

# 전공의를 위한 시골 의사의 ECMO 길라잡이

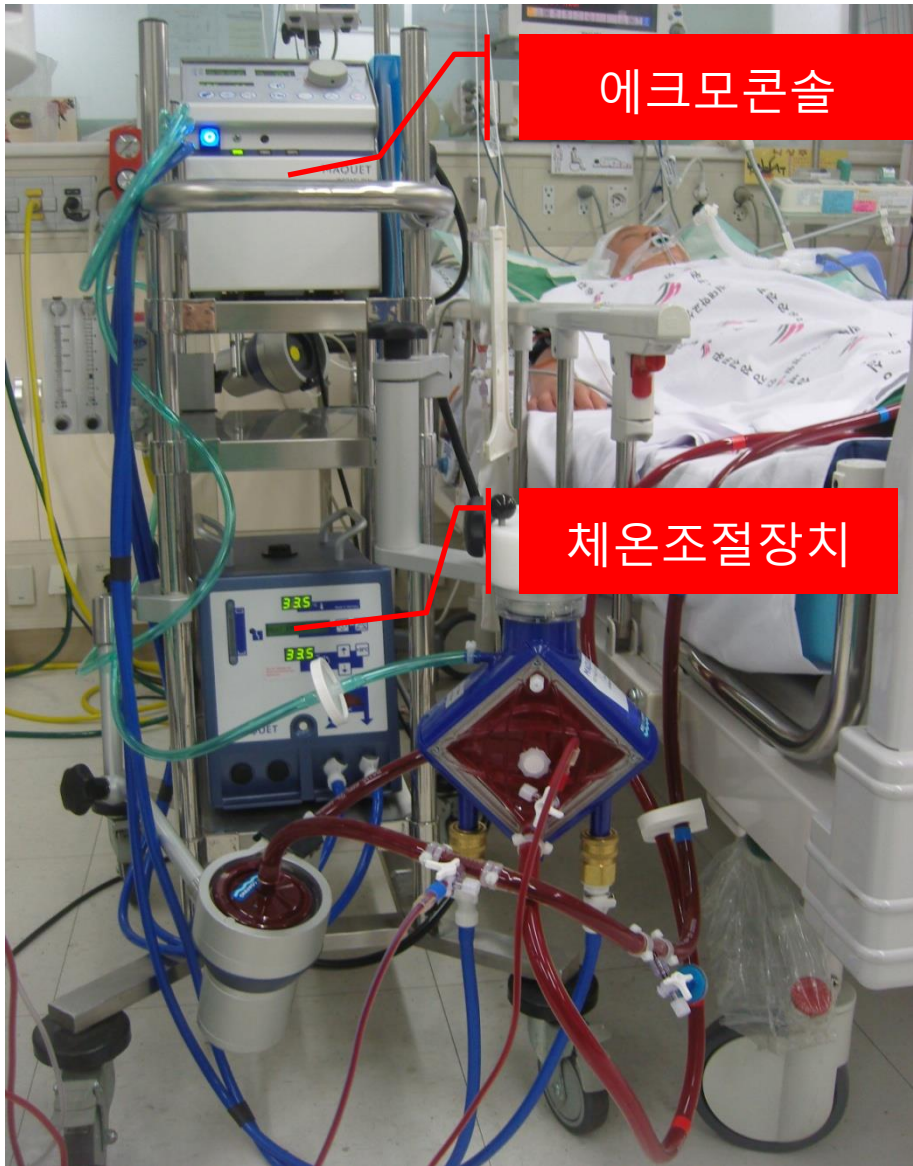
한림대학교 성심병원  
흉부외과 교수  
ECMO 센터장  
김형수



# ECMO란 ?

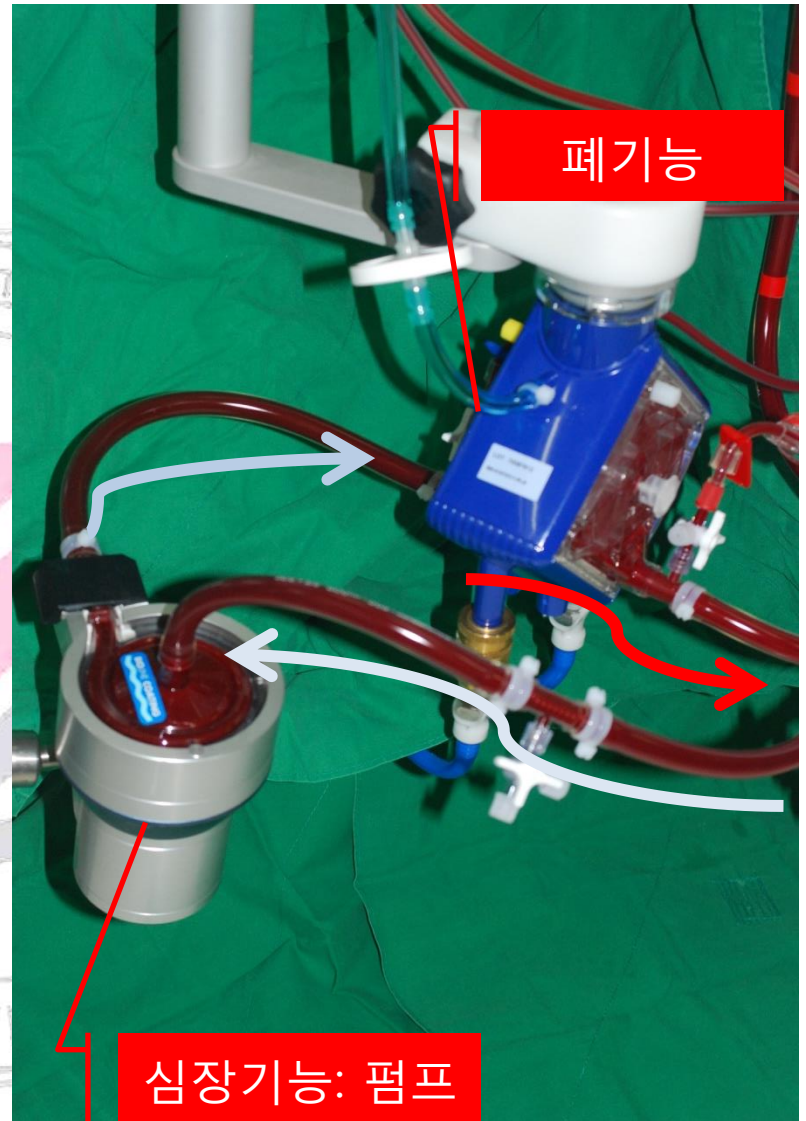
- 심장기능 또는 폐기능이 손상되어 기존 치료 방법으로는 생존이 불가능한 경우 시행하는 치료입니다.





