



일산화탄소 중독 치료

연세대학교 원주의과대학
원주세브란스기독병원 호흡기내과

이석정



CO 중독의 치료



호흡기내과 의사에게 고압산소의학이란?



■ 2000년도 내과학 학습목표

제 4 장 호흡기 질환 (34시간)

제 5 절 물리적, 화학적 그리고 흡입에 의한 폐손상 (1.5시간)

학 습 목 표

1. 열에 의한 폐손상시 즉시 나타나는 가장 흔한 합병증 및 치료를 설명한다.
2. 고압 산소가 치료로 이용되는 경우를 설명한다.
3. 산소 독성의 예방원칙을 설명한다. (신설)
4. 위장 내 물질의 흡인 후 폐렴의 정도를 결정하는 주요인자를 열거한다. (B⇒A)
5. 의사 후 응급조치의 원칙을 설명한다. (신설)

고압산소치료 인정기준



- 급성 일산화탄소 중독
- ✓ ■ 가스색전증
- 중심망막동맥폐쇄
- 감압병 (잠수병)
- 시안화물 중독
- 방사선치료후 조직괴사
- 당뇨병 족부궤양 (Wagner grade 3 이상)
- 식피술 또는 피판술 후
- 수지접합 수술 후
- 돌발성 난청
- 버거씨병
- 화상
- 난치성 골수염
- 머리농양
- 혐기성 세균 감염증 (가스괴저증)
- 과도한 출혈에 의한 빈혈

HOME > 기획특집 > DEEP DIVE

청와대에서 일산화탄소 중독 사고 발생해도 강원도로 가야

서울경기 지역에 중환자 치료할 고압산소치료실 하나도 없어
전문가들 "낮은 수가로 손해 보는 구조 때문...권역별 하나씩은 있어야"

송수연 기자 | 승인 2018.12.19 13:42 | 최종 수정 2018.12.21 09:45 | 댓글 0



HOME > 종합

경기도 다인용 고압산소치료기 설치 추진

안경환 기자 | 승인 2018.12.30 19:50 | 댓글 0 | 1면

도 의료원 산하 병원 등 검토
수도권 최초 남북부 각 1곳씩
지원예산 내년 1회 추경 반영

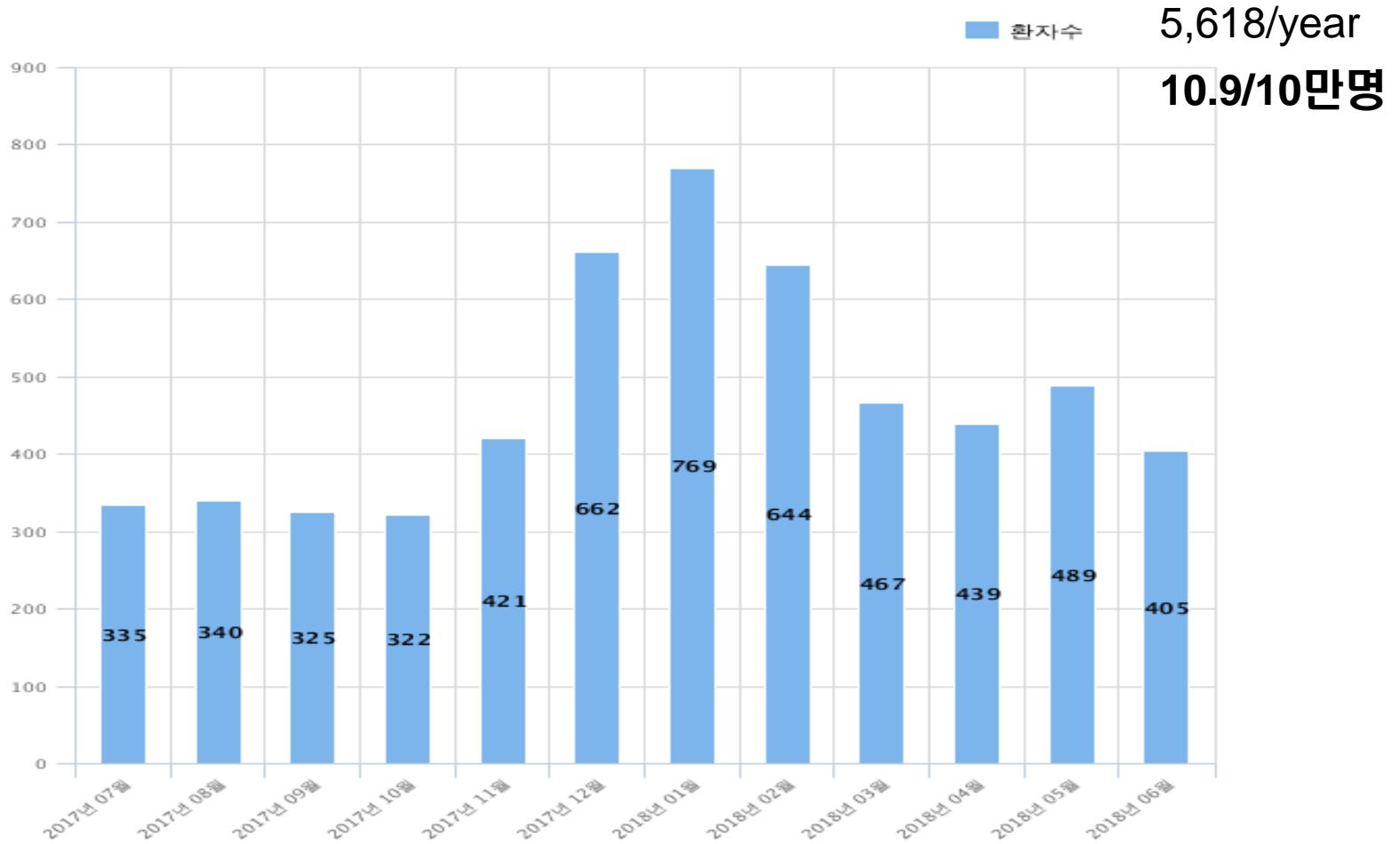


CO 중독의 유병률

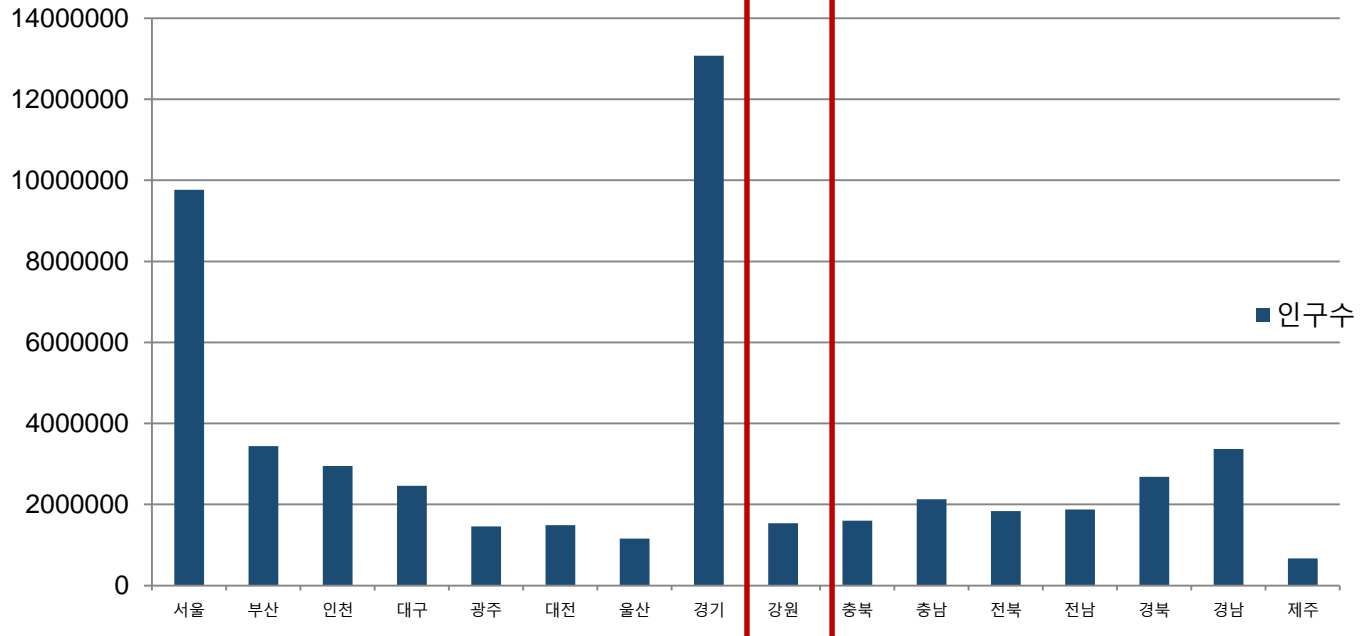
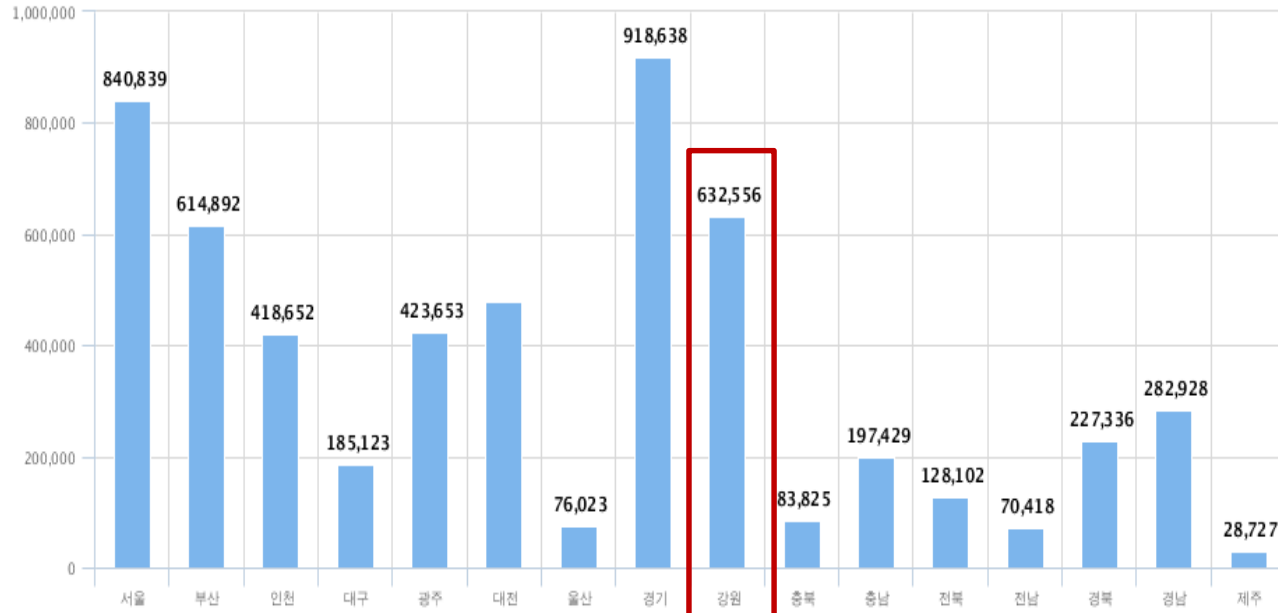


- 연간 발생률, 미국
 - 50,000 ED visit (16 case per 100,000명)
 - 자살시도 15,000
- CO 사망, 미국
 - 1,319 (2014) ← 2,700 (2000s)
 - 자살시도 CO 사망이 2/3
- 화재 관련 CO 독성
 - 화재관련 손상 25,000 중 50% 이상이 CO 독성
 - 화재 사망자 중 ¾이 사망 혹은 유사한 독성을 일으킬 정도의 고농도 COHb

