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Optimal Position of a Femorojugular Cannulation for Venovenous Extracorporeal Membrane Oxygenation in Acute Respiratory Distress Syndrome

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Published by Elsevier Inc.

0003-4975/$36.00
https://doi.org/10.1016/j.athoracsur.2022.10.023

Transplant & Mechanical Support: Research

Optimal Position of a Femorojugular Cannulation for Venovenous Extracorporeal Membrane Oxygenation in Acute Respiratory Distress Syndrome

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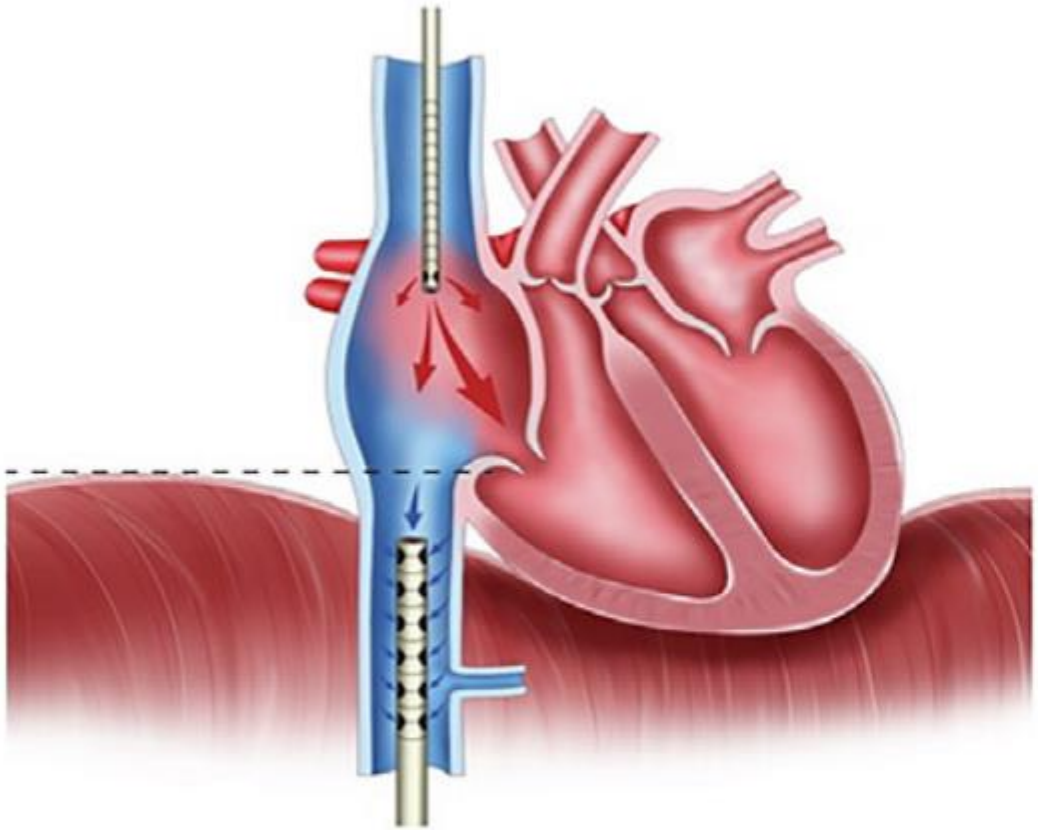
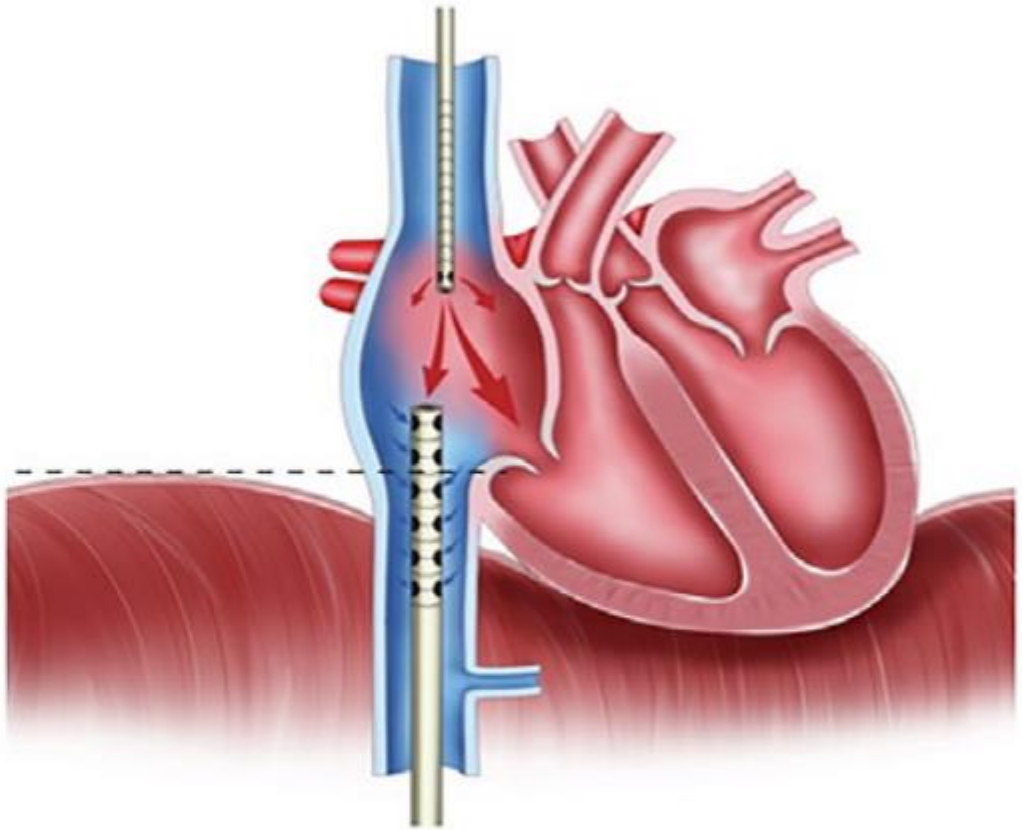
Femoro-jugular configuration of VV-ECMO

