YONSEI UNIVERSITY

When and How to Refer:
Lung Transplantation for Patients Complicated by PH and RV Failure

A Ia Woo,
Division of Pulmonary and Critical Care Medicine, Department of Internal medicine
Severance Hospital,
Yonsei University College of Medicine

Severance

Contents

- Introduction
- Complicated by PH and RV Failure
  - When to detect / How to detect
  - When to refer / Indications for referral
- How to safely transfer patients with PH and RV failure between ICUs

Indication of lung Transplantation

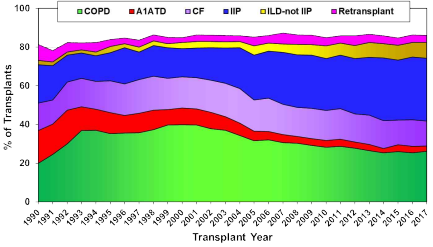


표. 3-2-44. 뇌사 이식(폐) - 진단명별

(단위: 건)

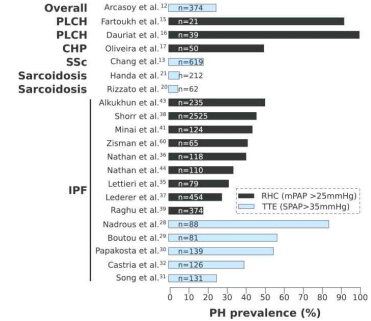
구분	2020	2021	2022	2023	2024
계	150	167	136	202	185
Bronchiectasis	6	7	6	1	3
Cystic Fibrosis	2			1	2
Eisenmenger Syndrome		2	2		3
Emphysema	2	4		1	3
Idiopathic Pulmonary Fibrosis	68	74	57	98	80
Interstitial Lung Disease					17
Lymphangioleiomyomatosis			2	1	2
Primary Pulmonary Hypertension	5	6	5	8	10
이식후 Bronchiolitis Obliterance	9	6	5	9	9
Unknown	1	1		1	
기타	57	67	59	82	56

JHLT. 2021 Oct; 40(10): 1023-1072
2024년도 장기 등 이식 및 인체조직기증 통계연보

Prevalence of PH in chronic lung disease

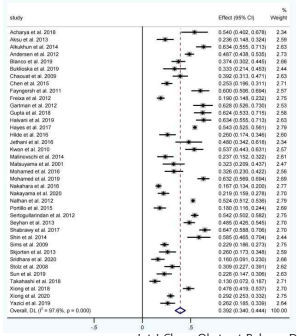
Fibrotic ILD

: RHC (39.1%), TTE (53.6%)



Int J Chron Obstruct Pulmon Dis. 2022; 17: 1365–1379.

COPD : 39.2%



Ruffenach et al. Respir Res (2020) 21:303

PH screening and diagnosis: Pro/Con

Pro

- Better understanding of clinical presentation
- **Better prediction of prognosis- timing of lung transplantation**
- Detection of other causes of PH
  - Left heart failure obstructive sleep apnea, thromboembolic disease

Con

- No specific therapeutic consequences
- Inconvenience of invasive diagnostics (RHC)
- Consumption of resources

Current Opinion in Pulmonary Medicine 27(5):p 396-404

When to detect?

: Screening for PH in lung disease: OPD

Panel 1: **When to consider assessment for pulmonary hypertension in patients with lung disease**

- When unexplained worsening of breathlessness occurs, particularly when worsening is rapid and not explained by other causes such as heart disease, pulmonary embolism, or anaemia
- When breathlessness is more severe than suspected from the extent of lung disease
- When risk factors for pulmonary arterial hypertension or chronic thromboembolic pulmonary hypertension exist
- When evaluation for lung volume reduction surgery is done
- When lung transplantation is considered

Lancet Respir Med. 2023 Sep;11(9):820-835.