우리나라에서 CO 중독



■ 요양급여비용총액



CO 독성의 원인



■ Sources

- 화재, 배기가스, 불량 난방기

CO
Colorless
Tasteless
Odorless

■ COHb 형성

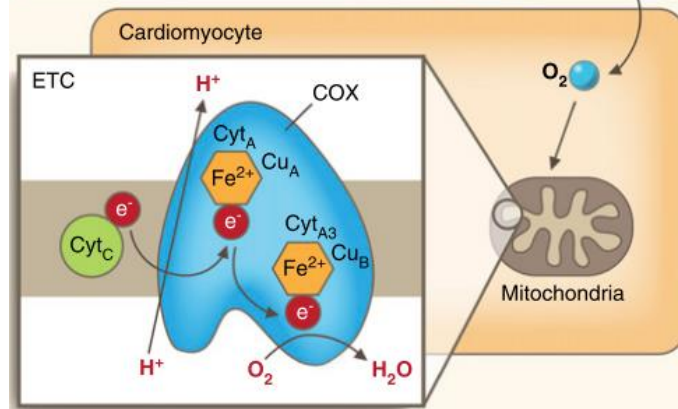
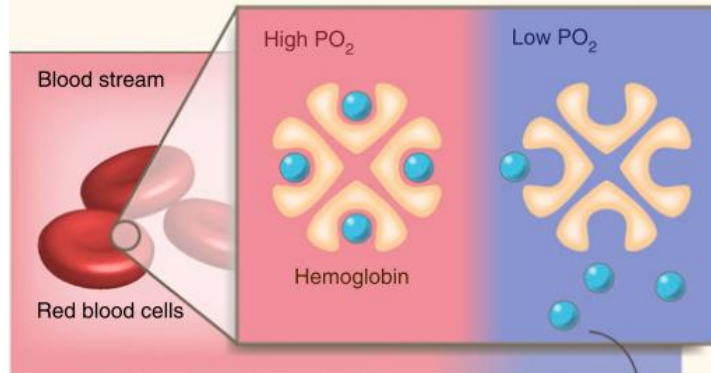
- High affinity with Hb (산소보다 250배)
- 10 ppm of CO → 2% COHb
- >2% in nonsmokers, >10% in smokers → Sx
- 임상적 중증도 (COHb level)와 회복 (COHb clearance)과는 관계가 없음.

CO 독성의 기전

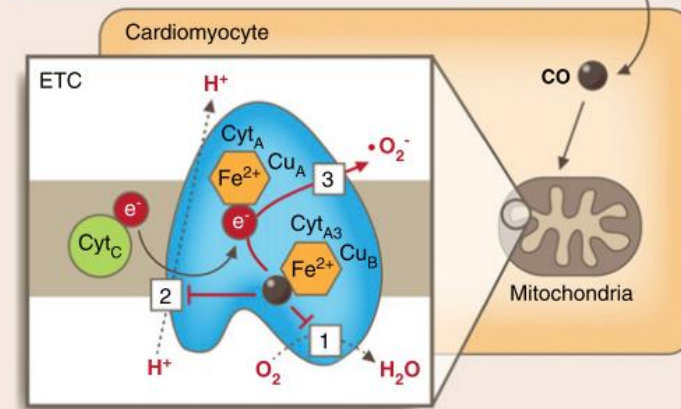
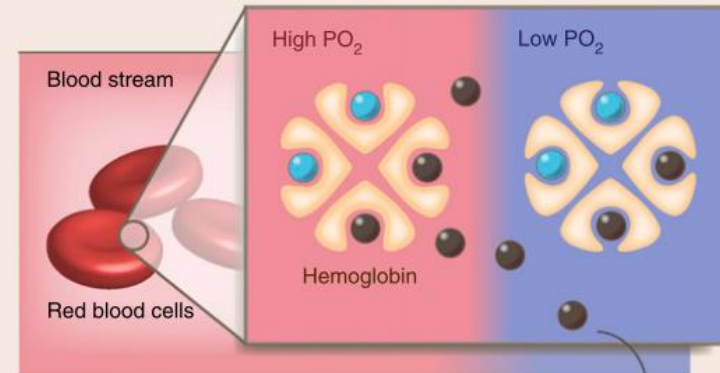


■ Hb and mitochondrial effects

Normal



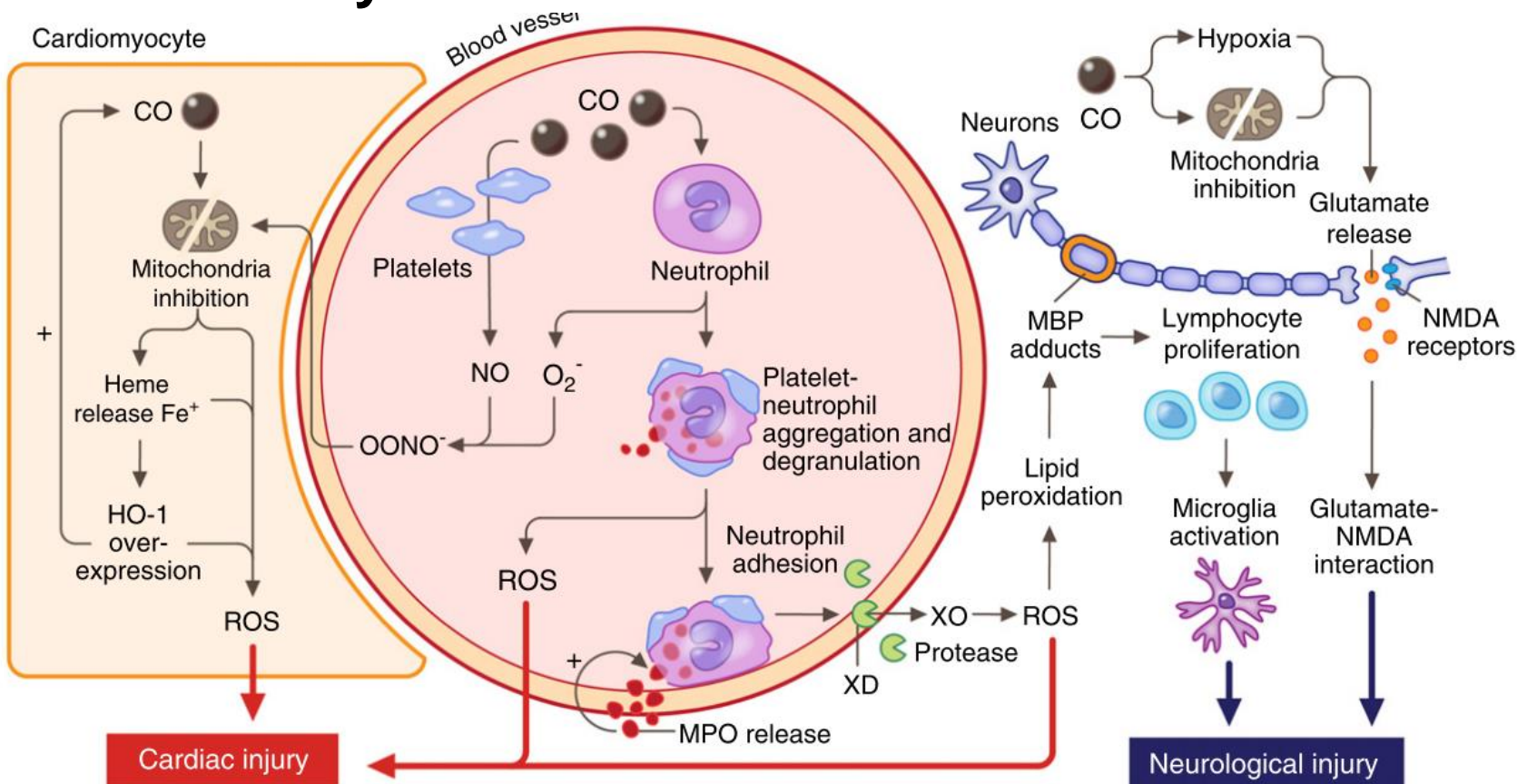
CO poisoning



CO 중독의 기전 (2)



■ Inflammatory mechanisms

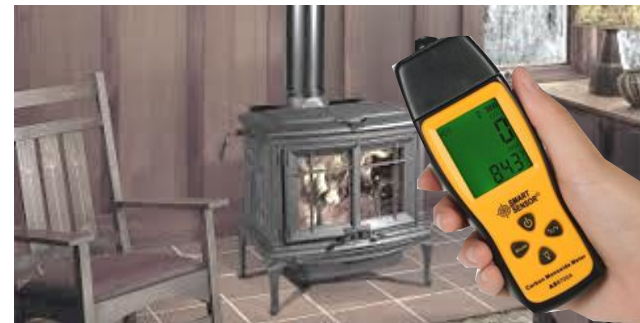


CO 중독 진단



■ Clinical triad

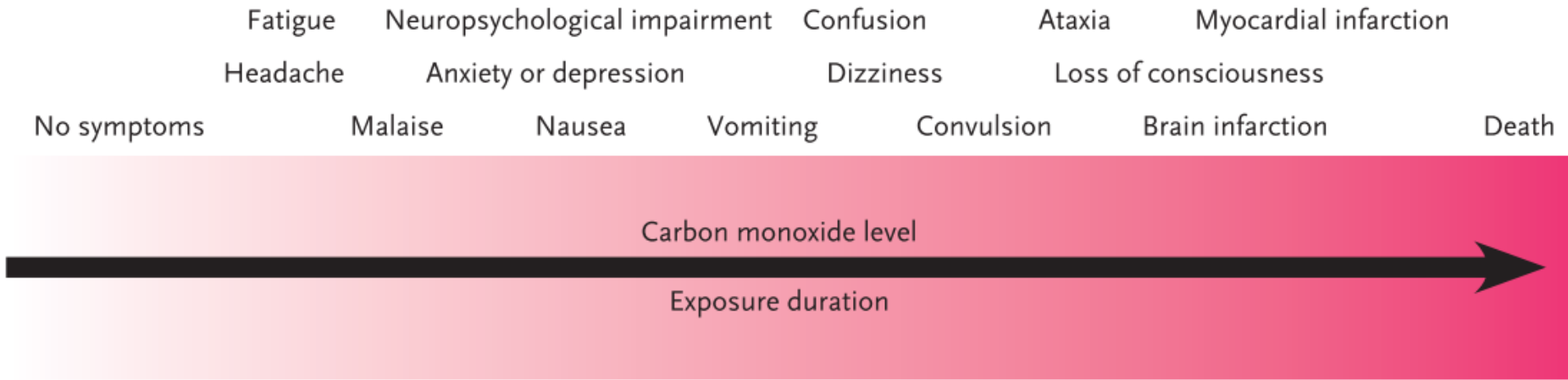
- 1) CO독성에 합당한 증상
- 2) CO노출 병력
- 3) COHb 증가



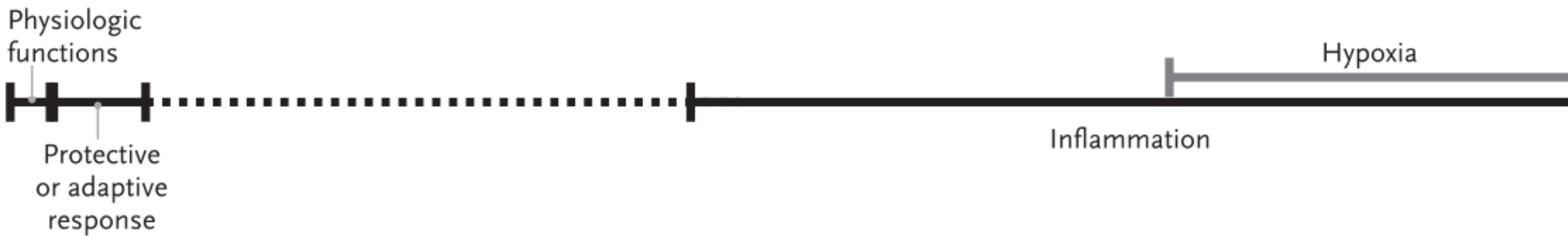
CO 중독의 임상 발현



Signs and Symptoms



Physiological Effects



중증 CO 중독



- Severe acute CO poisoning
 - 급격히 진행되는 뇌손상과 부종 및 이로 인한 인지기능 장애
- Risk factors for high short-term mortality
 - pH<7.20
 - 화재관련
 - 의식소실
 - High COHb
 - HBO₂ 치료 중에 기도삽관 요



