Hospital Authority Convention 2016

Use of Extracorporeal Membrane Oxygenation in Respiratory Failure

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將血液體外加氧送回 讓心肺暫休息

人工肺續命 存活增兩成

受嚴重肺炎、肺纖維化或禽流感侵襲的病人，可出現急性肺功能衰竭，導致氧氣無法進入血液，最終因多重器官衰竭死亡。本港近年引入俗稱「人工肺」的體外膜氧合器（ECMO），將病人血液於體外加氧再送回體內，暫代心肺功能，病人存活率可提高近兩成。

肺功能衰竭令其他器官壞死

人工肺吊命 存活率七

【本報訊】呼吸系統疾病可導致急性肺功能衰竭，身體器官可能因而缺氧和衰竭，甚至致命。本港多間公立和私營醫院近年引入俗稱人工肺的體外膜氧合器（ECMO），仿照呼吸循環系統，代替肺部把氧氣帶入血液，為肺衰竭的病人「買時間」避免器官衰竭，減低死亡率。

記者：林家華

每日收費約三萬元

「人工肺」治療 存活率達71%

俗稱「人工肺」的體外膜氧合器，以往常用於開放式心臟手術時幫助病人呼吸，近年發現也適用於患有急性肺炎或肺功能衰竭患者身上，如感染豬流感、癆疾等，國際有多個研究結果顯示，人工肺治療病人存活率可由五成提升七成一。本港公立醫院去年亦曾利用人工肺治療嚴重豬流感患者，有私家醫院更成功利用人工肺治癒一名感染癆疾的外籍人士，為全球首宗案例。

人工肺的運作原理是把病人體內的靜脈血液引流至體外密閉的矽膜或微孔膜氧合器內，代替病人肺部將氧氣溶入血內，再帶離血中的二氧化碳，經溫度調節後將含氧血液送回大動脈內，患者體內的血和氧不需經過自身肺部，而是在體外進行氣體交換，達到呼吸作用；從而減輕心臟壓力和讓肺部休息，維持患者生命，避免肺功能進一步喪失及多重器官衰竭。

一名卅八歲印度裔商人，去年十一月由柔佛出席商貿會

Wingate）指，該患者因出現嚴重肺炎，肺功能愈來愈差，瀕臨死亡邊緣；他說如半成紅血球有癆疾寄生蟲已是很嚴重。

助染癆疾印商在港康復

其後醫院利用「人工肺」，病人經兩日搶救後逐漸轉好，至今年一月，在住院約兩個月後更康復出院。鍾世文指，此宗是全球利用人工肺治癒癆疾的首宗個案。

澳洲及紐西蘭一項研究顯示，去年六十八名感染豬流感後引致急性呼吸窘迫綜合症的患者，曾入住深切治療部（ICU）接受人工肺治療，四十八人治療後病情好轉。呼吸系統科專科醫生曾華德指，綜合國際有關人工肺在治療嚴重肺炎的研究結果，整體使用後的存活率達七成一，相較沒有使用人工肺的患者，存活率則僅五成。但使用人工肺亦有一定風險，如有六成二患者曾出

醫豬流感 ECMO掂

人類豬流感去年肆虐全球，而本港亦有不少人受感染，當中部分屬嚴重患者，本港部分深切治療病房為病人提供體外膜氧合治療，在

人工肺醫豬流感 6人康復1

體外膜氧合治療甲流效佳

【明報專訊】120名感染甲型H1N1流感（人類豬流感）並要入住公立醫院深切治療部的病人中，有7人因肺功能極差需要接受俗稱人工肺的體外膜氧合（ECMO）治療，最後6人完全康復，1人死亡。東區、聯合及威爾斯3間醫院的深切治療科合作而完成的研究顯示，本港的深切治療病房能夠成功引進人工肺技術。

研究證技術引進成功

3間醫院於2009 2010年2月28日 名接受人工肺EC 感病人之治療效益

名病人 人有慢 數BMI 胖。

無

研究 及機械 10天及 療病房 及31天 引致可

【記者曾雁翔報道】最新一期《香港醫學雜誌》報道，曾經有120名甲型流感（H1N1）患者，在深切治療部接受儀器進行體外呼吸和循環，當中7人使用了新技術「體外膜氧合治療」(Extra Corporeal Membrane Oxygenation，簡稱ECMO)，此方法可暫時代替患者的心肺功能，讓醫療人員爭取更多救治時間，當中6人康復，且無引起致命的併發症，顯示本港可引進此技術醫治病人。

爭取治療時間

去年H1N1甲型流感大流行，香港有34,964人感染，死亡個案達60宗。患上了H1N1甲型流感有機會引發急性呼吸窘奉綜合症，導致呼吸困難，需要進行機械通氣。今次研究的體外膜氧合治療，屬於急症室的設備之一，用以暫時協助大部分醫療方法皆無效的重度心肺衰竭患者進行體外的呼吸與循環。葉克膜除了能暫時替代患者的心肺功能，減輕患者心肺負擔之外，最重要是可以為醫療人員爭取更多治療時間，提升治愈機會。

研究報告指出，在2009年5月至2010年2月，有120

結果顯示，香港要接受機械換氣的甲型流感患，在深切治療 為， 件， 國相 效益

人工肺治心肺衰竭重症

本港去年爆發人類豬型流感（H1N1）後，香港部分深切治療病房開始提供俗稱人工肺的體外膜氧合治療（ECMO），爲患者進行體外的呼吸與循環。最新一期《香港醫學雜誌》分析本港採用人工肺的治療結果，顯示與外國的報告相近，認爲香港有能力全面引進人工肺技術，用以治療重度心肺衰竭患者。

ECMO（俗稱人工肺）是一種醫療急救設備，可引流病人的靜脈血至體外，經氣體交換後再送回病人的動脈或靜脈，暫時替代患者的心肺功能。

六名H1N1危殆病人康復

年二月期間，共有一百二十名H1N1 病房接受機械通氣，其中七人接受 。最終一名患者死亡，其餘六人完 直接由人工肺引致可威脅生命或肢

誌》刊登一項本港運用人工肺治療 吸窘迫綜合症的研究報告，發現本 的患者，其住院死亡率與外國一些 近，認爲香港有能力成功引進此技術，但成本效益和最佳的提供模式仍有待商榷。

記者 郭慧嫻

體外膜氧合治療 肺衰竭患者救星

患嚴重甲型流感（H1N1）可致命，自甲型流感於去年爆發後，香港部份深切治療病房開始爲有需要病人提供體外膜氧合治療（俗稱ECMO），拯救嚴重肺衰竭患者，把病人的靜脈血引至體外，經氣體交換後再送回人體內。

《香港醫學雜誌》指，ECMO是一種醫療急救設備，當大部份醫療方法皆無效時，就會拯救嚴重肺衰竭患者，做體外的呼吸與循環。ECMO會將病人的靜脈血引流至體外，經氣體交換後再送回病人的動脈或靜脈。

這樣可暫時替代患者的心肺功能，並爲醫療人員爭取更多救治時間。直至今年二月爲止的十個月期間，並有七名甲型流感患者接受額外的ECMO治療，最終一名患者死亡，其餘六人完全康復，並無發現直接由ECMO引致可威脅生命或肢體的併發症。

傳染病專科醫生勞永樂表示，ECMO是患者最後的希望，當人體肺功能壞掉時，ECMO像人工肺一樣，但治療人力物力需要嚴謹及龐大，否則患者會受到血的細菌感染及生盎，均可致命。

數據並進行
月為止的10個月期間，有120位 並沒有發現直接由EC

Principles of ECMO

- Temporary support the failed lung
  - Not suitable for irreversible lung failure
  - Less suitable for the lung condition required long time to heal (complication risk > benefit)
- Buy time for the lung to recover
  - Keep patient alive
  - Create an optimal condition for the lung to heal
- Avoid complications related to ECMO

Zapol, : (NIH Trial) (VA ECMO +ventilation and ventilation only) Severe ARF. A Randomized Prospective Study.
JAMA 1979:242:2193-6

- 90 patients from across the US between 1974 and 1977.
- No benefit shown with survival of <10% in both groups
- Issues with the study:
  - Primitive ECMO design
  - Limited experience with ECMO and IPPV
  - During ECMO, lungs were not put to rest
  - High bleeding complications

Morris et al. PC-IRV vs Extracorporeal CO_2 Removal Am J Respir Crit Care Med 1994;149:295-305

- 40 patients with severe ARDS enrolled
- 33% survival in 21 patients $ECCO_2R$ + LFPPV
- 42% survival in 19 patients PCIRV
- P = 0.8
- 7/19 cases on $ECCO_2R$ with bleeding resulting in premature discontinuation of Rx
- High pressure ventilation used before and $ECCO_2R$ with peak inspiratory pressure 45-50cm H_2O

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamma M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration

www.thelancet.com **Published online September 16, 2009**

Lancet 2009, 374:1351-63

- 177 UK patients, aged 18-65 years
- Randomly allocated
  - Consideration for treatment by ECMO or to receive conventional management
- Survival to 6 months without disability
  - 63% (57/90) in the group considered for treatment by ECMO
  - 47% (41/87) in the group of conventional management
  - Relative risk 0.69 (0.05-0.97) & p=0.03
  - No. needed to save one life without disability is 6

ECMO 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):1888-1895. Published online October 12, 2009(doi:10.1001/jama.2009.1535)

- During winter 2009 (1 June 2009 to 31 August 2009), Australia & New Zealand ICUs
- 68(34%) required ECMO out of 133 patients with IPPV
- For patients given ECMO
  - 48/68 (71%) survived ICU
    - 32/68 (47%) survived hospital
    - 16/68 (24%) still in hospital
  - 6/68 (9%) still in ICU
  - 14/68 (21%) died

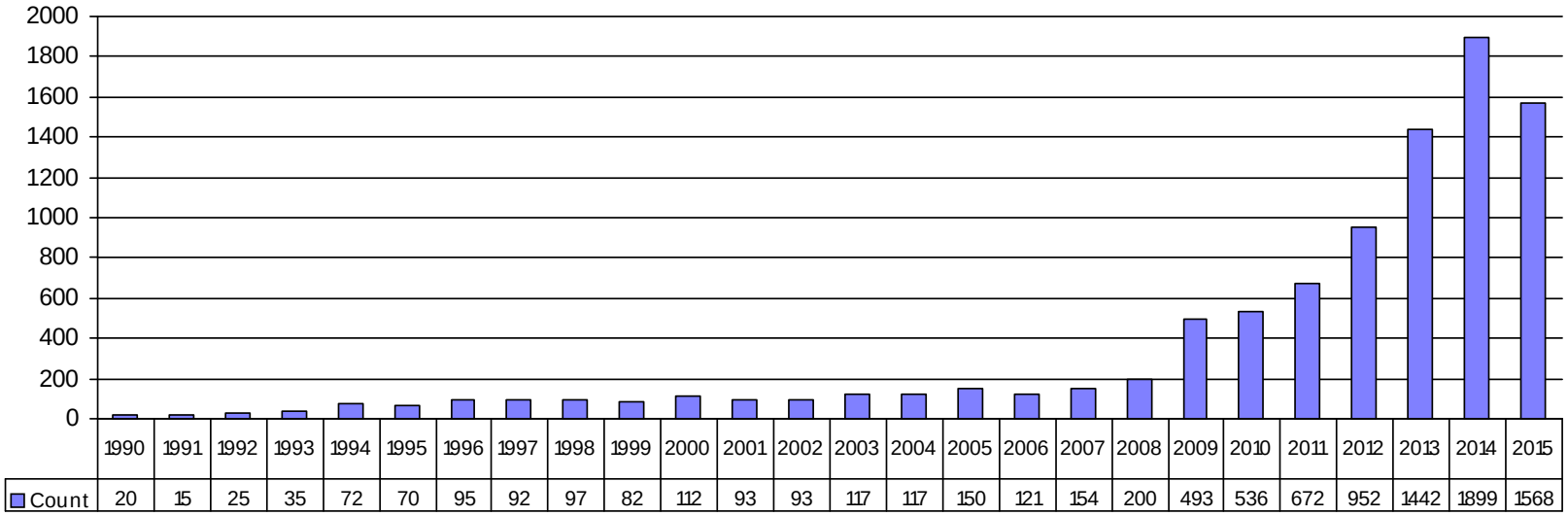
Referral to an ECMO center and mortality among patients with severe 2009 H1N1 – UK Study