How to detect?
: Screening for PH in lung disease: OPD

Clinical Examination

- Increased O2 requirements & deterioration of exercise tolerance
- Excessive and unexpected dyspnea
- Discrepancy with pulmonary function test (PFT) findings
- Presence of peripheral edema

Radiological Examination (CT Scan)

- Pulmonary artery / aorta ratio > 1
- Pulmonary artery diameter > 32 mm
- Enlarged right heart (RH) chambers
- Pruning of the peripheral vessels

Pulmonary Function & Exercise Tests

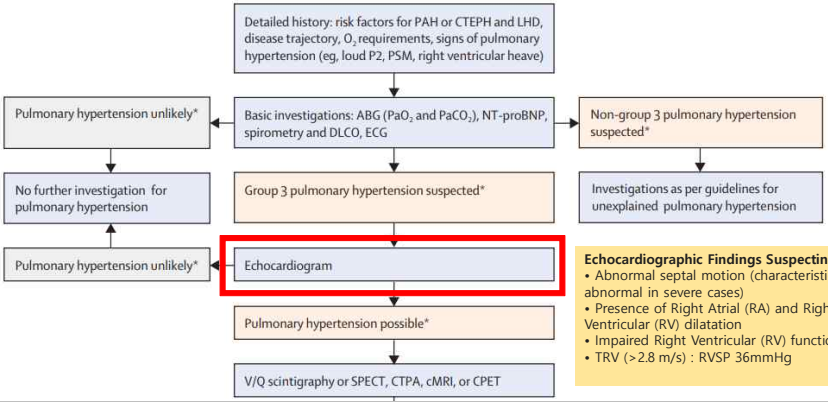
- FVC/DLCO ratio > 1.6
- Excessively low DLCO
- 6MWT: Rapid worsening of SaO2 & reduction in distance
- CPET: Exhausted circulatory reserve

Biomarkers

- Elevated BNP or NT-proBNP

Adv Ther. 2025 Apr;42(4):1627-1641.

How to diagnose?



Echocardiographic Findings Suspecting PH

- Abnormal septal motion (characteristically abnormal in severe cases)
- Presence of Right Atrial (RA) and Right Ventricular (RV) dilatation
- Impaired Right Ventricular (RV) function
- TRV (>2.8 m/s) : RVSP 36mmHg

G3 PH, Timing of listing for lung transplantation

- **COPD**
  - Presence of moderate to severe pulmonary hypertension
- **ILD**
  - Pulmonary hypertension on right heart catheterization or 2-dimensional echocardiography
- **Cystic fibrosis**
  - Pulmonary hypertension (pulmonary arterial systolic pressure > 50mmHg on echocardiogram or evidence of right ventricular dysfunction)
- **LAM**
  - Pulmonary hypertension

J Heart Lung Transplant 2021 Nov;40(11):1349-1379.

G3 PH, Timing of listing for lung transplantation

COPD

Timing of Listing

- BODE score 7-10
- Additional factors that may prompt listing include:
  - FEV_1 < 20% predicted
  - Presence of moderate to severe pulmonary hypertension
  - History of severe exacerbations
  - Chronic hypercapnia

ILD

Timing of Listing*

- Any form of pulmonary fibrosis with one of the following in the past 6 months despite appropriate treatment:
  - Absolute decline in FVC > 10%
  - Absolute decline in DLCO > 10%
  - Absolute decline in FVC > 5% with radiographic progression.
- Desaturation to < 88% on 6 minute walk test or > 50 m decline in 6 minute walk test distance in the past 6 months
- Pulmonary hypertension on right heart catheterization or 2-dimensional echocardiography (in the absence of diastolic dysfunction)
- Hospitalization because of respiratory decline, pneumothorax, or acute exacerbation.

CF

Timing of Listing

Listing for lung transplantation should occur for an individual with CF meeting any of the above referral criteria in combination with any of the following:

- FEV_1 < 25% predicted
- Rapid decline in lung function or progressive symptoms (>30% relative decline in FEV_1 over 12 months)
- Frequent hospitalization, particularly if > 28 days hospitalized in the preceding year
- Any exacerbation requiring mechanical ventilation
- Chronic respiratory failure with hypoxemia or hypercapnia, particularly for those with increasing oxygen requirements or needing long-term non-invasive ventilation therapy
- Pulmonary hypertension (Pulmonary arterial systolic pressure > 50 mmHg on echocardiogram or evidence of right ventricular dysfunction)
- Worsening nutritional status particularly with BMI < 18 kg/m^2 despite nutritional interventions
- Recurrent massive hemoptysis despite bronchial artery embolization
- World Health Organization functional class IV

LAM

Timing of Referral

Referral for lung transplantation evaluation should occur for an individual with LAM who has any of the following despite mTOR inhibitor therapy:

