB was used three (1.5%) times in re- transplant patients only

Conclusions. **LT with IVC preservation and without VVB use and portocaval shunting is possible in nearly all primary transplants and in the majority of re-LT**

Issues with VVB

- Morbidity 10-30%
- Costs and presence of skilled personnel
- Cannula related complications- reduced with percutaneous technique and use of USG/TEE
- Air embolism
- Disconnection
- Hypothermia
- Increased operative time and warm ischemia time
- Increased incidence of PRS upto 30% - proinflammatory cytokines due to EC circuit
- Currently – diminishing expertise is a problem

Schmitz et al.HBPD Int 2014; Gurusamy KS- Veno-venous bypass versus none for liver transplantation. Cochrane Database of Systematic Reviews 2011,Agarwal et al ; Transpl Proceedings 1987

Clin Transplant 2010: 24: 585–591 DOI: 10.1111/j.1399-0012.2009.01145.x

Clinical Transplantation

Insertion and management of percutaneous veno-venous bypass cannula for liver transplantation: a reference for transplant anesthesiologists

Tetsuro Sakaia, Silviu Gligorb*, John Diulusc, Richard McAffeed, J. Wallis Marshe and Raymond M. Planinsic

Liver Transpl 2007

Complications Associated With Percutaneous Placement of Venous Return Cannula for Venovenous Bypass in Adult Orthotopic Liver Transplantation

Tetsuro Sakai,[1] Raymond M. Planinsic,[1]* Ibetsam A. Hilmi,[1] and J. Wallis Marsh[2]

All OLT Starzl Transplant Institute from January 1, 2003 to June 30, 2004

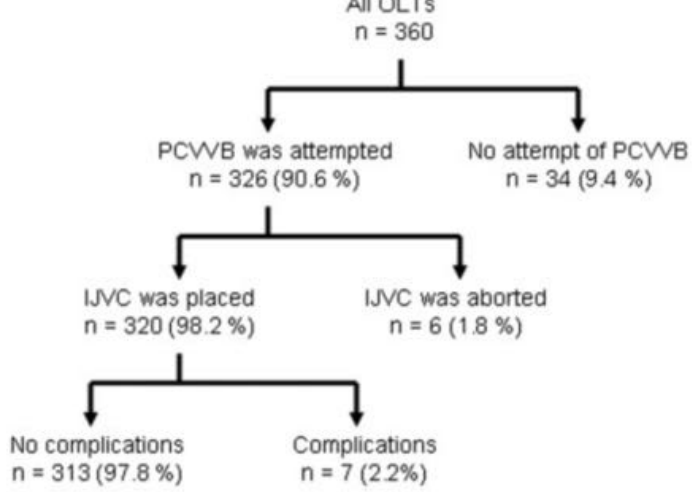


TABLE 2. Summary of 7 Patients With Complications Under Veno-Venous Bypass and Its Venous Return Cannula Placement in Orthotopic Liver Transplantation

Case	Gender	Age (yr)	Site	Complication	Consequence
1	Male	36	RIJ	s/o hemomediastinum	A chest CT was negative; VVB was reestablished via the axillary vein
2	Female	52	RIJ	Air embolism	VVB was stopped, air was purged from VVB, then VVB was resumed
3	Male	52	RIJ	Air embolism	Bubbles in the right atrium on TEE; VVB was continued without any problem
4	Female	38	RIJ	Low flow (1,000-1,500 mL/minute)	The target flow was 2,680 mL/minute; VVB was continued until reperfusion
5	Female	64	RIJ	Low flow (1,400 mL/minute)	The target flow was 2,100 mL/minute; VVB was terminated in 5 minutes; OLT was performed without VVB
6	Female	49	RIJ	Hypotension (40/15 mmHg)	VVB was terminated in 2 minutes; OLT was performed without VVB
7	Male	38	RIJ	Atrial fibrillation	VVB was continued; antiarrhythmic therapy was initiated; NSR was restored.

Percutaneous VVB cannulation can be performed by experienced transplant anaethesiologists within acceptable risk using a flexible 18-Fr cannula via the right IJV

Transplantation Proceedings, (2020)

Venovenous Bypass During Liver Transplantation: A New Look at an Old Technique

Narangkana Lapisatepun[a,b], Worakitti Lapisatepun[c], Vatche Agopian[d], and Victor W. Xia[a,*]

Advances in extracorporeal technologies offer new opportunities for VVB in managing critically ill patients in LT

Table 1. Indications for Venovenous Bypass

	System	Indications
1	Cardiovascular system	Ischemic disease, heart failure, hemodynamic instability, large amount in vasoactive agents and failed trial of the cross-clamping
2	Pulmonary system	Pulmonary hypertension
3	Central neural system	Cerebral edema in acute liver failure
4	Renal system	Renal failure, dysfunction, prevention of postoperative acute kidney injury
5	Surgical, anatomic concerns	Surgically challenging cases
6	Severe portal hypertension	Massive intraoperative bleeding due to elevated portal hypertension
7	MELD score	High MELD score with multiple organ failure
8	Donors	High-risk donors
9	New program/training purpose	Provide maximum safety during the initial phase of new liver transplantation program

Abbreviation: MELD, Model of End-Stage Liver Disease.

Polycystic liver disease, Redo transplants

ECMO in Liver Transplantation

Indications

Higher risks of cardiorespiratory failure

- Pathophysiological conditions that result in hemodynamic instability
  - Cirrhotic cardiomyopathy
  - autonomic dysfunction
  - obstructive coronary artery disease
  - severe vasodilation from nitric oxide overproduction
  - PoPH
  - Prothrombotic
- Surgical phases - hemodynamic impact- bleeding (medical and surgical), caval clamping, graft reperfusion,air embolism and fluid restriction can cause HDI
- Poor respiratory reserve- nutrition, restrictive causes and atelectasis
- HPS
- Intraop – retractors, fluid shifts, transfusion and cytokine release
- Immunosuppression – sepsis

Indications of ECMO in LT- Classical & Evolving Indications

- In 1972, Zapol, one of the fathers of ECMO, stated that ECMO “maintains life while intolerable pulmonary damage heals.”
- First ECMO following LT in 1994 in Taiwan
- Ideally rescue therapy when all conventional ventilatory and resuscitative efforts have failed
- Classical established Indications
  - Severe, acute, reversible respiratory failure pre and post LT – HPS, pneumonia, pulmonary hemorrhage, ARDS
  - Reversible cardiovascular collapse post-LT reperfusion secondary to massive pulmonary embolism, intra-cardiac thrombus, right heart failure due to PoPH, or air embolus
  - Cardiovascular collapse due to stress cardiomyopathy intraop or postop
  - Cardiovascular collapse secondary to septic shock post LT

Other rapidly evolving indications

The Utility of ECMO, Not Just After but Also During Liver Transplantation

Eric Levesque, MD, PhD,[1,2] Chady Saliba, MD,[3] Cyrille Feray, MD, PhD,[3] and Daniel Azoulay, MD, PhD[3]

ECMO in LT could be considered

Preoperatively, as a bridge to LT in recipients on the waiting list
Peroperatively, in cases to avoid hepatic congestion in cases of severe PoPH
Combined thoracic organ and liver transplantation - heart-liver and lung-liver or sequential – liver followed by lung
ECMO could optimize organ oxygenation in both brain-dead or non–heart beating donors – enhance donor pool

Braun et al Transplantation 2019; Stephanie G. et al Curr Opin Organ Transplant 2018 ; Huang et al . World J Emerg Med 2022 ; L. Wiklund et al. / European Journal of Cardio-thoracic Surgery 2011

Approach to initiation and Maintenance on ECMO

In all critical situations, a careful multidisciplinary approach is necessary to identify patients who will benefit from extracorporeal support and to allocate scarce organs ethically

Timely cannulation within 20 minutes of collapse and within the first 10 minutes of CPR

Figure 1. Suggested approach to use of ECLS for acute respiratory failure in liver transplant recipients. ARF, acute respiratory failure; ECLS, extracorporeal life support; LT, liver transplantation; VV-ECMO, venovenous extracorporeal membrane oxygenation.