에크모콘솔

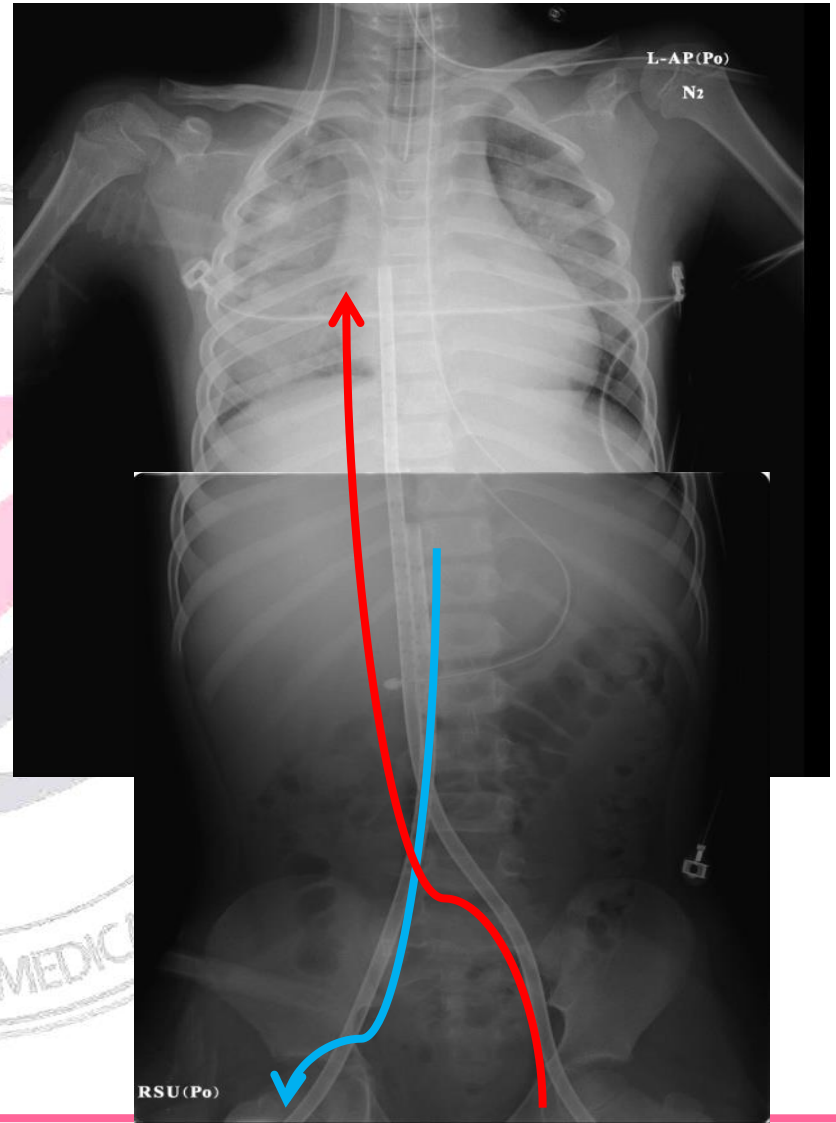
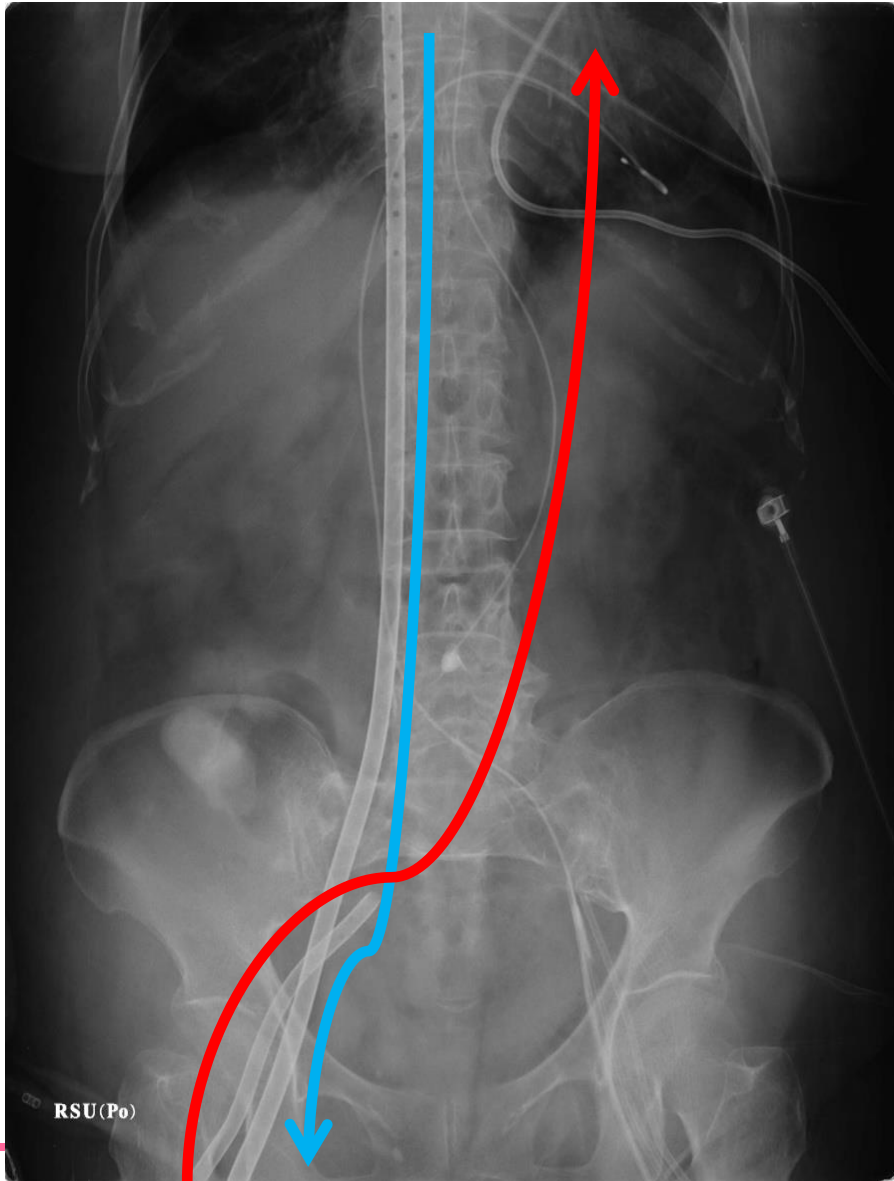
체온조절장치



폐기능

심장기능: 펌프



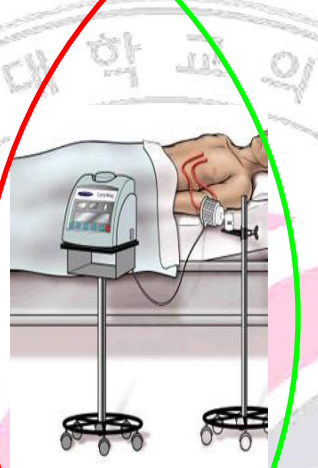


**Salvage**

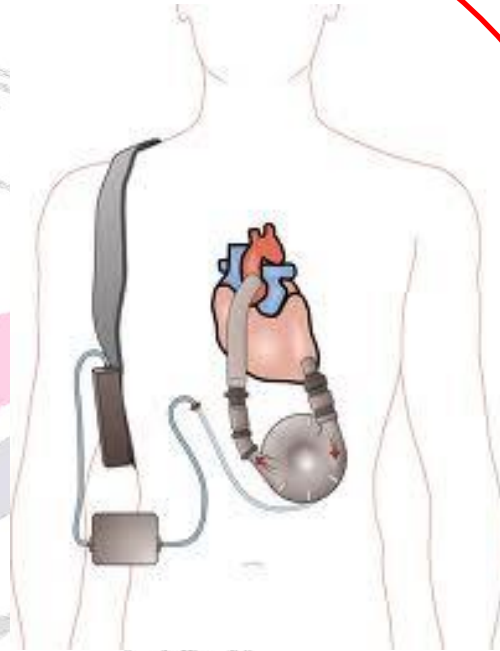
**Maintenance**



**ECMO**



**VAD**



**Implantable VAD or TAH**

**Hours**

**Days**

**Months**

**Years**



[http://www.elsonet.org/index.php?option=com\\_phocadownload&view=category&id=4&Itemid=627](http://www.elsonet.org/index.php?option=com_phocadownload&view=category&id=4&Itemid=627)



## **Extracorporeal Life Support Organization (ELSO)**

### **General Guidelines for all ECLS Cases**

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ELSO Guidelines

Version 1.3 November 2013



Hallym University  
Sacred Heart Hospital

ECLS is the use of mechanical devices to temporarily (days to months) support heart or lung function (partially or totally) during cardiopulmonary failure, leading to organ recovery or replacement.

## I. **Patient condition**

### A. **Indications**

Acute severe heart or lung failure with high mortality risk despite optimal conventional therapy. ECLS is considered at 50% mortality risk, **ECLS is indicated in most circumstances at 80% mortality risk.** Severity of illness and mortality risk is measured as precisely as possible using measurements for the appropriate age group and organ failure. See patient- specific protocols for details.

### B. **Contraindications**

**Most contraindications are relative, balancing the risks of the procedure (including the risk of using valuable resources which could be used for others) vs. the potential benefits. The relative contraindications are:** 1) conditions incompatible with normal life if the patient recovers; 2) preexisting conditions which affect the quality of life (CNS status, end stage malignancy, risk of systemic bleeding with anticoagulation); 3) age and size of patient; 4) futility: patients who are too sick, have been on conventional therapy too long, or have a fatal diagnosis. See patient-specific protocols for details.

### C. **Specific patient considerations**

See patient-specific protocols





## **Extracorporeal Life Support Organization (ELSO)**

### **Guidelines for Adult Cardiac Failure**

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ELSO Adult Cardiac Failure Supplement to the ELSO General Guidelines

Version 1.3

December 2013

Page 1





**A. Indication for ECMO in adult cardiac failure is cardiogenic shock:**

1. Inadequate tissue perfusion manifested as hypotension and low cardiac output despite adequate intravascular volume.
2. Shock persists despite volume administration, inotropes and vasoconstrictors, and intraaortic balloon counterpulsation if appropriate.
3. Typical causes: Acute myocardial infarction, Myocarditis, Peripartum Cardiomyopathy, Decompensated chronic heart failure, Post cardiectomy shock.
4. Septic Shock is an indication in some centers.

Guidelines on relative survival without ECMO:

IABP score postcardiotomy(Hausmann H Circ 2002)

Samuels score postcardiotomy (Samuels LE J Cardiac Surg 1999)

Options for temporary circulatory support

Surgical temporary VAD: Abiomed, Levitronix

Percutaneous VAD:TandemHeart, Impella

ECMO: Advantages: Biventricular support, bedside immediate application, oxygenation, Biventricular failure, Refractory malignant arrhythmias, Heart failure with severe pulmonary failure

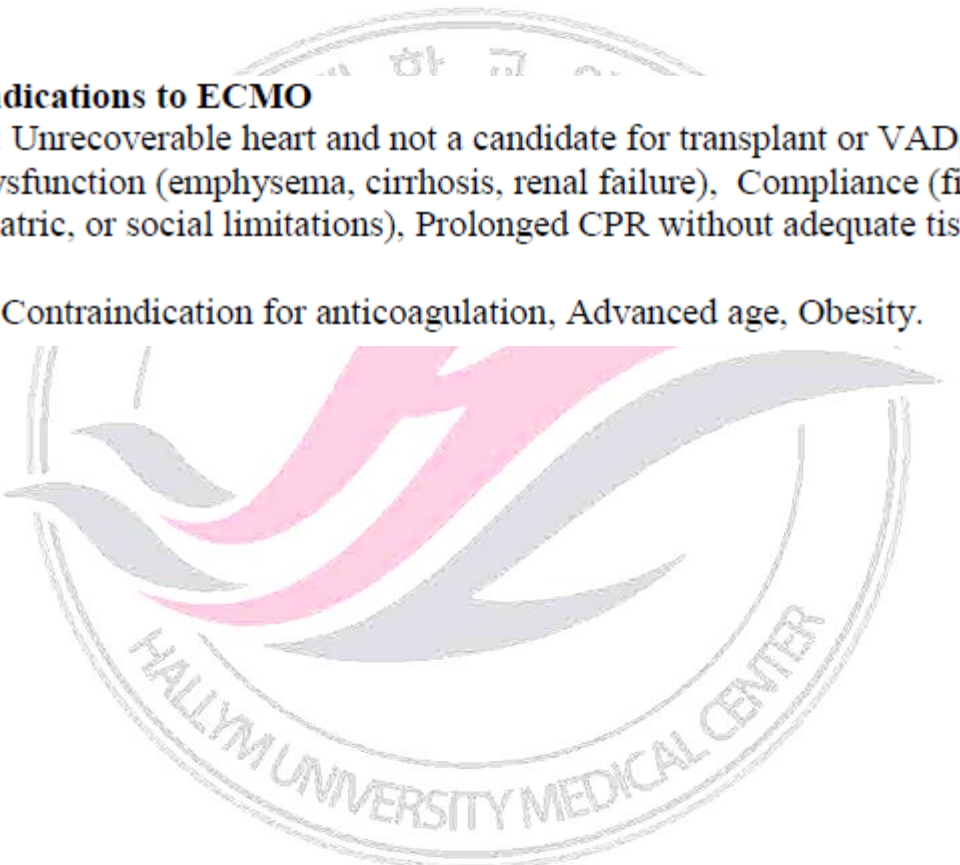
ECMO is a bridge to...