- Severely abnormal lung function (e.g. FEV_1 < 30% predicted)
- Exertional dyspnea (NYHA class III or IV)
- Hypoxemia at rest
- Pulmonary hypertension
- Refractory pneumothorax

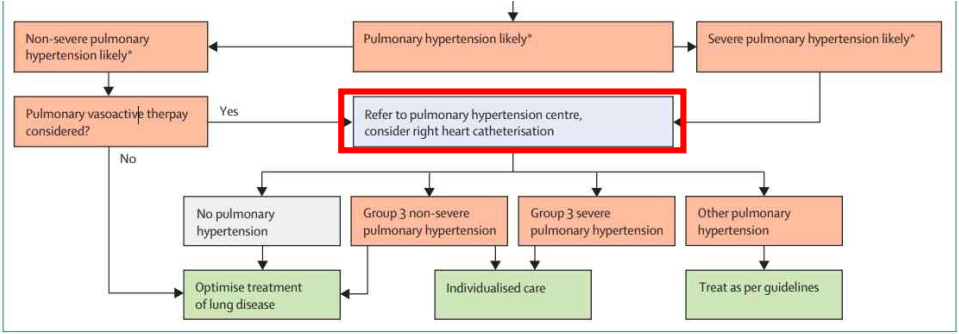
Timing of Listing

Listing for lung transplantation should occur for an individual with LAM who meets the above referral criteria and has evidence of disease progression despite mTOR inhibitor therapy.

Cessation of mTOR inhibitor therapy should occur at the time of transplant but cessation should not be required for placement on the waiting list. It may be preferable to use everolimus and target trough levels in the lower therapeutic range for patients on the waiting list.

J Heart Lung Transplant 2021 Nov;40(11):1349-1379.

How to diagnose?



Lancet Respir Med. 2023 Sep;11(9):820-835.

Right heart catheterization?

Panel 2: **Considerations for right heart catheterisation in patients with lung disease**

When to consider right heart catheterisation

- After detailed non-invasive assessment indicating pulmonary hypertension
- When pulmonary vasoactive therapies would be considered in the clinical context
- When pulmonary arterial hypertension or chronic thromboembolic pulmonary hypertension are suspected
- During work-up for lung volume reduction surgery or lung transplantation

When not to perform right heart catheterisation in patients with lung disease

- When this will not inform therapeutic decisions
- In patients with end-stage lung disease or multiple comorbidities in which supportive care is indicated

Lancet Respir Med. 2023 Sep;11(9):820-835.

Refer?:
Absolute Contraindication of lung Transplantation

1. Lack of patient willingness or acceptance of transplant
2. Malignancy with high risk of recurrence or death related to cancer
3. Glomerular filtration rate < 40 mL/min/1.73m^2 unless being considered for multi-organ transplant
4. Acute coronary syndrome or myocardial infarction within 30 days (excluding demand ischemia)
5. Stroke within 30 days
6. Liver cirrhosis with portal hypertension or synthetic dysfunction unless being considered for multi-organ transplant
7. Acute liver failure
8. Acute renal failure with rising creatinine or on dialysis and low likelihood of recovery
9. Septic shock
10. Active extrapulmonary or disseminated infection
11. Active tuberculosis infection
12. HIV infection with detectable viral load
13. Limited functional status (e.g. non-ambulatory) with poor potential for post-transplant rehabilitation
14. Progressive cognitive impairment
15. Repeated episodes of non-adherence without evidence of improvement (Note: For pediatric patients this is not an absolute contraindication and ongoing assessment of non-adherence should occur as they progress through different developmental stages.)
16. Active substance use or dependence including current tobacco use, vaping, marijuana smoking, or IV drug use
17. Other severe uncontrolled medical condition expected to limit survival after transplant

Lack of Patient Willingness or Adequate Compliance

Critical Co-existing Organ Dysfunction or Malignancy

Uncontrolled Infections or Severe Systemic Medical Conditions

J Heart Lung Transplant. 2021 Nov;40(11):1349-1379

Refer?:
General candidacy considerations

Lung transplantation should be considered for adults with chronic, end-stage lung disease who meet all the following general criteria

1. High (>50%) risk of death from lung disease within 2 years if lung transplantation is not performed.
2. High (>80%) likelihood of surviving at least 90 days after lung transplantation.
3. High (>80%) likelihood of 5-year post-transplant survival from a general medical perspective provided that there is adequate graft function.