Park et al ASAIO Journal 2022

Figure 2. Suggested approach to use of ECLS for acute cardiac failure in liver transplant recipients. ECLS, extracorporeal life support; LT, liver transplantation; VV-ECMO, venovenous extracorporeal membrane oxygenation.

Park et al ASAIO Journal 2022

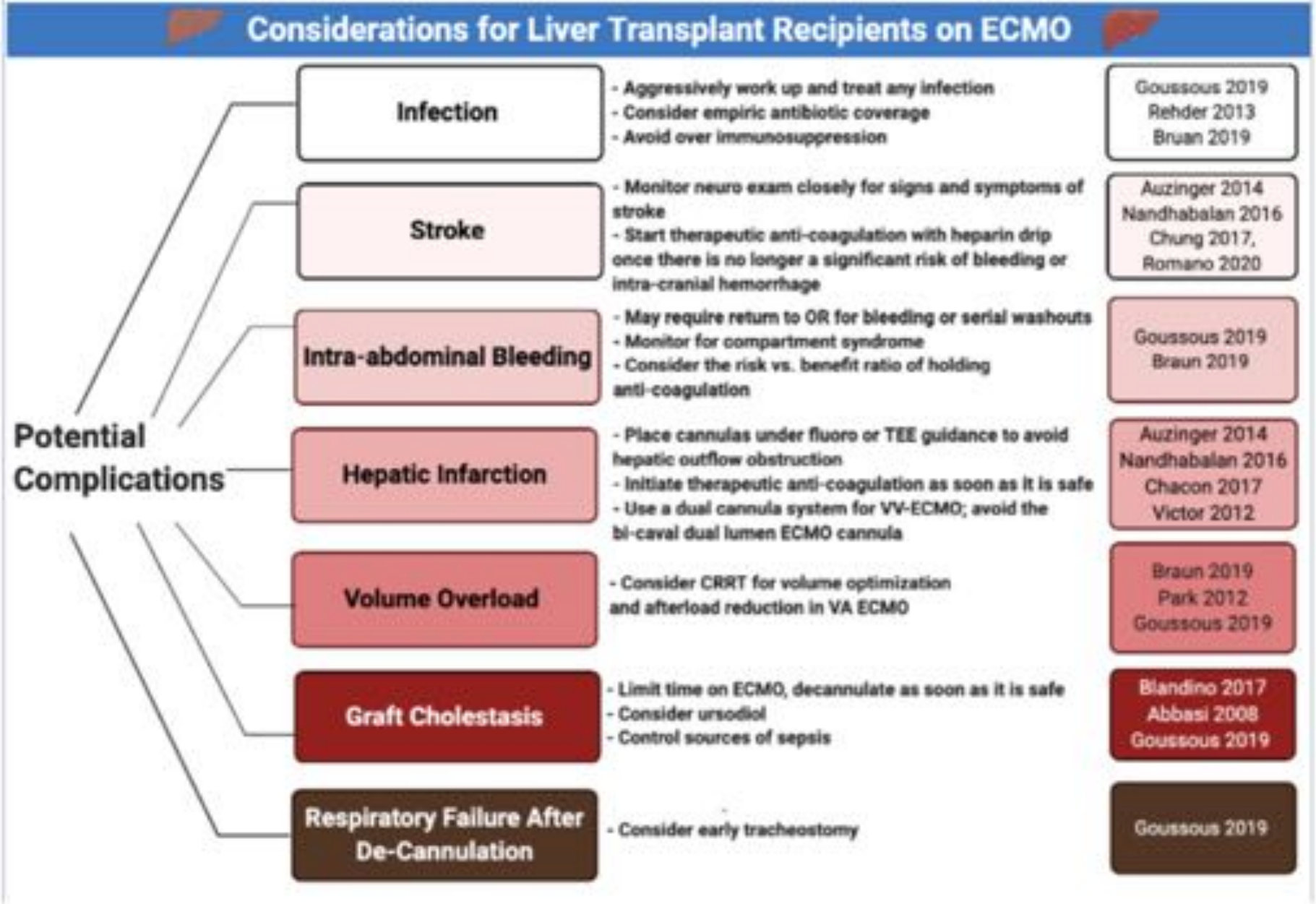


Figure 2:
Considerations for the Liver Transplant Recipient on ECMO.

Hogan et al. Curr Opin Organ Transplant. 2021

Cannula Placement

- Always under fluoroscopic or TEE guidance to avoid hepatic venous outflow obstruction in the new allograft
- The tips of the cannulas must be spaced adequately to prevent re-circulation, which can be detected with doppler studies or pre- membrane blood gas analysis
- The bi-caval dual lumen ECMO cannula (Avalon) for VV-ECMO has the risk of migration, leading to hepatic venous congestion

LIVER TRANSPLANTATION 20:1141–1144, 2014

LETTER FROM THE FRONTLINE

Extracorporeal Membrane Oxygenation for Refractory Hypoxemia After Liver Transplantation in Severe Hepatopulmonary Syndrome: A Solution With Pitfalls

ECMO in 6 patients (5 adults and 1 child) before and after LT since December 2012

3 patients required VA the other 3 patients underwent V-V ECMO

Figure. 3. Left lobe graft infarction. The ECMO cannula is positioned in the retrohepatic inferior vena cava.