Recovery: Acute MI after revascularization, Myocarditis, Postcardiotomy

Transplant: Unrevascularizable acute MI, Chronic heart failure

Implantable circulatory support: VAD, TAH





**B. Contraindications to ECMO**

1. Absolute: Unrecoverable heart and not a candidate for transplant or VAD, Advanced age, Chronic organ dysfunction (emphysema, cirrhosis, renal failure), Compliance (financial, cognitive, psychiatric, or social limitations), Prolonged CPR without adequate tissue perfusion.
2. Relative: Contraindication for anticoagulation, Advanced age, Obesity.





## **Extracorporeal Life Support Organization (ELSO)**

### **Guidelines for ECPR Cases**

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ELSO ECPR Supplement to the ELSO General Guidelines

Version 1.3

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**A Indications**

AHA guidelines for CPR recommends consideration of ECMO to aid cardiopulmonary resuscitation in patients who have an easily reversible event, have had excellent CPR.

Contraindications: All contraindications to ECMO use (such as Gestational age < 34 weeks) should apply to ECPR patients.

DNR orders

Futility: Unsuccessful CPR ( no return of spontaneous circulation) for 5-30 minutes. ECPR ma be indicated on prolonged CPR if good perfusion and metabolic support is documented.





## **Extracorporeal Life Support Organization (ELSO)**

### **Guidelines for Adult Respiratory Failure**

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ELSO Adult Respiratory Failure Supplement to the ELSO General Guidelines

Version 1.3

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## A: Indications

1. In hypoxic respiratory failure due to any cause (primary or secondary) ECLS should be considered when the risk of mortality is 50% or greater, and is indicated when the risk of mortality is 80% or greater.

a. 50% mortality risk is associated with a  $\text{PaO}_2/\text{FiO}_2 < 150$  on  $\text{FiO}_2 > 90\%$  and/or Murray score 2-3.

b. 80% mortality risk is associated with a  $\text{PaO}_2/\text{FiO}_2 < 100$  on  $\text{FiO}_2 > 90\%$  and/or Murray score 3-4 despite optimal care for 6 hours or more.

2. CO<sub>2</sub> retention on mechanical ventilation despite high Pplat (>30 cm H<sub>2</sub>O)

3. Severe air leak syndromes

4. Need for intubation in a patient on lung transplant list

5. Immediate cardiac or respiratory collapse (PE, blocked airway, unresponsive to optimal care)



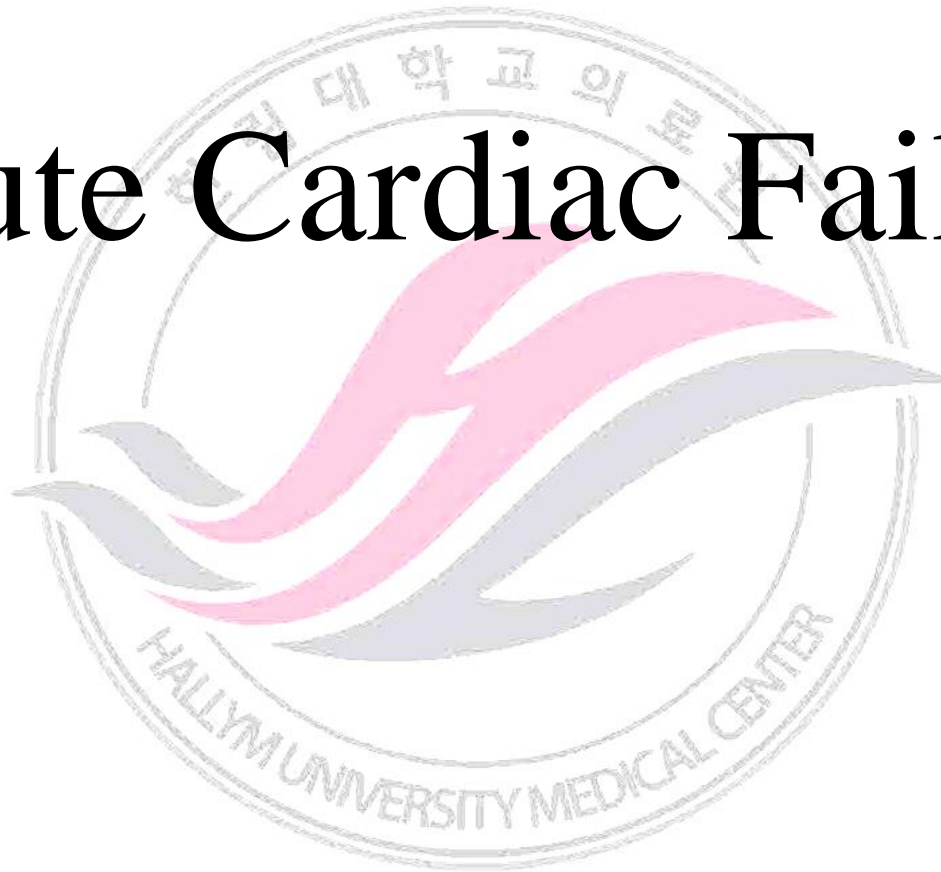
## **B: Contraindications**

There are no absolute contraindications to ECLS, as each patient is considered individually with respect to risks and benefits. There are conditions, however, that are associated with a poor outcome despite ECLS, and can be considered relative contraindications.

1. Mechanical ventilation at high settings ( $FiO_2 > .9$ ,  $P\text{-plat} > 30$ ) for 7 days or more
2. Major pharmacologic immunosuppression (absolute neutrophil count  $< 400/mm^3$ )
3. CNS hemorrhage that is recent or expanding
4. Non recoverable co morbidity such as major CNS damage or terminal malignancy
5. Age: no specific age contraindication but consider increasing risk with increasing age

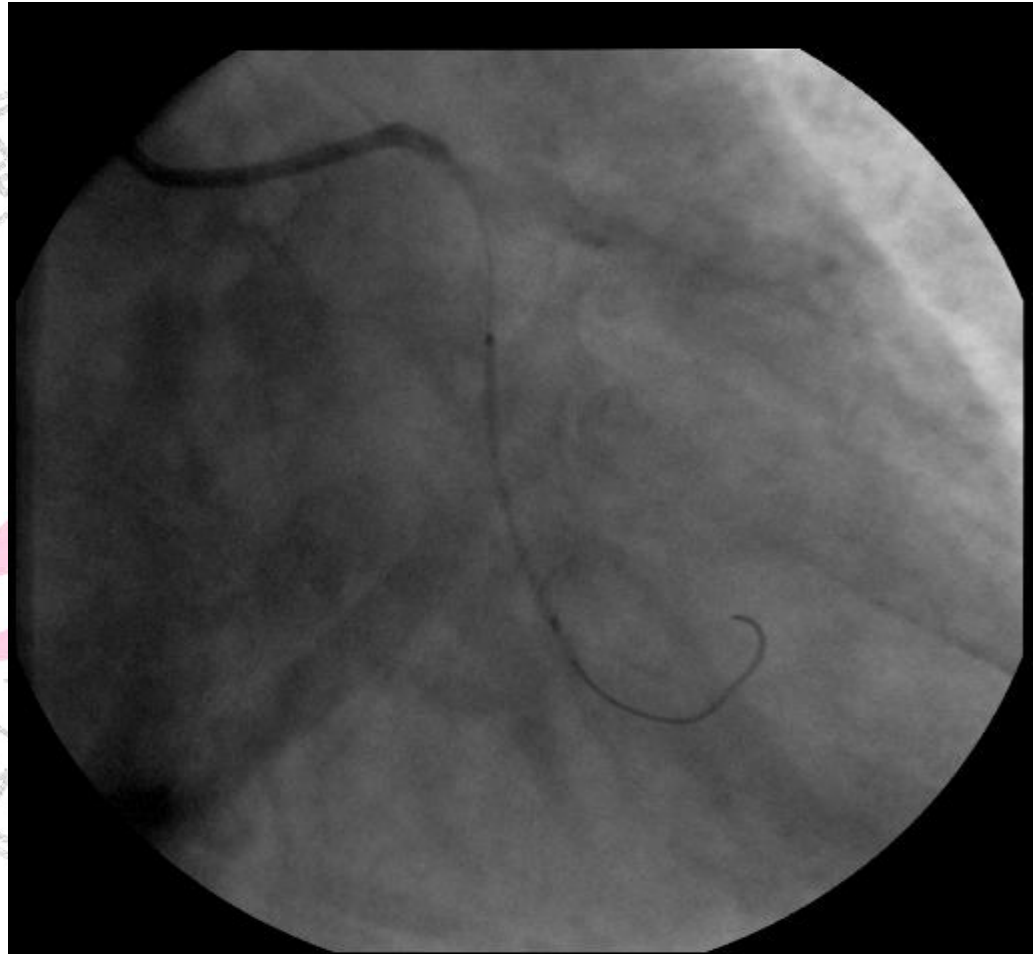
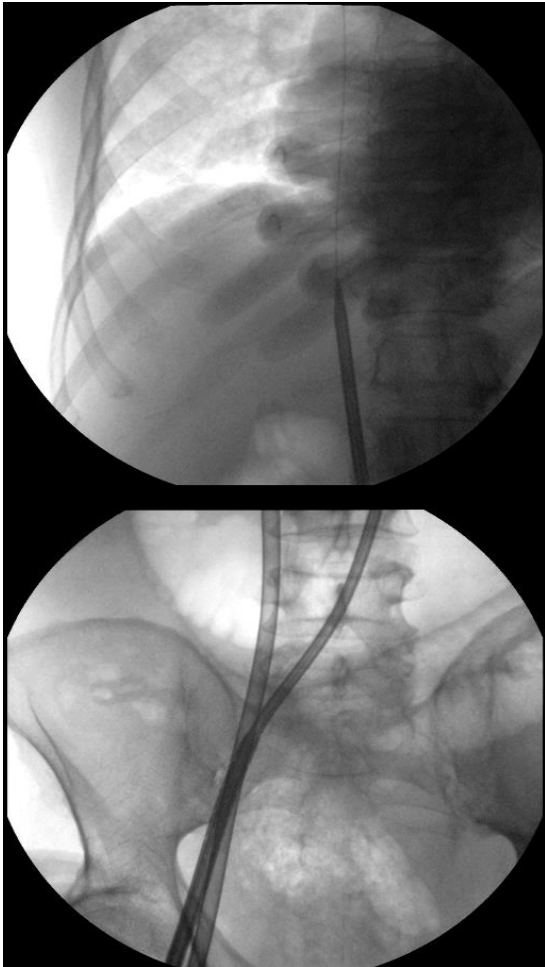