JAMA. 2011;306(15):doi:10.1001/jama.2011.1471

- Cohort study involving 4 adult ECMO centers
  - 80 ECMO referred patients: H1N1 with severe ARDS, referred, accepted and transferred
  - 69(86.3%) actually received ECMO therapy
  - 22(27.5%) died
- Hospital mortality
  - Individual matching: 23.7% vs 52.5%, RR 0.45, p=0.006
  - Propensity score: 24.0% vs 46.7%, RR 0.51, p=0.008
  - GenMatch matching: 24.0% vs 50.7%, RR 0.47, p=0.001
- Number needed to refer to save 1 life is 4

Adult Respiratory (18 years and over)

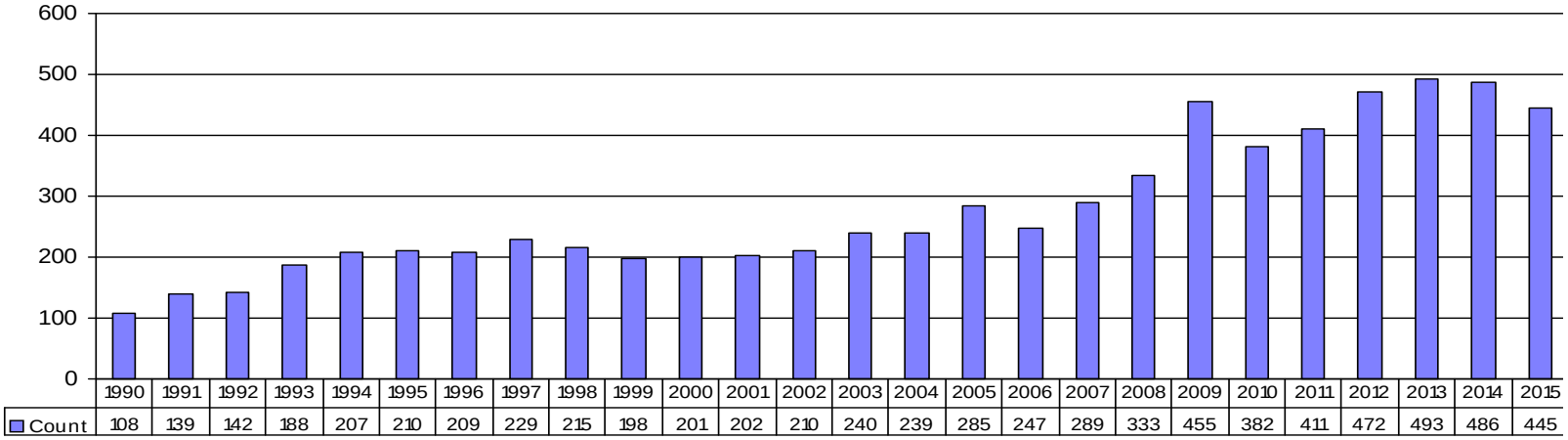
Annual Respiratory Adult Runs



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Count	20	15	25	35	72	70	95	92	97	82	112	93	93	117	117	150	121	154	200	493	536	672	952	1442	1899	1568

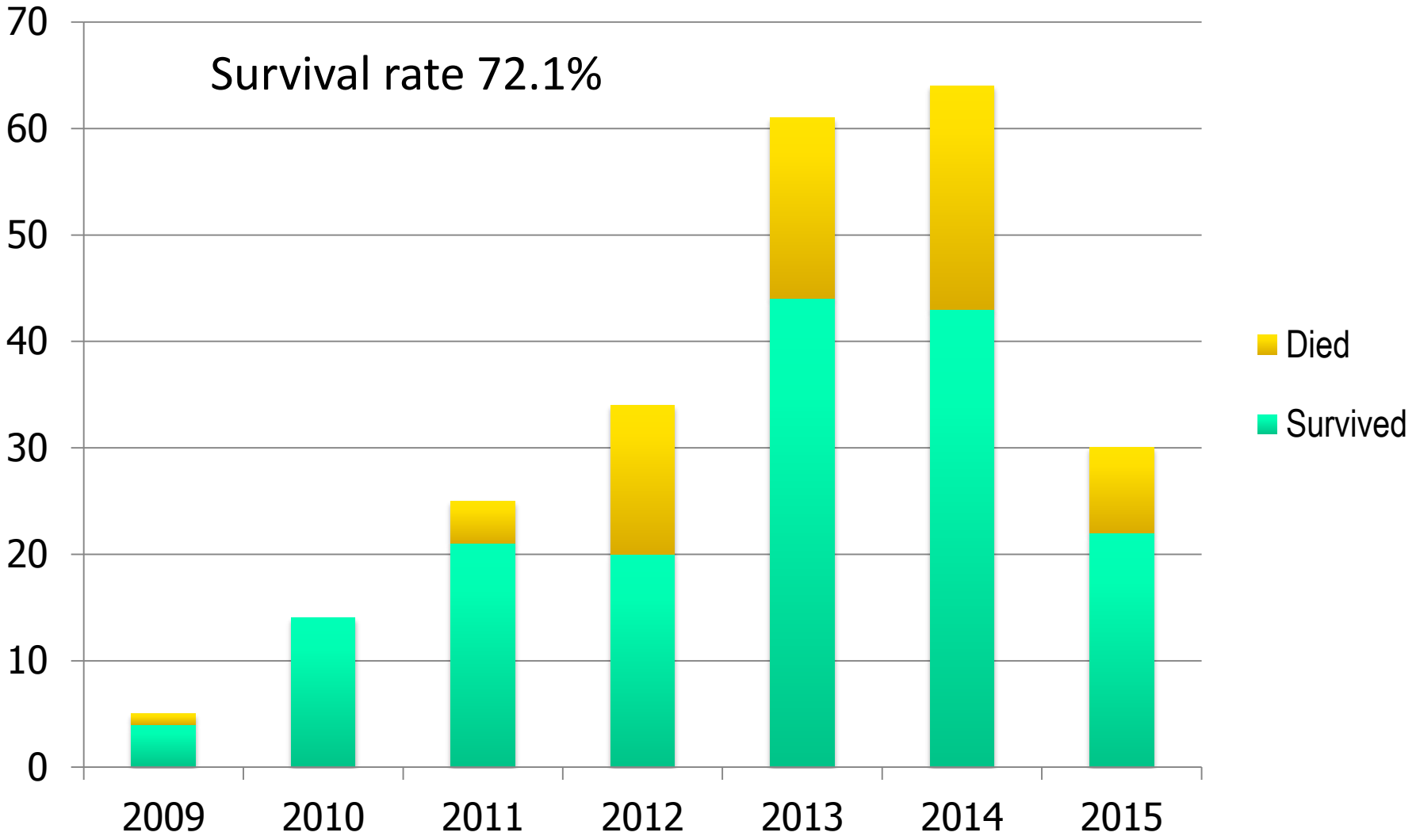
Pediatric Respiratory (> 30 days and < 18 years)

Annual Respiratory Pediatric Runs



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Count	108	139	142	188	207	210	209	229	215	198	201	202	210	240	239	285	247	289	333	455	382	411	472	493	486	445