- A sudden rise in venous access pressures and a drop in the pump flow some 24 hours after ECMO initiation- AST elevation to 2400 U/L without evidence of graft dysfunction/failure
- Cannula in this case was initially probably not inserted far enough and appeared to be placed with its tip at the level of the piggyback anastomosis -it may have subsequently slipped into donor's IVC cuff
- This resulted in the venous infarction of the left liver lobe and hematoma formation
- Cannula was repositioned and advanced into the retrohepatic portion of the recipient's IVC

Anticoagulation on ECMO

- No consensus on the management of anti-coagulation in the post-LT ECMO patient
- UCSF group reported the use of systemic anticoagulation in the majority of post-LT patients on ECMO without any reported increased in bleeding events
- Individual case reports - LT performed on VV-ECMO without anti-coagulation ; VV-ECMO without anticoagulation for several weeks, with no apparent adverse effects
- More neurologic complications are reportedly associated with VA-ECMO (13%) than VV-ECMO; VV-ECMO has been associated with a 5% risk of intracerebral bleeding
- There is no data on the incidence of stroke in LT recipients, specifically, on ECMO
- Risks and benefits of anti- coagulation in patients with stroke must be carefully weighed

Auzinger G, Liver Transplantation. 2014 ;Romano DN. Semin Cardiothorac Vasc Anesth. 2020;Nandhabalan P. Liver transplantation 2016;Monsel A, Critical care.2011; Frank PN, J Clin Anesth. 2018; Braun HJ, Transplantation. 2019; Xie A etal .Journal of cardiothoracic and vascular anesthesia. 2017

Fluid Management

- Improved outcomes with post-LT ECMO in patients who received CRRT
- AKI - due to the circulatory collapse and transient hypoxemia with background HRS
- In patient receiving VA-ECMO support, the arterial inflow cannula provides retrograde flow through the descending aorta. Thus, afterload reduction is needed to ensure distal perfusion, particularly to the new, potentially fragile graft, and volume optimization may be important to improve outcomes

Braun HJ, Transplantation 2019; 3. Park et al. Transplantation proceedings. 2012; Goussous N et al. Clinical transplantation. 2019

Graft Function

- LFT interpretation and determination of graft function in post-LT recipients on ECMO may be challenging
- VA-ECMO - 65% had early elevation of LFTs after ECMO cannulation ; normalizing after 5 days
- 47% had elevation of AST and/or ALT above 1,000 UI/L
- Reversible cholestasis has also been associated with ECMO use, and ECMO duration is an independent risk factor for cholestasis
  - lack of usual physiologic pulsatile blood flow associated with VA- ECMO
  - circuit induced hemolysis causing a large bilirubin load that overwhelms the excretory function of the liver
  - cholestasis simply caused by sepsis or acute illness

Goussous N et al. Clinical transplantation. 2019 Abbasi S, et al. ASAIO J. 2008

Immunosuppression

- IS -independent risk factor for ECMO related mortality, and in parallel, ECMO related mortality is most commonly due to infection-Should avoid over- immunosuppression
- Patients should be started on empiric broad spectrum antibiotics while cannulated
- UCSF group did not change their immunosuppression regimen (high dose steroids, anti-proliferative agents like mycophenolate mofetil and calcineurin inhibitors started on post-operative day three) amongst ECMO patients. Only one of their five deaths was reportedly due to severe sepsis

ECMO during surgery

- Anticoagulation and bleeding
- Meticulous surgical techniques - Care must be taken when separating the liver from the IVC because an injury to the IVC can introduce air into the ECMO circuit, which is likely to occur if the blood volume in the IVC is insufficient
- Operative planning for LT to be performed on ECMO should plan for piggyback implantation as the positioning and flow requirements of ECMO cannulae prohibit full clamping of the IVC
- Careful coordination between the ECMO perfusionist, anaesthetist, and transplant surgeon is required to prevent air embolism during hepatectomy and implantation of the allograft, particularly when a patient is on VA-ECMO

Outcome Studies

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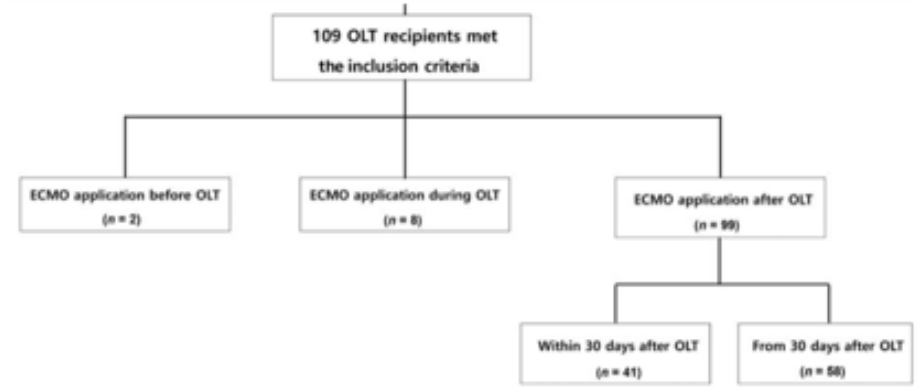
DOI: 10.1002/lt.26567

ORIGINAL ARTICLES

Role of extracorporeal membrane oxygenation as a salvage therapy for liver transplantation recipients in a high-volume transplant center

Young-In Yoon[1] | Jung-Hyeon Lim[2] | Sung-Gyu Lee[1] | Pil-Je Kang[2] | Gyu-Sam Hwang[3] | Su-Min Ha[1] | Ha-Yeon Do[1] | Suk-Kyung Hong[4] | Jin-Won Huh[5]



IGURE 1 Flowchart of the patient selection process

Asan Medical Centre- 2000-2020

4676 patients - 3799 living and 877 deceased donors

109 adult patients with refractory respiratory or cardiac failure- ECMO support for more than 24 hours