# Acute Cardiac Failure

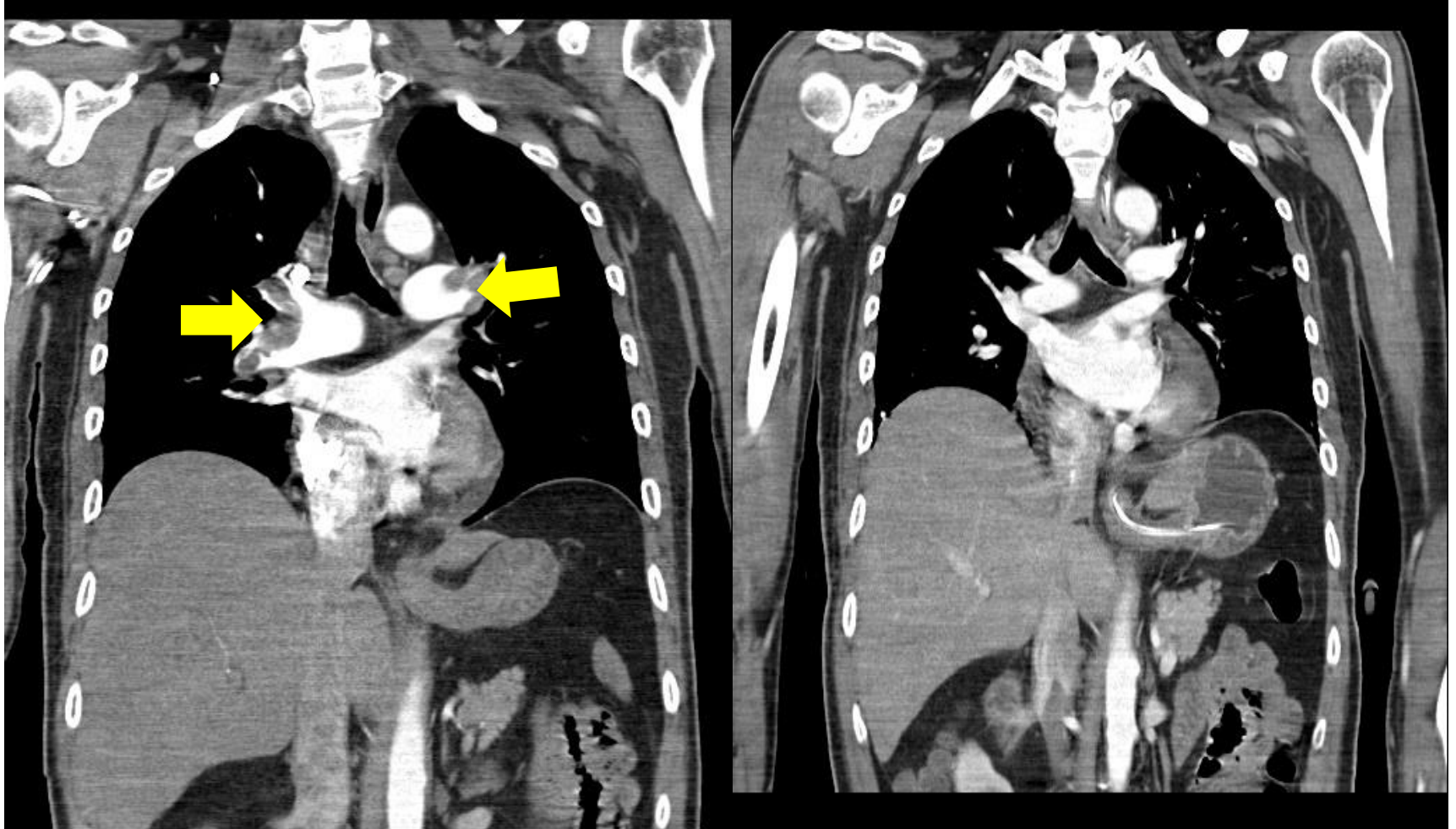




# ECPR & PCI

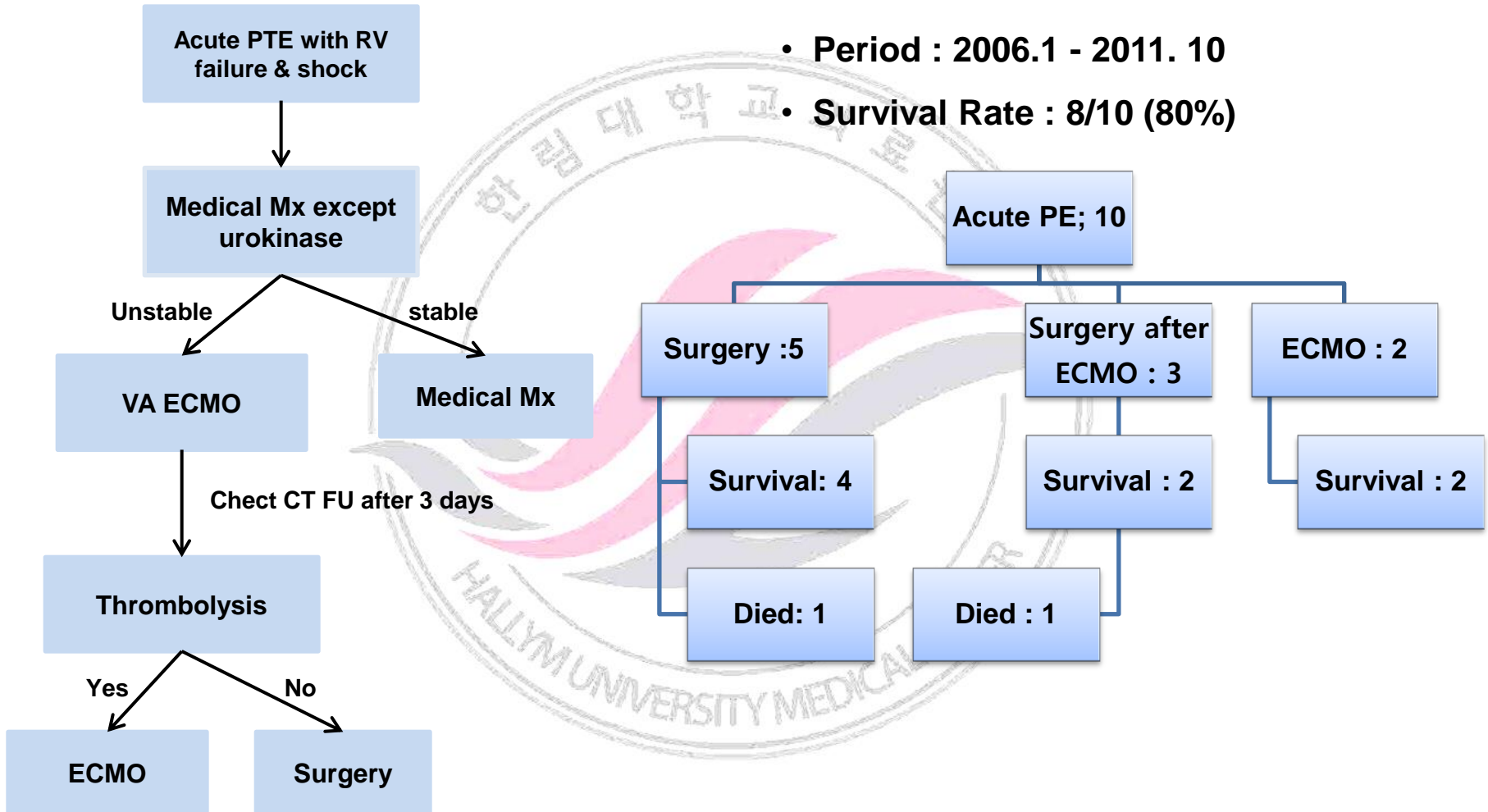


# Acute PTE



# Acute PTE Mx protocol

- Period : 2006.1 - 2011. 10
- Survival Rate : 8/10 (80%)