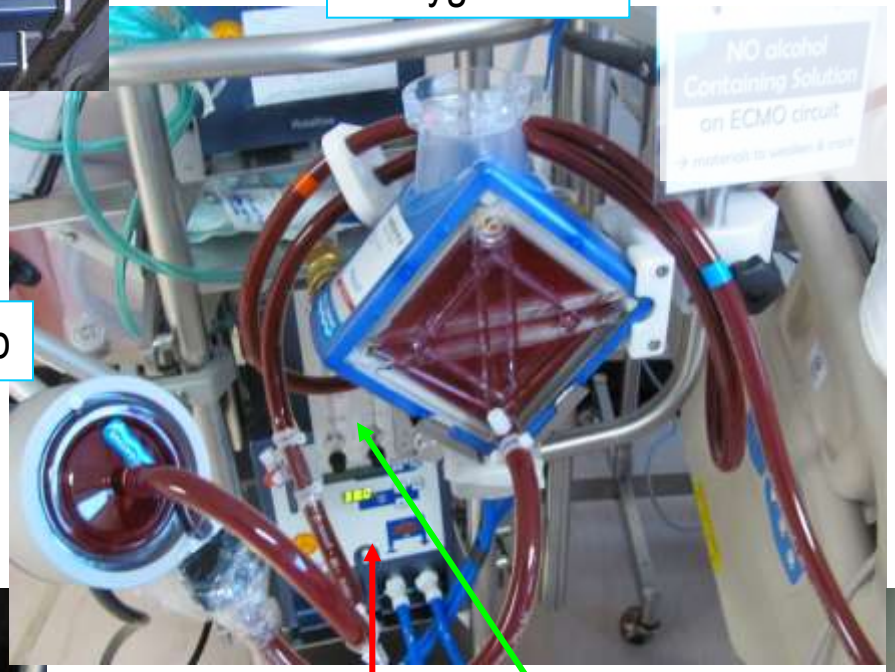
Respiratory ECMO in Hong Kong



Set Up

System console

Oxygenator



Return cannula

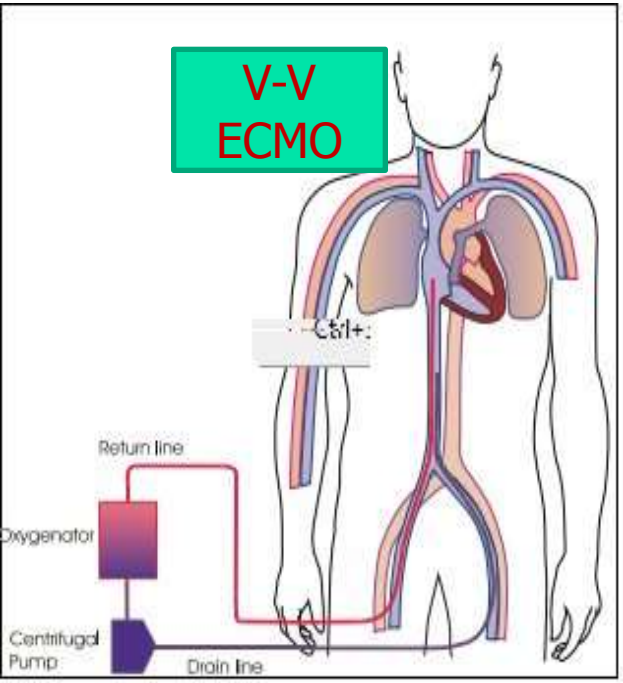
Access cannula

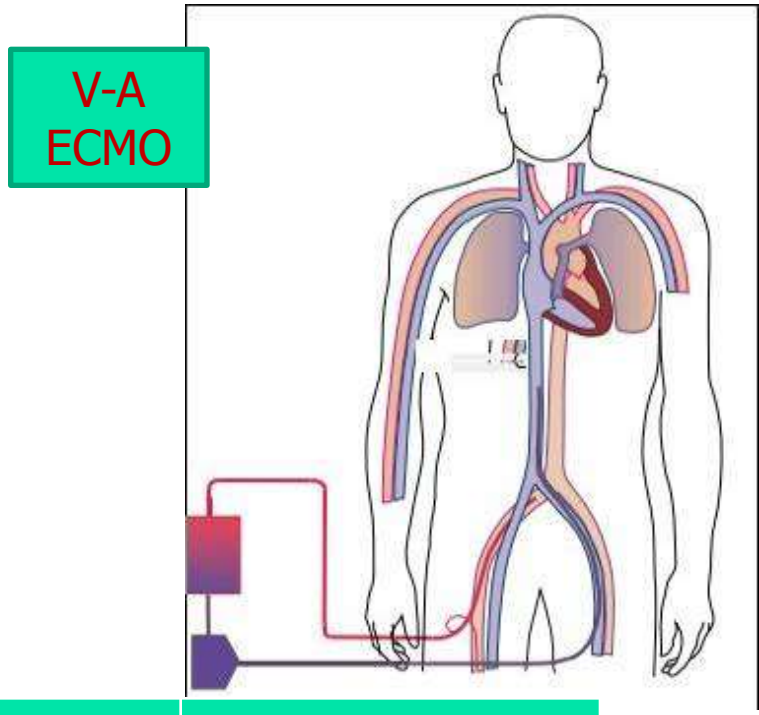
Centrifugal pump

Warmer

Air/O_2 blender

Types of ECMO





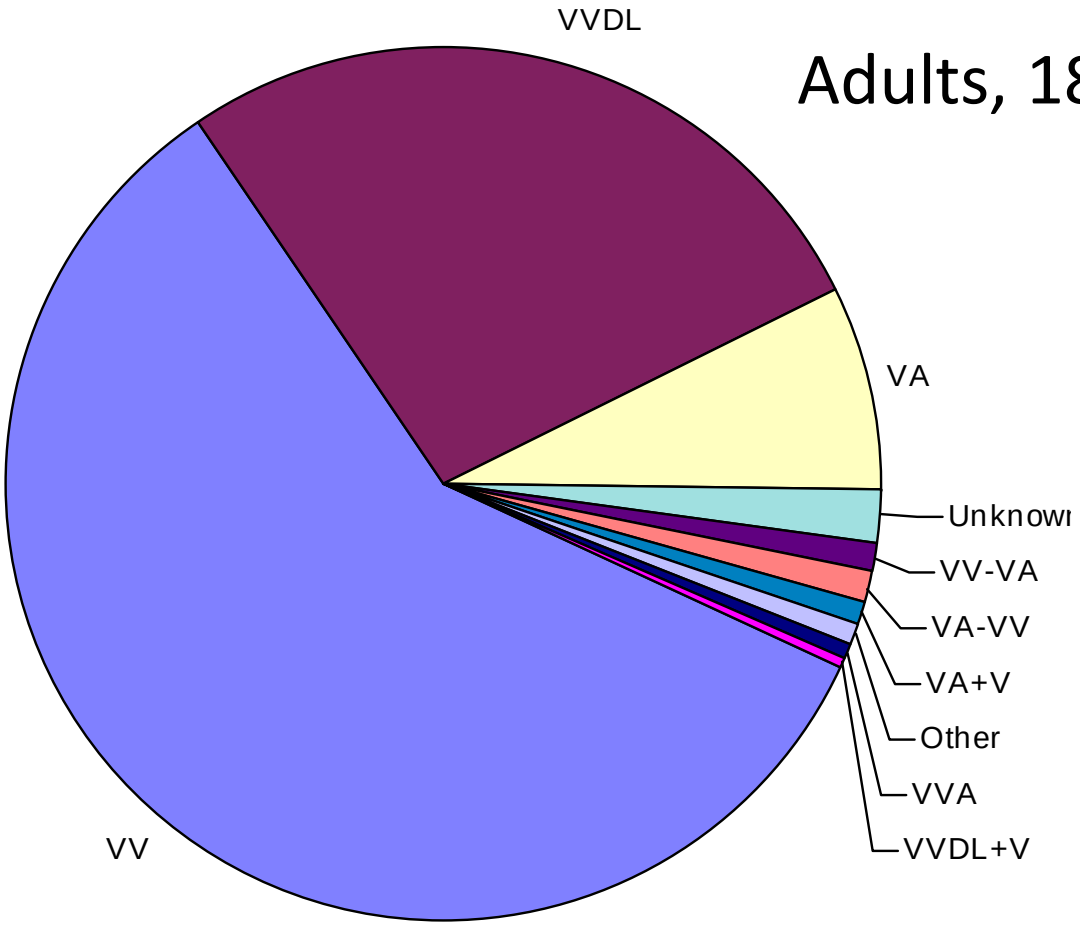
	Bad lung good Heart	Good lung Bad heart	Bad lung Bad heart
V-V	√	X	X
V-A	X	√	√