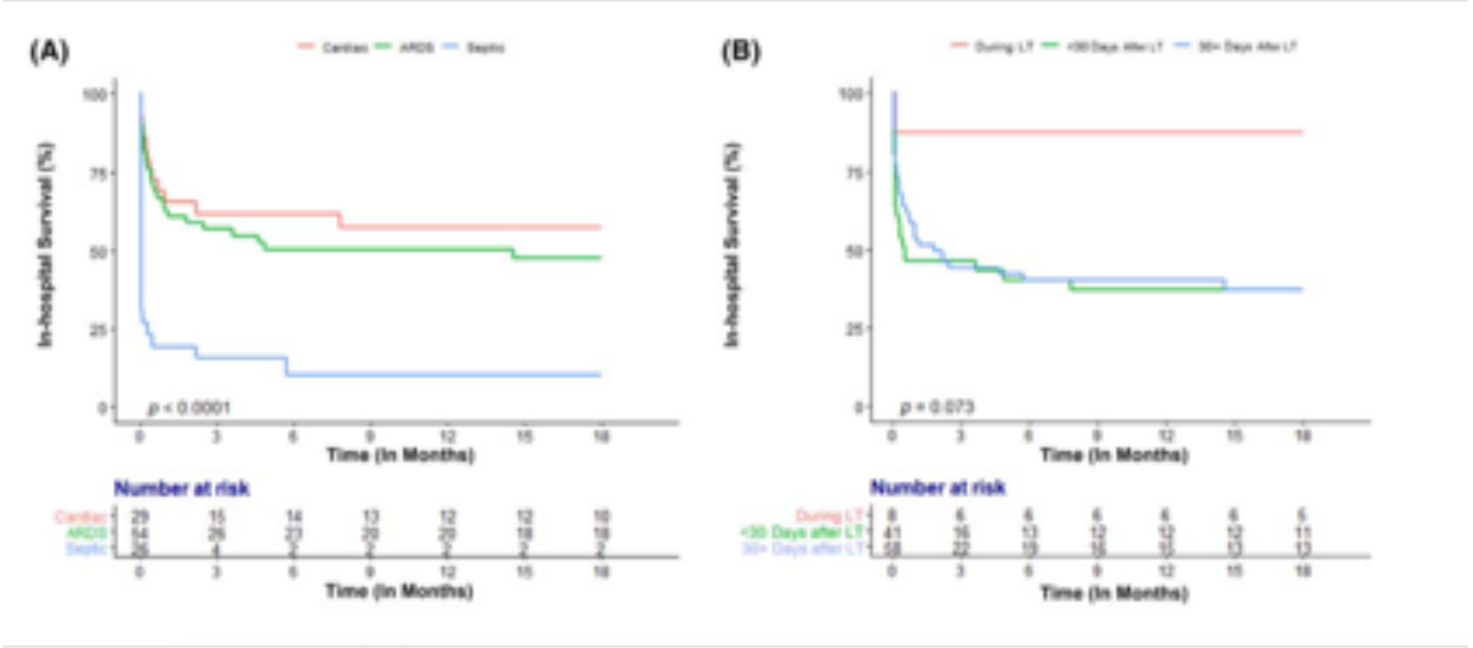
ECMO related complications-5%

50% weaned

1-year survival rate of 42.6%.

Septic shock as the indication for ECMO treatment, a total bilirubin level of ≥5.0 mg/dl and ECMO treatment prior to 2011 were significant risk factors for in-hospital mortality

Survival outcome of patients receiving intraoperative or postop ECMO as a salvage therapy



In our study, in the cohort on VA ECMO 87.5% (7/8) of these patients were successfully decannulated and 75.0% (6/ 8) survived until hospital discharge

These results suggest that intraoperative ECMO during OLT should be considered as a viable rescue strategy to complete the transplantation and serve as a bridge to treat the cause of acute severe cardiopulmonary failure

- Overall survival to discharge rates among LT recipients supported with ECLS, 44% for respiratory failure, 55% for cardiac failure, and 56% for ECPR

- In comparison overall ECLS survival rates as reported in the Extracorporeal Life Support Organization (ELSO) registry for 2021 was 59%, 44%, and 29%, respectively


ASAIO Journal 2022 Adult Circulatory Support

Applications and Outcomes of Extracorporeal Life Support Use in Adult Liver Transplantation: A Case Series and Review of Literature

Jeeun Park,* Michael Y. Lin,† Christopher L. Wray,‡ Fady M. Kaldas,§ Peyman Benharash,¶ and Vadim Gudzenko†

Intraoperative Salvage VA ECMO

Romano et al . SCVA 2020

Table 2. VA ECMO as Intraoperative Salvage During LT, Including the Current Case.

Case report	Age/sex	Indication for transplant	Indication for VA ECMO	Duration (days)	Survived decannulation?	Survived hospital admission?
Braun et al[1]	59/Male	HBV, HCC	Massive PE/cardiac arrest	2	Yes	Yes Discharged on POD 28
Lauterio et al[2]	53/Male	HCV, HCC	Cardiogenic shock Multivessel CAD discovered, CABG on ECMO	4	Yes	Yes Discharged on POD 26
Goussous et al[3]	52/Female	Budd-Chiari and POPH	Massive intracardiac thrombus	1	Yes	Yes Discharged, lost to follow-up
Martucci et al[4]	60/Male	Alcoholic cirrhosis	RV failure, arrest	8	No	No Died on POD 8 Septic shock
Tejani et al[5]	61/Male	HBV, HCC	VF	2	Yes	Yes Discharged on POD 20
Szocik et al[6]	54/Female	PBC	Massive intracardiac thrombus	1	Yes	Yes Discharged on POD 12 (died at ninth week)

62/Male-HCV-HCC massive ICT after reperfusion- 5 days of ECMO – care withdrawn on POD13- IC bleed and sepsis

6 out of 7 (85.7%) were successfully decannulated, of whom 5 (71.4%) survived
Values suggest ECMO may be a viable rescue strategy but may be artificially high due to reporting bias

Transplantation Reviews 36 (2022) 100693

Review article

Extracorporeal membrane oxygenation in patients with hepatopulmonary syndrome undergoing liver transplantation: A systematic review of the literature

W. Kelly Wu [a,b], William M. Grogan [b], Ioannis A. Ziogas [a], Yatrik J. Patel [b], Matthew Bacchetta [b,c,d], Sophoclis P. Alexopoulos [a,*]

16 studies from 4 continents - 17 patients
ECMO initiation prior to (2), during (1) or after LT (14)

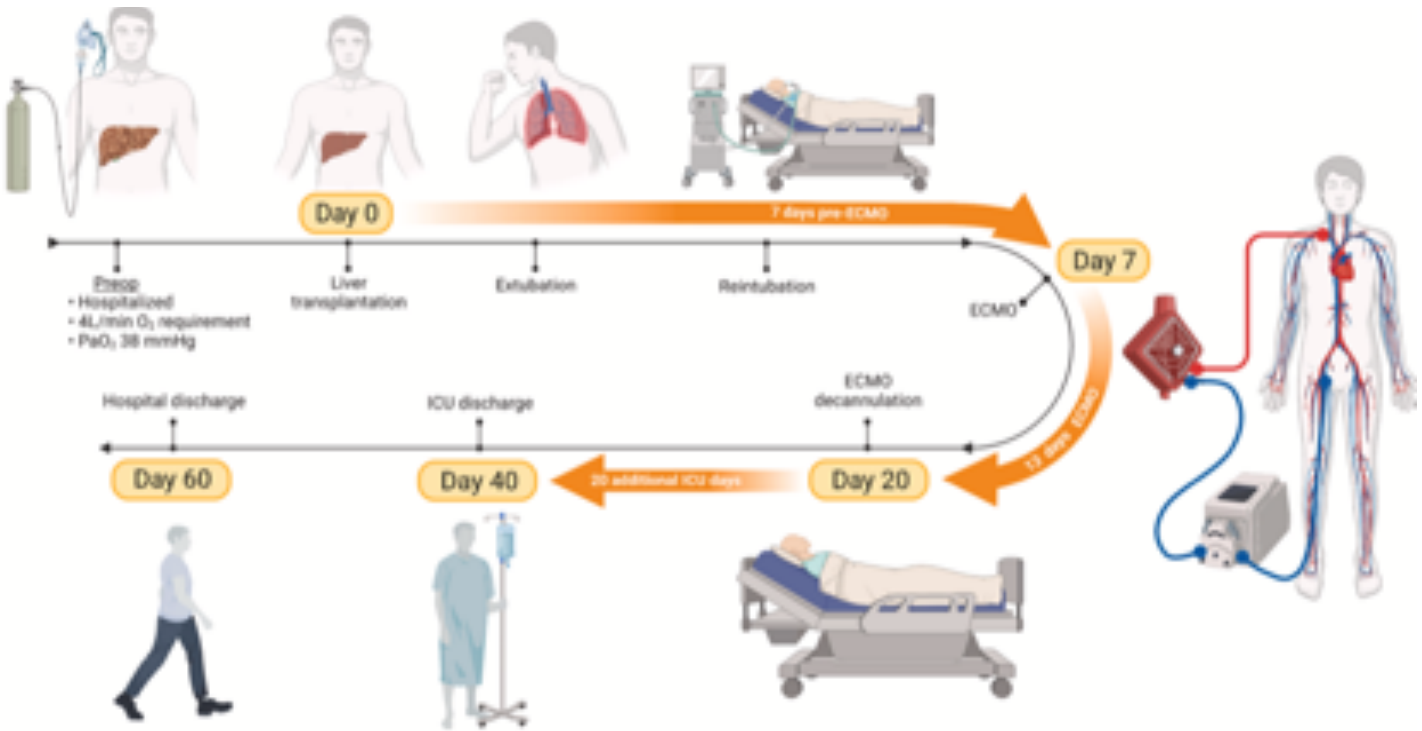


Fig. 3. Schematic depicting the clinical course for the "average" patient with HPS undergoing LT that require ECMO support, from our systematic review.