# Refractory shock state (?)

	Refractory cardiogenic shock	Refractory septic shock
Cause	AMI, Malignant arrhythmia, Myocarditis.....	Various
Inotropics	INEPI : 0.5ug/kg/min (?)	INEPI : 0.5ug/kg/min (?)
IABP	With/without	-
Mode	VA, VA → VV or VAV	VA, VV, VAV

# ECMO in Trauma Patients



# Accidental Hypothermia



**17:19 Calling 119 to report victim**

**17:53 Rescued by 119 helicopter**

**vital sign 0-0-0 SpO2 0**

**pupil F8/F8**

**AED : arrest**

**CPR**

**17:59 Arrived at ED**

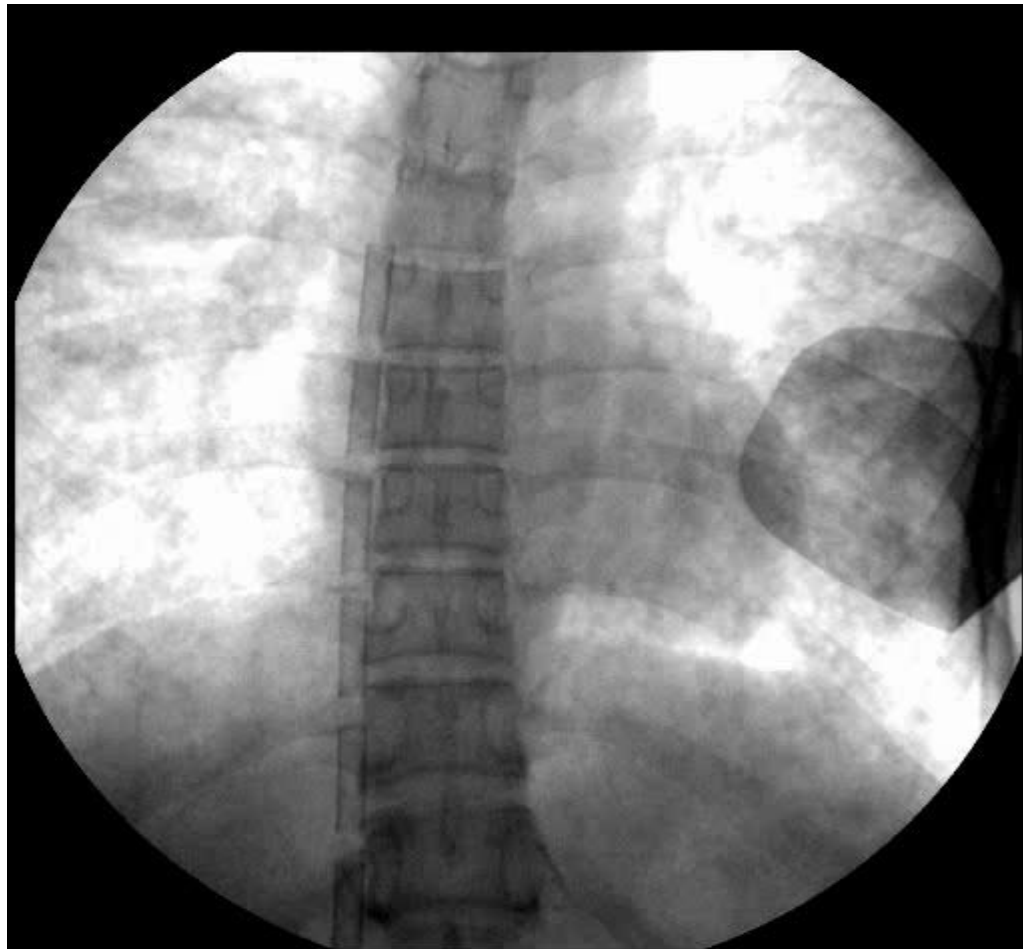
**pupil F6/F6**

**DC shock d/t Vf →no response**

**18:36 transported to CAG room**

검사항목	2013-03-02 18:29	2013-03-02 18:10
pH	6,800	6,800
pCO2	92	105
pO2	71	37
HCO3-act		
BE(B)		
BE(ecf)		
ctco2		
Hct	47,0	46,0
ctHb(est)	16,0	15,6
O2SAT(est)		
Na+	133	120
K+	3,6	9,0
Ca++	0,81	0,86
Lactic acid -현장검사	15,0	15,0
Glu	341	224





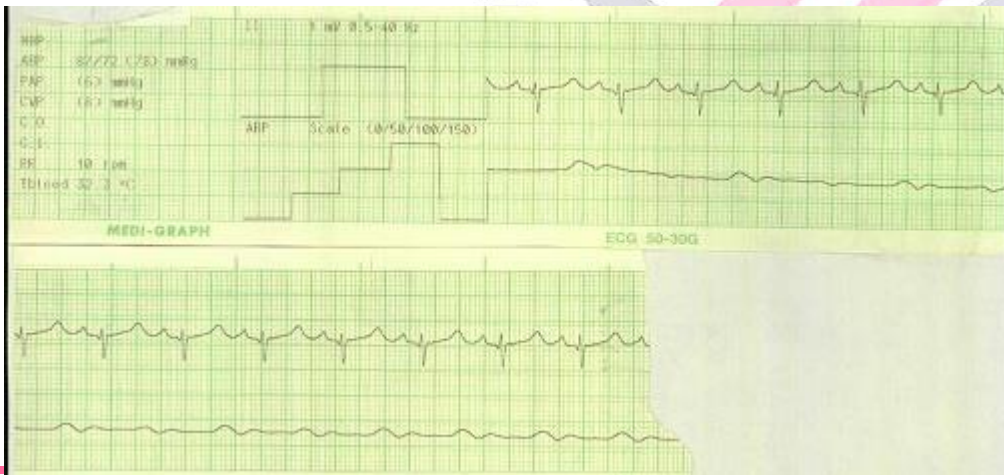
**19:00 VA ECMO start**  
**Biomedicus 17Fr, 21Fr**  
**PLS system**  
**Heater 33 °C**  
**EKG Vf,**  
**BP 110mmHg**  
**NEPI 0.38ug/kg/min**  
**Pump flow 3.5L/min**  
**19:10 Brain CT check : WNL**  
**19:20 ICU**

검 사 항 목	2013-03-02 21:14	2013-03-02 21:02
pH	6,676	6,741
pCO2	33	11
pO2	657	639
HCO3 <sup>-</sup> act	3,7	1,4
BE(B)	-32,3	-33,8
BE(ecf)	-32,8	-34,1
ctco2	4,8	1,7
Hct	34	46
ctHb(est)	11,6	15,6
O2SAT(est)	99,7	99,8
Na <sup>+</sup>	137	131
K <sup>+</sup>	2,4	2,2
Ca <sup>++</sup>	0,49	0,40





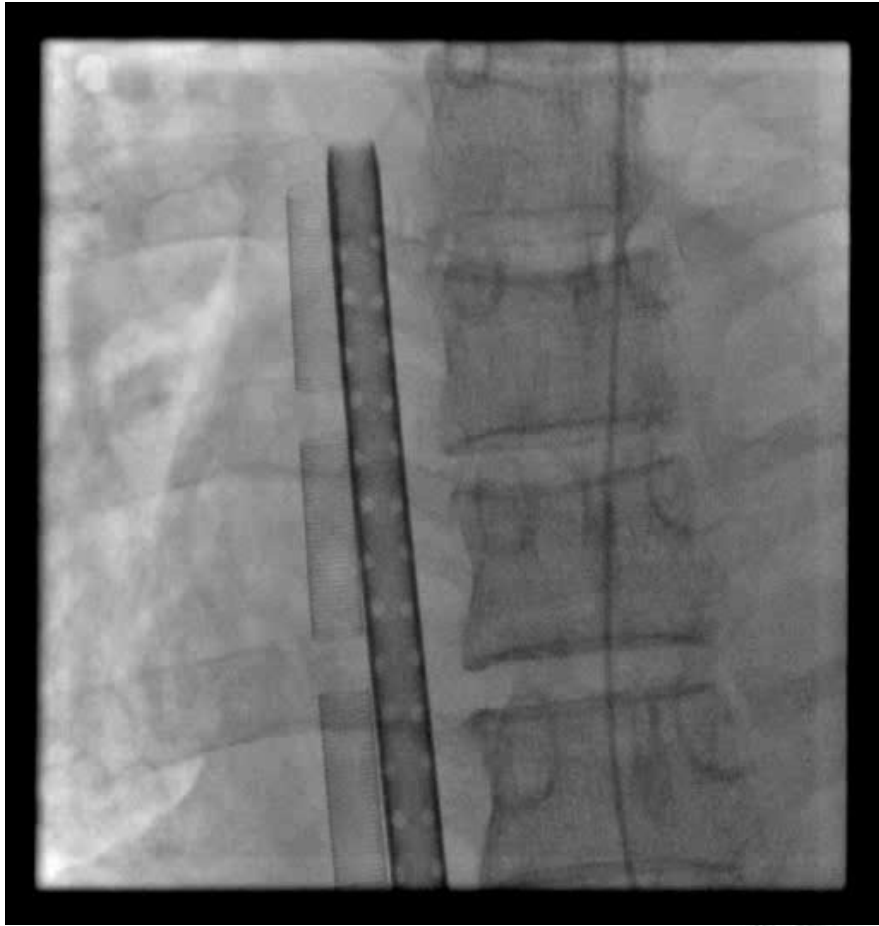
**19:20 EKG; Vf**  
**CMV-370ml-10-0.6-8cmH2O**  
**BP:100-130mmHg**  
**pupil F7/F7, CRRT apply**  
**20:43 Gross hematuria**  
**21:30 DC shock 200J**  
**Junctional rhythm**  
**21:56 self respiration**  
**22:31 Movement(+)**  
**22:50 EKG NSR, BT : 32.3 °C**  
**BP 70-100mmHg**  
**00:15 Obey(+)**