CO 중독의 임상 발현-심장 손상



■ Myocardial injury

- 중등도 이상 CO독성의 1/3, 장기 사망률과 관련
- High COHb는 myocardial infarction과 관련
- LV dysfunction이 HBO₂ 치료 환자 1/2에서 관찰
- 기전
 - 보상성 CO 증가 이후 심혈관 허탈로 인한 산소 운반 저하, 활성산소에 의한 coronary vasoconstriction, CO에 의한 혈전 생성 증가

■ Arrhythmia

- Altered calcium gradients and sodium current → adrenergic, proarrhythmic



CO 중독의 임상 발현-신경 손상



- Long-term neurocognitive sequelae
 - Impaired memory, cognitive dysfunction, depression, anxiety, psychosis, and/or vestibular and motor deficits, peripheral neuropathy
 - Incidence
 - 6주 우울, 흥분, 인지장애 >40%
 - 6년 인지장애 19%, 신경학적 장애 37%
 - 6주 인지장애 위험요인: age>36y, CO exposure>24h
 - 초기 증상이 반드시 장기적 신경학적 문제와 관련되지는 않음



Delayed neuro

sequelae

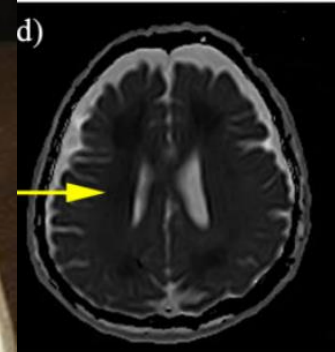
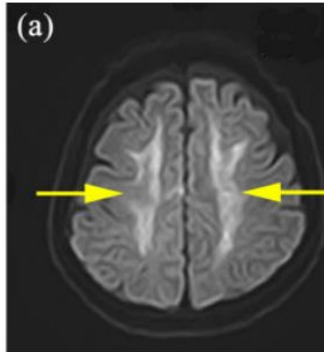


Table 3. Predictors of delayed neuro

Variables

- Age
- CO exposure time (h)
- Initial GCS
- Troponin I
- Presence of pathology in DWI

OR: odds ratio; CI: confidence interval
resonance imaging.

gression.

Multivariate analysis		
OR	95% CI	p Value
31	0.981–1.083	0.227
43	0.984–1.328	0.080
72	0.609–0.979	0.033
32	0.834–1.276	0.774
38	1.201–34.499	0.030

DWI: diffusion-weighted magnetic



응급실 내원 전 치료



- Normobaric oxygen (NBO₂)
 - Nonrebreather reservoir face mask
 - High flow oxygen or 100% oxygen
 - Artificial airway

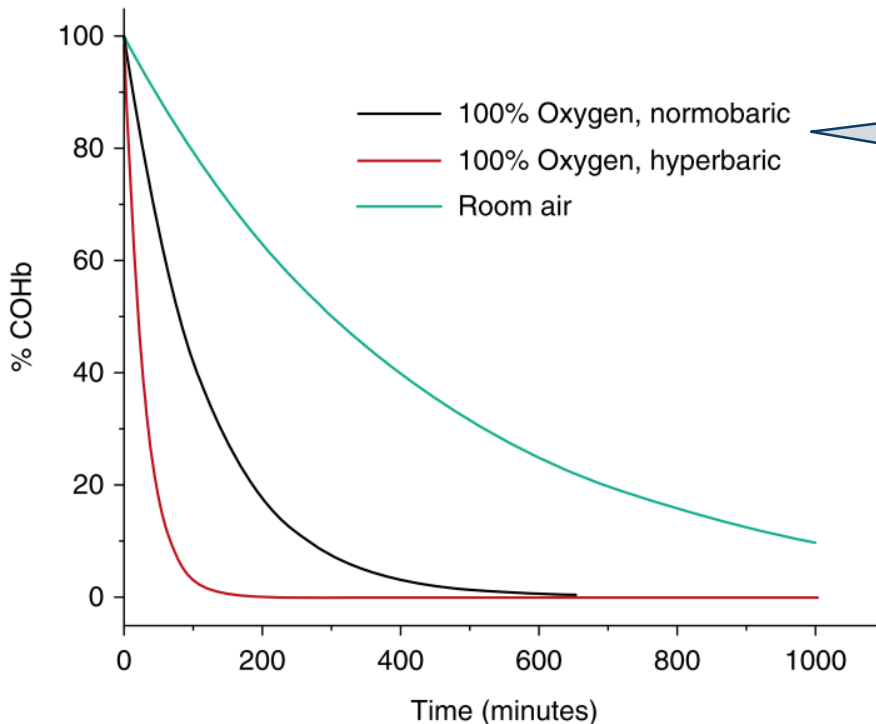


Hyperbaric oxygen



■ Hyperbaric oxygen (HBO₂)

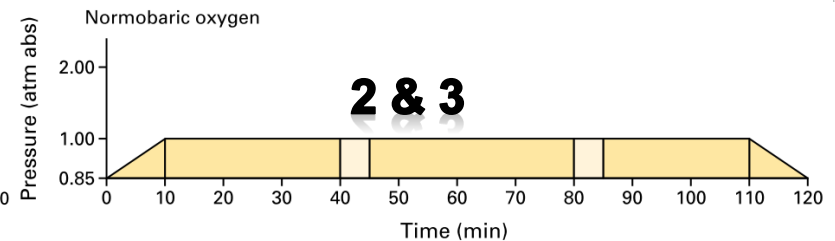
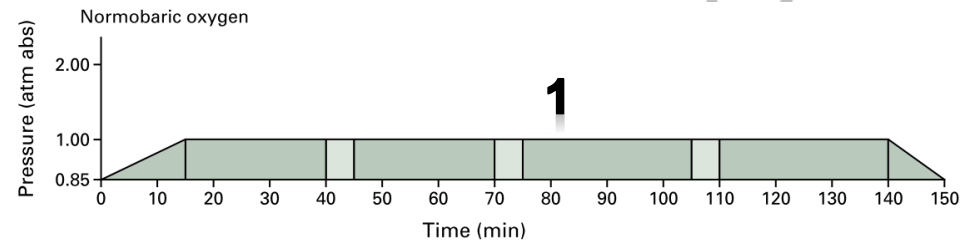
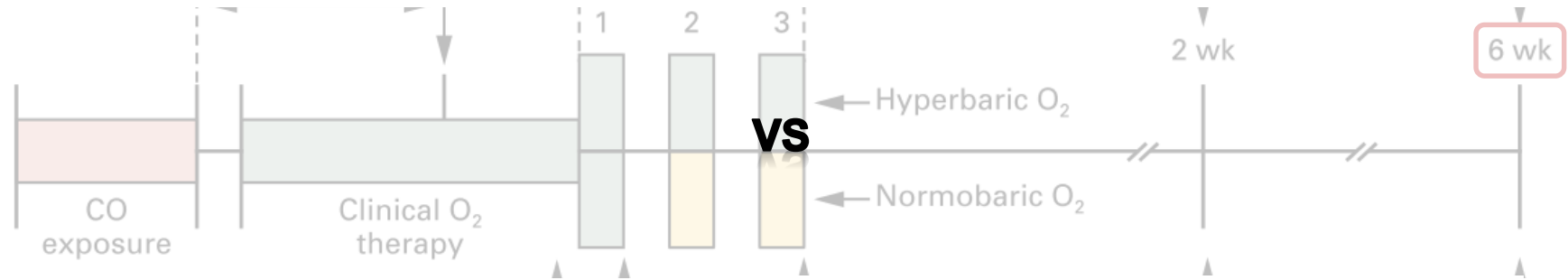
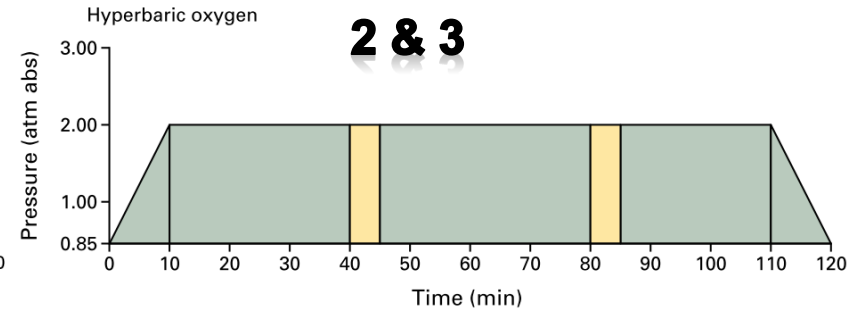
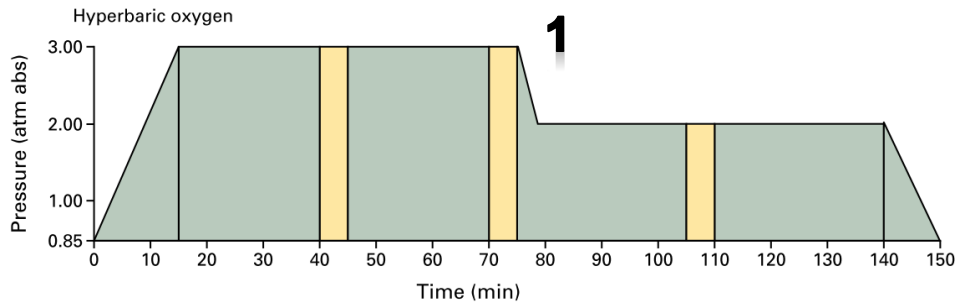
- 정의: 1.4기압 이상의 고압 챔버에서 100% 산소로 호흡
- 모든 serious acute CO poisoning에서 2.5-3.0기압으로 치료고려