Median pre-ECMO PaO2 of 45 mmHg
Each day between LT and ECMO initiation was associated with
a 3.5-day increase in total ECMO duration

82.4% of patients (14 of 17) survived to discharge

Extracorporeal membrane oxygenation support for refractory septic shock in liver transplantation recipients

Kyo Won Lee, Chan Woo Cho, Nuri Lee, Gyu-Seong Choi, Yang Hyun Cho[1], Jong Man Kim, Choon Hyuck David Kwon, Jae-Won Joh

Departments of Surgery, [1]Thoracic and Cardiovascular Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

Purpose: This study was designed to assess the outcome of the extracorporeal membrane oxygenation (ECMO) in liver transplantation (LT) recipients with refractory septic shock and predict the prognosis of those cases.
Methods: From February 2005 to October 2012, ECMO was used in 8 cases of refractory septic shock. Laboratory values including lactate and total bilirubin level just before starting ECMO were obtained and sepsis-related organ failure assessment (SOFA) score, acute physiology and chronic health evaluation (APACH) II score and simplified acute physiology score (SAPS) 3 were calculated. Subsequent peak serum lactate and total bilirubin level, and SOFA score after 24 hours of starting ECMO were measured.
Results: Comparisons were made between survivors and nonsurvivors. ECMO was weaned off successfully in 3 patients (37.5%) and 2 patients (25%) survived to hospital discharge. Clinical scores including SOFA, APACH II, and SAPS3 and laboratory results including lactate, total bilirubin and CRP were not significantly different between survivor and nonsurvivor groups. Lactate level and SOFA score tended to decrease after ECMO support in survivor group and total bilirubin and CRP level tended to increase in nonsurvivor group.
Conclusion: Our findings suggest that the implantation of ECMO might be considered in highly selected LT recipients with refractory septic shock.
[Ann Surg Treat Res 2017;93(3):152-158]

Key Words: Liver transplantation, Septic shock, Extracorporeal membrane oxygenation

- Survival of adult LT recipients with refractory septic shock was 25% (2 of 8) in spite of ECMO support
- Serum lactate level and SOFA score tended to decrease over the course of ECMO treatment in the survivor group
- Serum total bilirubin and CRP levels tended to increase in the non-survivor group

From March 2005 to September 2012, 854 patients underwent LT procedures from 689 (80.7%) living and 165 (19.3%) deceased donors. Of those, 24 recipients received ECMO support due to cardiogenic shock (n = 5), septic shock (n = 8), respiratory failure (n = 10), and hypovolemic shock (n = 1)

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ORIGINAL ARTICLE

WILEY

The role of extracorporeal membrane oxygenation in pediatric abdominal transplant patients: A qualitative systematic review of literature

Trista D. Reid[1,2] | Ian Kratzke[1] | Diana Dayal[1] | Lauren Raff[1,2] | Aman Kumar[1,3] | Michael R. Phillips[1,4] | Rebecca Carlson[5] | Chirag S. Desai[1,3]

Pediatric Transplantation. 2020

- 15 case reports and 2 case reviews – 19 Liver transplant recipients
- Complications did not appear to be specifically attributable to ECMO except for bleeding/ re exploration

- Overall 74% survival in paediatric liver transplant recipients associated with ECMO
- In 2015 ELSO registry- 561 paediatric patients placed on ECMO had a survival to discharge of 60%

Extracorporeal Membrane Oxygenation in Pediatric Liver Transplantation: A Multi-Center Linked Database Analysis and Systematic Review of the Literature

Children receiving ECMO at the time of or following liver transplantation

Pediatric Health Information System/Scientific Registry of Transplant Recipients Dataset
N = 34

Systematic Review of the Literature
N = 21

When adjusting for recipient weight:

time from liver transplantation to ECMO initiation

risk of mortality (HR: 1.03, 95% CI: 1.00-1.06, P=0.049)

6-month Patient Survival

55.7% (95% CI: 37.6-70.5)

66.7% (95% CI: 42.5-82.5)

Acceptable survival should encourage consideration of ECMO use in pediatric liver transplantation recipients with potentially reversible severe respiratory or cardiovascular failure refractory to conventional treatment.

Ziogas et al. *Transplantation*. July 2021

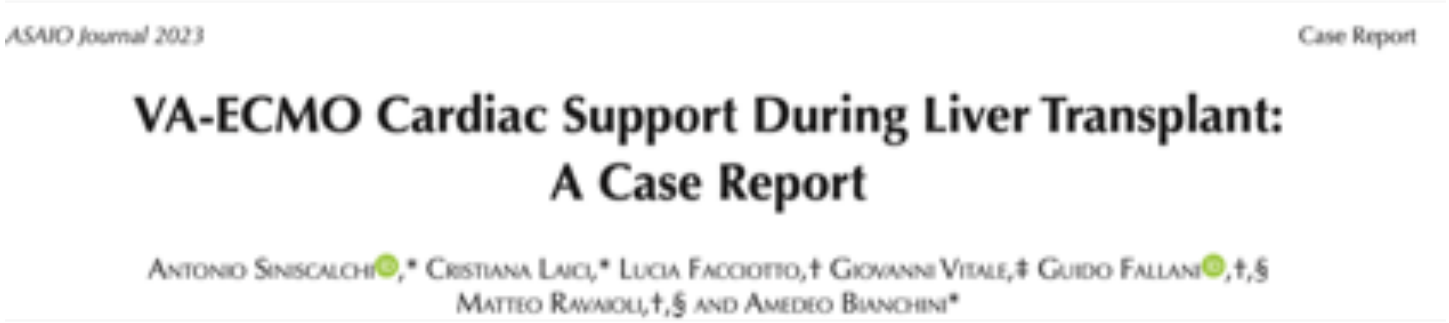
@TransplantJrnl

Transplantation

TRANSPLANTATION

Preemptive ECMO

Preemptive ECMO



ASAIO Journal 2023 Case Report

VA-ECMO Cardiac Support During Liver Transplant: A Case Report

Antonio Siniscalchi,* Cristiana Laici,* Lucia Facciotto,† Giovanni Vitale,‡ Guido Fallani,†,§ Matteo Ravaioli,†,§ and Amedeo Bianchini*