ECLS Registry Report

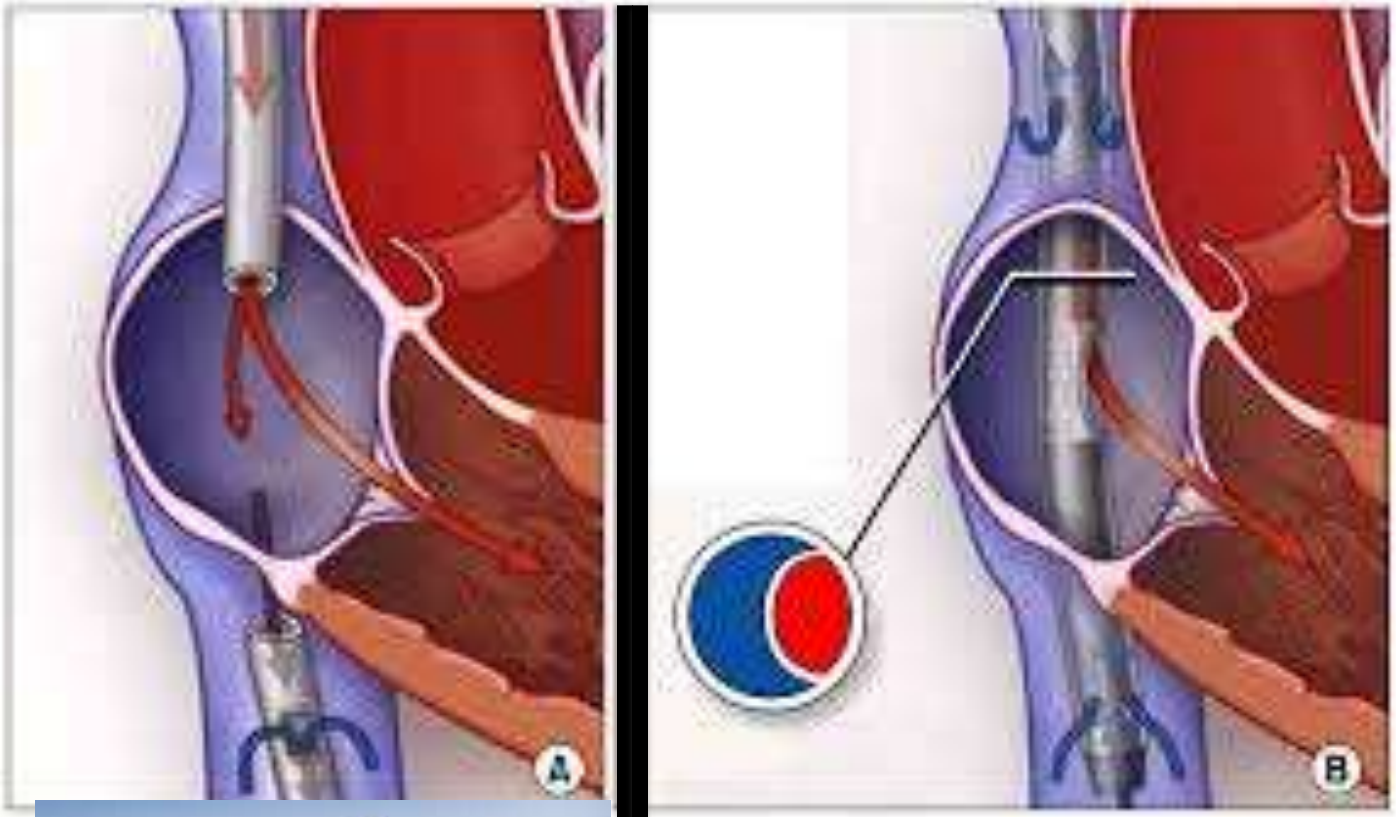
International Summary

Respiratory Support Mode

Adults, 18 years and over



VV & VV-DL ECMO



Dual Lumen ECMO Cannula

Difference between VA and VV ECMO

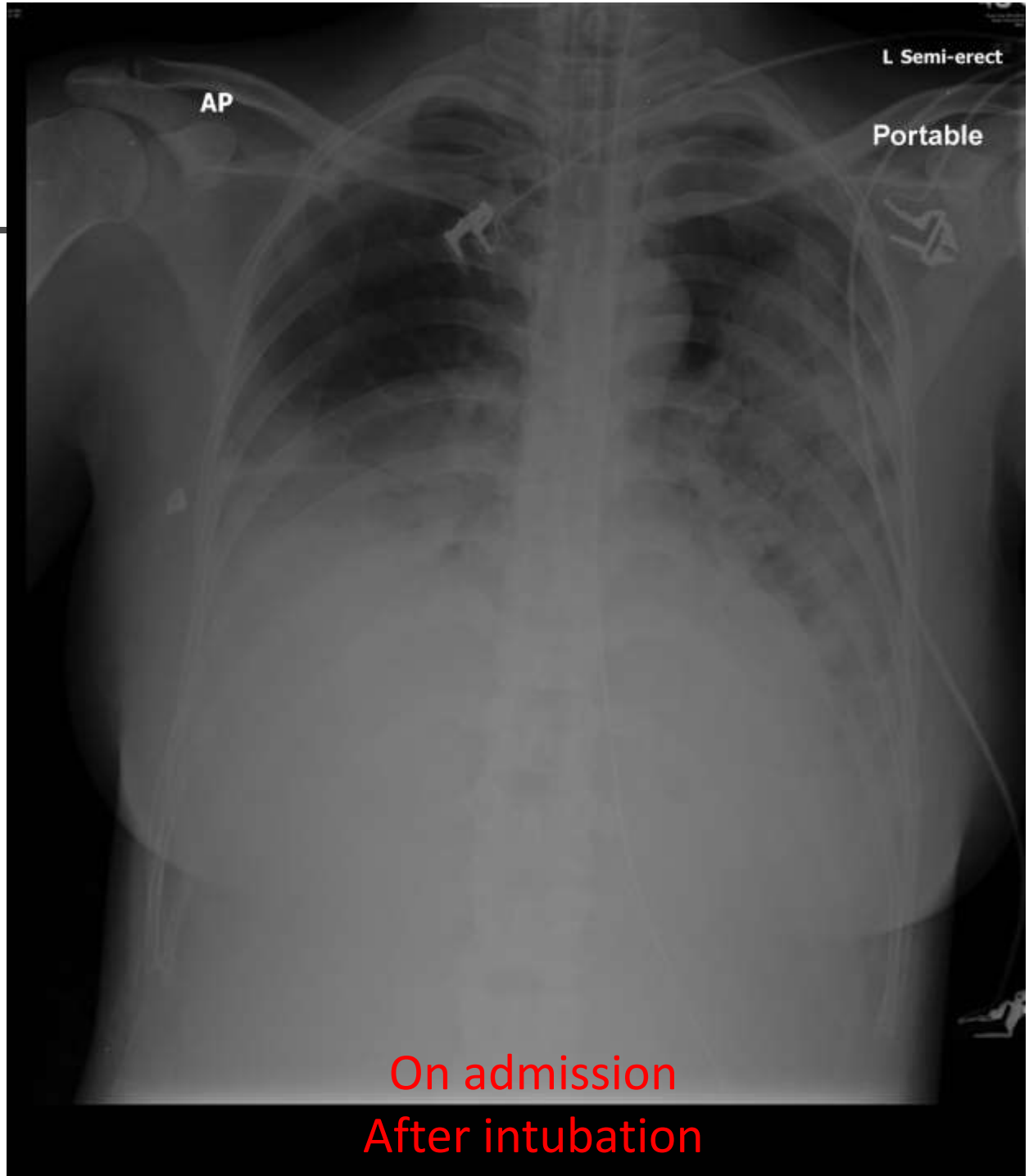
	VA	VV
Hemodynamic		
Systemic perfusion	ECMO flow and cardiac output	Cardiac output only
Arterial BP	Pulse contour damped	Pulse contour full
PA pressure	Decrease in proportion to ECMO flow	Not affected
Effect of R-L shunt	Present	None
Differential body perfusion	Occurs (in peripheral VA)	Does not occur

Difference between VA and VV ECMO

	VA	VV
Gas exchange		
Arterial oxygenation	Saturation depends on site (perfused by ECMO flow or native CO)	Same throughout systemic circulation (if no residual lung function, saturation <90% unless high flow VVV-ECMO)
Weaning	Cannot decrease O2 flow to zero	Can disconnect O2 flow
Arterial cannulation	Risk of limb ischaemia	None

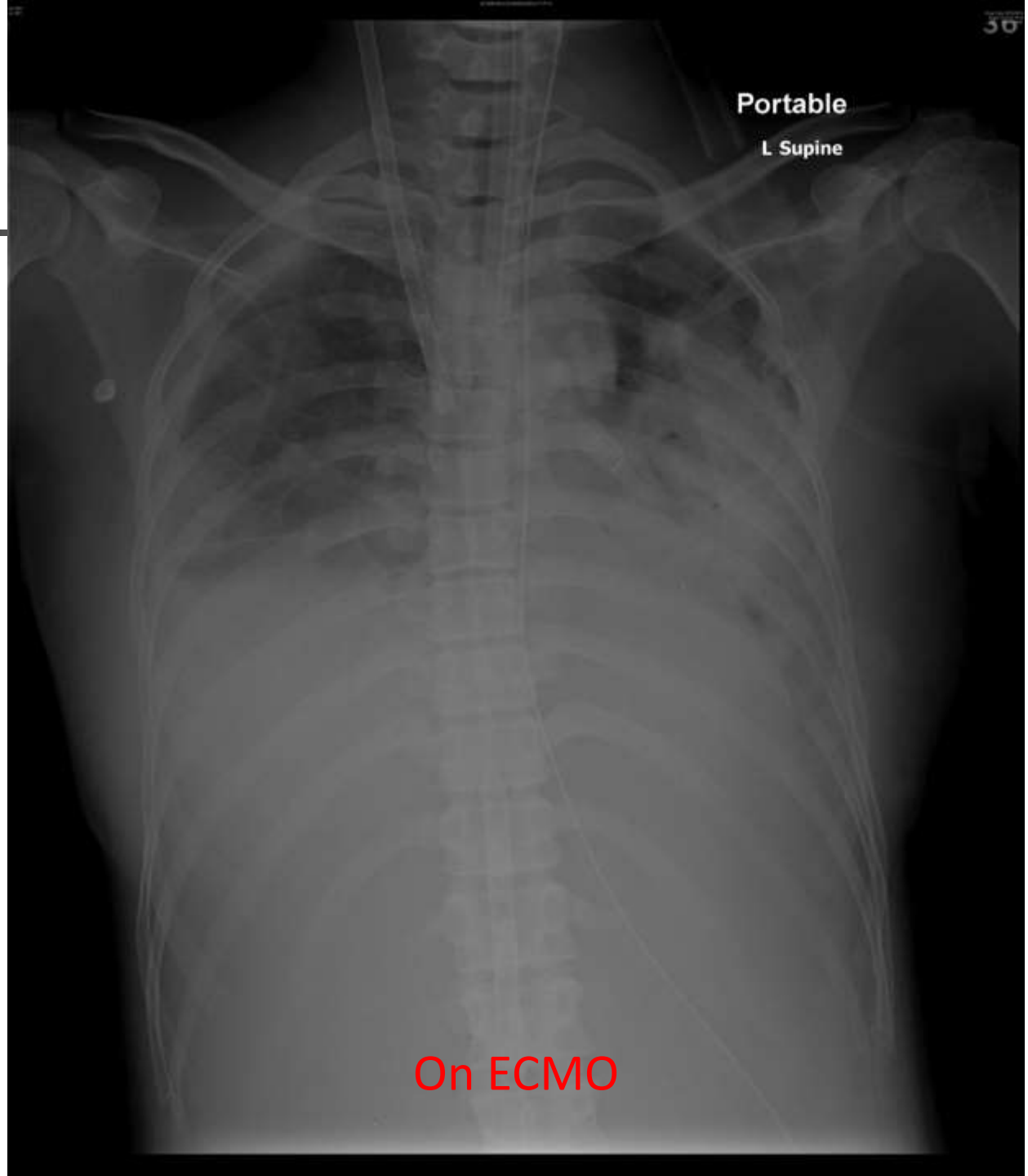
Case 1

- LSS, female/41 year-old
- Necrotizing pneumococcal pneumonia
- Complicated R empyema thoracis
- Severe respiratory failure & intubated
- Progressively worsen despite maximal support including IPPV
- PaO_2 <10kPa with FiO_2 1.0 & PEEP >15cmH_2O



On admission

After intubation

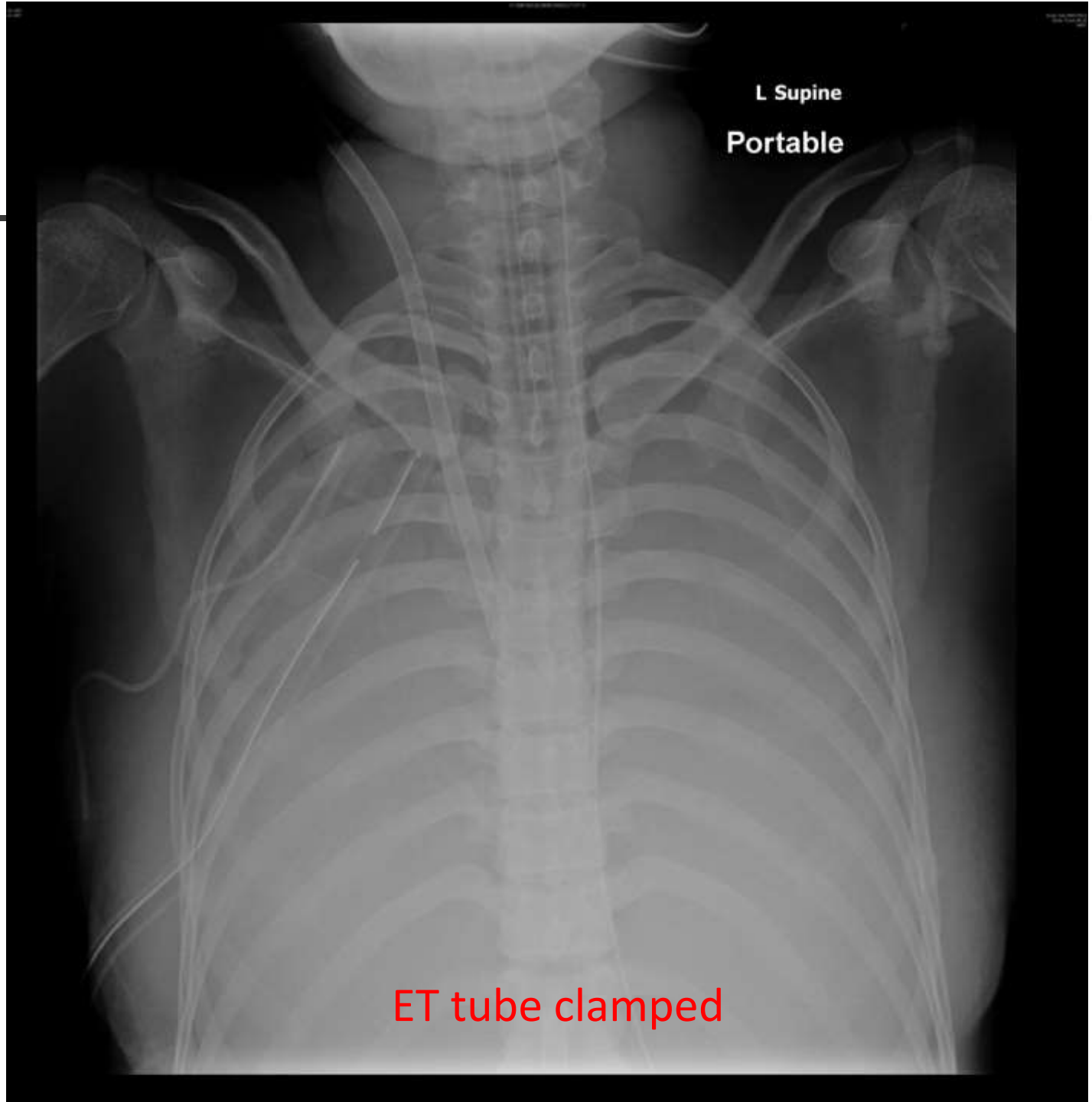

Portable
L Supine
On ECMO

LSS, F/41

- VV-ECMO was started
- R chest drain, pus drainage was good initially
- Later blocked by fibrin
- Urokinase locally instilled to R chest drain
- Developed massive hemoptysis two days later