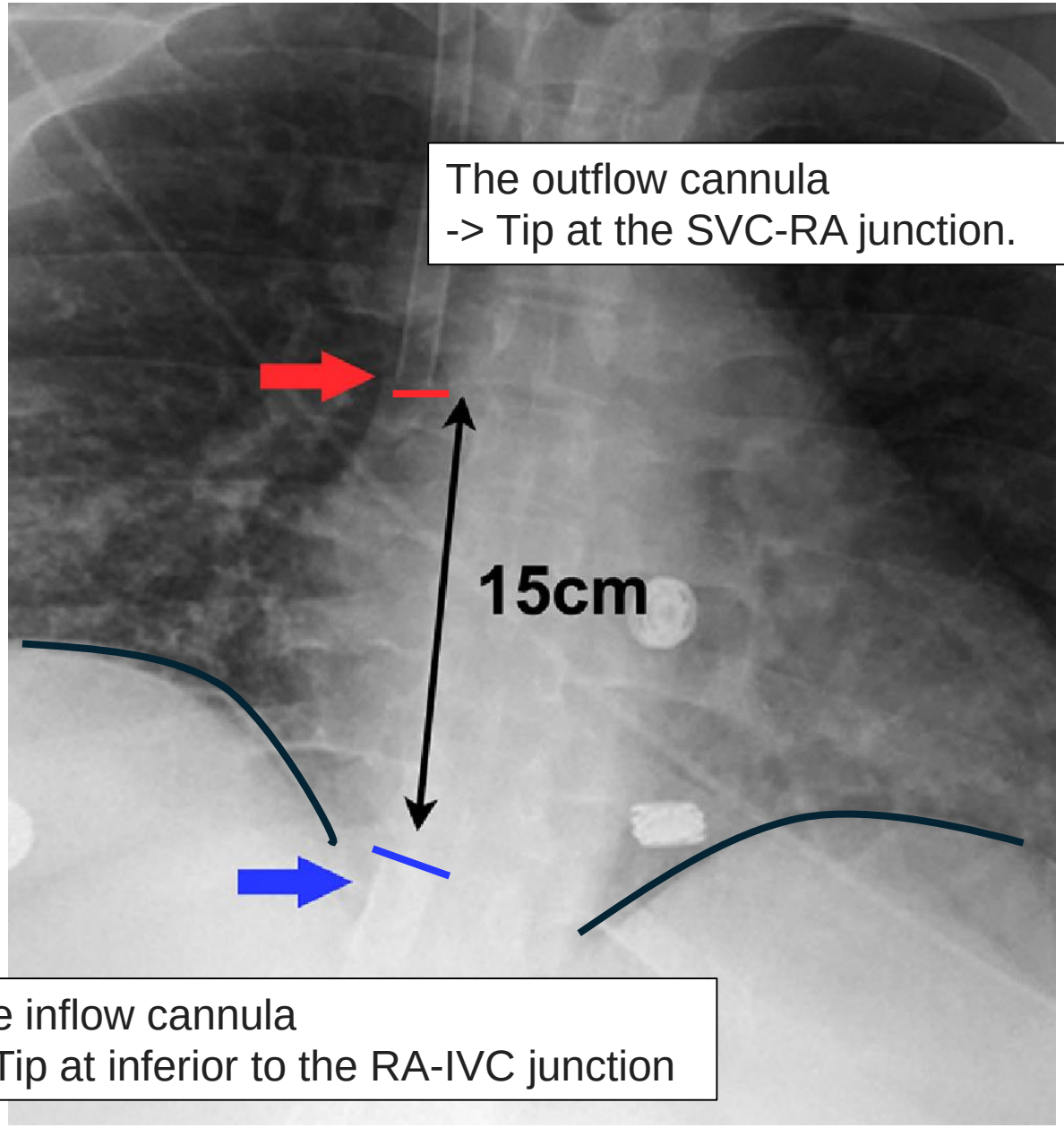


IVC group



RA group

To reduce recirculation



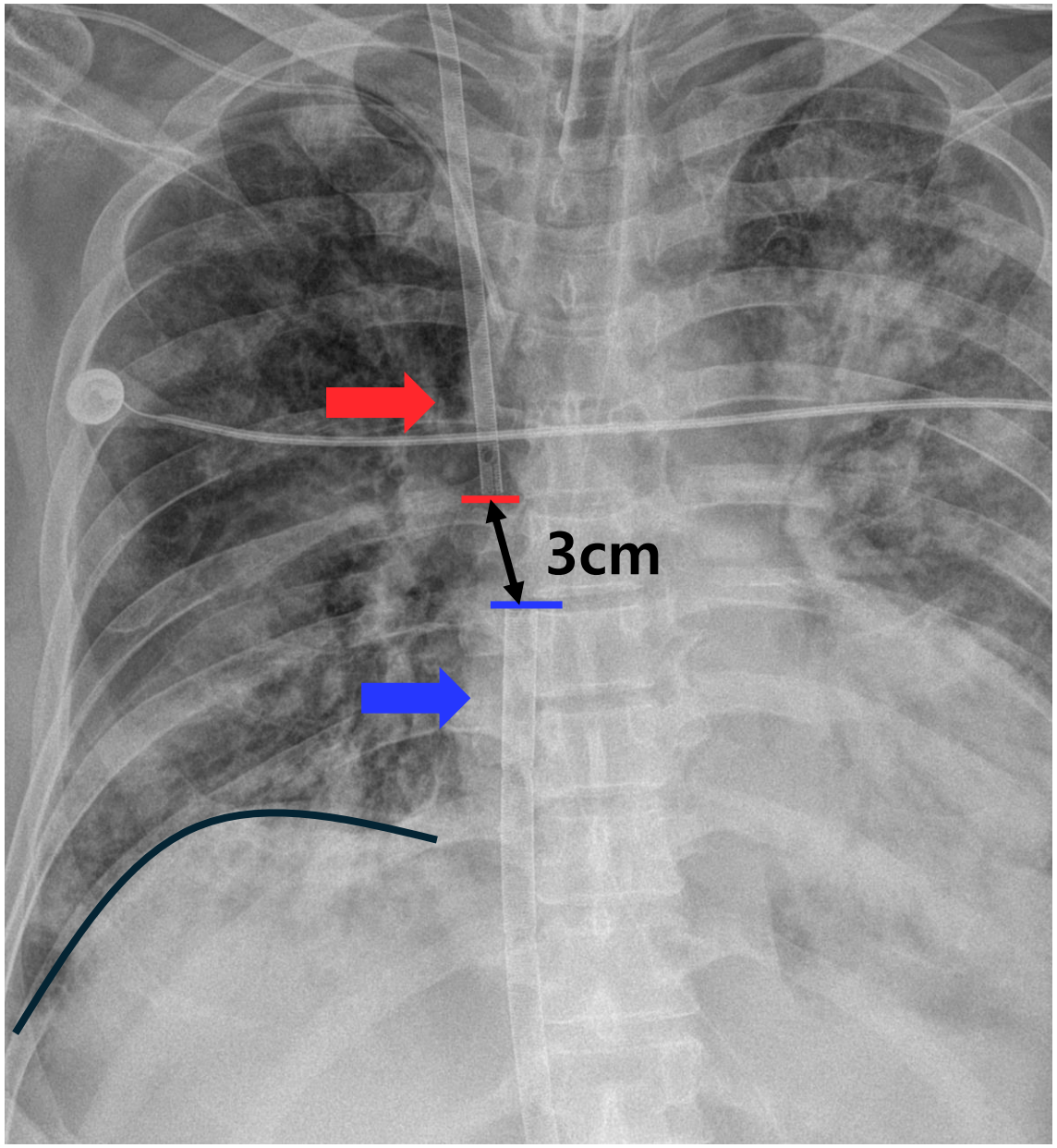
In sufficient VV-ECMO drain

- -Chattering
- -Volume replacement
- -Positive fluid balance
- -Pulmonary edema aggravation

Jayaraman A.L et al. *Ann Card Anesth.* 2017;20:S11–S18.

Douflé G et al. *Crit Care.* 2015;19:326.

Banfi C et al. *J Thorac Dis.* 2016; 8:3762-3773.