A Catch-22 state

- Patient with severe pulmonary hypertension, mitral valve steno-insufficiency, and right heart dysfunction; EF 40% with no segmental kinetic deficits, dilation of the right ventricle with moderate-to-severe tricuspid insufficiency, and an estimated systolic pulmonary arterial pressure (PAPs) of 65 mmHg - Fluid challenge test demonstrated poor cardiac tolerance with an increase in wedge pressure up to 20 mmHg, and central venous pressure upto 22

- LT surgery in presence of severe heart disease would have contraindicated LT, but simultaneous liver cirrhosis contraindicated mitral valve surgery, leaving the patient locked in a “Catch-22” state

- Best solution was to perform LT with VA-ECMO support before, during, and after the surgery to

Under TEE and Fluoroscopic guidance

VA-ECMO flow 0.9 and 2.1L/min/m2

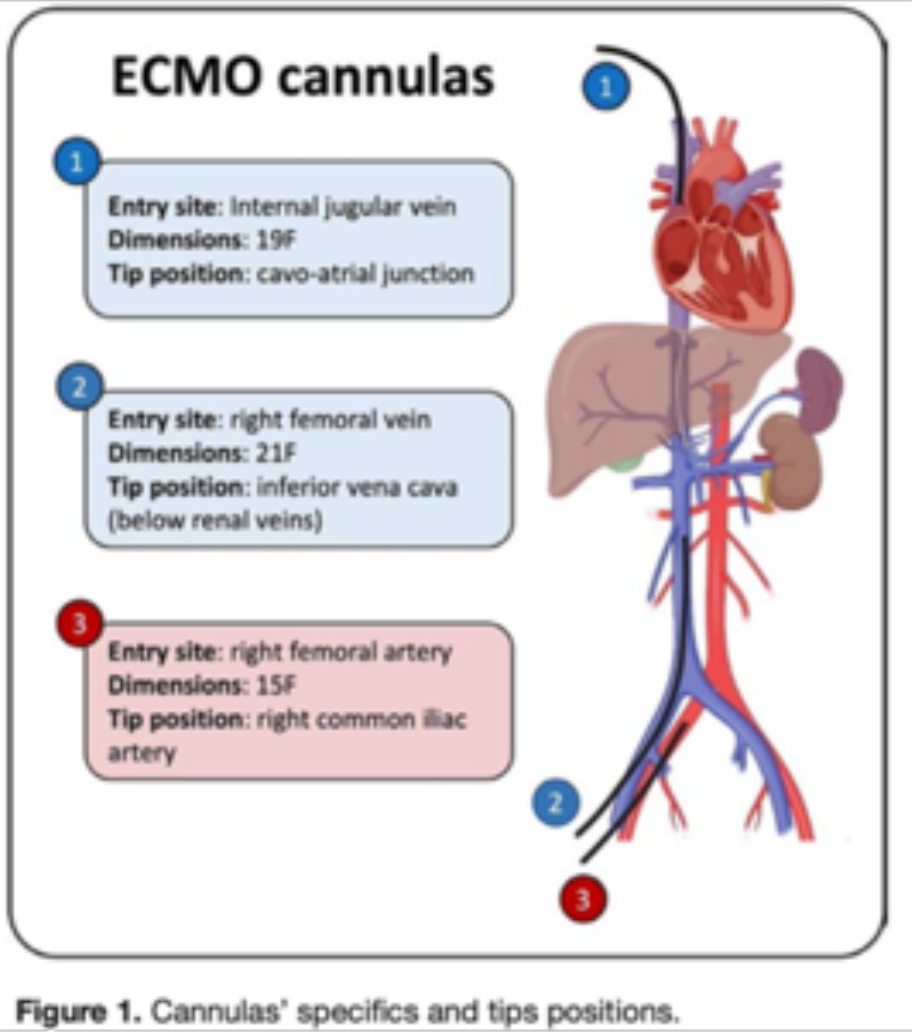


Figure 1. Cannulas' specifics and tips positions.

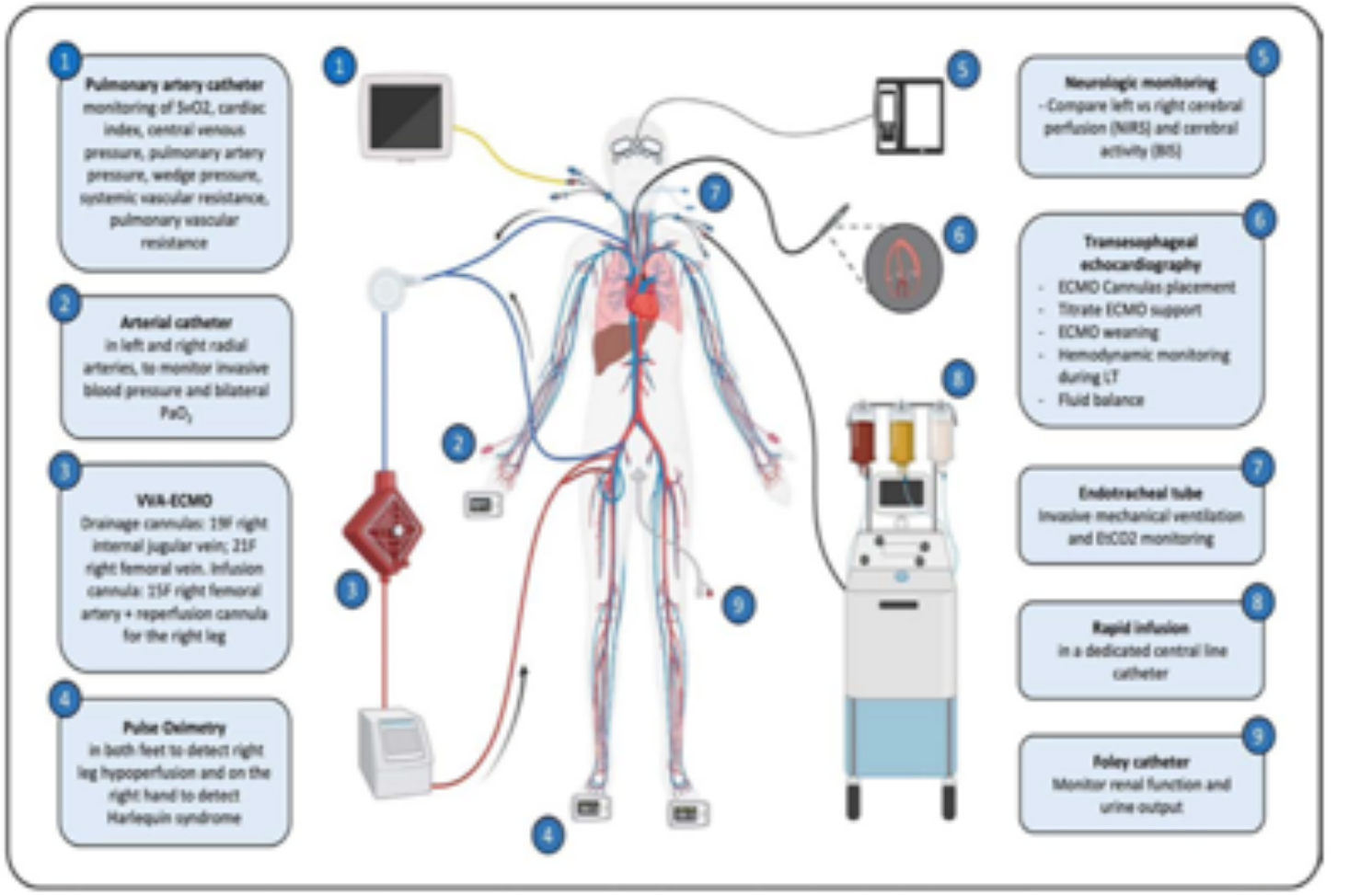


Figure 2. Anesthesiologic monitoring and medical devices used during liver transplant.