Massive hemoptysis

- Spigot the endotracheal tube for two days
- Surgeon performed rigid bronchoscopy to clear the blood clots later


L Supine
Portable
ET tube clamped

Rigid bronchoscopy record

Preoperative Diagnosis:

Blood clots in main airways. Necrotising pneumonia with haemoptysis

Operative Diagnosis:

*(*Modifier: ?=Provisional; C=Complications)*

Haemorrhage from respiratory passage

Upper airway obstruction

Procedure:

Removal of intraluminal foreign body from trachea and bronchus without incision (blood clots)

Lavage of bronchus and trachea

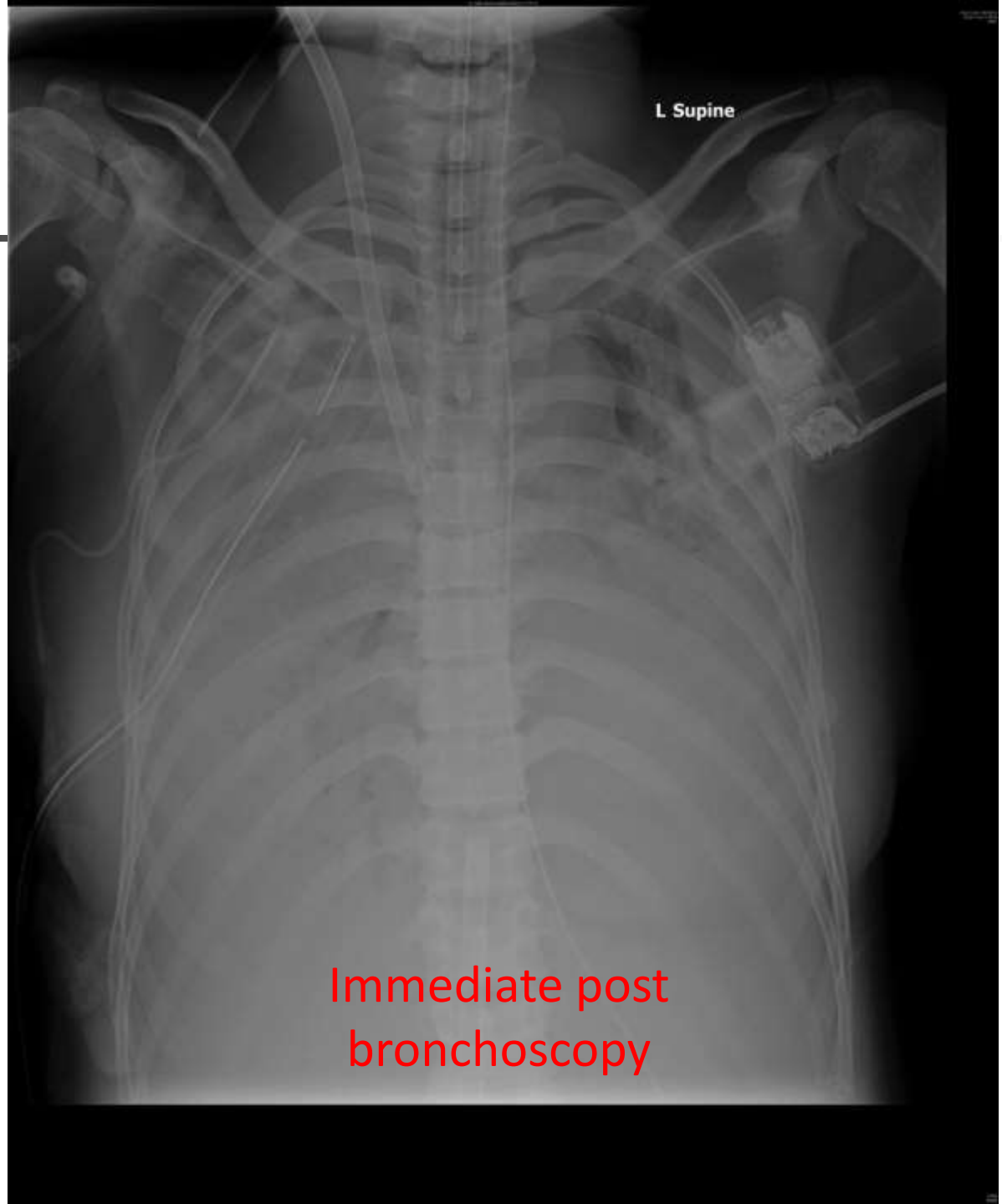
Bronchoscopy, rigid

Fibre-optic bronchoscopy

Specimens sent for Pathological Examination:

Findings:

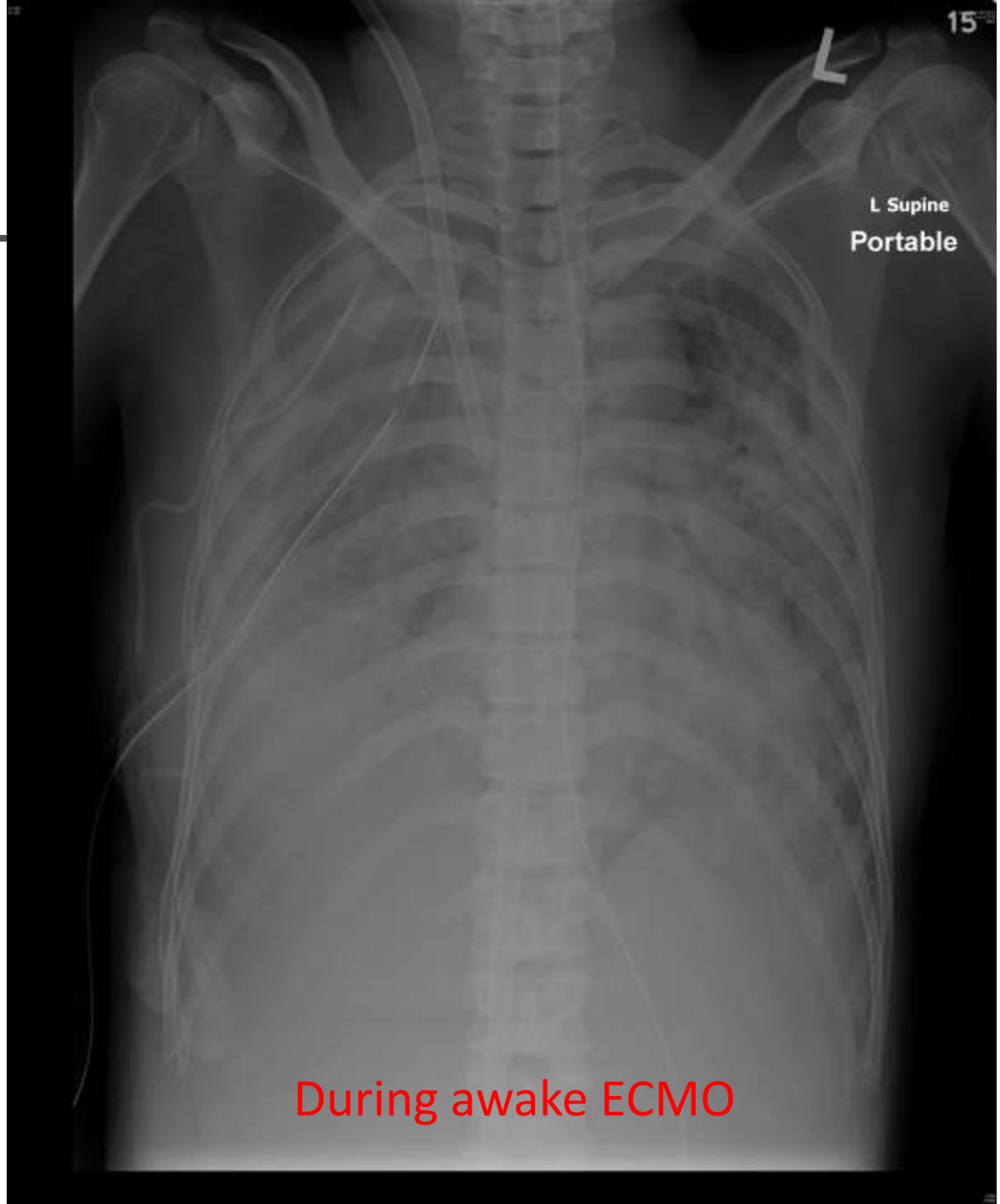
Lower trachea and both main bronchi completely occluded by blood clots.