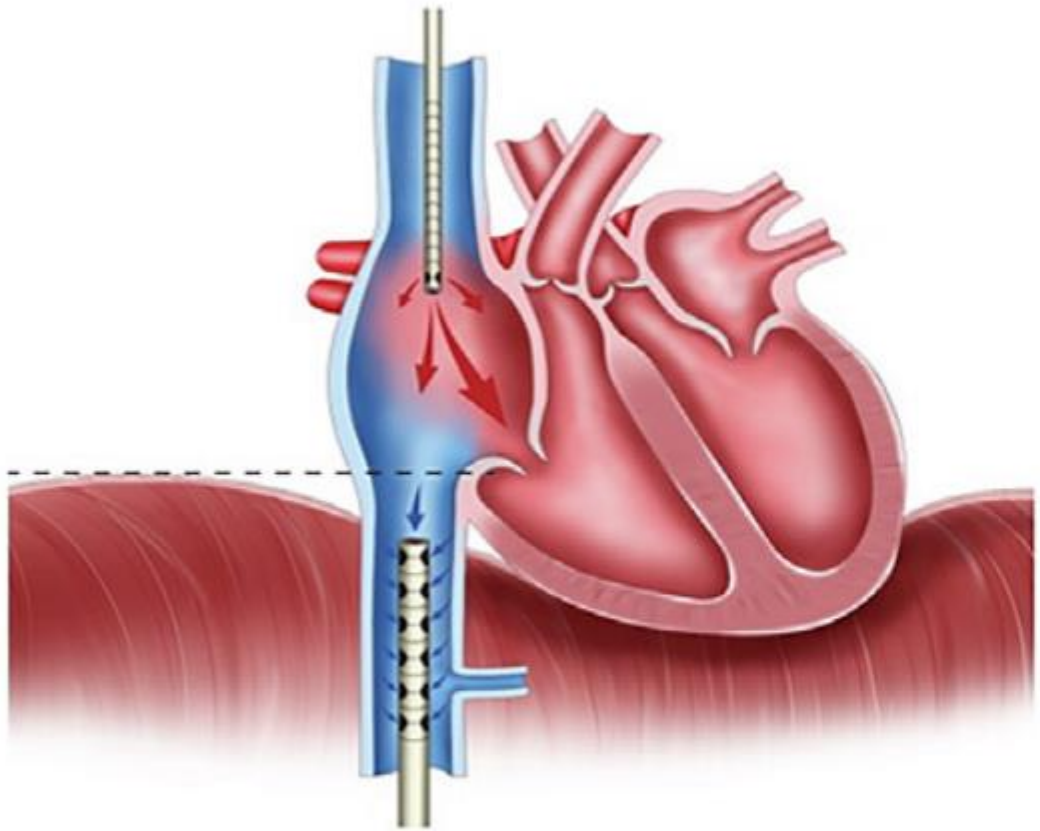


✚ FiO_2 1.0

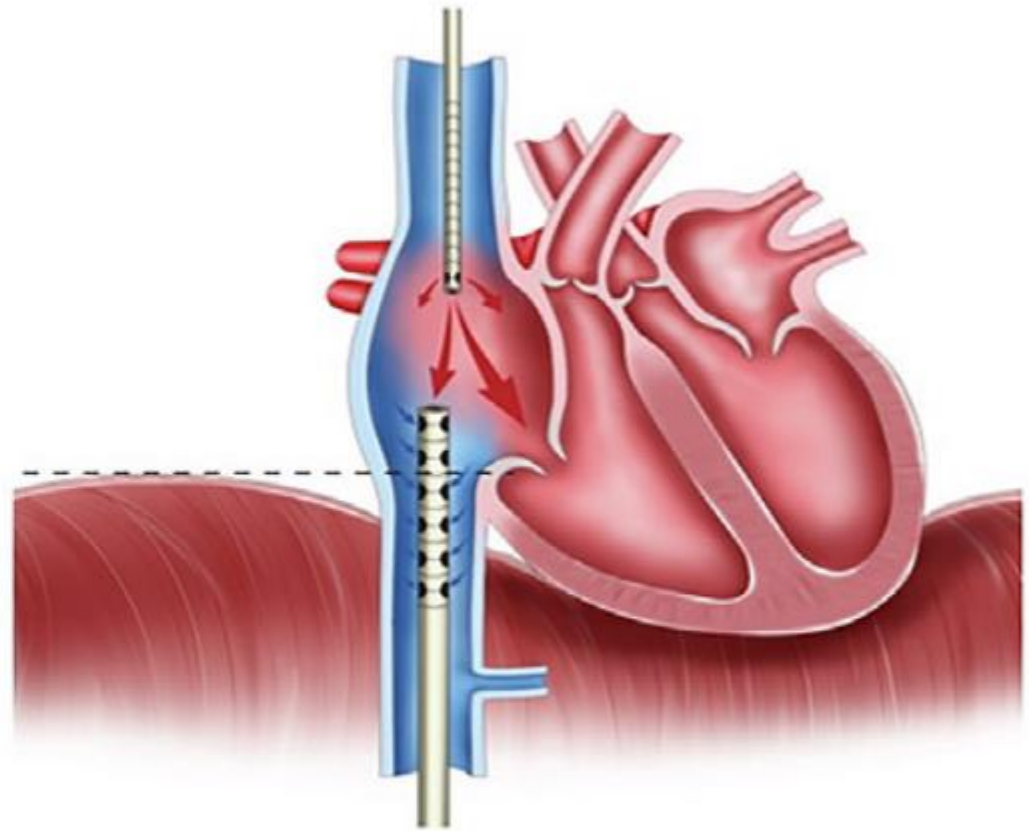
Recirculation fraction??