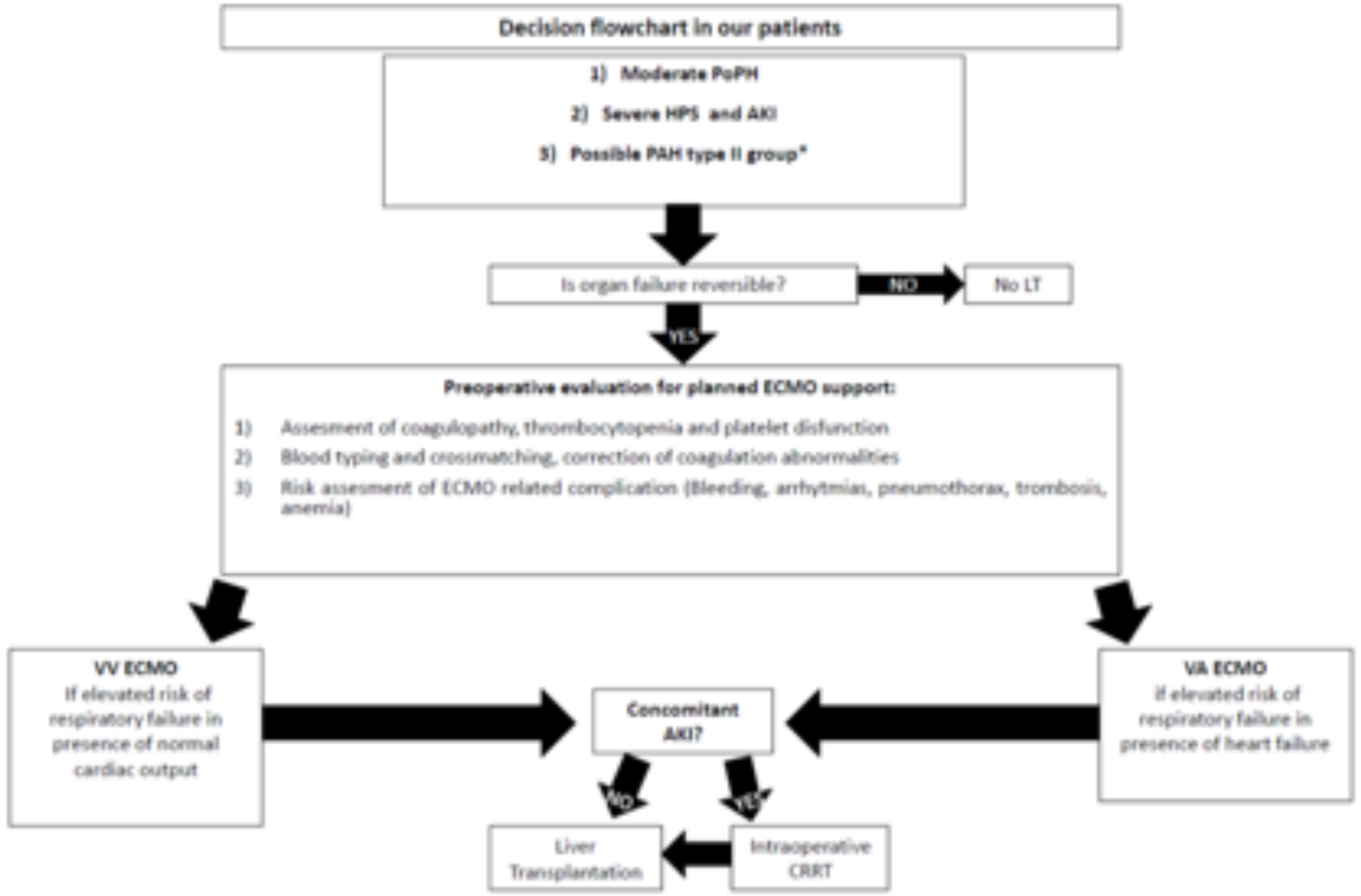
Rapid weaning from VA-ECMO 6 hours after surgery

CVVHF for 10 days – avoid graft congestion

ICU discharge on day 15 post-LT, EF was 55%,

Six months after LT, kidney and liver function tests were normal

Ten months after the transplant, the patient successfully underwent MVR with simultaneous tricuspid annuloplasty


Decision flowchart in our patients
1) Moderate PoPH
2) Severe HPS and AKI
3) Possible PAH type II group*
Is organ failure reversible?
NO
No LT
YES
Preoperative evaluation for planned ECMO support:
1) Assesment of coagulopathy, thrombocytopenia and platelet disfunction
2) Blood typing and crossmatching, correction of coagulation abnormalities
3) Risk assesment of ECMO related complication (Bleeding, arrhytmias, pneumothorax, trombosis, anemia)
VV ECMO
If elevated risk of respiratory failure in presence of normal cardiac output
Concomitant AKI?
VA ECMO
if elevated risk of respiratory failure in presence of heart failure
NO
YES
Liver Transplantation
Intraoperative CRRT