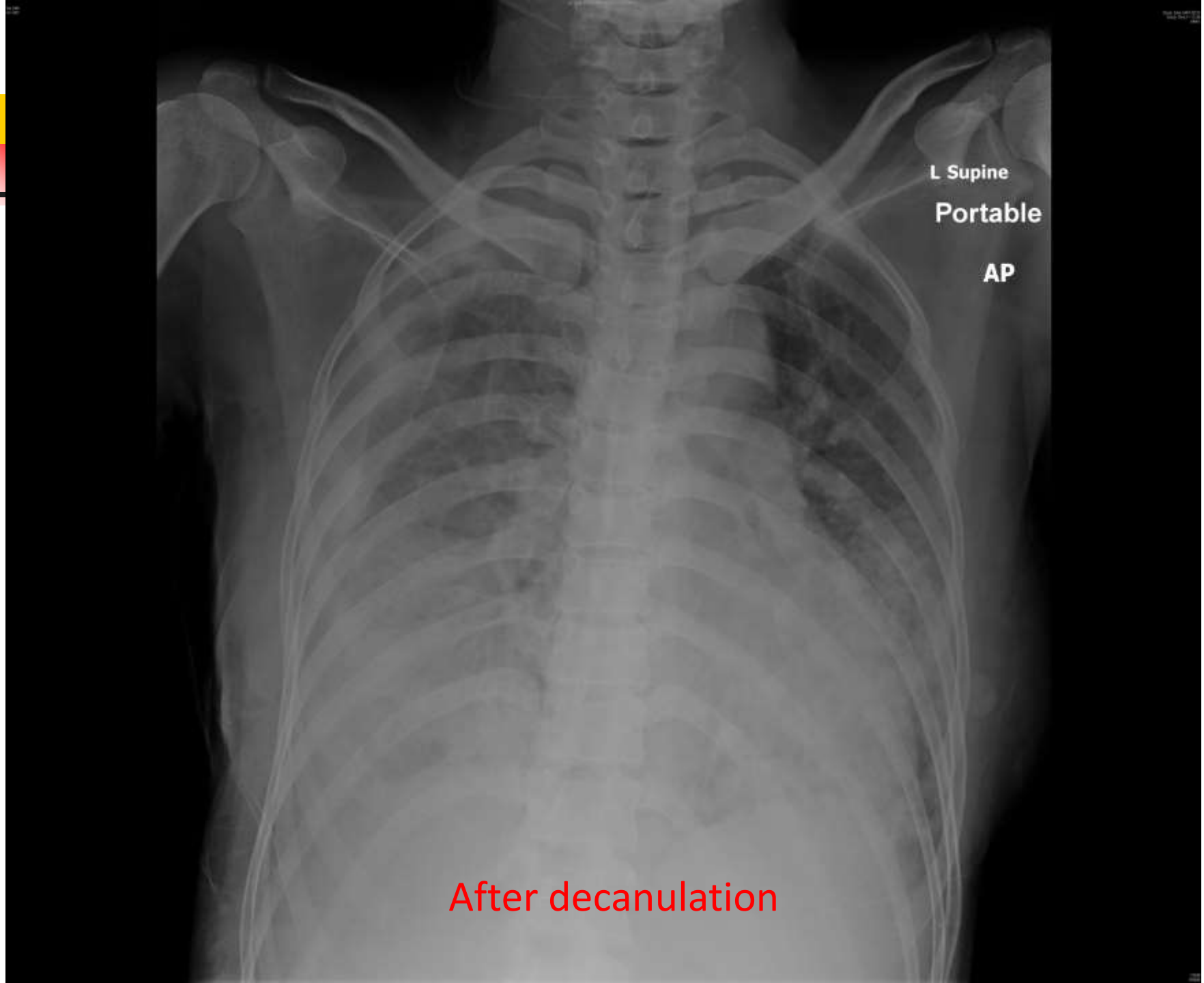
Immediate post bronchoscopy

LSS, F/41

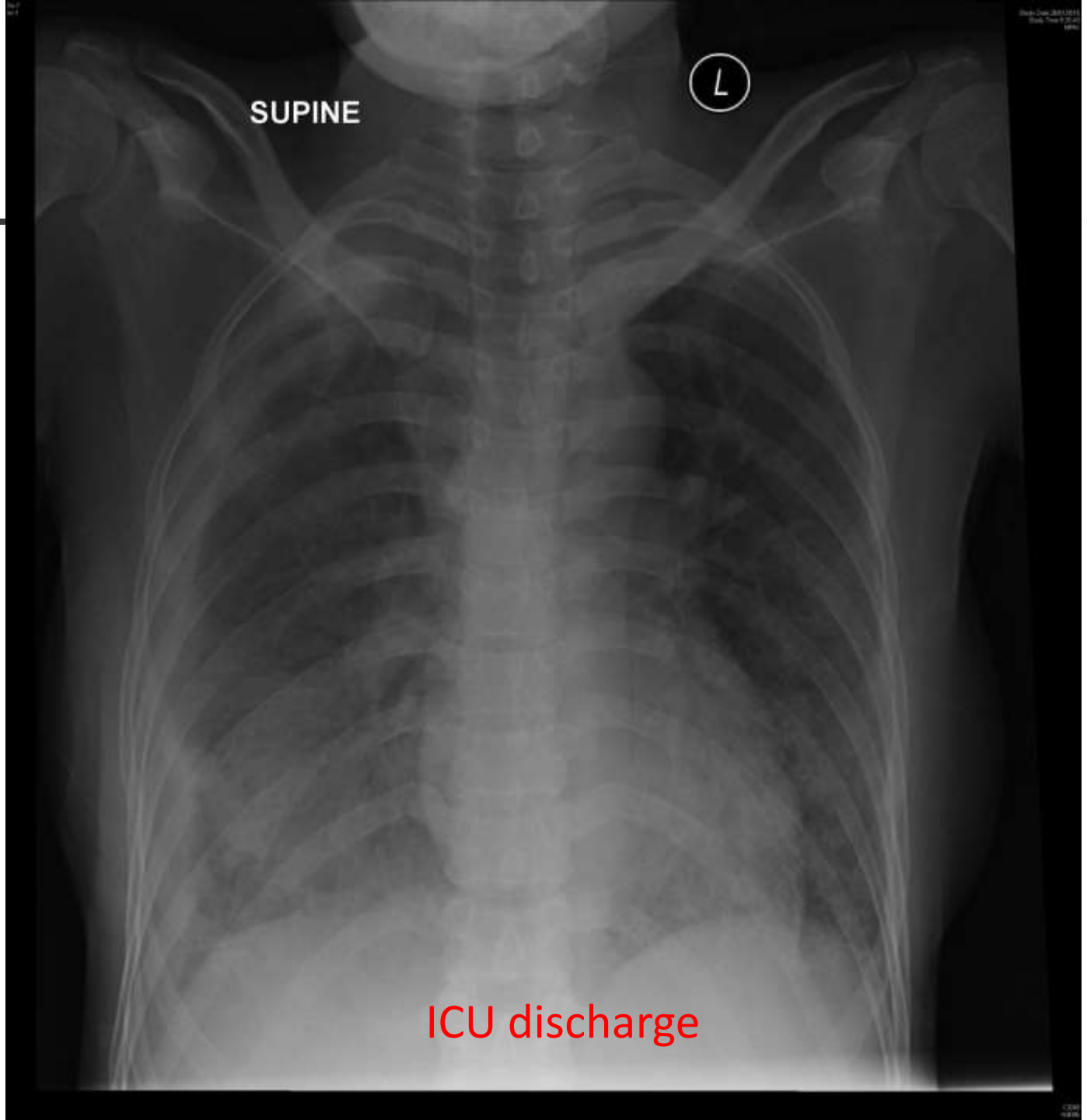
- On day 26, hemodynamics stabilized but oxygenation remained very poor
- Patient was put on “awake ECMO”, i.e. extubated the patient & off mechanical ventilation
- Gradually patient’s oxygenation improved
- Weaned off ECMO on day 35
- Discharged from ICU on day 39
- Discharged from hospital on day 77