Sufficient patients' SaO_2

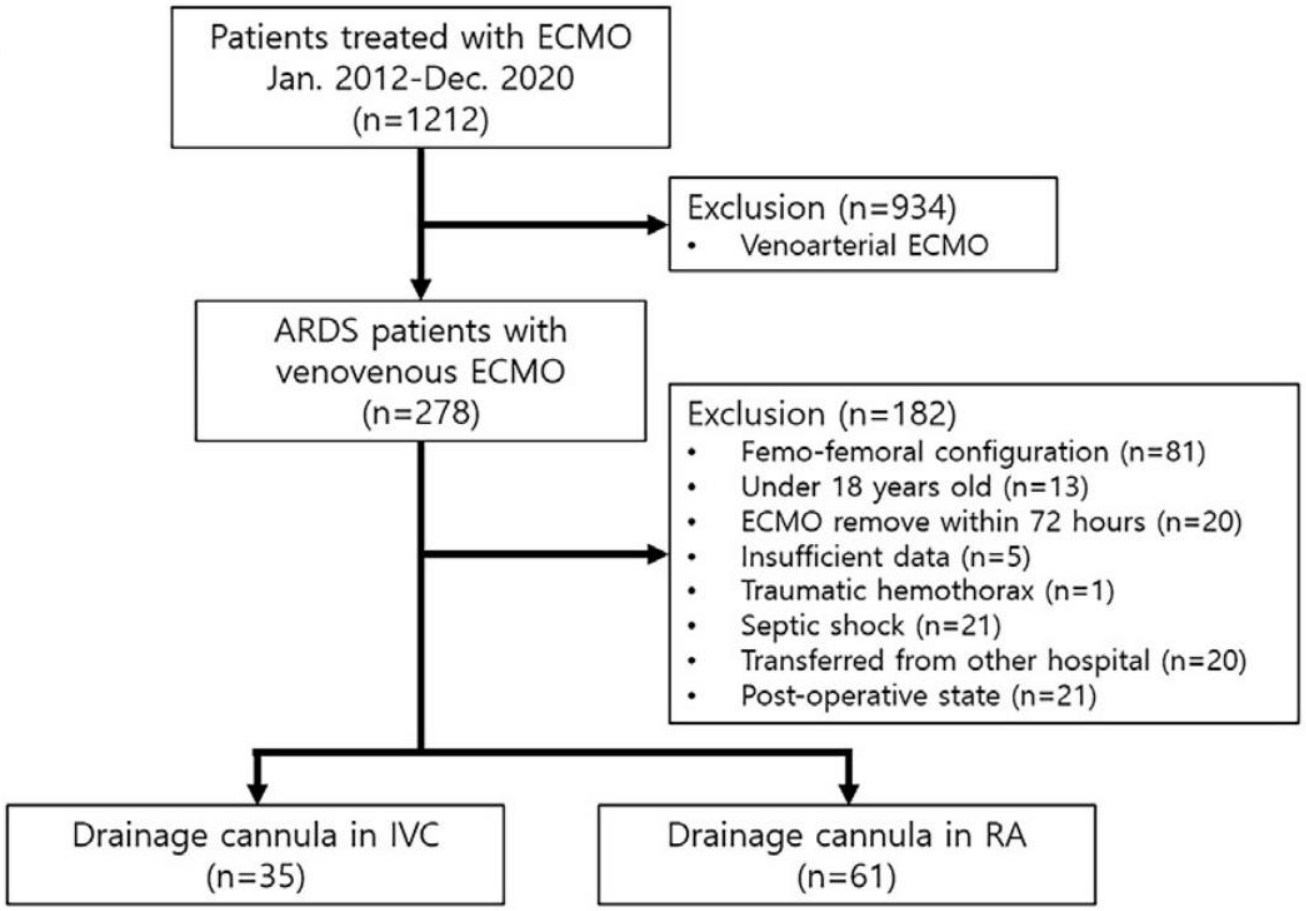
Sufficient VV-ECMO flow
-> Awaken ECMO



IVC group



RA group



Primary outcome

-Change in **body weight and fluid balance**

during 72 hr

Secondary outcome

-90-day mortality after VV-ECMO insertion

-Ratio of awake ECMO after 72 hr

-Recirculation fraction

DEFINITIONS

Awake under ECMO

-ECMO without mechanical ventilation in spontaneously breathing patients

Evaluation of recirculation fraction

-Preoxygenator partial O_2 (pre-oxyPO_2)/Postoxygenator partial O_2 pressure (post-oxyPO_2)

VV-ECMO management

-The initial fraction of oxygen in the sweep gas circuit was set at **FiO_2 1.0** with a sweep gas flow rate of 2 to 5 L/min.

-ECMO flow per minute were set to achieve a 50 to 80 mL/kg/min flow.

-**Target oxygen saturation and $PaCO_2$ levels were >85% and 35 to 45 mm Hg**.

-Heparinization: Activated clotting time between 150 and 180 seconds or activated partial prothrombin time between 55 and 75 seconds.

RESULT

TABLE 1 Patient Clinical and Treatment Characteristics

Variable	IVC Group (n = 35)	RA Group (n = 61)	*P* Value
Male sex	28 (80)	45 (73.8)	.47
Age, y	59.40 ± 11.92	58.61 ± 13.31	.77
Hypertension	11 (31.4)	23 (37.7)	.38
Diabetes mellitus	8 (22.9)	18 (29.5)	.50
Diuretic use	29 (82.9)	48 (78.7)	.62
Etiology of respiratory failure			.24