응급실 도착 전 시행한 산소치료로 초기 COHb level이 과소평가되어 HBO 치료를 결정할 때 영향을 줄 수 있음



HBO₂ vs NBO₂ in CO poisoning



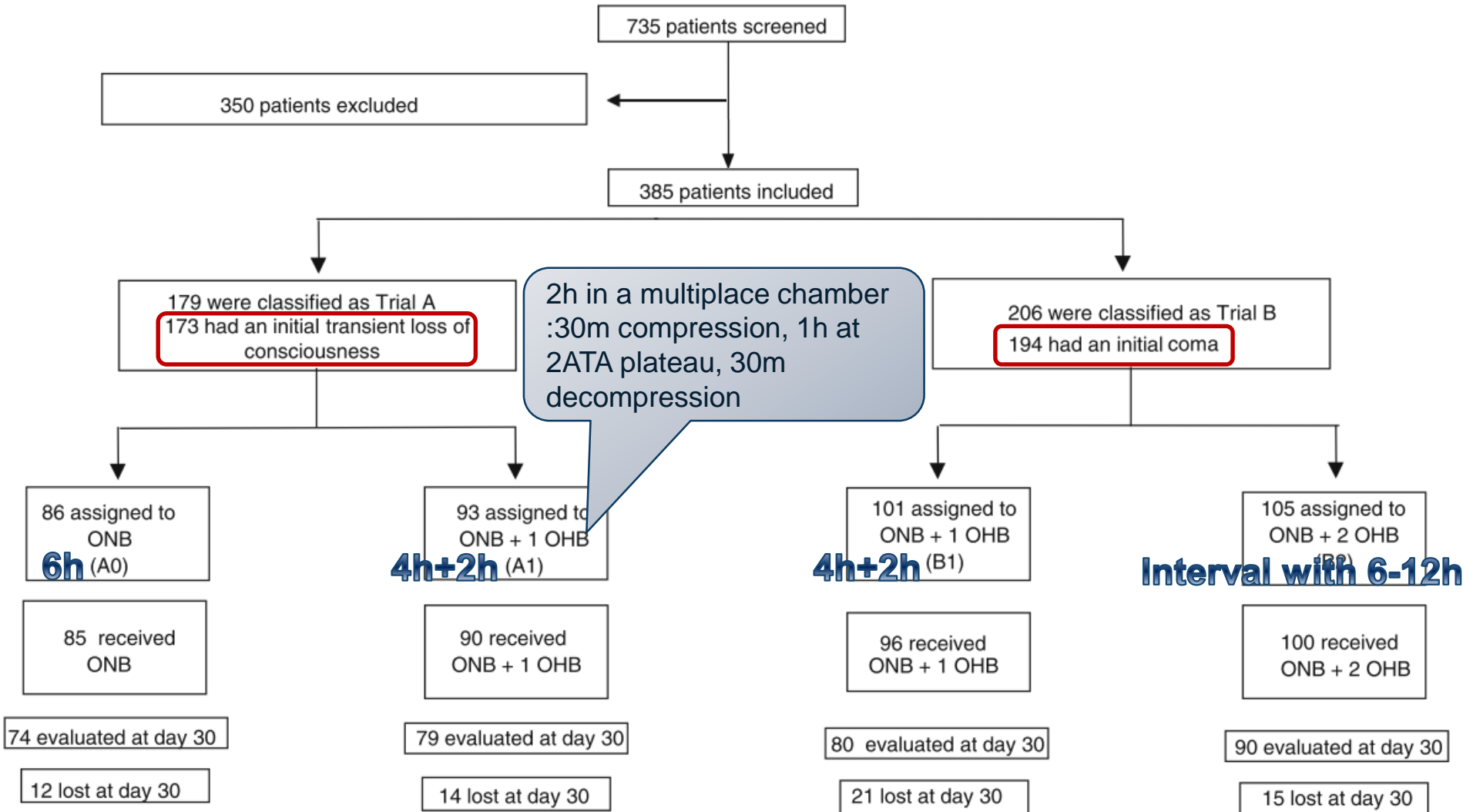
HBO₂ vs NBO₂ in CO poisoning



TABLE 2. OUTCOMES AT 6 WEEKS, 6 MONTHS, AND 12 MONTHS AFTER ENROLLMENT.*

OUTCOME	HYPERBARIC- OXYGEN GROUP (N=76)	NORMOBARIC- OXYGEN GROUP (N=76)	UNADJUSTED ODDS RATIO (95% CI)†	P VALUE
	no./total no. (%)			
Cognitive sequelae				
At 6 wk				
Intention-to-treat population	19/76 (25.0)	35/76 (46.1)	0.39 (0.20–0.78)	0.007
Patients with complete data	18/75 (24.0)	31/72 (43.1)	0.42 (0.21–0.85)	0.01
Results on cerebellar testing before treatment				
Normal	16/69 (23.2)	23/59 (39.0)	0.47 (0.22–1.02)	0.05
Abnormal	1/3 (33.3)	9/11 (81.8)	0.11 (0.01–1.92)	0.18
At 6 mo				
Intention-to-treat population	16/76 (21.1)	29/76 (38.2)	0.43 (0.21–0.89)	0.02
Patients with complete data	10/58 (17.2)	21/59 (35.6)	0.38 (0.16–0.90)	0.03
At 12 mo				
Intention-to-treat population	14/76 (18.4)	25/76 (32.9)	0.46 (0.22–0.98)	0.04
Patients with complete data	9/62 (14.5)	18/66 (27.3)	0.45 (0.19–1.10)	0.08
Symptoms				
Reported by patient at 6 wk				
Difficulties with memory	21/75 (28.0)	37/72 (51.4)	0.37 (0.19–0.73)	0.004
Difficulties with attention or concentration	24/75 (32.0)	31/72 (43.1)	0.62 (0.32–1.22)	0.17

2 RCTs in CO poisoning



2 RCTs in CO poisoning



Table 3 Comparison of the main end point according to randomization, adjusted effect and sensitivity analysis to assumption for recoding of missing values

Odds ratio [95 CI]; <i>p</i> value	Trial A (<i>n</i> = 153)		Trial B (<i>n</i> = 170)	
	A0	A1	B1	B2
Observed sample: complete case analysis				
Recovery rate	61% (45/74)	58% (46/79)	68% (54/80)	47% (42/90)
Unadjusted effect	0.90 [0.47–1.71]; 0.75		0.42 [0.23–0.79]; 0.007	
Adjusted effect	0.92 [0.43–1.97]; 0.84 ^a		0.39 [0.19–0.80]; 0.0096 ^b	
Recoding missing values: sensitivity analyses				
Allocation to poor outcome				
Recovery rate	52% (45/86)	49% (46/93)	53% (54/101)	40% (42/105)
Unadjusted effect	0.89 [0.50–1.60]; 0.70		0.58 [0.33–1.01]; 0.054	
Adjusted effect	0.85 [0.43–1.66]; 0.63 ^a		0.58 [0.31–1.07]; 0.0793 ^b	
Allocation to good outcome				
Recovery rate	66% (57/86)	64% (60/93)	74% (75/101)	54% (57/105)
Unadjusted effect	0.93 [0.50–1.71]; 0.80		0.41 [0.23–0.74]; 0.003	
Adjusted effect	1.05 [0.51–2.16]; 0.89 ^a		0.38 [0.19–0.74]; 0.0015 ^b	
Extreme case favoring control arm				
Recovery rate	66% (57/86)	49% (46/93)	74% (75/101)	40% (42/105)
Unadjusted effect	0.50 (0.27–0.91); 0.02		0.23 (0.13–0.42); 0.0001	
Adjusted effect	0.50 (0.25–1.00); 0.05 ^a		0.20 (0.10–0.40); 0.0001 ^b	
Extreme case favoring experimental arm				
Recovery rate	52% (45/86)	64% (60/93)	53% (54/101)	54% (57/105)
Unadjusted effect	1.66 (0.91–3.02); 0.10		1.03 (0.60–1.79); 0.91	
Adjusted effect	1.66 (0.84–3.29); 0.15 ^a		0.86 (0.47–1.60); 0.64 ^b	

^a Adjusted for sex, duration of intoxication, time to randomization, and initial COHb level

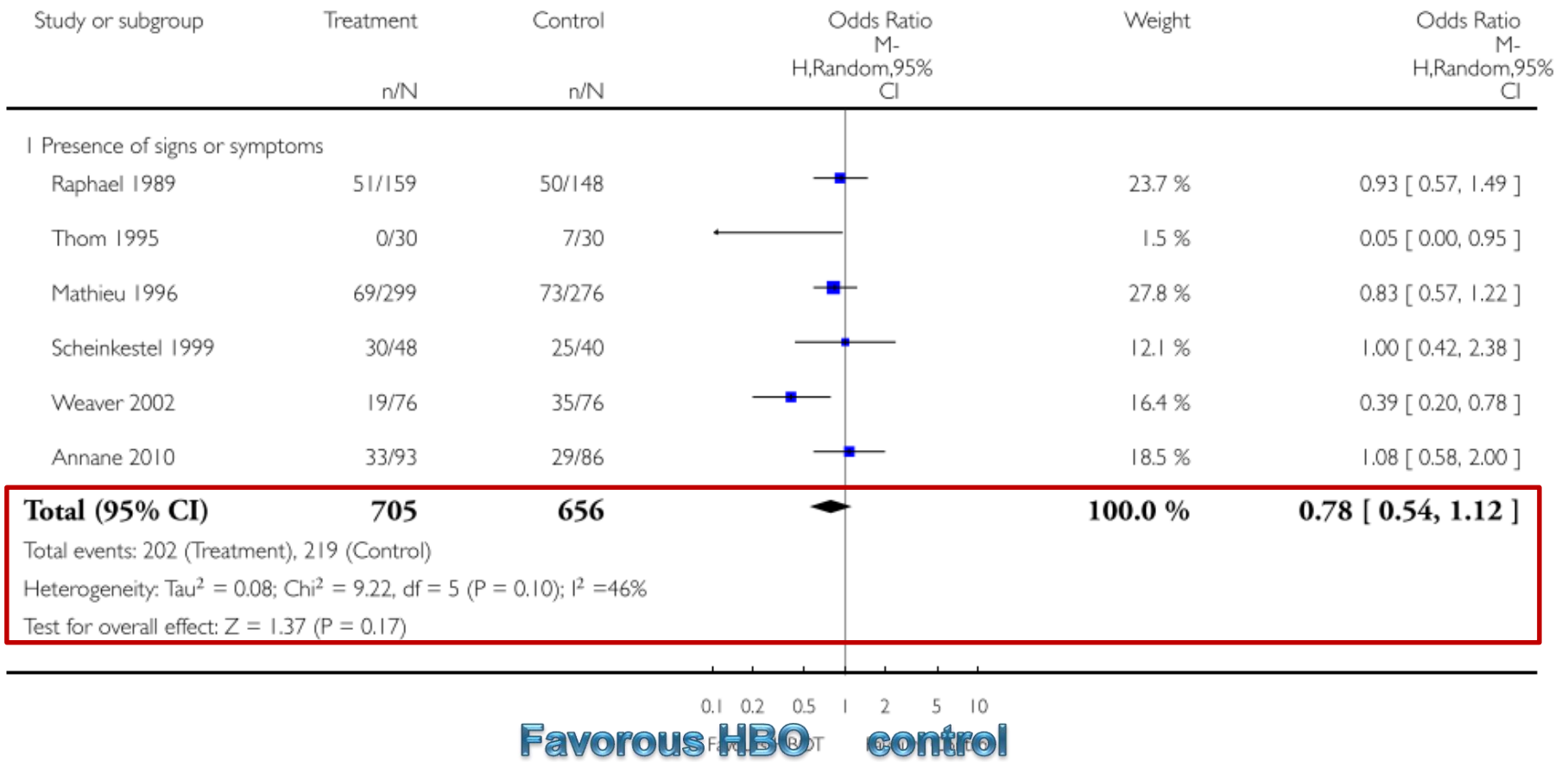
^b Adjusted for duration of intoxication, time to randomization, coma before and at admission, and initial COHb level



Meta-analysis with RCTs



Symptoms or signs at 4-6 weeks



메타분석 결과의 해석



- Heterogeneous trials
- CO 독성 치료로는 부적절한 HBO₂ 기압 (only 2기압)
- 한 달 이상의 neurocognitive outcomes 부족
 - 장기간 기능저하를 확인한 유일한 연구에서 HBO₂ 효과를 확인함