검사항목	2013-03-02 23:29	2013-03-02 22:40	2013-03-02 22:04
pH	7.187	6.981	6.890
pCO2	31	48	36
pO2	266	491	532
HCO3-act	11.3	11.0	6.7
BE(B)	-15.6	-20.3	-25.2
BE(ecf)	-16.9	-20.6	-26.3
ctco2	12.3	12.4	7.8
Hct	38	38	30
ctHb(est)	12.9	12.9	10.2
O2SAT(est)	99.5	99.7	99.7
Na+	126	127	122
K+	3.2	3.1	2.1
Ca++	0.36	0.25	NO RST







### ECMO #3

2D echo : RV & LV preserve  
EF 55%

ECMO#5 weaning try  
lung problem

ECMO#6 VV ECMO

ECMO#4 → ECMO#8

Organism #1 : Acinetobacter baumannii Organism #1 : Acinetobacter baumannii

Ampicillin/Sulbactam	S <= 2	Ampicillin/Sulbactam	R >= 32
Aztreonam	R 32	Aztreonam	R >= 64
Ciprofloxacin	S <= 0.25	Ciprofloxacin	R >= 4
Colistin	S <= 0.5	Colistin	S <= 0.5
Cefepime	S 4	Cefepime	R >= 64
Gentamicin	S <= 1	Gentamicin	R >= 16
Imipenem	S <= 0.25	Imipenem	R >= 16
Meropenem	S <= 0.25	Meropenem	R >= 16
Minocycline	S <= 1	Minocycline	I 8
Piperacillin	S 16	Piperacillin	R >= 128
Trimethoprim/Sulfa	S <= 20	Trimethoprim/Sulfa	R >= 320
Cefotaxime	I 16	Cefotaxime	R >= 64
Ceftazidime	S 8	Ceftazidime	R >= 64
Ticarcillin/CA	S <= 8	Ticarcillin/CA	R >= 128
Tigecycline	S <= 0.5	Tigecycline	S 2
Piperacillin/Tazobac	S <= 4	Piperacillin/Tazobac	R >= 128



## Chest PA. HD#1 ~ HD#55



**ECMO #12 ECMO remove**

**HD#15 Extubation**

**HD#20 G/W 이실**

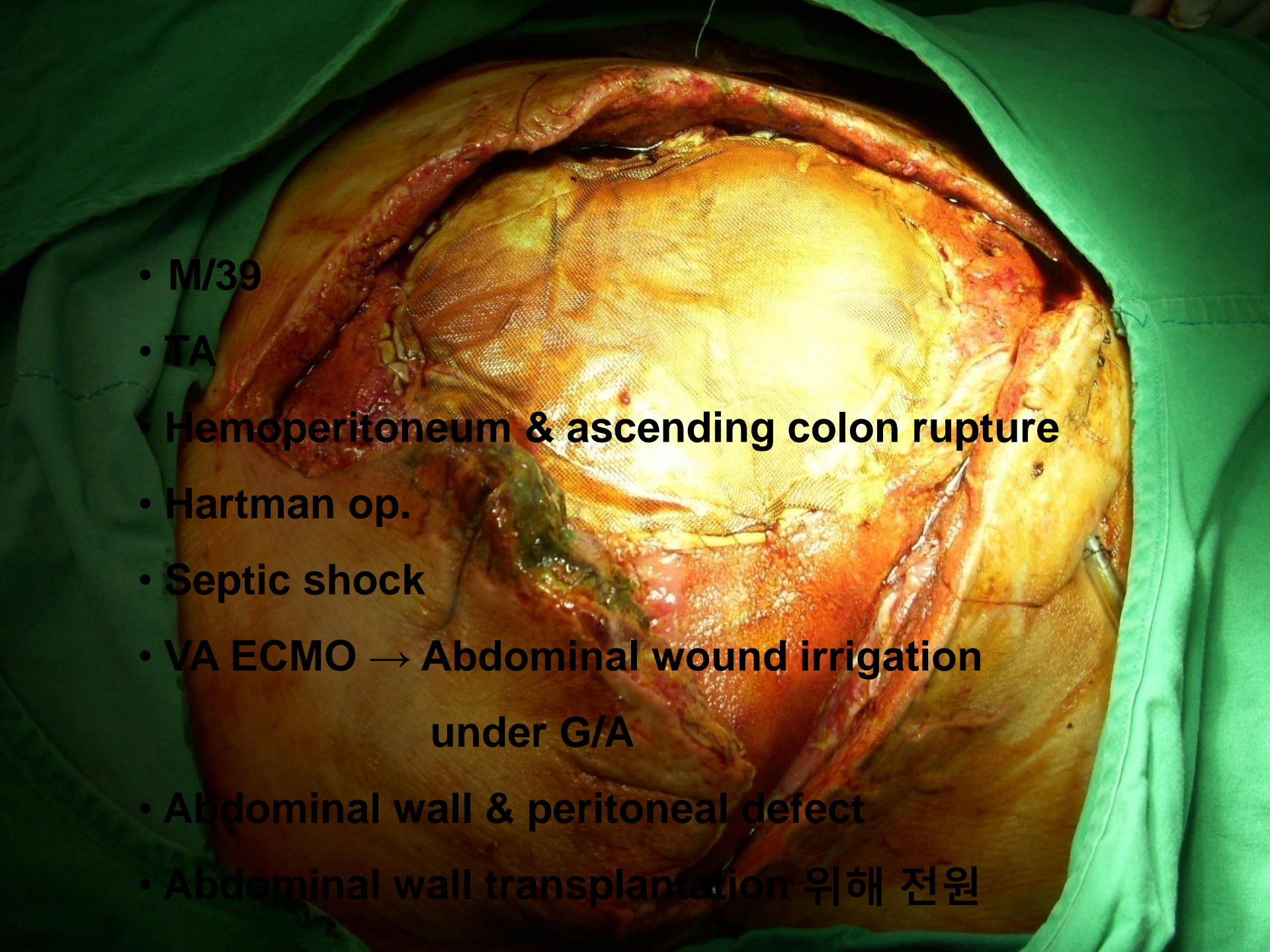
**Hd#55 Discharged**



# School Violence

- M/15
- Commotio Cordis
- Total CPR time : 43min
- Door to ECMO time: 33min



- 
- An intraoperative photograph showing a large, open abdominal cavity. The abdominal wall is significantly deficient, and the peritoneal cavity is covered with a large, yellowish, mesh-like graft. The surrounding tissues are reddish and appear inflamed. The patient is lying on a green surgical drape.
- M/39
  - TA
  - Hemoperitoneum & ascending colon rupture
  - Hartman op.
  - Septic shock
  - VA ECMO → Abdominal wound irrigation  
under G/A
  - Abdominal wall & peritoneal defect
  - Abdominal wall transplantation 위해 전원

# Traumatic Lung Contusion with Traumatic Brain Injury

F/19

Traffic Accident

23:05 ER

23:13 O2 7L/min mask inhalation M/S : stupor

23:23 to CT room

23:59 Intubation : full ambu bagging

00:55 Ventilator mode : PC, RR 20회/분, FiO2 1.0

P/F ratio: 47, inotropic drugs(-)

02:05 VV-ECMO start

측정일시	S,B,P (mmHg)	D,B,P (mmHg)	M,A,P (mmHg)	맥박 (회)	호흡 (회)	체온 (°C)	Comment
13/04/24 02:30				100	11	36.0	중환자실
13/04/24 01:55	60	0	20	150	10	35.0	
13/04/24 01:40	60	0	20	152	10	35.0	
13/04/24 01:03	60	0	20	156			[응급실]
13/04/24 00:42							78% [응급실]
13/04/24 00:34	100	50	66	150	26		72% [응급실]
13/04/23 23:53	100	70	80	128	40	36.0	93% [응급실]
13/04/23 23:22	90	60	70	122	22	35.8	86% [응급실]
13/04/23 23:07	60	0	20	138			[응급실]
13/04/23 23:05	0	0	0	163	24	35.8	응급정보조사지

검사항목	2013-04-24 00:55	2013-04-23 23:58	2013-04-23 23:16
Ca <sup>++</sup>	0.71	0.95	0.91
pH	7.240	7.320	7.250
pCO <sub>2</sub>	43	43	47
pO <sub>2</sub>	28	47	32
HCO <sub>3</sub> -act	18.4	22.2	20.6
BE(B)	-8.7	-3.8	-6.7
BE(ecf)	-9.0	-3.9	-6.6
ctco <sub>2</sub>	19.7	23.5	22.0
Hct	40.0	36.0	41.0
ctHb(est)	13.6	12.2	13.9
O <sub>2</sub> SAT(est)	40	79	50