Viral pneumonia	5 (14.3)	15 (24.6)	
Bacterial pneumonia	17 (48.6)	30 (49.2)	
COPD/Asthma	0 (0)	2 (3.3)	
Aspiration pneumonia	2 (5.7)	0 (0)	
Interstitial lung disease	9 (25.7)	9 (14.8)	
Pulmonary contusion	1(2.9)	1 (1.6)	
Other	1 (2.9)	4 (6.6)	
Laboratory variables before ECMO			
White blood cells	14.2 ± 8.1	15.5 ± 7.8	.44
Hemoglobin	11.6 ± 4.2	10.5 ± 2.1	.07
Platelets	148.9 ± 123.0	184.3 ± 130.2	.19
Creatine	1.1 ± 0.7	1.1 ± 0.7	.88
eGFR	107.3 ± 79.8	102.8 ± 61.3	.42
Total bilirubin	1.3 ± 1.2	1.8 ± 4.1	.54
SOFA score before ECMO	7.7 ± 1.9	6.9 ± 2.1	.08
Arterial blood gas before ECMO			
PaO_2/FiO_2	64.7 ± 14.1	79.1 ± 26.2	*< .001*
PaO_2	58.9 ± 9.4	65.6 ± 11.2	*.004*
SaO_2	88.0 ± 5.8	86.9 ± 14.7	.69
PaO_2	48.7 ± 14.2	50.4 ± 13.7	.56
pH	7.4 ± 0.1	7.4 ± 0.1	.35
Pre-ECMO rescue therapy			
FiO_2	92.4 ± 9.8	87.2 ± 15.7	*.05*
Mechanical ventilator	32 (91.4)	55 (90.2)	.84

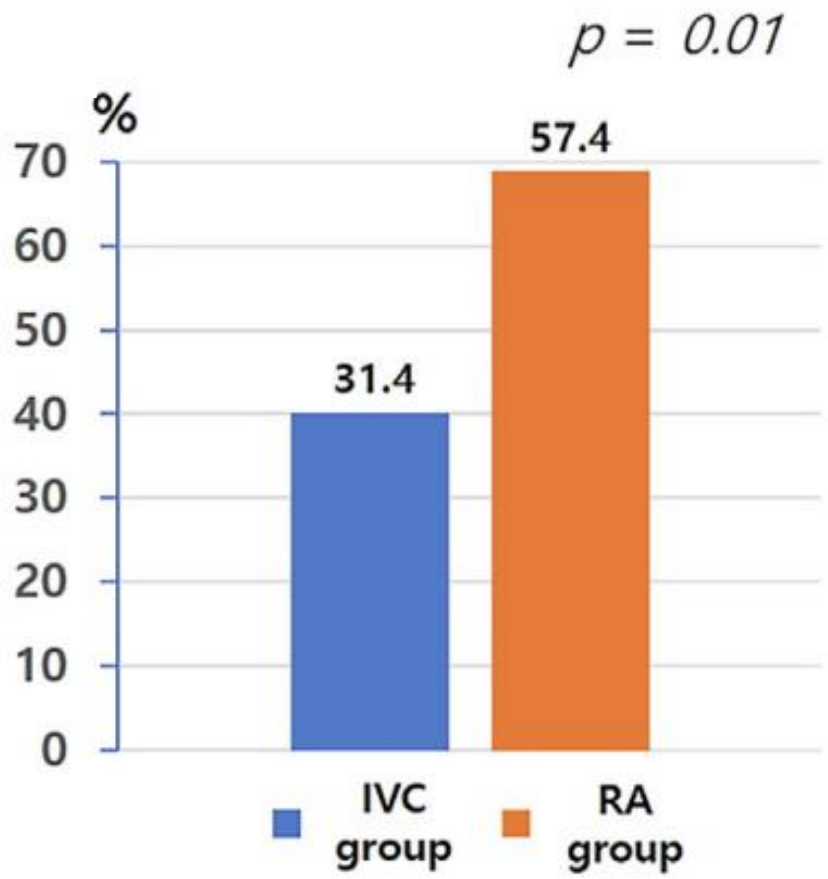
Values are expressed as mean ± SD, or n (%). Significant *P* values are presented in italics. COPD, chronic obstructive pulmonary disease; ECMO, extracorporeal membrane oxygenation; eGFR, estimated glomerular filtration rate; IVC, inferior vena cava; PaO_2/FiO_2, ratio of arterial oxygen partial pressure to fractional inspired oxygen; RA, right atrium; SaO_2, oxygen saturation; SOFA, sequential organ failure assessment.