동반질환 및 장기 합병증



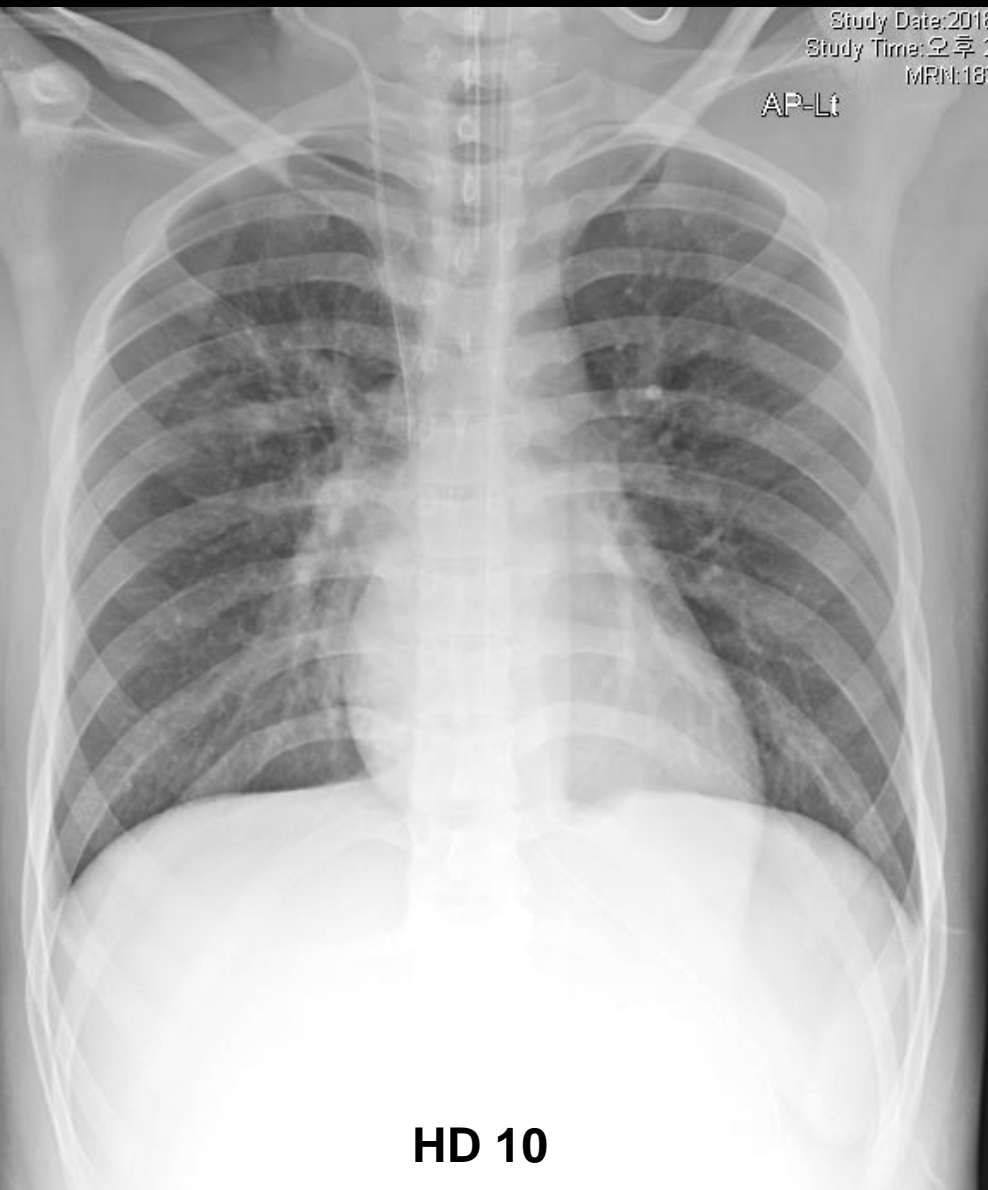
■ 화재관련 및 자살시도

- 주택화재에서 cyanide 독성 동반
- 자살시도 환자에서 동반 약물복용 확인 요
- 자살시도 환자에서 정신과 협진 요

Alcohol
Benzodiazepines
Narcotics
Amphetamines

■ 장기 사망률 증가

- 사망 원인: 알코올, 교통사고 및 기타 사고, 자해, 신경·정신의학적 합병증
- 사건 이후 1-2개월 추적관찰 및 치료 요함: 신경인지장애, 우울, 불안
- 심근경색의 위험 증가



Aspiration pneumonia



임상증상 (기침, 가래, 청진)
+ 영상 (48h 이내 침윤)

- 19.2% in CO poisoning with loss of consciousness

Finding	Aspiration Pneumonia Group (n = 103)	Non-Aspiration Pneumonia Group (n = 434)	P Value
Clinical outcome			
Ventilator use	54 (52.4)	14 (3.2)	<.001
Ventilator hours	26.5 (13.8-53.8)	7.0 (2.8-16.8)	<.001
Hospital days	3.6 (2.1-5.1)	1.3 (0.6-2.1)	<.001
In-hospital mortality	6 (5.8)	0 (0.0)	<.001



Factor	Odds Ratio	95% CI	P Value	Confirmed pathogen in 15/103 patients	Number (%)
Altered mental status (P or U) on ED arrival	9.46	4.92-18.19	<.001	Methicillin-sensitive <i>Staphylococcus aureus</i>	4 (26.7)
WBC/mm ³	1.19	1.13-1.26	<.001	<i>Klebsiella pneumoniae</i>	3 (20.0)
WBC >12,000/mm ³	9.21	5.38-15.79	<.001	<i>Escherichia coli</i>	3 (20.0)
Duration of exposure (h)	1.12	1.06-1.19	<.001	<i>Klebsiella oxytoca</i>	2 (13.3)
Altered mental status (P or U) on ED arrival + WBC >12,000/mm ³	17.75	10.65-29.59	<.001	Methicillin-resistant <i>Staphylococcus aureus</i>	1 (6.7)
				<i>Streptococcus pneumoniae</i>	1 (6.7)
				<i>Staphylococcus warnei</i>	1 (6.7)



Empirical antibiotics?



98 patients with aspiration syndrome

Among 250 coma patients under MV

연사 (MV 495 0111 110)

TABLE 3. Outcome in Patients With Non-Bacterial Aspiration Pneumonitis and Bacterial Aspiration Pneumonia.

Outcome	Patients With Non-Bacterial Aspiration Pneumonitis (n = 49)	Patients With Bacterial Aspiration Pneumonia (n = 43)	p
Nosocomial infection, n (%)	4 (8.2)	5 (11.6)	> 0.99
Ventilator-associated pneumonia, n (%)	2 (4.1)	2 (4.6)	> 0.99
Vasopressors during ICU stay, n (%)	25 (51.0)	21 (48.8)	> 0.99
Mechanical ventilation duration (hr), median (IQR)	68.7 (35.4–121.0)	94.4 (43.6–167.8)	0.13
Mechanical ventilation-free days by day 28 (d), mean ± SD	23.4 ± 4.9	22.1 ± 5.7	0.43
ICU stay length (hr), median (IQR)	101.8 (60.3–159.0)	127.9 (73.6–238.8)	0.10
Hospital stay length (d), median (IQR)	6 (2–19)	9 (3–28)	0.06
ICU mortality, n (%)	15 (30.6)	13 (30.2)	> 0.99
Hospital mortality, n (%)	17 (34.7)	13 (30.2)	> 0.99
Time with antibiotics during first 8 d (d), median (IQR)	4 (3–7)	7 (5–8)	0.08

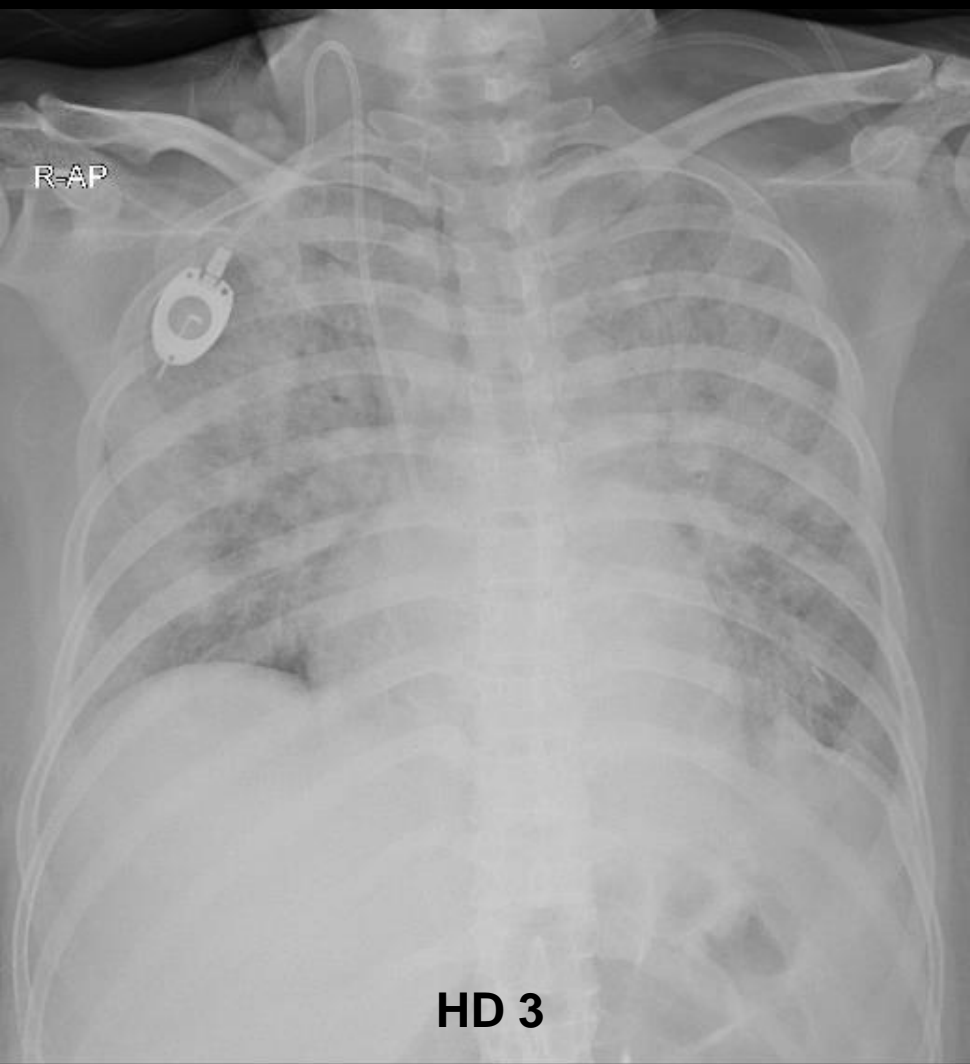
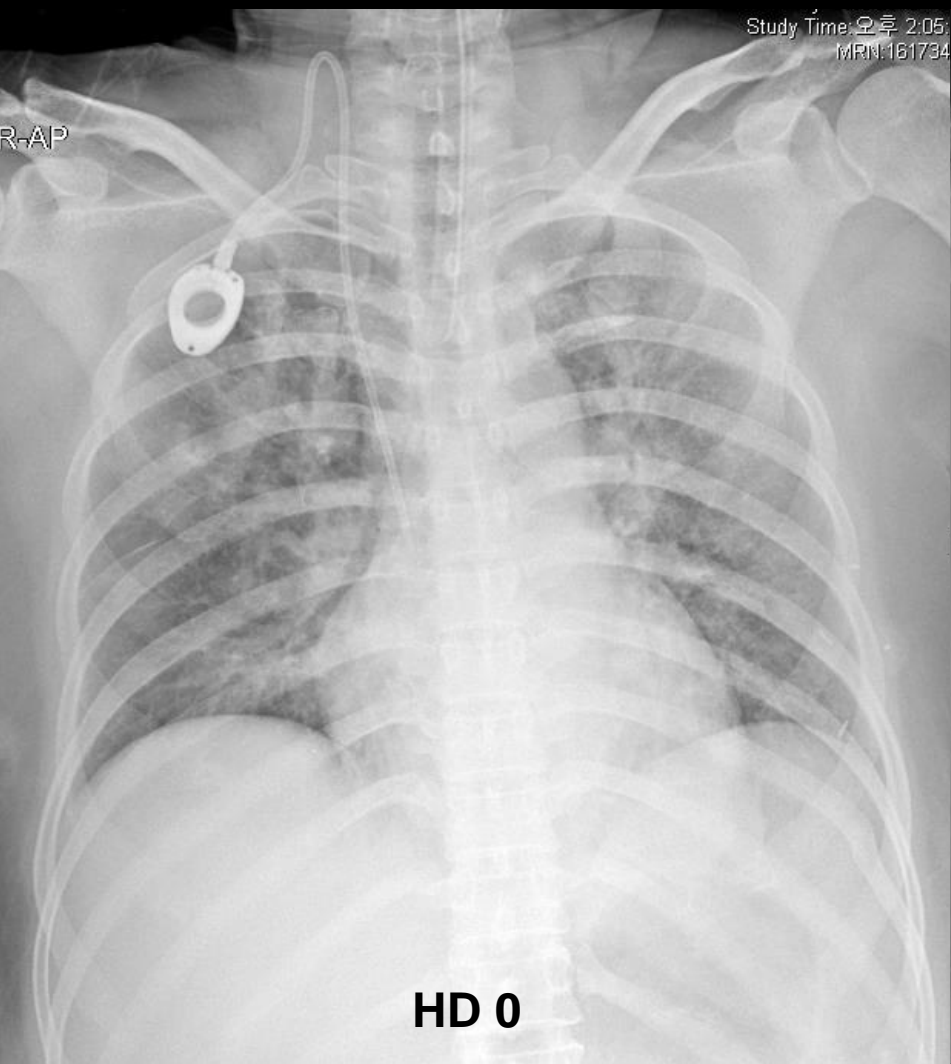
1 treated with antibiotics

3 taken off antibiotics

15 treated with antibiotics

30 taken off antibiotics





ARDS after CO poisoning



Table 2. Risk Factors for ARDS.