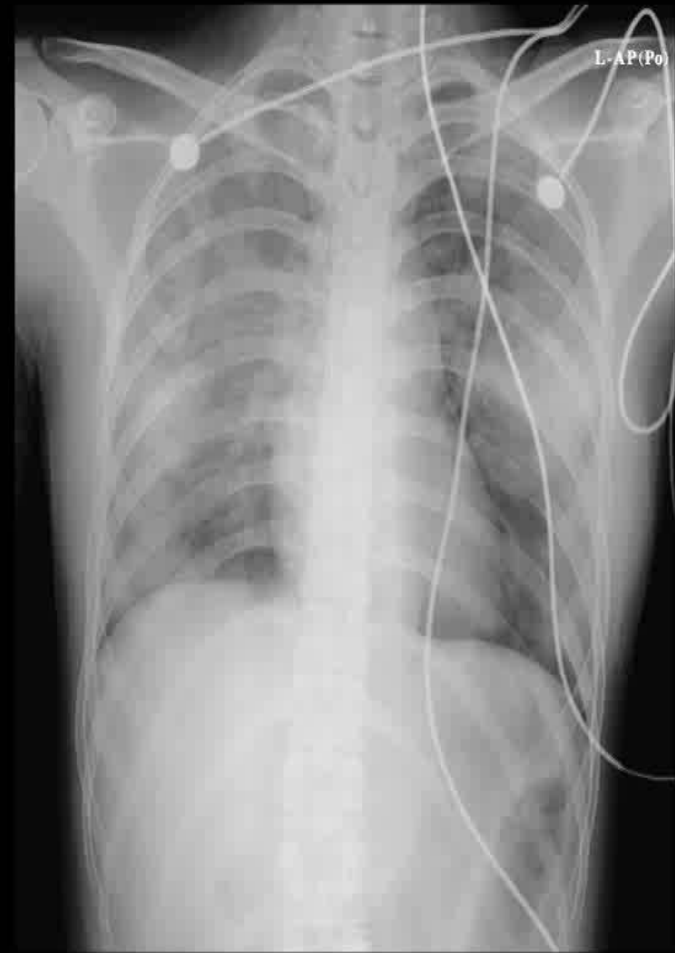
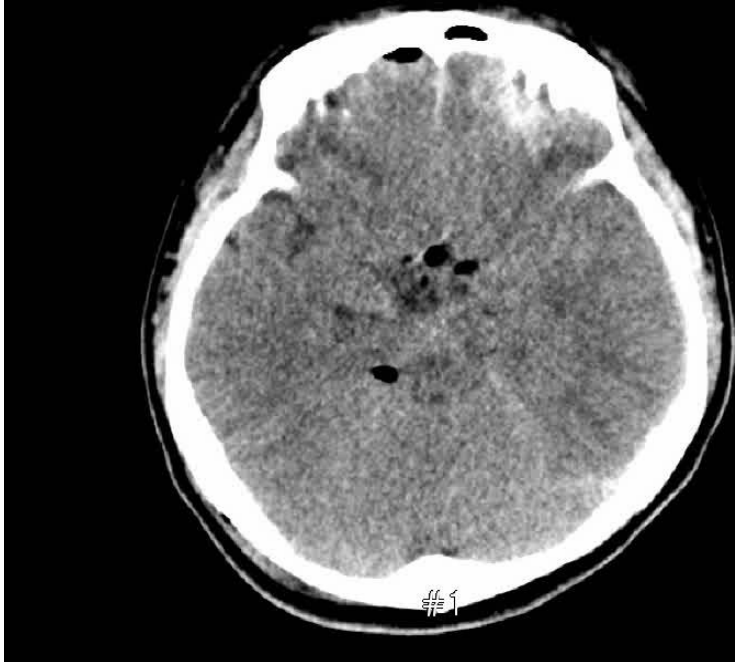


# Traumatic Lung Contusion with Traumatic Brain Injury

- Brain injury : Lt frontal contusional hematoma, Lt frontal SDH, multiple pneumocephalus, Basal skull fracture
- Chest injury : Hemorrhagic lung contusion, mediastinal hematoma
- Abdomen & Pelvis : Lt kidney parenchymal laceration, small hemoperitoneum in pelvic cavity, Rt superior pubic ramus fracture
- Heparin 2000u loading
- Nafamostat mesilate used as an anticoagulant: aPTT 60-80 sec



# Traumatic Lung Contusion with Traumatic Brain Injury



**VV ECMO for 6 days**

**ICU stay for 17days**

**She was discharged after 3months**

**She returns to her normal life now**



## Extracorporeal Membrane Oxygenation for Acute Life-Threatening Neurogenic Pulmonary Edema following Rupture of an Intracranial Aneurysm

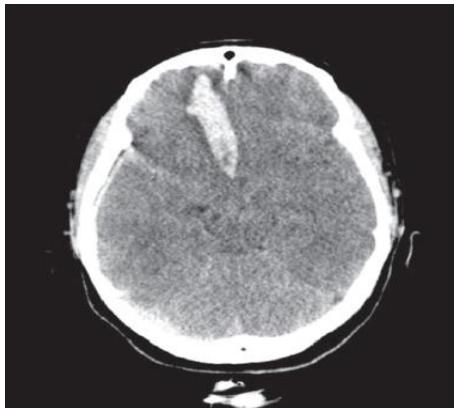


Fig. 1. Computed tomographic scan showing a hematoma with mass effect in the right frontal base, suggesting rupture of an anterior communicating artery aneurysm.



- ✓ F/28
- ✓ A-com rupture
- ✓ Neurogenic pulmonary edema
- ✓ FiO<sub>2</sub> 1.0 : PaO<sub>2</sub> 32-44mmHg, PaCO<sub>2</sub> 48-68mmHg
- ✓ VV ECMO
- ✓ Aneurysm clipping and decompression craniectomy for ICP control
- ✓ ECMO was weaned off 7days after application
- ✓ Neurologic status recovered fully by 1 month after op.
- ✓ She returned to her normal life at 3month after treatment.





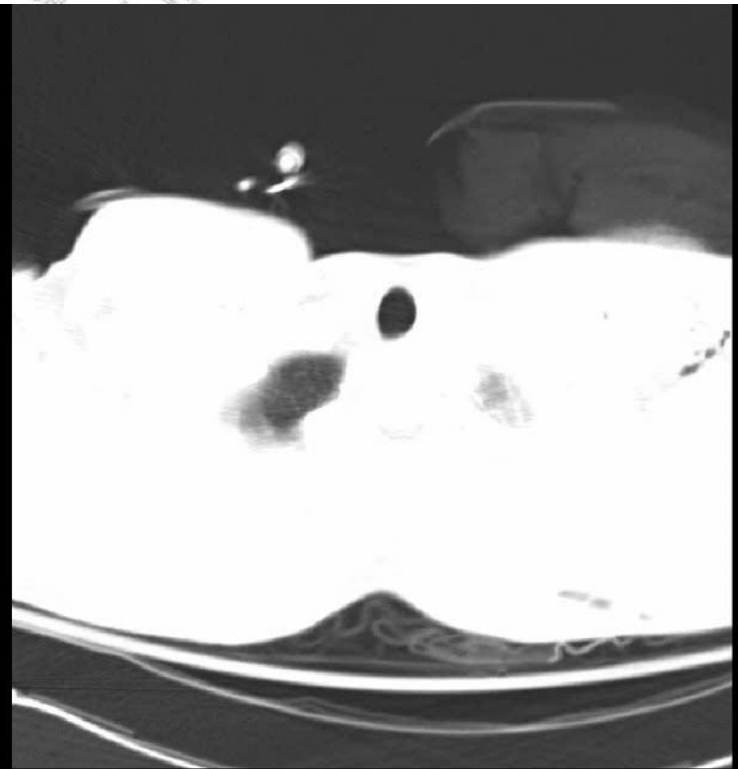
# **Thoracic Surgery Assisted with VV ECMO**