TABLE 2 Clinical Outcomes of Venovenous ECMO Treatment

Variable	IVC Group (n = 35)	RA Group (n = 61)	*P* Value
Initial ECMO setting			
FsO_2	1.0	1.0	
Return cannula size, F	17.1 ± 0.9	17.0 ± 1.0	.18
Drainage cannula size, F	23.5 ± 2.2	23.2 ± 1.9	.47
Flow	3.8 ± 0.8	4.1 ± 0.7	.08
Cardiac index	2.3 ± 0.4	2.4 ± 0.4	.26
Gas flow	4.8 ± 1.8	4.2 ± 1.3	.10
72 h after ECMO			
ECMO flow	3.7 ± 1.0	4.0 ± 0.9	.07
Respiratory support FiO_2	35.7 ± 10.1	33.6 ± 8.6	.29
$_{pre\text{-}oxy}PO_2/_{post\text{-}oxy}PO_2$ (72 h)	0.128 ± 0.106	0.114 ± 0.088	.48
Peripheral ABGA (72 h)			
PaO_2	89.2 ± 21.0	88.9 ± 20.2	.99
SaO_2	95.9 ± 3.2	96.2 ± 2.0	.90
$PaCO_2$	42.9 ± 12.7	39.7 ± 7.0	.17
ECMO support days	27.6 ± 38.0	28.4 ± 24.6	.90
In-hospital mortality	23 (65.7)	40 (67.2)	.88
ECMO weaning	17 (48.6)	27 (44.3)	.68
90-d mortality	22 (62.9)	40 (67.2)	.83
Ventilator-free days	10.0 ± 11.1	11.7 ± 10.7	.68
Catheter repositioning	1 (2.9)[a]	4 (6.6)[b]	.65

[a]Additional femoral venous drain catheter was inserted in opposite femoral vein due to poor drainage; [b]Drainage catheter was repositioned due to low SaO_2. ABGA, arterial blood gas analysis; ECMO, extracorporeal membrane oxygenation; FiO_2, fractional inspired oxygen; FsO_2, fraction of oxygen in the weep gas; IVC, inferior vena cava; $_{pre\text{-}oxy}PO_2/_{post\text{-}oxy}PO_2$, ratio of preoxygenator partial O_2 pressure ($_{pre\text{-}oxy}PO_2$) to postoxygenator partial O_2 pressure ($_{post\text{-}oxy}PO_2$); RA, right atrium; SaO_2, oxygen saturation.