Direct lung-injury risk factors

Pneumonia (bacterial, viral, fungal, or opportunistic)*

Aspiration of gastric contents*

Pulmonary contusion

Inhalation injury

Near drowning

Indirect lung-injury risk factors

Sepsis (nonpulmonary source)*

Nonthoracic trauma or hemorrhagic shock

Pancreatitis

Major burn injury

Drug overdose

Transfusion of blood products

Cardiopulmonary bypass

Reperfusion edema after lung transplantation or embolotomy

* Pneumonia, aspiration of gastric contents, and sepsis together account for more than 85% of cases of ARDS in recent clinical trials.



ARDS in burn patients (1)



- 51.8% Invasive mechanical ventilation
- 35.3% Inhalation injury
- 20.0% ARDS (38.6% in patients under IMV)

85 burn patients admitted to ICU

Variables	Univariate			Multivariate*		
	OR	CI 95%	<i>P</i>	OR	CI 95%	<i>P</i>
Female	1.58	0.34 – 7.34	0.55			
Age	1.00	0.96 – 1.05	0.72			
TBSA burned	1.00	0.97 – 1.04	0.67			
Inhalation injury	12.89	2.52 – 65.75	0.002	9.75	2.79 – 33.95	<0.001
3 rd degree burns	2.54	0.23 – 27.67	0.44			
Alcoholism	7.57	0.79 – 71.90	0.07			
Smoking	0.13	0.01 – 1.96	0.14			
Sepsis	0.65	0.09 – 4.46	0.66			

OR = odds ratio; CI = confidence interval; TBSA= total body surface area
 *multiple logistic regression analysis

ARDS in burn patients (2)



159 burn patients with burn extent $\geq 20\%$ BSA

- 28.3% ARDS
 - 66.7% Severe ARDS
- 25.1% Inhalation injury

Criteria		ARDS n. (%)	Non-ARDS n. (%)	p
Gender	Male	33 (26.2)	93 (73.8)	.35
	Female	12 (36.4)	21 (63.6)	
Age	16 - 40	25 (23.1)	83 (76.9)	.07
	41 - 60	20 (39.2)	31 (60.8)	
Inhalation injury	Yes	22 (54.9)	18 (45.1)	.003
	No	23 (19.3)	96 (80.7)	OR = 4.2
Criteria		ARDS n. (%)	Non-ARDS n. (%)	p
Burn surface area (% TBSA)	20 - 40%	5 (7.8)	59 (92.2)	.006
	41 - 60%	23 (31.5)	50 (69.5)	
	> 60%	17 (73.9)	6 (26.1)	
	Mean (%)	58.6 \pm 19.6	38.4 \pm 13.7	.003
Full thickness burn area (% TBSA)	0 - 20%	10 (15.2)	56 (84.8)	.007
	21 - 40%	19 (26.8)	52 (73.2)	
	> 40%	16 (72.7)	6 (27.3)	
	Mean	29.5 \pm 18.5	10.6 \pm 2.8	.002
ARDS = acute respiratory distress syndrome; Non-ARDS = no acute respiratory distress syndrome; TBSA = total body surface area				

ARDS in burn patients (3)



- 13.5% ARDS
 - 53.7% Inhalation injury
 - 13.4% ECMO
 - 55% inhalation injury
 - 91% in-hospital mortality

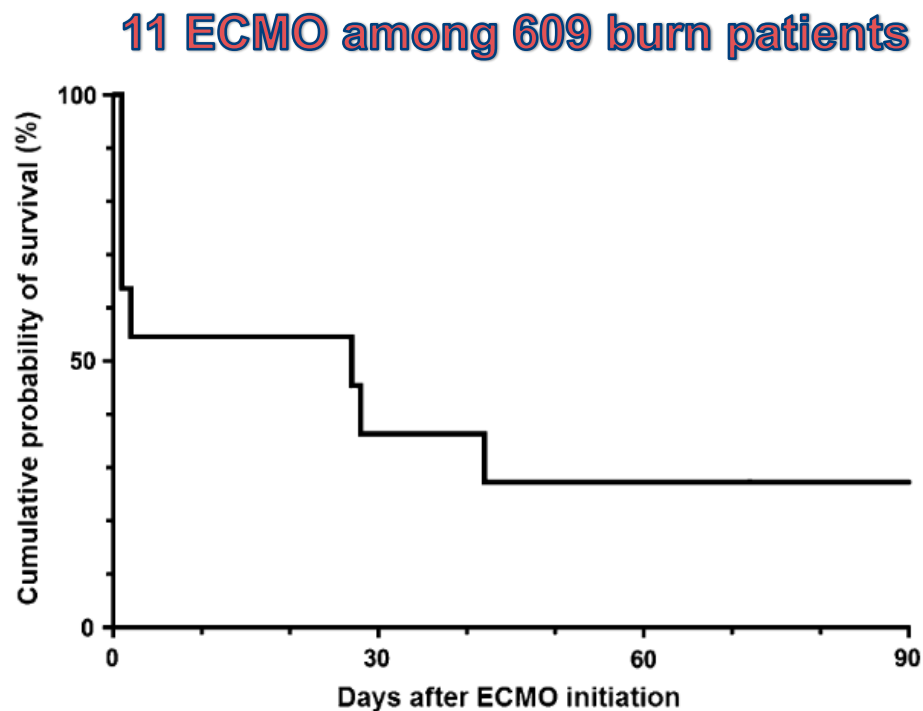


Fig. 1 Kaplan–Meier estimates of cumulative probabilities of 90-day survival after initiation of extracorporeal membrane oxygenation (ECMO). Note the immediate drop in survival after the start of ECMO: 5/6 non-weaned patients from ECMO died in the first 48 h of its onset from burn injury-related multiple organ failure

ECMO for ARDS in burn patients



50% among burn or inhalation injury

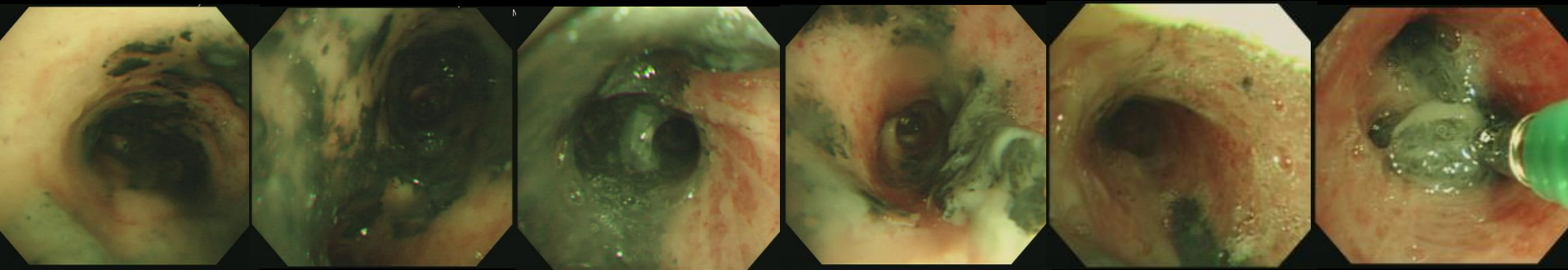
Table 1 – Patient demographics and clinical information.

Patient number	Initial injury/ illness	Age	Gender	Inhalation injury grade	Survived to hospital discharge	TBSA burned or affected by TEN	ECMO duration
1	TEN	42	Female		Yes	46%	23 days
2	Thermal burn	59	Male		No	11.5%	9 days
3	Inhalation injury	31	Male	3	Yes		6 days
4	Thermal burn	19	Male		No	24%	23 days
5	Thermal burn	26	Female	1	No	19%	14 days
6	TEN	27	Female		Yes	47%	14 days
7	Thermal burn	19	Male	2	No	76%	6 days
8	Thermal burn	48	Male		Yes	10%	4 days
9	Thermal burn	31	Male	1	Yes	51%	14 days
10	Thermal burn	28	Female		Yes	30%	19 days
11	Thermal burn	25	Male		Yes	25%	5 days
12	Thermal burn	45	Male		No	35%	6 days
13	Thermal burn	54	Male		No	17%	19 days
14	Thermal burn	58	Male		Yes	0.25%	8 days

41%

Patient number	Causes of death
2	Multi-organ failure, placed on hospice care
4	Multi-organ failure, placed on hospice care
5	Cerebral Hemorrhage
7	Multi-organ failure, placed on hospice care
12	Multi-organ failure, placed on hospice care
13	Multi-organ failure, placed on hospice care





Trachea

Carina

RUL

RML & RLL

Lt. mainstem

LUL

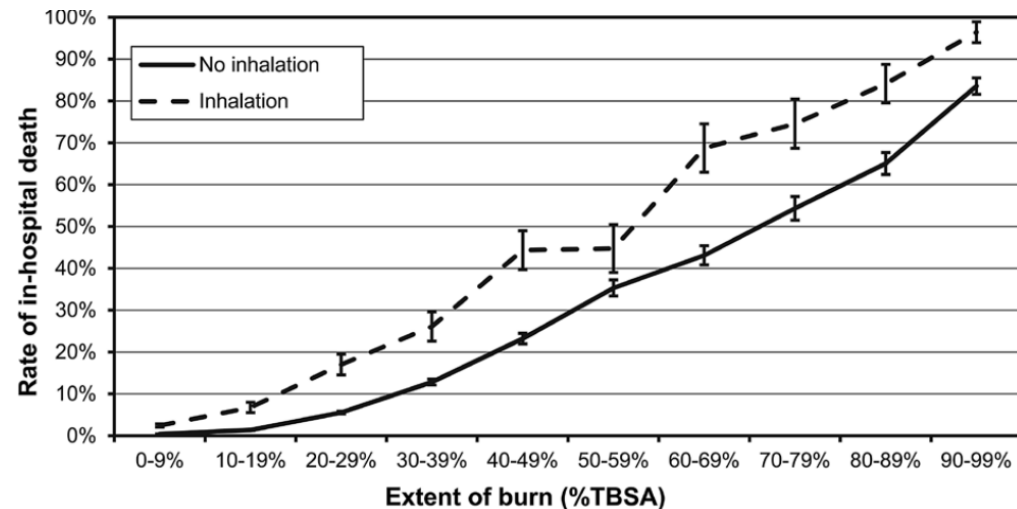
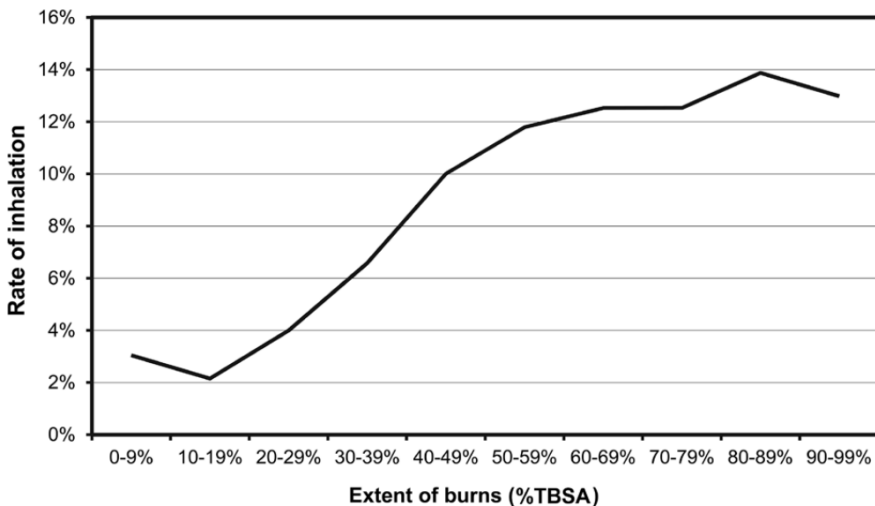
Suction 후