# Gun shot

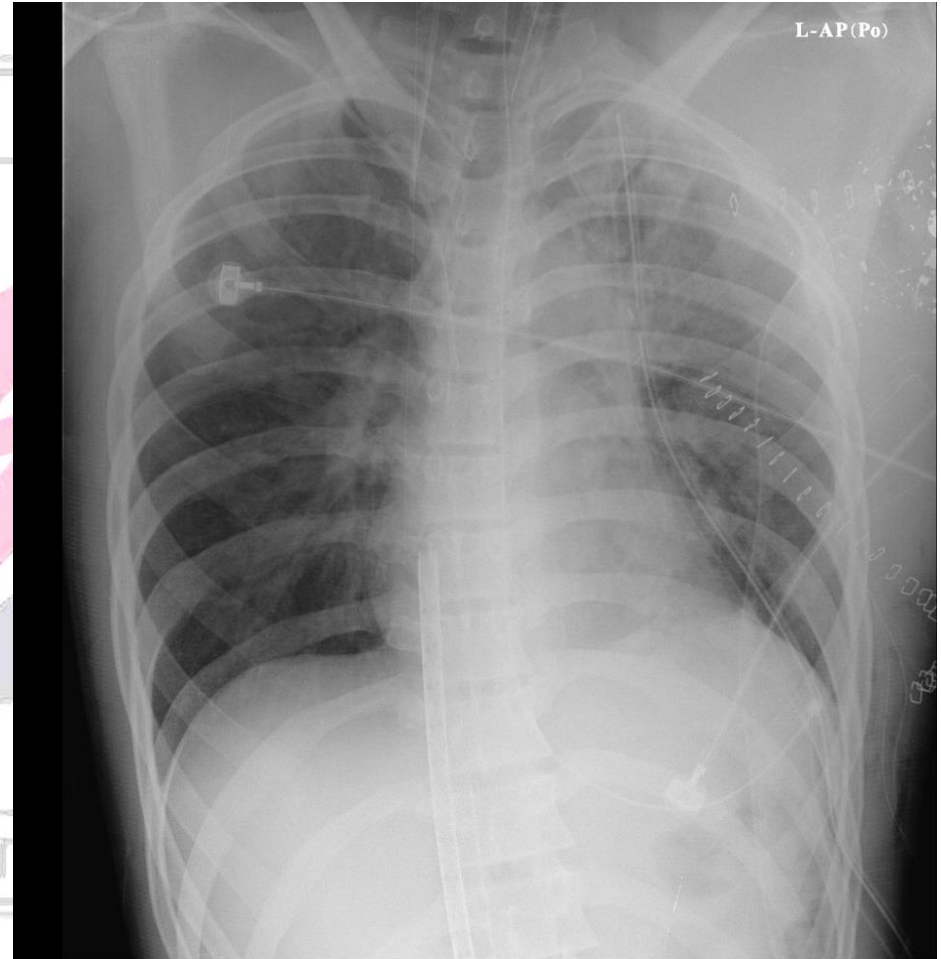
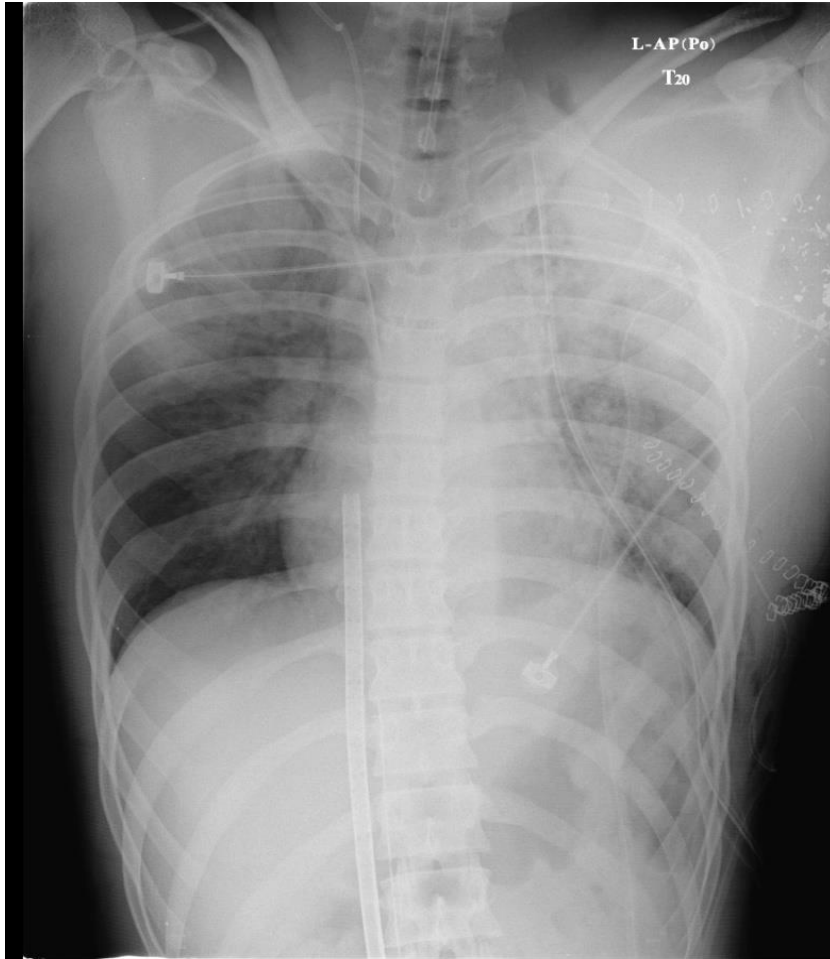
P/F ratio : 351

P/F ratio : 75 → 350 ⇒ 250

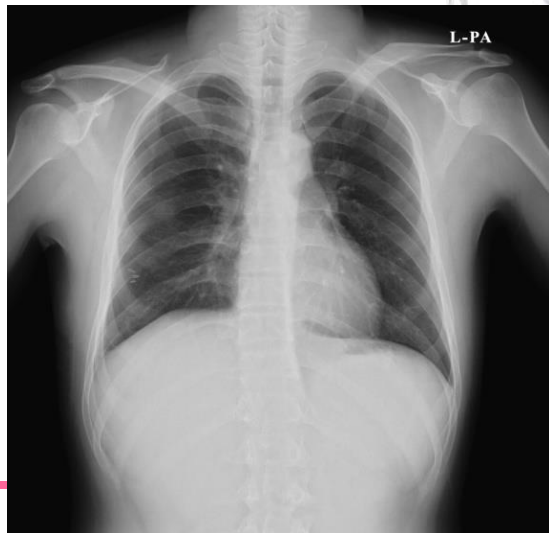
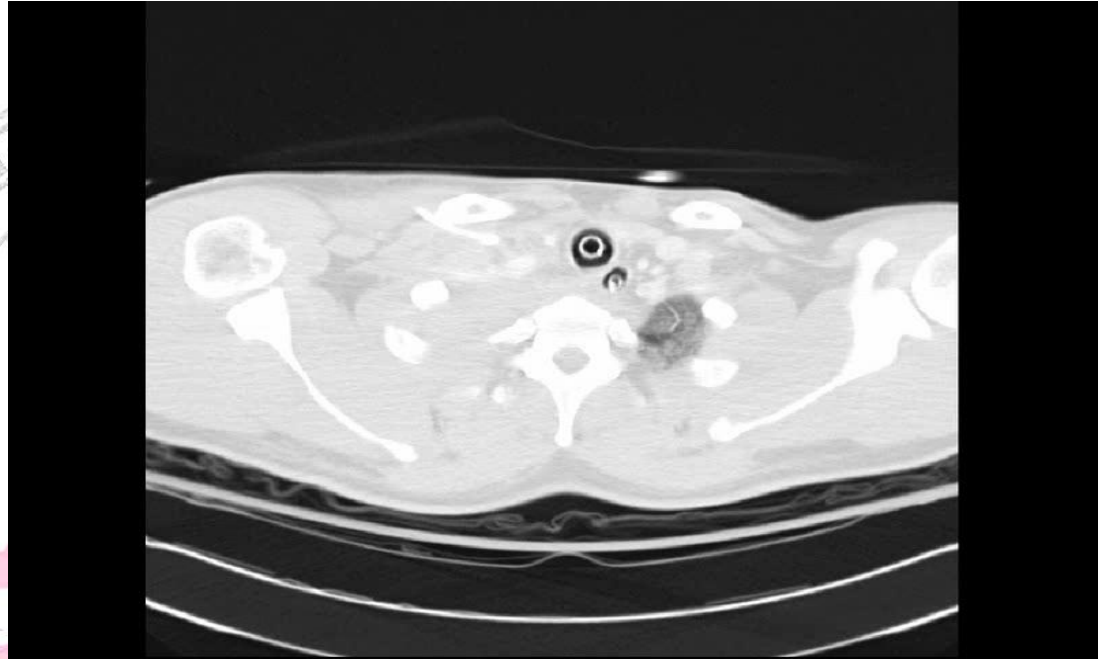


# Chest PA after LUL lobectomy

## POD #1



# Rt subclavian artery bleeding d/t DIC



P/F ratio : 43

vv-ECMO under CPR (5min)

Dx: ICH, IVH, Rt renal injury, Spleen injury, L-spine Rt

1-5 transverse process Fx, Lt femur head Fx



# Initial Settings and Goals of ECMO

---

Circuit flow	50 ~ 80 mL/kg/min
Sweep gas flow	50 ~ 80 mL/kg/min
FiO <sub>2</sub> (sweep gas)	100%
Inlet pressure	> -100 mmHg
SaO <sub>2</sub> (return cannula)	100%
SaO <sub>2</sub> (drainage cannula)	> 65%
Arterial oxygen saturation	VA > 95%, VV: 85 ~ 92%
SvO <sub>2</sub>	> 65%
PaCO <sub>2</sub>	35 ~ 45 mmHg
pH	7.35 ~ 7.45
Mean arterial pressure	65 ~ 95 mmHg
Hematocrit	30 ~ 40%
Activated partial thromboplastin time	60 ~ 80 sec ; 1.5 ~ 2 times normal
Platelet count	> 50,000/uL

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# Schedule of initial Point of Care and Laboratory Testing During ECMO

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Arterial blood gases	3 ~ 4 hourly
Mixed venous O2	Daily
Pre- and post-oxygenator blood gases	Daily
Complete blood count	6 hourly
Coagulation tests	6 hourly
Thromboelastograph	12 hourly
Blood chemistry, renal function, and liver function	12 hourly
Plasma free hemoglobin	12 hourly
Blood culture from the circuit	Daily

---



# Transfusion

Lab Monitoring		Maintain	
Platelets	q 6-12hr	> 50,000-100,000	Platelets concentrates
INR	q 6-12hr	< 2.0	Fresh frozen plasma
Fibrinogen	q 12-24hr	> 100mg/dL	Cryoprecipitate
CBC	q 8-12hr	Hct >35%	pRBC
Antithrombin	Daily and/or prn	> 50%	FFP. AT3



# ECMO program





경청해주셔서 감사합니다.