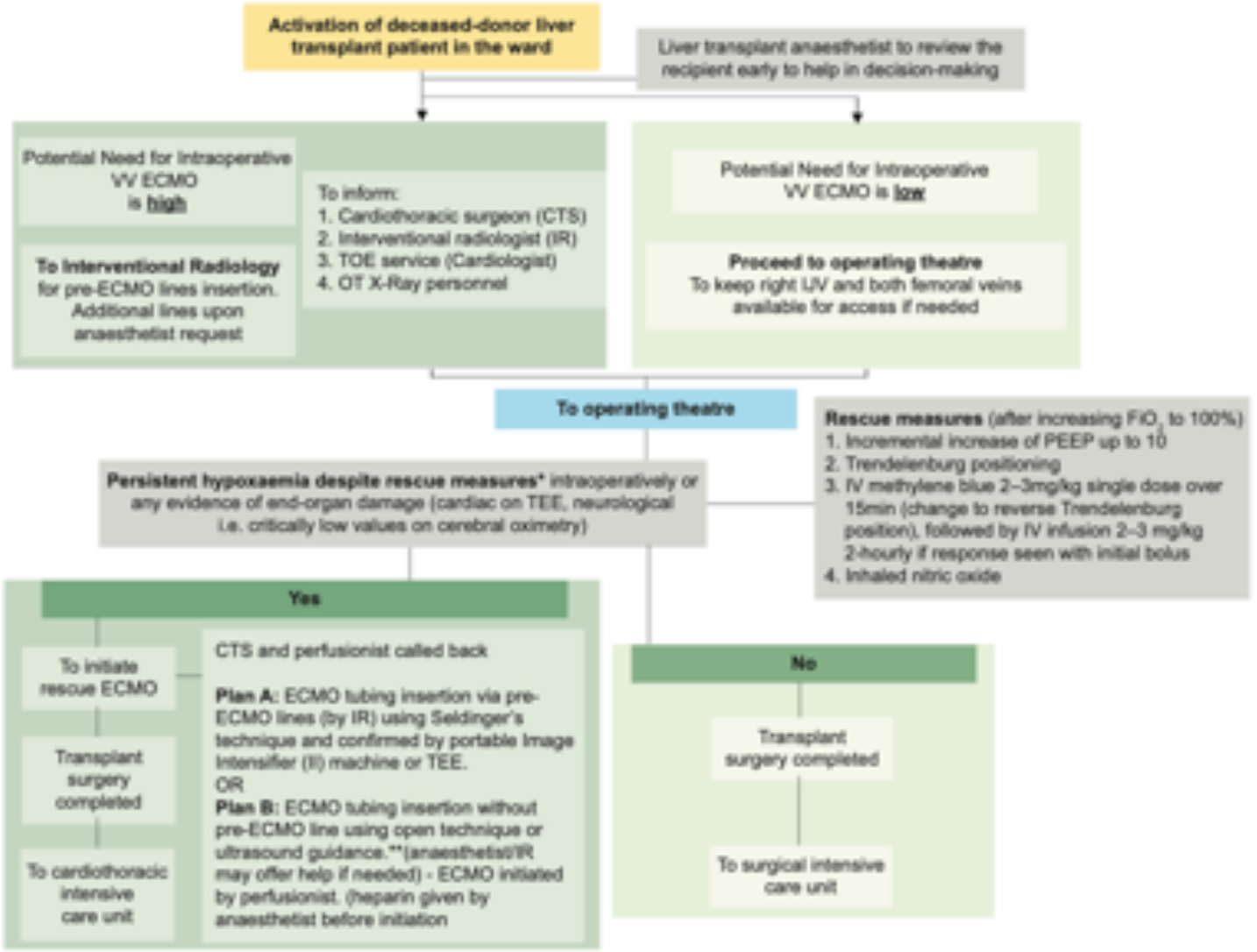
Letter to the Editor

Navigating a complicated liver transplant in a patient wit severe hepatopulmonary syndrome without extracorpore membrane oxygenation: a case report

62 year old NASH ESLD for DDLT

Pao2 of 42.5 with a shunt fraction of 39%

2L/min of home oxygen therapy



16G Certofix cannulas placed in RIJV and RCFV for immediate initiation of ECMO

Chan et al Singapore Med Journ 2023. ; Arguedas et al..Hepatology 2003

ECMO in donors

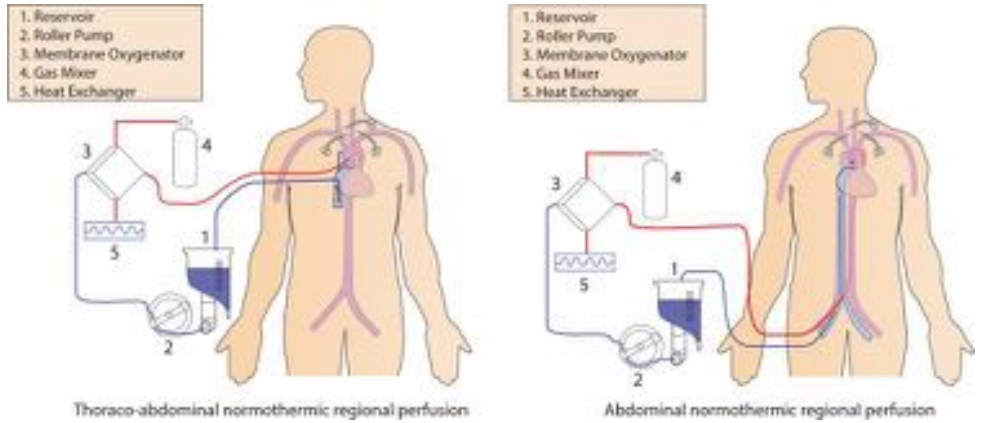
DBD donors

- DBD-drug vs DBD ECMO (19) from China
  - PNF incidence 10 vs 0 %
  - Improved renal function indices
  - Donation success rate increased steadily from 47.8% in 2011 to 84.6% in2014 after the ECMO intervention
- In situ split with 2 brain dead donors on VA ECMO- 4 liver recipients,1 heart, two lungs and 4 kidneys

•*Fan et al- Clin Transpl 2016*

•*Assalino et al -Am J Transplant.* 2018

DCD donors -NRP with ECMO



Norwegian experience with 8 donors - Postmortem cannulation after a no touch period — results comparable with DBD donors

Spanish experience with 46 DCD donors- premortem cannulation allowed-no ischemic cholangiopathy or graft loss seen

Italian experience-20 minute no touch rule- Sequential NRP+ ex situ machine perfusion before LT- 20 grafts procured and perfused with 18 implanted- acceptable outcomes with overextended WIT

NRP improves organ quality and maintenance before cold preservation, turns the DCD procedure into a more unhurried one, and allows the assessment of organ function following the warm ischemic injury

They contribute to the donor pool with high quality donor organs

Outcomes and Rate of complications similar to using conventional DBD grafts

Ruiz P, Transplantation 2018; Hagness et al Transplant Proc 2019 ; Ghinolfi et al Liver Transpl 2021

The Evolving Role of Extra-corporeal Membrane Oxygenation in Liver Transplantation.

Curr Opin Organ Transplant. 2021

Rachel Hogen, MD[1], Ashraf H. Sedra, MD[2], Arash Motamed, MD[2], Juliet Emamaullee, MD, PhD[1]

ECMO should be considered in the peri-LT period for patients with severe, acute, and reversible causes of respiratory and/or cardiovascular collapse, with acceptable outcomes in patients that would otherwise not be expected to survive

Management of the post-LT patient on ECMO is challenging with a slowly enlarging body of literature to inform decision making

Future prospective, multi-center studies examining ECMO use in LT are unlikely, and thus continued reporting of single center experiences as well as careful review of the non-LT ECMO literature is necessary to develop best practices.

Summary

- Use of VVB should be reserved for special instances as per local expertise
- ECMO should be considered in severe acute reversible cardio respiratory failure peri transplantation
- Improved survival could be achieved through the earlier implementation of ECMO rather than as a final, heroic salvage procedure
- ECMO is expensive, and complications can result in a prolonged postoperative course
- Risk-to-benefit ratio is controversial and evidence is emerging more in its favour

Thank you