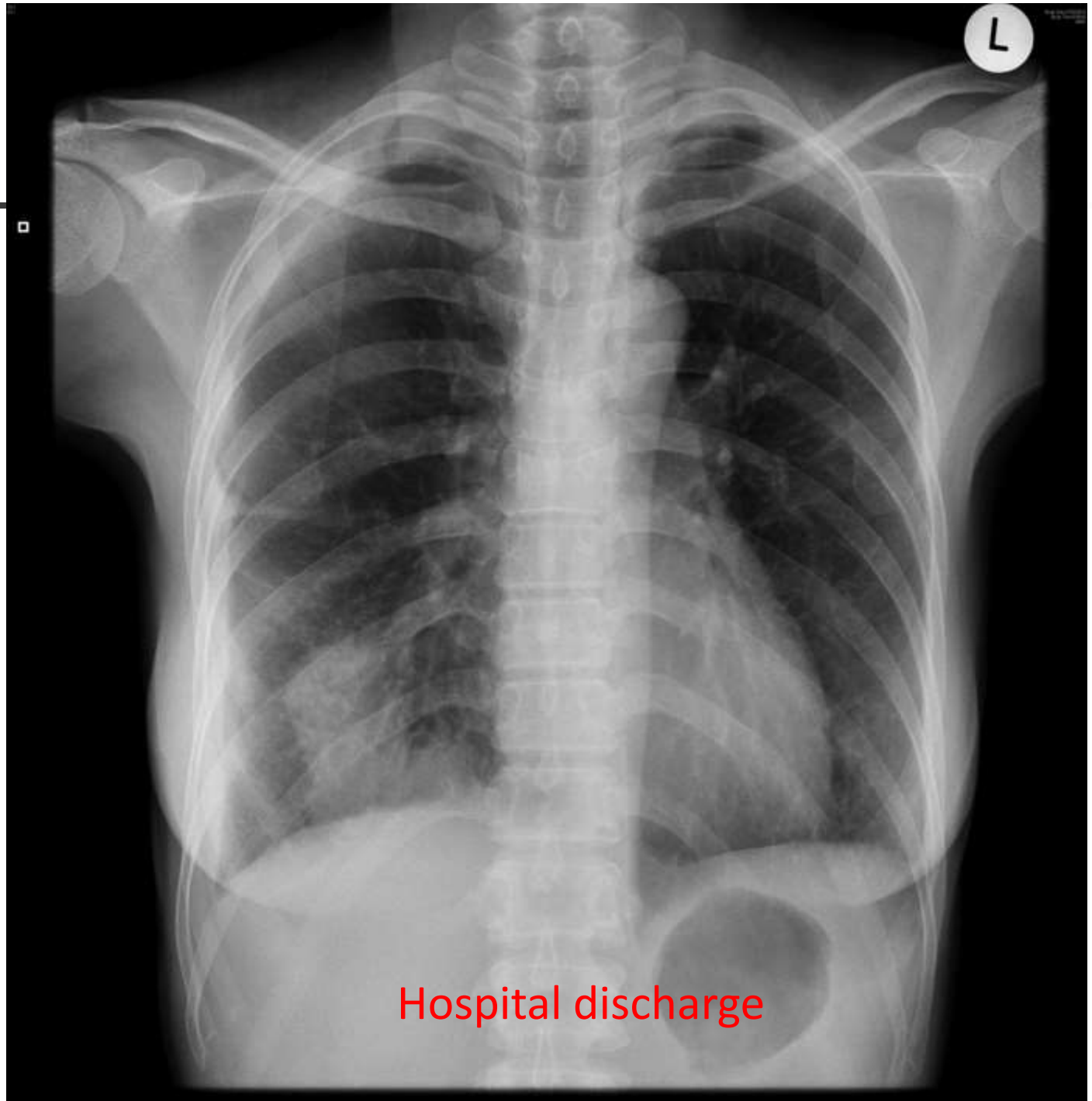
During awake ECMO

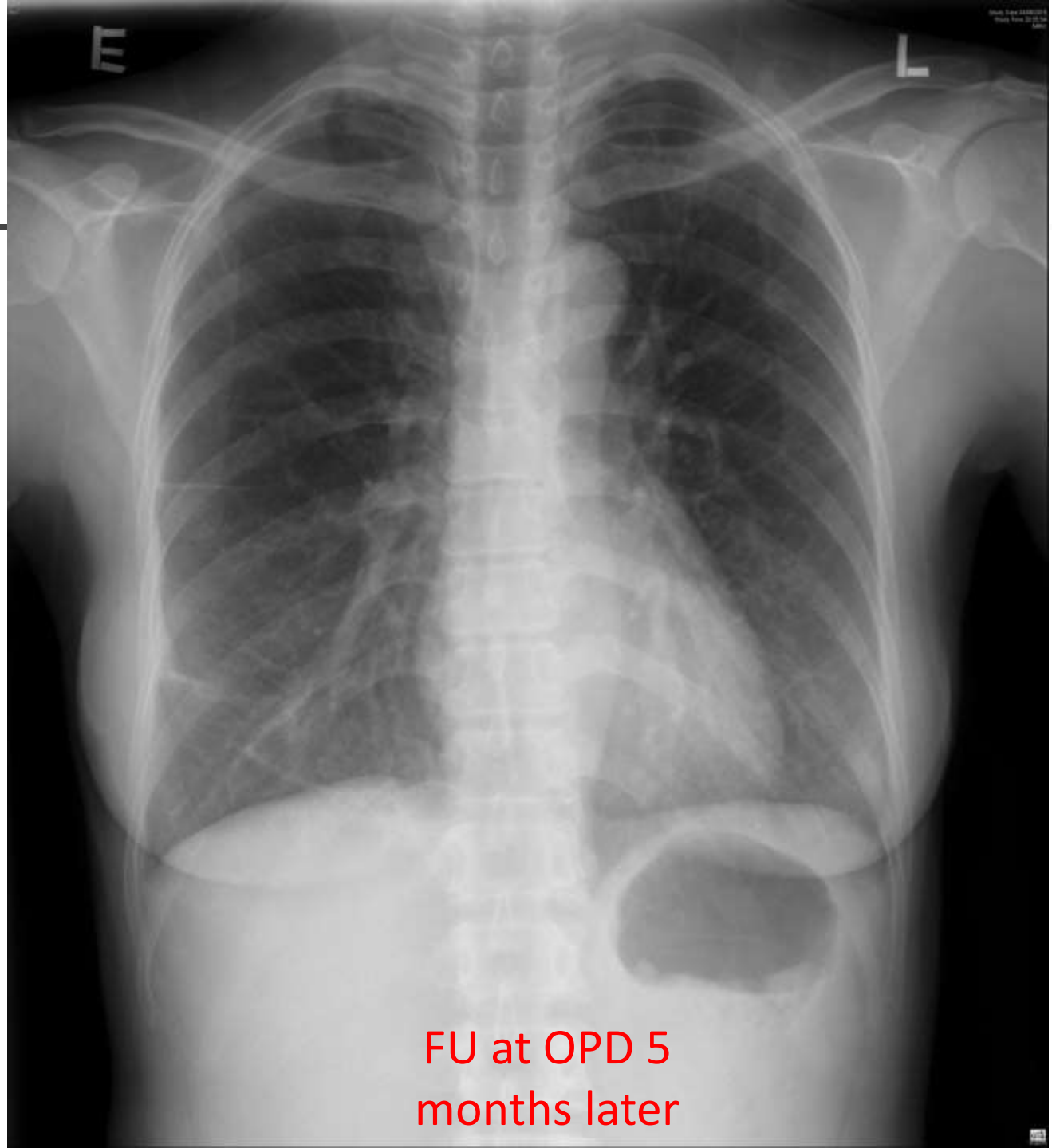


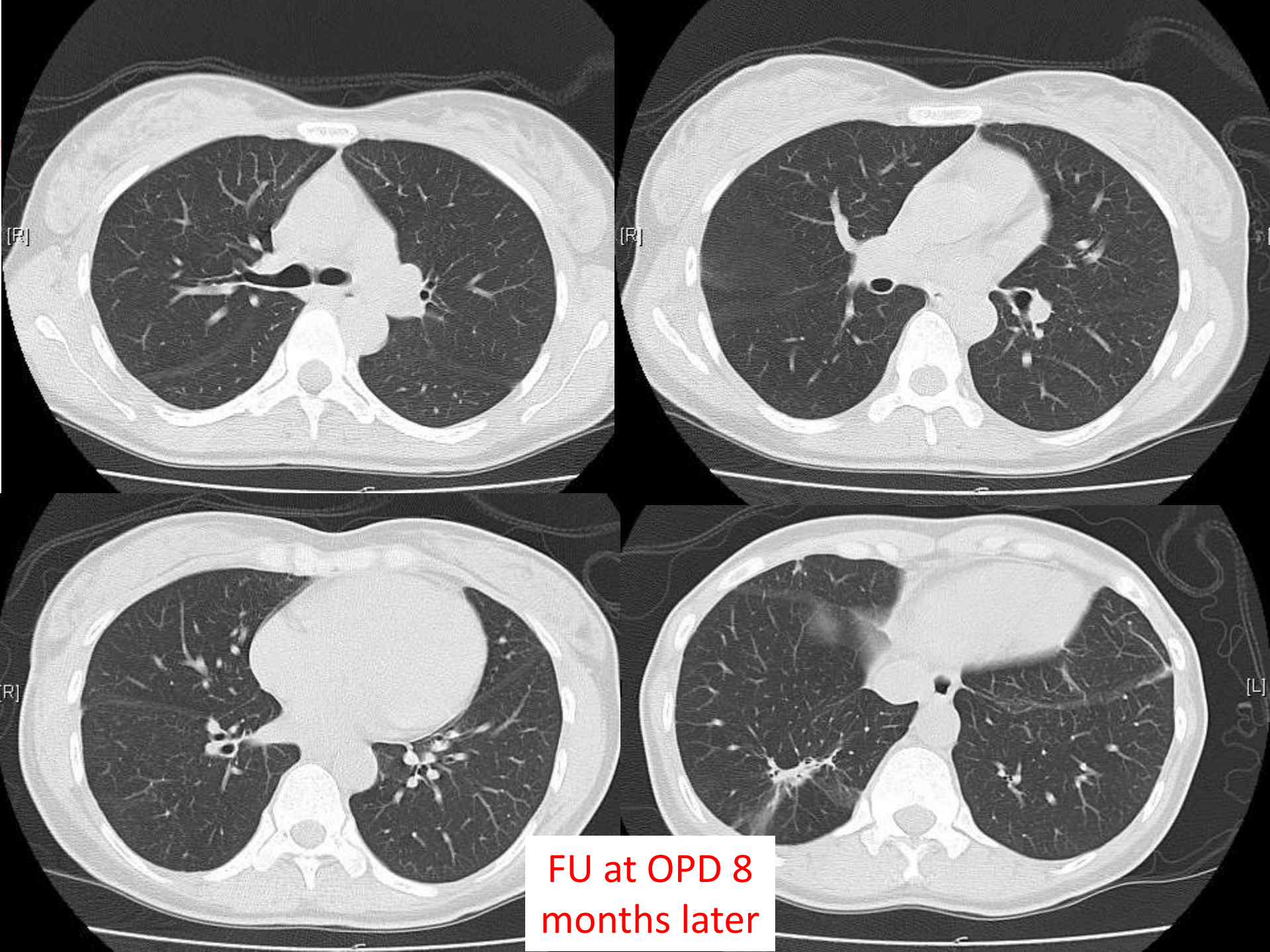
After decanulation



ICU discharge


L
Hospital discharge


E
L
FU at OPD 5
months later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FU at OPD 8 months later

Awake ECMO

- Body saturation supported by ECMO only
- No intubation
- Improve patient's comfort
- Easy to monitor neurological status
- No ventilator associated lung injury
  - Already having pneumothorax with persistent gas leak
- No ventilator associated pneumonia
  - Immunocompromised patient
  - Patient waiting for transplant
- Allow patient to cough but needs
- A conscious and cooperative patient


Portable
L Sitting

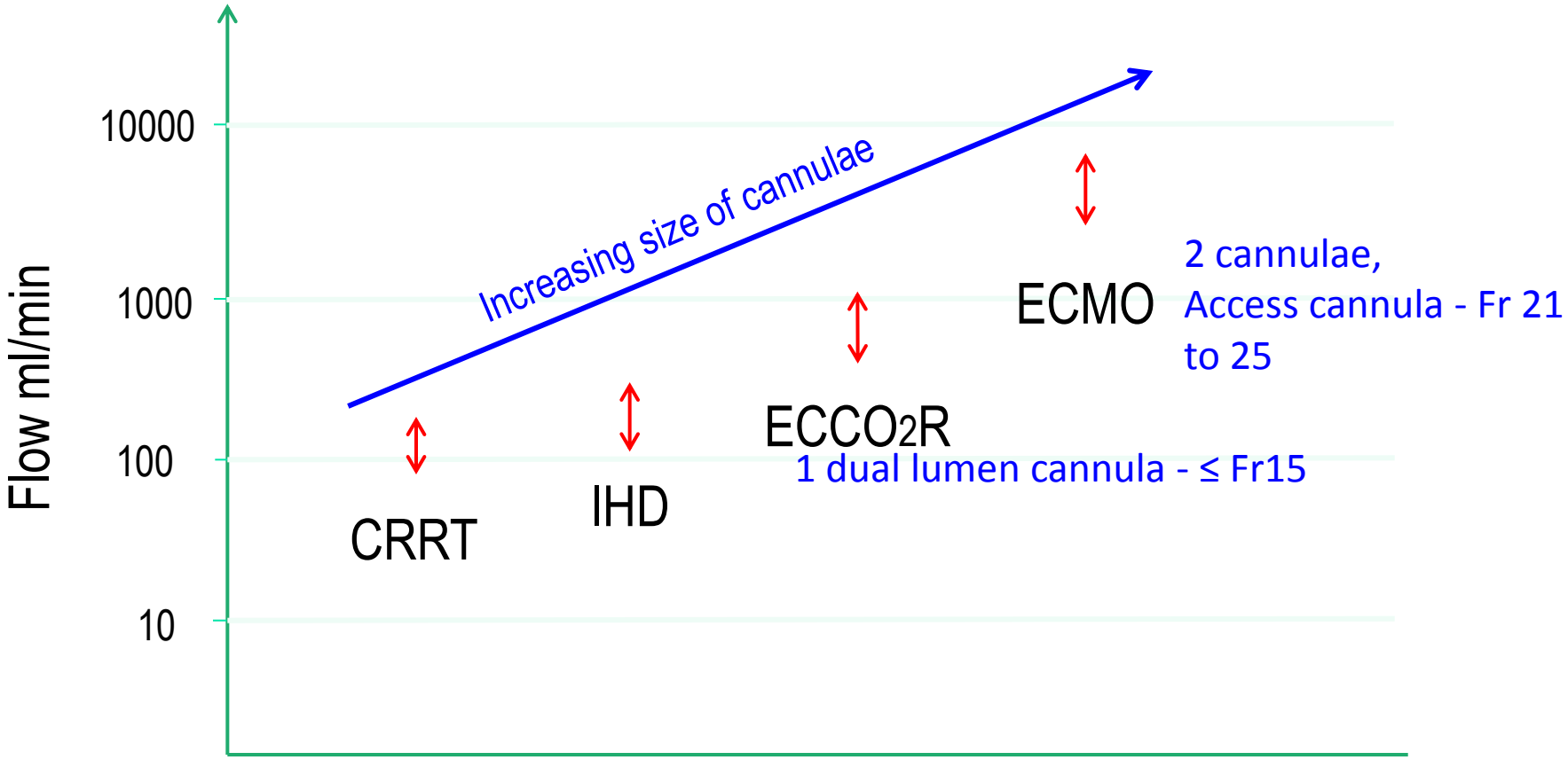
Complications of ECMO

- Vessel damage during insertion
- Unidentified heart failure
- Bleeding
- Circuit thrombosis
- Oxygenator failure
- Haemolysis
- Air embolism
- Circuit rupture
- Infection

2 Forms of VV-ECMO

- Extracorporeal membrane oxygenation (ECMO)
  - High flow (4 – 6 L/min)
  - Both oxygenation & CO_2 removal
- Extracorporeal CO_2 removal ($ECCO_2R$)
  - Low flow (0.5 to 1 L/min)
  - Only CO_2 removal