Inhalation injury



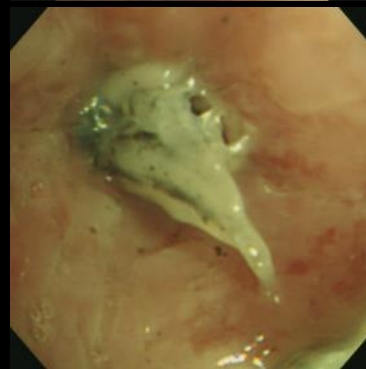
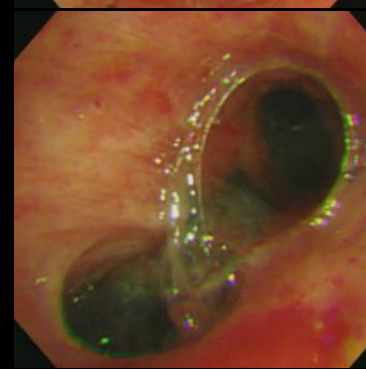
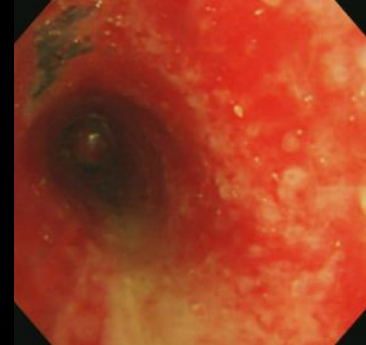
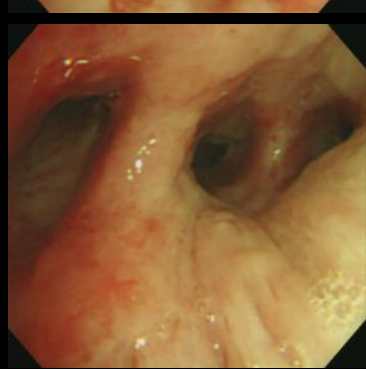
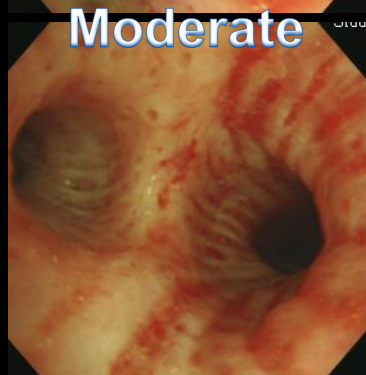
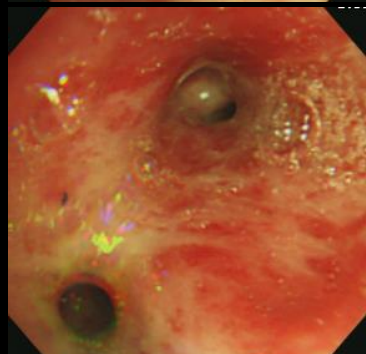
- 3.5% of total burn cases, 1998-2008 US
- 16% overall mean mortality



Bronchoscopic criteria



Grade	Description of inhalation injury
0 (no injury)	Absence of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction
1 (mild injury)	Minor or patchy areas of erythema, carbonaceous deposits in proximal or distal bronchi (any or combination)
2 (moderate injury)	Moderate degree of erythema, carbonaceous deposits, bronchorrhea, with or without compromise of the bronchi (any or combination)
3 (severe injury)	Severe inflammation with friability, copious carbonaceous deposits, bronchorrhea, bronchial obstruction (any or combination)
4 (massive injury)	Evidence of mucosal sloughing, necrosis, endoluminal obliteration (any or combination)



Mild

Moderate

Severe

Massive

Severity of inhalation injury



Multivariable logistic regression model for variables independently associated with in-hospital mortality

	Adjusted odds ratio for death	P-value
Age	1.13 (1.05–1.22)	0.002
APACHE II score (with age component removed)	1.18 (0.95–1.47)	0.13
% TBSA burnt	1.10 (1.05–1.16)	<0.001
Bronchoscopic assessment of inhalational injury		
None/mild	1.00 (reference group)	
Moderate	2.39 (0.34–17.06)	0.38
Severe	24.6 (1.88–322.3)	0.015

APACHE, Acute Physiology and Chronic Health Evaluation; TBSA, total body surface area. Number of observations=222; Pseudo $R^2=0.61$, area under receiver operator characteristic curve = 0.97; Hosmer–Lemeshow C statistic=2.3, P -value=0.97.

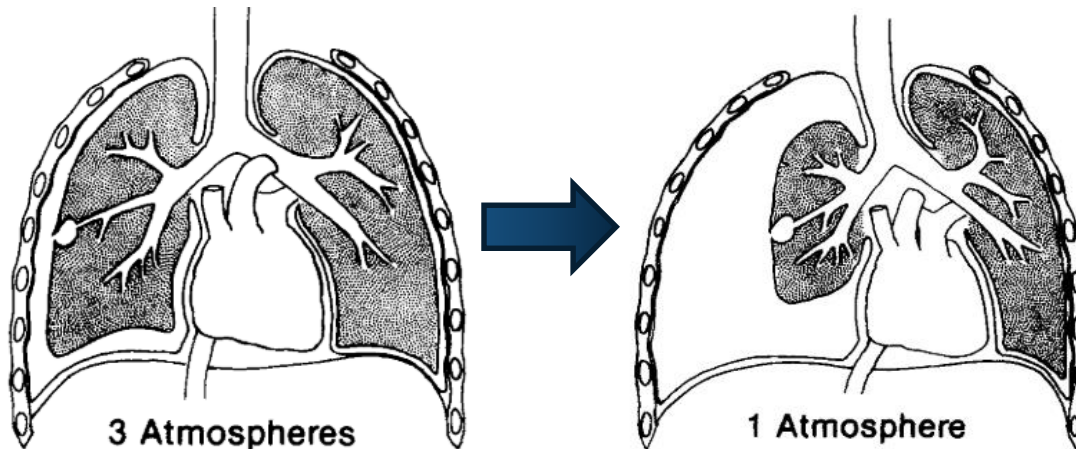
Pneumothorax after HBOT



- Rare complication

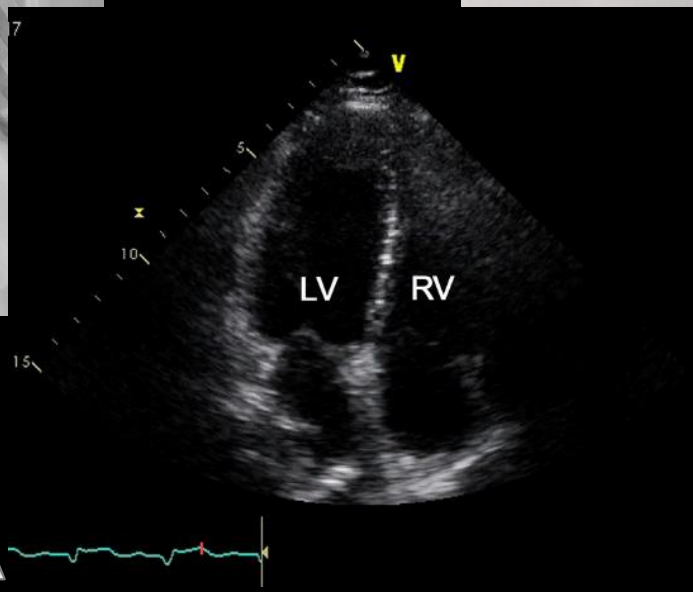
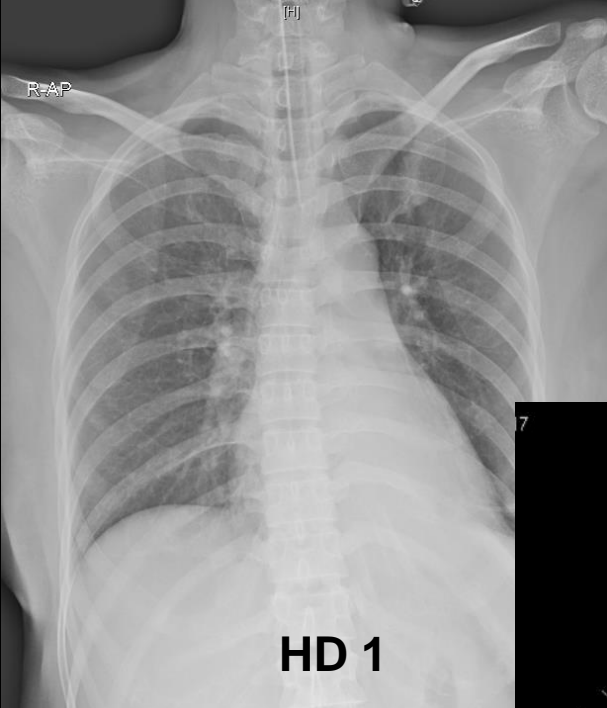
- **주의!**

- Post-CPR patients
- Central catheter insertion in jugular or subclavian vein before HBOT
- Patients with wheezing and airway debris → 상대적 치료금지



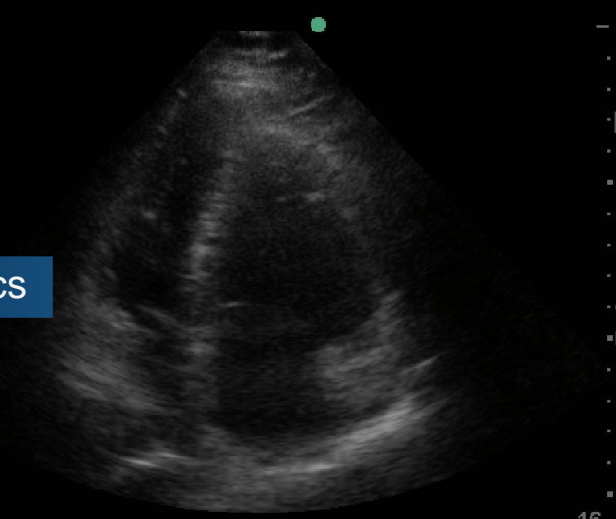
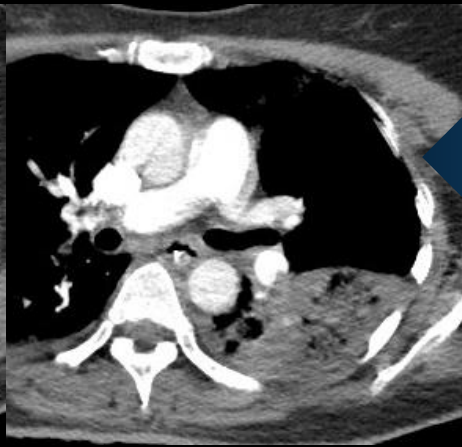
N Engl J Med. 2016;375(5):464-9
J Trauma. 1999;47(2):426-35
Am J Emerg Med. 1991;9(2):176-9