D. Weill et al. *The Journal of Heart and Lung Transplantation* (2015)

When to refer
:Patients Complicated by PH and RV Failure in ICU

표. 3-2-44. 뇌사 이식(폐) - 진단명별

(단위: 건)

구분	2020	2021	2022	2023	2024
계	150	167	136	202	185
Bronchiectasis	6	7	6	1	3
Cystic Fibrosis	2			1	2
Eisenmenger Syndrome		2	2		3
Emphysema	2	4		1	3
Idiopathic Pulmonary Fibrosis	68	74	57	98	80
Interstitial Lung Disease					17
Lymphangioleiomyomatosis			2	1	2
Primary Pulmonary Hypertension	5	6	5	8	10
이식후 Bronchiolitis Obliterance	9	6	5	9	9
Unknown	1	1		1	
기타	57	67	59	82	56

Timing of listing for lung transplantation: ARDS

Acute Respiratory Distress Syndrome (ARDS)		
2014 Consensus Statement	2021 Consensus Statement	Consensus N (%)
	Timing of Listing and Referral Persistent requirement for mechanical ventilatory support and /or ECLS without expectation of clinical recovery and with evidence of irreversible lung destruction.	24 (100%)

J Heart Lung Transplant. 2021 Nov;40(11):1349-1379

Patients Complicated by PH and RV Failure: ARDS

TABLE 1 Characteristics of Studies Evaluating the Prognostic Value of Right Ventricular Dysfunction Assessed by Echocardiography for Mortality in Patients With ARDS

Study/Year	Type	ARDS Definition/ Ventilation Strategy	No.	Diagnostic Modality: TTE/TEE/ PAC	Timing of Echocardiography Following Diagnosis of ARDS	Definition of RVD	Prevalence of RVD	Outcome	Nonsurvivors (No.)	Nonsurvivors With RVD (No.)	*P* Value (< .05 Statistically Significant)
Wadia et al[11]/ 2016	Retrospective	Berlin/LPV	14	TTE	Within 2 wk	Not defined (authors examined changes in TAPSE, MPI, FAC before and after ARDS)	42.9%	30-d mortality	8 (57%)	. . .	.002 (for TAPSE)
Shah et al[10]/ 2016	Retrospective	Berlin/LPV	38	TTE	Within 2 wk	TAPSE < 17 mm	55%	30-d mortality	18 (47%)	. . .	.004
Mekontso Dessap et al[17]/ 2016	Prospective observational	Berlin/LPV	752	TEE	Within 3 d	Septal dyskinesia with dilated right ventricle (RVEDA/LVEDA > 0.6)	22%	Hospital mortality	322 (43%)	78/164 (48%) (31 of 54 [57%]) in severe RVD)	.17 .03
Lazzeri et al[18]/ 2016	Prospective observational	Berlin/LPV	21	TEE/TTE	Prior to VVECMO implantation	sPAP > 40 mm Hg or dilated right ventricle or septal dyskinesia with dilated right ventricle (RVEDA/LVEDA > 0.6) or TAPSE < 16 mm Hg	90.5% 9.5% 47.6%	ICU mortality	12 (57.1%)	. . .	.004 .04
Lhéritier et al[19]/ 2013	Prospective observational	American and European consensus/ LPV	201	TEE/TTE	Within 48 h	Septal dyskinesia with dilated right ventricle (RVEDA/LVEDA > 0.6)	22.5%	28-d mortality	46 (23%)	11 of 45 (24%)	.79
Boissier et al[12]/ 2013	Prospective observational	Berlin/LPV	226	TEE	Within 3 d	Septal dyskinesia with dilated right ventricle (RVEDA/LVEDA > 0.6)	22%	28-d mortality ICU mortality	114 (50%)	28 of 49 (57%) 31 of 49 (63%)	< .01 .04 .02

Prevalence of RVD

With in 24-36h
~ 20%

Within 2wks
~50%

Prior to VV ECMO
~ 90%

Chest. 2017 Jul;152(1):181-193.