Negative fluid balance during 72 hr



Body weight change during 72hr

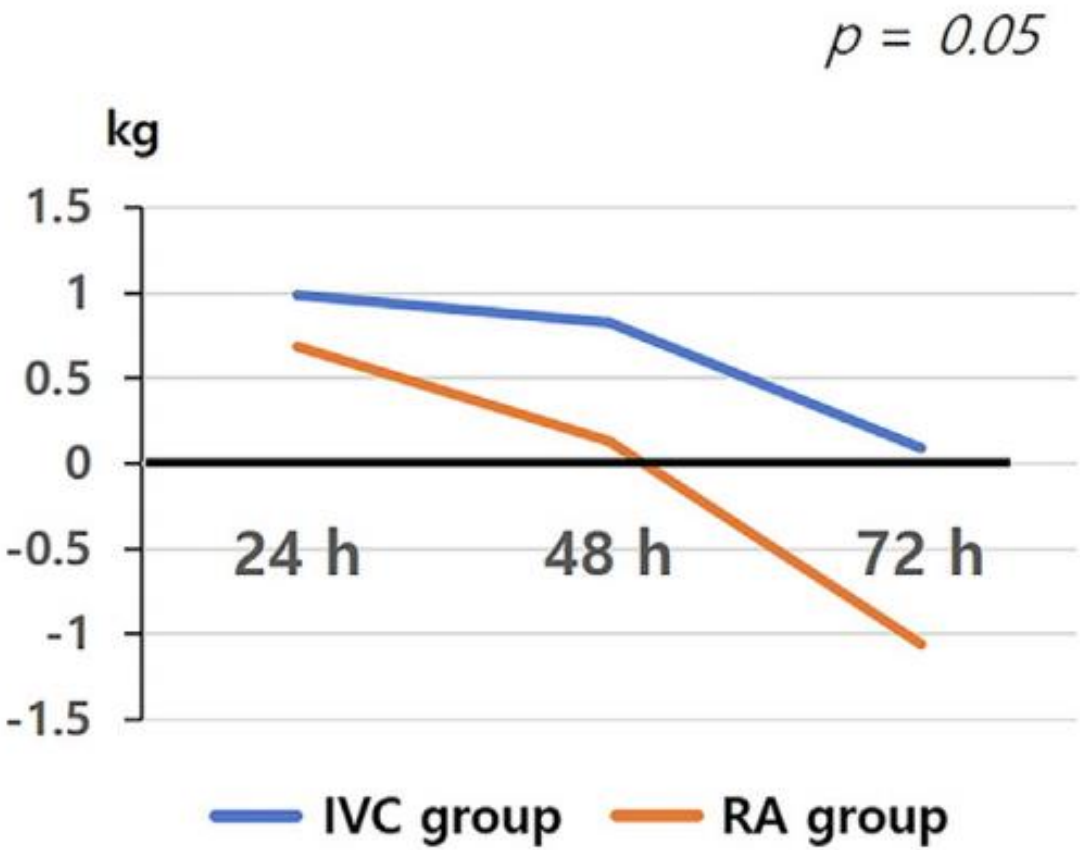


TABLE 4 Predictors of Bodyweight Reduction After 72 Hours

	Univariate		Multivariate	
Variable	***P* Value**	**OR (95% CI)**	***P* Value**	**OR (95% CI)**
RA group	.007	3.316 (1.394-7.887)	*.007*	*3.546 (0.113-0.702)*
Venous cannula size, F	.81	0.975 (0.795-1.196)		
Body surface area	.14	5.660 (0.552-58.058)	.40	2.978 (0.239-37.141)
Female sex	.84	1.103 (0.428-2.843)		
CRRT	.27	1.667 (0.677-4.102)		
Awake ECMO	.63	1.249 (0.512-3.048)		
Index flow of ECMO	.18	0.487 (0.170-1.397)	.14	0.418 (0.132-1.328)

Significant *P* values are presented in italics. CRRT, continuous renal replacement therapy; ECMO, extracorporeal membrane oxygenation; OR, odds ratio; RA, right atrium.

Ratio of awaken ECMO

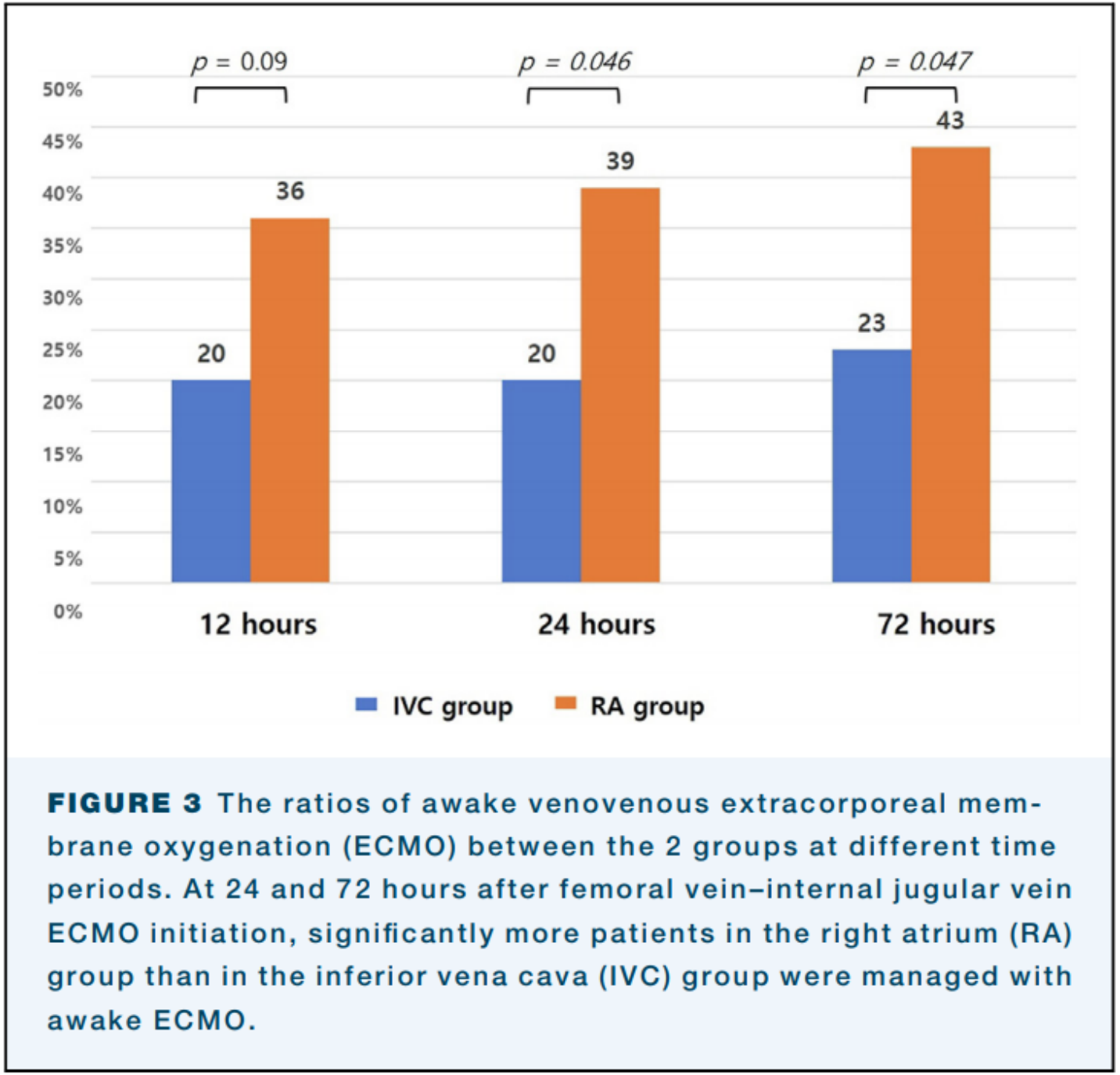


FIGURE 3 The ratios of awake venovenous extracorporeal membrane oxygenation (ECMO) between the 2 groups at different time periods. At 24 and 72 hours after femoral vein–internal jugular vein ECMO initiation, significantly more patients in the right atrium (RA) group than in the inferior vena cava (IVC) group were managed with awake ECMO.