Extracorporeal flow needed

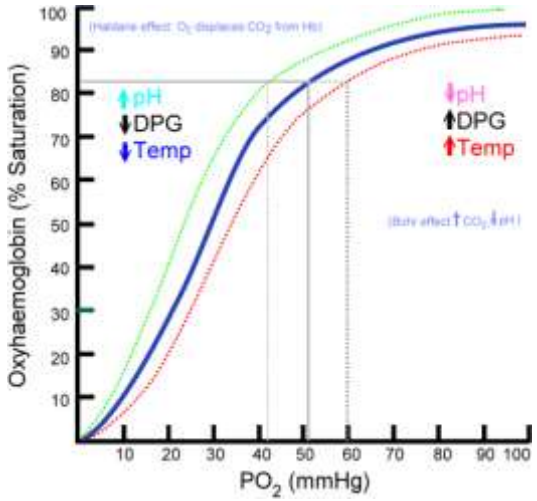


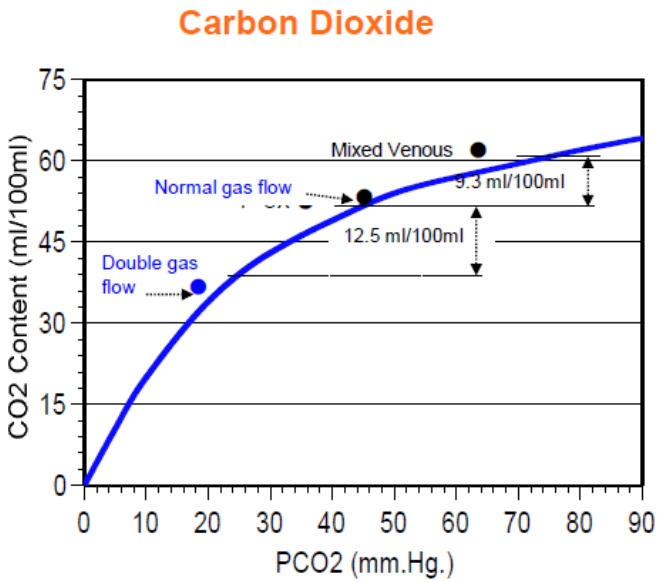
Physiology Of O_2 delivery

- O_2 consumption ~ 240 ml/min
- Amount of O_2 added to the blood via ECMO ~ 40-60 ml/L
  - 1.34 * Hb * ($S_{out}O_2 - S_{in}O_2$)
- 4 – 6 L/min blood flow is needed

Physiology of CO_2 removal

- CO_2 generation ~ 200 ml/min
- Amount of CO_2 stored in blood ~ 500 ml/L
- Achieved adequate CO_2 removal with < 1L/min





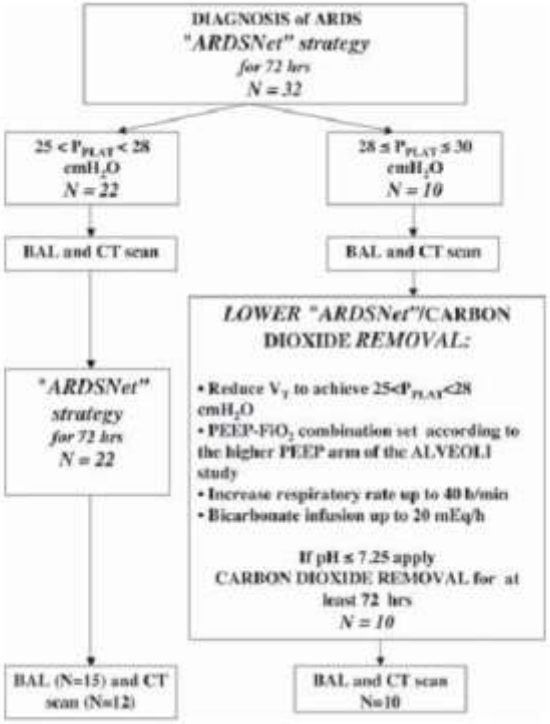
Tidal Volume Lower than 6 ml/kg Enhances Lung Protection

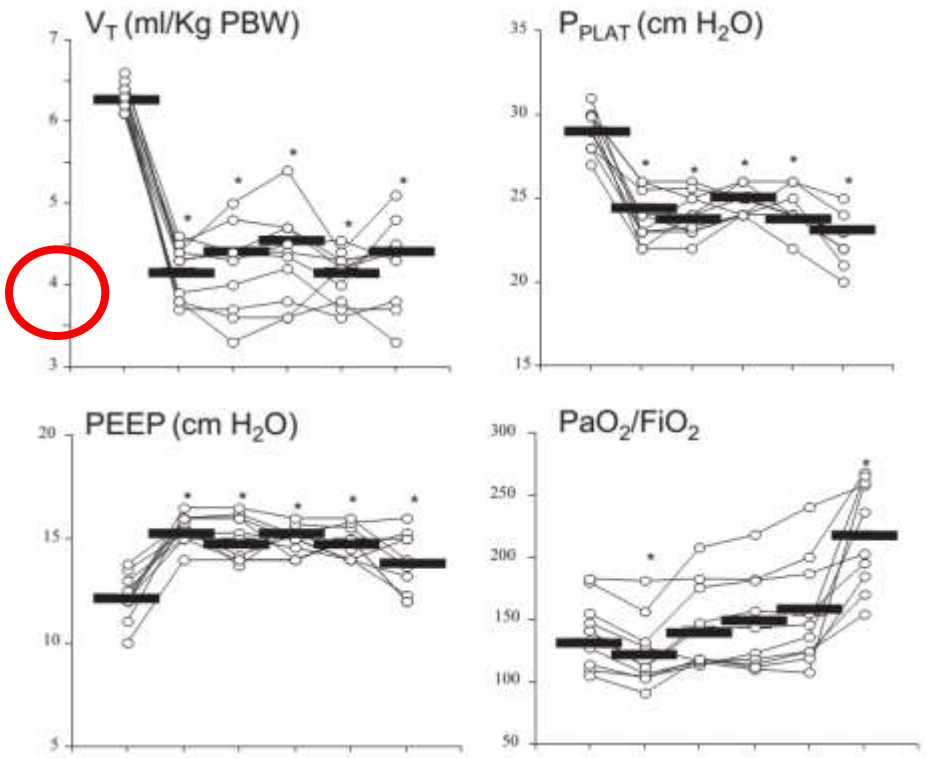
Anesthesiology 2009;111:826-35

Role of Extracorporeal Carbon Dioxide Removal

Pier Paolo Terragni, M.D., Lorenzo Del Sorbo, M.D.,* Luciana Mascia, M.D., Ph.D.,* Rosario Urbino, M.D.,* Erica L. Martin, Ph.D.,* Alberto Birocco, M.D.,† Chiara Faggiano, M.D.,† Michael Quintel, M.D.,‡ Luciano Gattinoni, M.D.,§ V. Marco Ranieri, M.D.‖*

Ultra-Protective Lung Ventilation

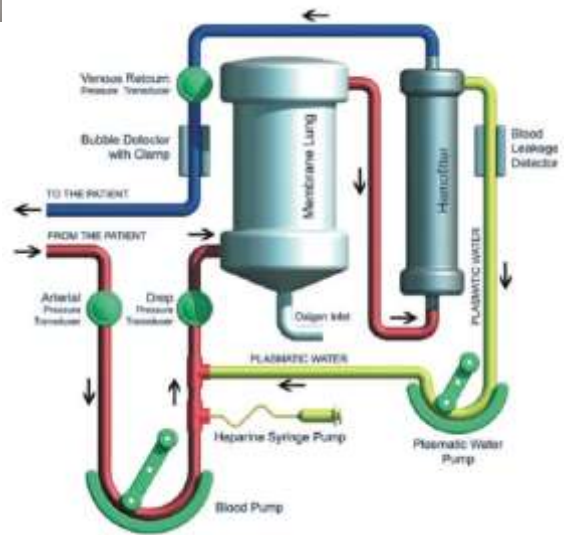


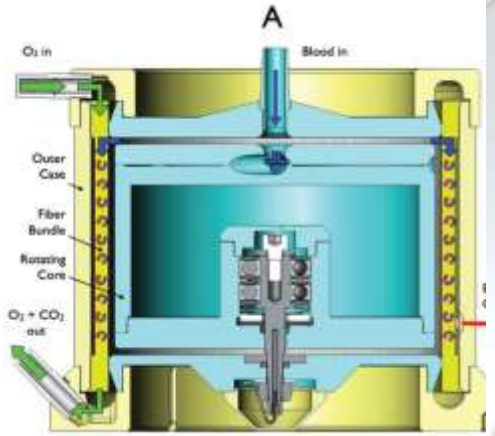


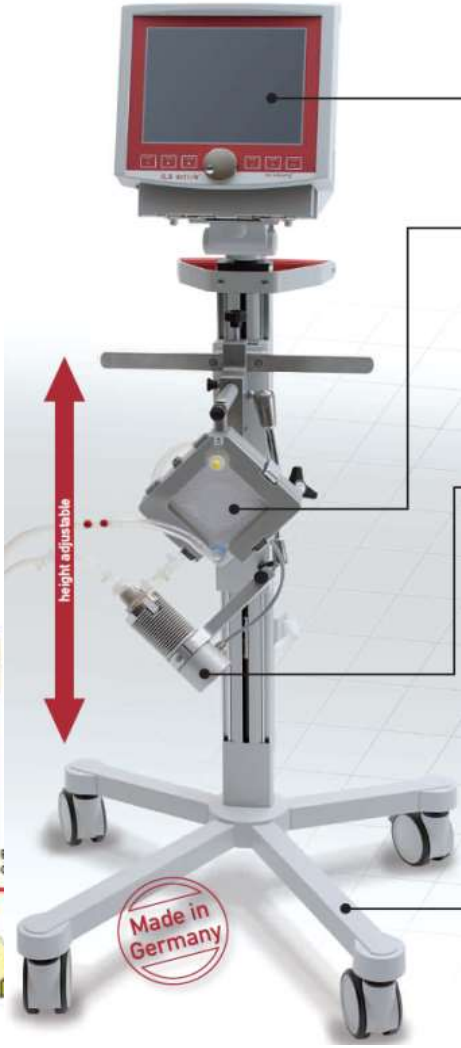
$ECCO_2R$ potential applications

- ARDS (moderate severity) with ultra-protective lung ventilation
  - Ventilated using tidal volume of 4 ml/kg,
  - Less lung injury but hypercapnia
- COPD exacerbation
  - Failed NIV
- Status Asthmaticus
- Bridge to lung transplant (CO2 retention problem only)

$ECCO_2R$ machines







Conclusions

- ECMO - Evolving life support technology for respiratory failure
- Definite role in very severe respiratory failure

- ? How about its role in less severe failure
- ? What should be the positions of
  - $ECCO_2R$ (low flow & less invasive)
  - Especially in the presence of new modes of ventilation, prone positioning, ……etc.

Thank you for your attention.