ECLS in ARDS

EXTRACORPOREAL LIFE SUPPORT

Q1 **In adult patients with severe ARDS or COVID-19 does veno-venous extracorporeal membrane oxygenation (VV-ECMO) compared with conventional ventilation improve outcomes?**

1 We **recommend** that patients with severe ARDS not due to COVID-19 as defined by the EOLIA trial eligibility criteria, should be treated with ECMO in an ECMO centre which meets defined organisational standards, adhering to a management strategy similar to that used in the EOLIA trial.

MODERATE LEVEL OF EVIDENCE

2 This recommendation applies also to severe ARDS from COVID-19.

LOW LEVEL OF EVIDENCE

Intensive Care Med. 2023 Jul;49(7):727-759.

Inclusion and Exclusion of EOLIA

INCLUSION CRITERIA

+ Confirmed **ARDS diagnosis** fulfilling the AECC definition.
+ Endotracheal intubation with mechanical ventilation for **< 7 days**.
+ **Severe Hypoxemia**: PaO_2:FiO_2 < 50 mmHg for > 3 hours OR PaO_2:FiO_2 < 80 mmHg for > 6 hours.
+ **Severe Acidosis**: pH < 7.25 with $PaCO_2$ ≥ 60 mmHg for > 6 hours.
+ Failure despite **ventilation optimization** (FiO_2 ≥ 0.80, Vt 6 ml/kg PBW, PEEP ≥ 10 cmH_2O).

EXCLUSION CRITERIA

− Age **< 18 years** OR mechanical ventilation duration of **≥ 7 days**.
− **Pregnancy** OR severe obesity (Weight > 1 kg/cm height or **BMI > 45**).
− Long-term chronic respiratory failure under home oxygen or non-invasive ventilation.
− Active VA-ECMO treatment for cardiac failure OR history of heparin-induced thrombocytopenia.
− Malignancy with **life expectancy < 5 years** OR SAPS-II score **> 90**.
− Coma post-cardiac arrest, irreversible neurologic injury, or decision to withdraw life-sustaining therapy.

N Engl J Med 2018;378:1965-197

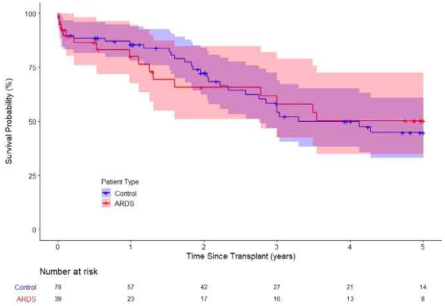
High risk factors for lung Transplantation

1. Age > 70 years
2. Severe coronary artery disease that requires coronary artery bypass grafting at transplant
3. Reduced left ventricular ejection fraction < 40%
4. Significant cerebrovascular disease
5. Severe esophageal dysmotility
6. Untreatable hematologic disorders including bleeding diathesis, thrombophilia, or severe bone marrow dysfunction
7. BMI > 35 kg/m^2
8. BMI < 16 kg/m^2
9. Limited functional status with potential for post-transplant rehabilitation
10. Psychiatric, psychological or cognitive conditions with potential to interfere with medical adherence without sufficient support systems
11. Unreliable support system or caregiving plan
12. Lack of understanding of disease and / or transplant despite teaching
13. *Mycobacterium abscessus* infection
14. *Lomentospora prolificans* infection
15. *Burkholderia cenocepacia* or *gladioli* infection
16. Hepatitis B or C infection with detectable viral load and liver fibrosis
17. Chest wall or spinal deformity expected to cause restriction after transplant
18. Extracorporeal life support
19. Retransplant <1 year following initial lung transplant
20. Retransplant for restrictive CLAD
21. Retransplant for AMR as etiology for CLAD

J Heart Lung Transplant. 2021 Nov;40(11):1349-1379

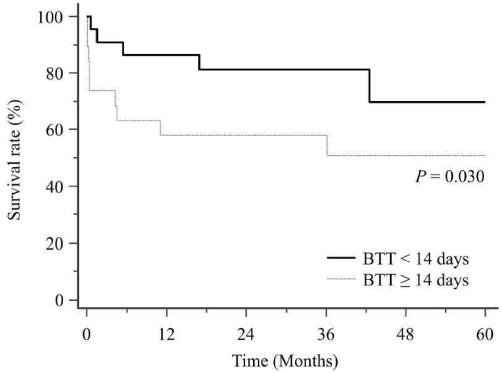
Transplantation in ARDS

- 63 patients with ARDS (UNOS)
- **Recipients' Characteristics:**
  - The median age of the transplanted ARDS patients was **35 years.**
  - The median Lung Allocation Score (LAS) was 88.4.
  - 30 patients (76.9%) required extracorporeal membrane oxygenation (ECMO) support, and 5 patients (12.8%) were on mechanical ventilation prior to transplantation.
  - **The median waiting time from listing** to transplantation **was 8 days**.
- **Control Group**
  - 78 propensity-matched control lung transplant recipients with restrictive lung disease (without ARDS) were selected for comparison



Clin Transplant. 2021 Feb;35(2):e14182.