119/84 mmHg
107 beats/min
25 breaths/min
SpO₂ 95% in RA

70/54 mmHg



DVT and PE in Cohort of CO poisoning



Table 2 Incidence and adjusted HR of DVT and PE by sex, age and comorbidity for carbon monoxide poisoning patients compared to controls

Variables	Carbon monoxide poisoning						Compared to control	
	Yes n=8,316			No n=33,264			Crude HR† (95% CI)	Adjusted HR§ (95% CI)
	Events n	PY	Rate†	Events n	PY	Rate†		
<i>DVT</i>								
All	23	40 586	5.67	26	177 321	1.47	3.82 (2.18 to 6.69)***	3.85 (2.17 to 6.83)***
<i>Gender</i>								
Female	12	20 235	5.93	14	85 501	1.64	3.58 (1.66 to 7.74)**	3.75 (1.71 to 8.22)**
Male	11	20 351	5.41	12	91 820	1.31	4.07 (1.80 to 9.22)***	3.86 (1.65 to 8.99)**
<i>Age, years</i>								
≤39	11	24 989	4.40	3	104 425	0.29	15.0 (4.19 to 53.8)***	13.8 (3.80 to 49.9)***
40–54	7	11 544	6.06	9	52 502	1.71	3.50 (1.30 to 9.41)*	2.46 (0.86 to 7.10)
>55	5	4053	12.3	14	20 393	6.86	1.76 (0.63 to 4.88)	1.60 (0.56 to 4.60)
<i>Comorbidity¶</i>								
No	13	30 426	4.27	14	149 415	0.94	4.53 (2.13 to 9.64)***	5.39 (2.52 to 11.5)***
Yes	10	10 161	9.84	12	27 906	4.30	2.23 (0.96 to 5.17)	2.26 (0.97 to 5.25)
<i>PE</i>								
All	8	40 655	1.97	18	177 338	1.02	1.94 (0.84 to 4.47)	1.66 (0.70 to 3.92)
<i>Gender</i>								
Female	5	20 283	2.47	6	85 513	0.70	3.47 (1.06 to 11.4)*	2.62 (0.77 to 8.89)
Male	3	20 372	1.47	12	91 824	1.31	1.13 (0.32 to 3.99)	1.18 (0.33 to 4.26)
<i>Age, years</i>								
≤39	3	25 026	1.20	6	104 423	0.57	2.09 (0.52 to 8.35)	2.04 (0.51 to 8.21)
40–54	4	11 574	3.46	6	52 507	1.14	3.04 (0.86 to 10.8)	2.28 (0.58 to 8.89)
>55	1	4055	2.47	6	20 408	2.94	0.86 (0.10 to 7.14)	0.48 (0.06 to 4.20)
<i>Comorbidity¶</i>								
No	3	30 479	0.98	13	149 424	0.87	1.14 (0.32 to 3.99)	1.32 (0.37 to 4.66)
Yes	5	10 176	4.91	5	27 914	1.79	2.78 (0.81 to 9.61)	2.92 (0.84 to 10.2)

*p<0.05, **p<0.01, ***p<0.001.

†Rate, incidence rate, per 10 000 person-years.

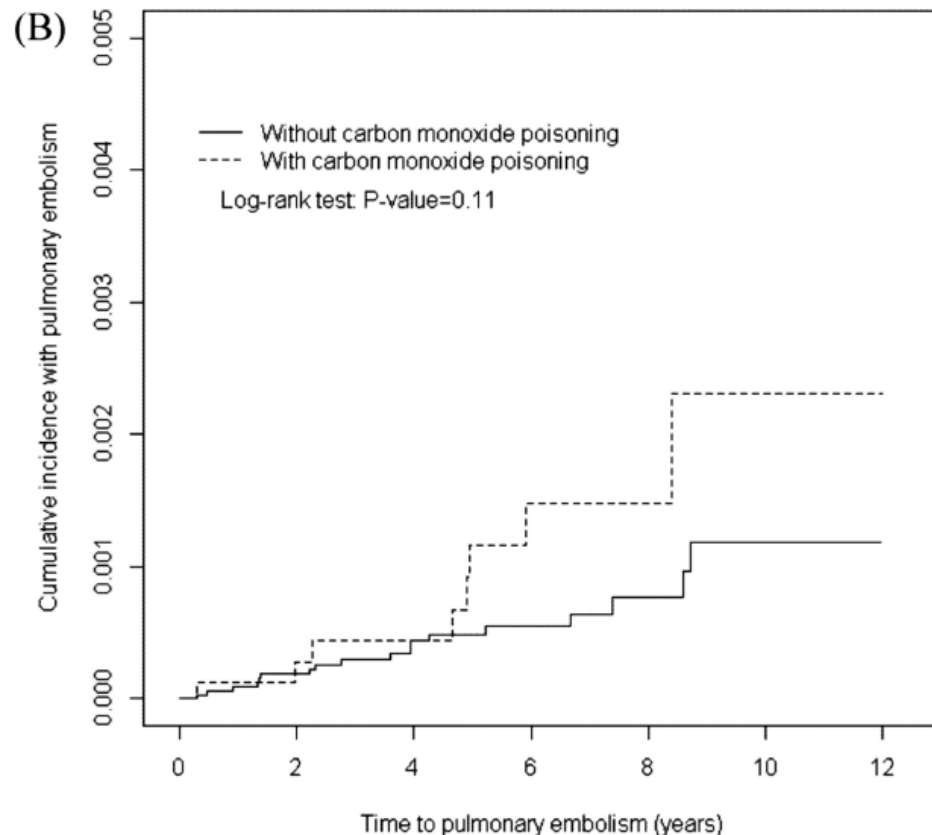
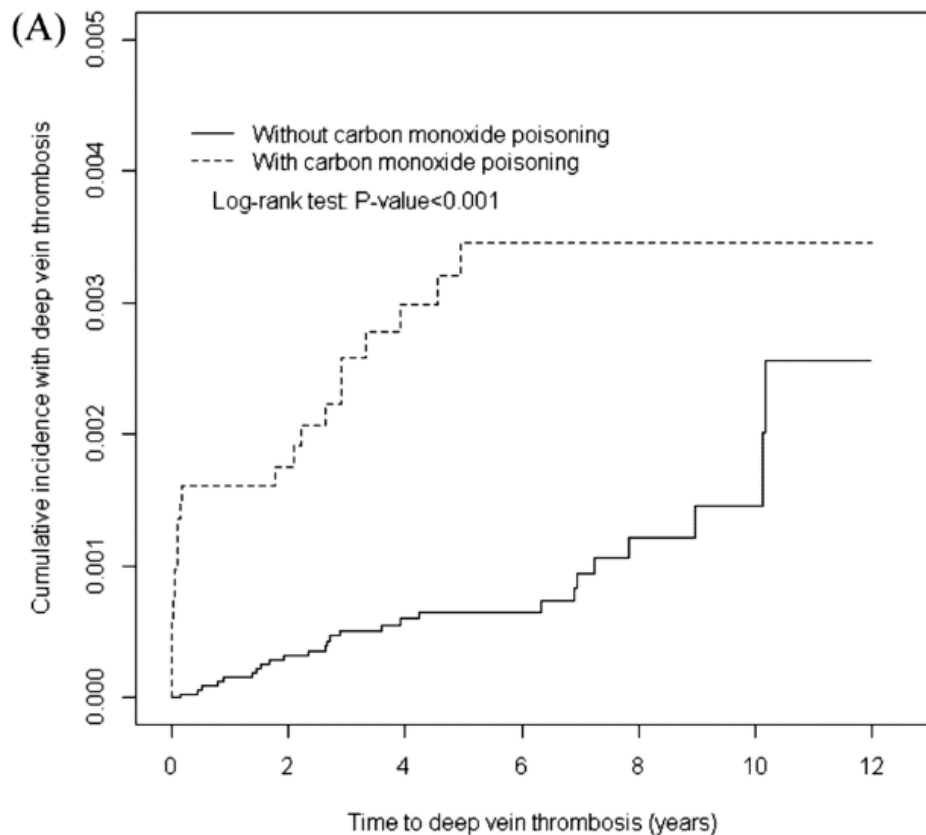


DVT and PE in Cohort of CO poisoning



DVT

PE



Intracardiac thrombus

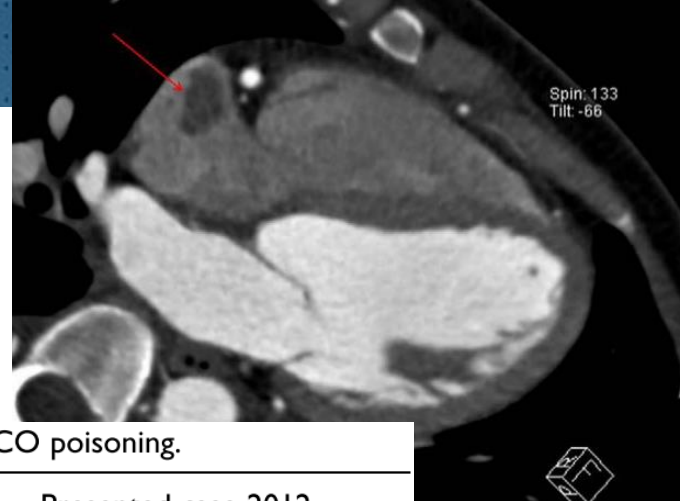


Table 1. Clinical features of three cases of intracardiac thrombus formation following CO poisoning.

Reference	Yildirim et al. ⁷	Lee et al. ⁸	Presented case 2012
Age/Sex	22/M	66/M	24/F
Medical history	No	Hypertension	No
Symptoms and signs	Mental change, Generalized rhonchi Tachycardia (118/min)	Dyspnea	Mental change, Focal memory loss
CO level (%)	Dx. by MRI finding	20.2%	16%
Troponin (Trop.)	0.136 ng/mL (Trop.T)	0.88 ng/mL (Trop.T)	1.899 mg/mL (Trop.I)
CK-MB	147 U/L	9.7 ng/mL	90.6 ng/mL
EKG finding	RBBB	T wave inversion at II, III, aVF, and V ₃₋₆	T wave inversion at II, III, aVF, and V ₁₋₆ QT prolongation
Cardiomyopathy and RWMA	Not mentioned	EF 30% Akinesia of apex	EF 42% Akinesia of apex and Lateral wall
Coronary artery disease	Not evaluated	Significant stenosis in all three vessels	Normal coronary artery
Thrombus location	Right atrium	Left ventricle	Right atrium appendage
Thrombus size	5 × 2 cm	1.2 × 1.0 cm	3.0 × 1.5 cm
Treatment drug	No	Heparin and warfarin	Low molecular heparin
Treatment duration	21 days hospitalized	2 days (d/t ulcer bleeding)	7 days
Follow-up (f/u) and result	29 days f/u Echo Residual thrombus remained	21 days f/u Echo Complete resolution of thrombus	7 days f/u Echo Complete resolution of thrombus

Venous thromboembolic risk and CO



- Unclear
 - Mechanisms
 - NO activation and oxygen free radicals → oxidative stress
 - Mitochondrial dysfunction
 - Augmentation of coagulation by CO itself
 - Acute respiratory failure-induced hypoxemia → hypercoagulability, endothelial dysfunction, immobilisation
- ⇒ Need for DVT prophylaxis

Blood Coagul Fibrinolysis. 2011;22(4):345-8

Dimens Crit Care Nurs. 2011;30(6):303-14

Hum Exp Toxicol. 2011;30(2):160-4

Curr Opin Crit Care. 2002;8(3):242-50



Summary



- 고압산소 치료의 요구도 증가
- CO 중독 이후의 다양한 폐 합병증
 - 흡인 폐렴에서 빠른 항생제 투여
 - ARDS의 높은 위험도, 적절한 MV 처치
 - 흡인 손상의 조기 평가와 처치
 - 적절한 DVT 예방 약물