DISCUSSION

Key points of this study

Drain cannula in RA

- Insignificant recirculation change

- More stable VV-ECMO flow

-> less unnecessary volume replacement, more awakening ECMO

DISCUSSION – Negative fluid balance in ARDS

A **net positive fluid balance** occurs in most patients at the onset of ARDS

-> Leading to prolonged mechanical ventilation, longer intensive care unit and hospital stays, and higher mortality rates. (1-3)

However, patients subjected to **restricted fluid management** at the early stage of ARDS

-> lower mortality, longer ventilator-free days (4-6)

1) Rosenberg AL et al. *J Intensive Care Med.* 2009;24:35-46.
2) Van Mourik N et al. *PLoS One.* 2019;14:e0224563.
3) Jia X et al. *Chest.* 2008;133:853-861.
4) Wiledemann HP et al. *N Engl J Med.* 2006;354:2564-2575.
5) Silversides JA et al. *Intensive Care Med.* 2017;43:155-170.
6) Malbrain ML et al. *Anaesthesiol Intensive Ther.* 2014;46:361-380.

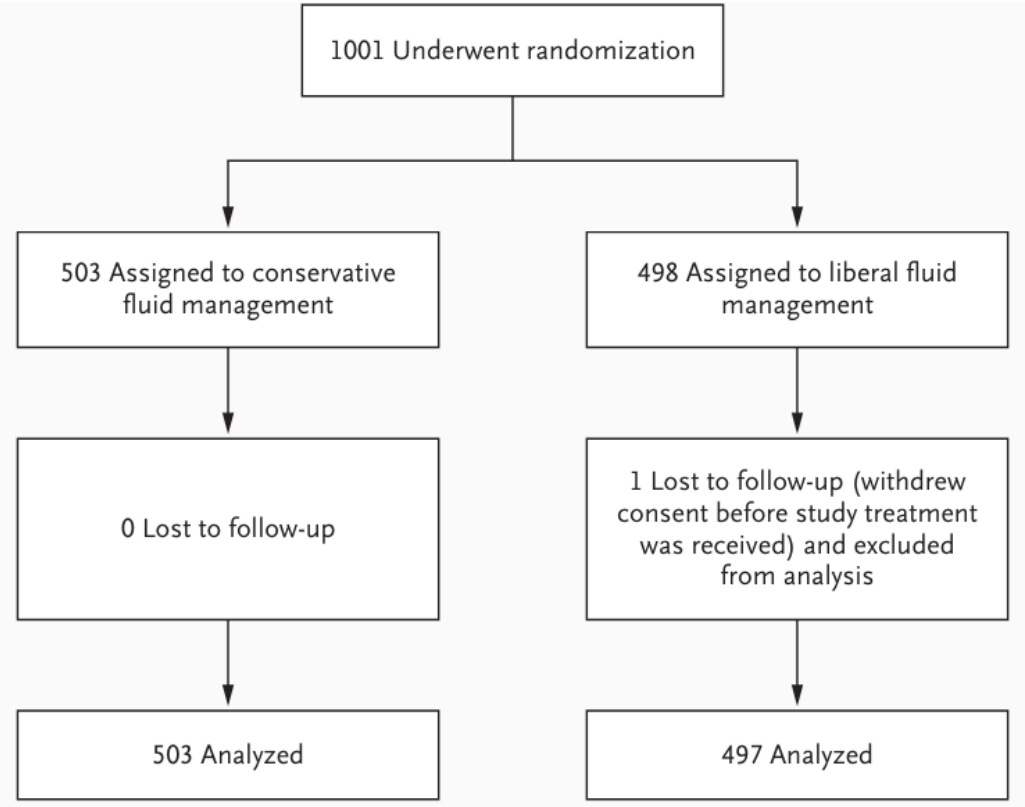
N Engl J Med 2006;354:2564-75.

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Comparison of Two Fluid-Management Strategies in Acute Lung Injury

The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network*



The primary end point : Death at 60 days

Secondary end points : Ventilator-free days

Organ-failure–free days

The mean cumulative fluid balance during the first seven days

-> 136±491 ml vs. 6992±502 ml (***P<0.001***)

The number of ventilator-free days during the first 28 days

-> 14.6±0.5 vs. 12.1±0.5 (***P<0.001***)

Days not spent in the intensive care unit during the first 28 days

-> 13.4±0.4 vs. 11.2±0.4, (***P<0.001***)

The incidence or prevalence of shock

-> 10% vs. 14% (P=0.06)

The rate of death at 60 days

-> 25.5% vs. 28.4% (P=0.30).

DISCUSSION – Recirculation

Insignificant difference in recirculation

-> No significant difference in peripheral oxygenation and pre-oxyPO_2/postoxyPO_2

Review Article

J Thorac Dis 2018;10(Suppl 5):S606-S612

Cannulation for veno-venous extracorporeal membrane oxygenation

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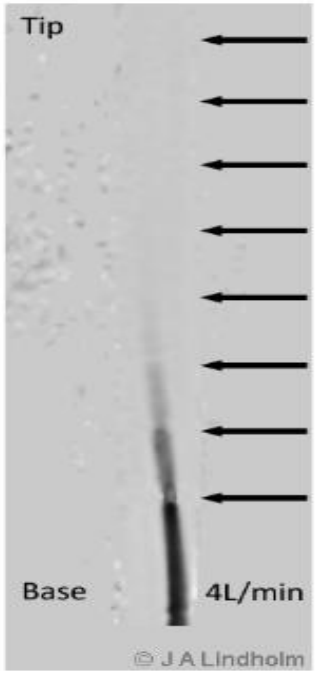

<MRI velocity scan>

At pump flow of 4 L/min and with all the side holes open the cannula is **mainly draining from the most proximal holes** and almost nothing at the tip.

CONCLUSION

Placement of a drainage cannula into the RA

->More stable VV-ECMO treatment without increasing recirculation.

less unnecessary volume replacement, more awaken ECMO.

-> Not related to survival outcome.

경청해주셔서 감사합니다.