Prolonged ECMO: Poor survival



PLoS One. 2021 Jul 1;16(7):e0253520.

국내 폐이식 응급도

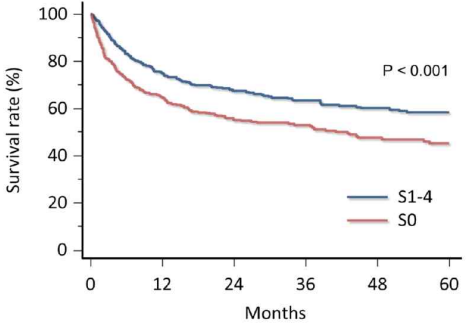
(가) 응급도 0

입원환자로 다음 중 한 가지 이상 해당하여야 하며, 해당 응급도를 연장할 경우 8일 이내 재등록할 수 있다. 다만 19세 미만 이식대기자는 재등록 횟수 제한이 없으며, 19세 이상은 8일마다 3회까지 등록이 가능하다.

① 호흡부전증으로 인공호흡기(Intubation ventilator)를 부착중인 환자

② 체외막형 심폐기를 가동 중인 환자

5-year survival by status



KONOS, 2010-2020

When to refer : ARDS

- Consider **immediate transfer** to a specialized transplant center for patients on MV or ECMO who are **young & without significant comorbidities**

- Initiate referral **before** the development of pulmonary hypertension

How to safely transfer

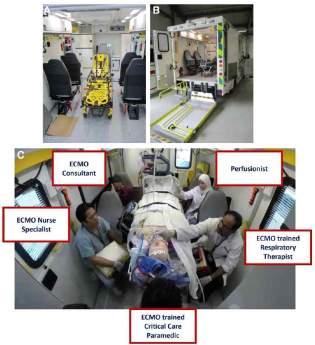


Figure 1. (A, B, and C). Spacious ICU ambulance with 360° access to patient. Seating for 5 medical personnel. Note sealed cabinet and floor for easy cleaning and infection control.

ASAIO Journal 2022 Guidelines

Extracorporeal Life Support Organization Guideline for Transport and Retrieval of Adult and Pediatric Patients with ECMO Support

AHMED LABIB,* ERIN AUGUST,† CARA AGERSTRAND,‡ BJORN FRENCKNER,§ DE'ANN LAUFENBERG,¶ GERALD LAVANDOSKY,|| CHRISTIAN FAJARDO,# JASON A. GLUCK,** AND DANIEL BRODIE††
REVIEWERS: THOMAS MULLER,‡‡ CHRIS HARVEY,§§ GILES PEEK,¶¶ PETA ALEXANDER,||| PHILLIP MASON,## AND ROBERT BARTLETT***

Patient Information Form (ECMO Referral)

- Patient location (Hospital, City, State, Unit/Bed #):
- Requesting provider:
- Call back phone number:
- Is family aware of potential for ECMO? Yes/No (circle one)
- Consent/assent obtained, by whom?
- Admission diagnosis:
- Mode of ECMO support:
- Brief patient history (working diagnosis, past medical history, reason for ECMO, etc.):

Date/Time:
Patient Name:
Patient Health Number:
DOB:
Admission date:

Flu positive? Yes/No (circle one)
Viral panel:
COVID-19? Yes/No (circle one)

Current and admission weight:
Height:
Chronic renal failure? Yes/No (circle one)
Dialysis? Yes/No (circle one)
Acute renal failure? Yes/No (circle one)
Active bleeding? Yes/No (circle one)
Requiring transfusion Yes/No (circle one)
Current continuous medications:
Current neurological status:

If yes, where?

Cardiac arrest this admission? Yes/No (circle one)
Trauma? Yes/No (circle one)
Surgery/type/date:

ASAIO Journal 68(4):p 447-455, April 2022.

How to safely transfer: 서울, SMICU

How to safely transfer: 서울, SMICU

SMICU 출동 요청 방법

Tel. 02-762-2525

이송이 필요한 환자의 주치의가 직접 전화하여
환자 상태 파악에 필요한 내용을 전달

SMICU 당직번호를 받는 사람은 전문의이며, 전문의가 환자상태의 정확한 판단과
출동 요청 기준을 평가하기 위해 주치의 연락이 필수입니다.

서울 내 병원간 이송

출동 요청 기준에 해당사항이 없는 환자 출동요청 시 SMICU 당직전문의와 상의해 주시기 바랍니다.

SMICU 출동 요청 시 전달사항

구분	상시내용
요양병원 연락처	전원 담당자 혹은 주치의 연락처
연령 및 성별	남성 / 여성 / 연령(만)
과거력 및 현병력	과거력 / 현병력
활력징후	혈압 / 맥박수 / 호흡수 / 산소포화도 / 체온
의식수준	GCS score 혹은 AVPU 등
처치내역	환자 처치를 위해 투약된 약물 / 술기 / 검사 등
현재 적용 중 약물	승압제 / 진정제 / 근이완제 / 심혈관계약물 등
현재 적용 중 장비	HFNC / Ventilator / ECMO / TTM / Incubator 등 C-line / A-line / Chest tube 등
전원 사유	응급 수술 / 중환자실 부재 등

How to safely transfer: 경기/경북

병·의원. > 대학병원

한림대성심, Mobile ICU 출범…중증환자 '골든타임' 사수

이지현 기자 | 발행날짜: 2025-02-12 16:20:42

가

병원 간 중증환자 전담 구급차 운영…이송 중 중환자 치료 가능
중증 ECMO 환자, 폭설 속 140km 거리 이송 성공사례 눈길

[메디칼타임즈=이지현 기자] 한림대성심병원이 중증환자 전담 구급차(Mobile ICU)를 출범하면서 중증환자 병원간 이송에 새로운 기준을 제시했다.

한림대성심병원은 Mobile ICU 출범식을 열고 체계적이고 전문적인 응급의료 서비스를 제공할 수 있게 됐다고 12일 밝혔다.

Mobile ICU는 중증환자 이송을 위해 특수 제작된 전담구급차로, 의료진이 차량 내에서 중환자실(ICU) 수준의 치료를 제공할 수 있어 '움직이는 중환자실'로 불린다. 한림대성심병원은 Mobile ICU를 통해 타 병원으로 전원이 필요한 중증환자를 병원 간 이송하는 핵심 역할을 맡게 됐다.

출범식에는 보건복지부와 경기도청, 중앙응급의료센터, 한림대학교성심병원 등 관계자 60여 명이 참석했다. 행사는 주요 인사 축사를 시작으로 Mobile ICU 사업 소개, 성과 보고, 차량 및 장비 소개, 시연 순으로 진행됐다.

중증환자 전담구급차 신규 배치 지역으로 경상북도 선정

- 구미차병원에 중증환자 전담구급차 배치하고 안전한 병원 간 이송 제공 -

보건복지부(장관 조규홍)는 **중증환자 병원 간 이송체계 구축 시범사업** 공모 심사 결과 **경상북도(구미차병원)**가 선정됐다고 밝혔다.

중증환자 병원 간 이송체계 구축 시범사업은 **중환자실과 동일한 환경을 갖춘 구급차**(이하 '중증환자 전담구급차')에 **의사를 포함한 응급의료인력이 탑승해 중증환자를 치료 가능한 병원으로 안전하게 이송(전원)**하는 사업이다. **2024년 경기도**가 첫 대상 지역으로 선정되어, **한림대 성심병원**에 중증환자 전담구급차를 배치·운용하고 있다.

How to safely transfer: Severance

이식 대상자 ECMO 전원 process

Version 1.0, 2021.8 Last

0. 전원 전 절차

- 전원 문의 시 폐 이식 외래로 안내
- 환자 보호자 면담 및 의무기록 확인
- 이식 회의 -> 전원 여부 결정
- 중환자실 공석 및 ECMO 여분 확인
- 공실 및 기계 확보 후 전원 일자 확정
- 전원 병원 주치의에게, 전원 checklist 전달하여 환자 상태 미리 파악

How to safely transfer: Severance

1. 전원 process

0.	이송 담당 의사와 의사소통하며, 전원 일자/도착시간 확인. 중환자실 및 응무외과, 원무과, 보안 팀에 예상시간 전달.
1.	● 물품 확인. ■ ECMO 및 Ventilator 용 Portable O2 tank (완전 충전, 3개 이상 준비). ■ ECMO Console 이동용 카트. ■ IV infusion pump 용 Pole (1개). ● 이송 경로 확인. ■ 원무과 및 보안팀에 미리 연락. ■ 크로닉 상황. ◆ 본관 3층 정문에서 앰뷸런스 하차하여 이송. ■ 명심시. ◆ 응급실 당직 Staff(#87979)/코디간호사(#86584)에 이송 정보 공유. ◆ 응급실 검사/중환 필요할 경우 응급실 처방 위해 응급의학과 의가 필요. ◆ 응급실 앰뷸런스 구역 하차 후 통로 지나 바로 엘리베이터로 9층 중환자실 이동. ● 이송 인력 (앰뷸런스 하차 시 대기). ■ 담당 주치의(전공의/중환자실 담당 강사/중환자실 전담 교수/우어라 교수). ■ 간호사. ■ 이송직원. ● 중환자실 준비. ■ 환자 사전 진수하여, 미리 필요한 처방. ■ 약제 본원 약제로 용량 및 속도 계산하여 교환 준비. ■ Ventilator Prep. ■ 심혈관외과(CS 전공의 → 연락 안될 시 pt. → 연락 안될 시 HICU NP #70471). ■ 본원 ECMO 준비: ECMO filter 및 circuit 교환 가능성에 대비. ◆ 도착시간 공유하여 기계 교환이 지연되지 않도록. ◆ 심혈관외과에서 ICU 대기 후 바로 ECMO 기계 교체.

ECMO 전원 checklist (전원 보내는 병원용)

		특이사항
키/몸무게	cm/ Kg	
의료행위	□ 의사: □ 간호사: □ 제의 순환사: □ 앰뷸런스:	서울 지역이면 SMICU 이용 → SMICU (02-870-1990/02-762-2525)
ECMO 삽입일	YYYY/MM/DD	
ECMO 마지막 Filter 교환일	YYYY/MM/DD	
ECMO 종류	□ EBS Terumo □ PLS Marquet □ 기타	
ECMO MODE	□ VV □ VA □ VAV □ Oxy-R-VAD	
ECMO Configuration	□ Fem-Fem □ IJV-Fem □ 기타	
ECMO Cather size	Drainage (Fr): Return (Fr):	
ECMO setting		
RPM		
LPM (L/min)		
FiO2		
Sweep gas (L/min)		
Ventilator 여부	□ Yes □ No	
Ventilator mode	□ PCV □ VCV	
Ventilator setting		
FiO2		
RR		
PEEP		
Inspiratory pressure (Tidal volume)		
Vasopressor	□ Yes □ No	

Vasopressor 용량		
Norepinephrine (μg/kg/min)		
Vasopressin (μ/min)		
Epinephrine (μg/kg/min)		
기타		
심 초음파 결과		
Rt. Side heart failure	□ Yes □ No	
Sedative 약제 및 용량		
약제 1		
약제 2		
약제 3		
의식상태		
Delirium	□ Yes □ No	
Alertness	□ Alert □ Drowsy □ Stupor □ Coma	
재활 정도	□ Bed-ridden (Bed-side PT) □ Sitting □ Standing □ 기타	
동반감염여부	□ Yes □ No	
감염병소	□ Pneumonia □ Abdominal infection □ Catheter related infection □ 기타	
항생제 약제 및 기간		
스테로이드 여부, 용량, 사용기간		

Summary

- **When to detect**
  - Worsening of symptoms
  - DLco, 6MWD, BNP, CT
  - TTE
- **When to refer**
  - OPD: Possible pulmonary hypertension
  - ICU : Before the development of pulmonary hypertension
- **How to safely transfer patients with PH and RV failure between ICUs**
  - Safe transfer requires a specialized mobile ICU team

YONSEI UNIVERSITY
COLLEGE OF MEDICINE