2024 수면호흡장애 연구회 & 집중치료 연구회 공동심포지엄
2024년 6월 8일(토) 15:00~15:30

# Sleep apnea syndrome in patients with acute hypercapnic respiratory failure in the ICU

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김상하

# 내 용

- 증례 1 & 2
- 얼마나 있을까?
- 어떻게 예측/확인할까?

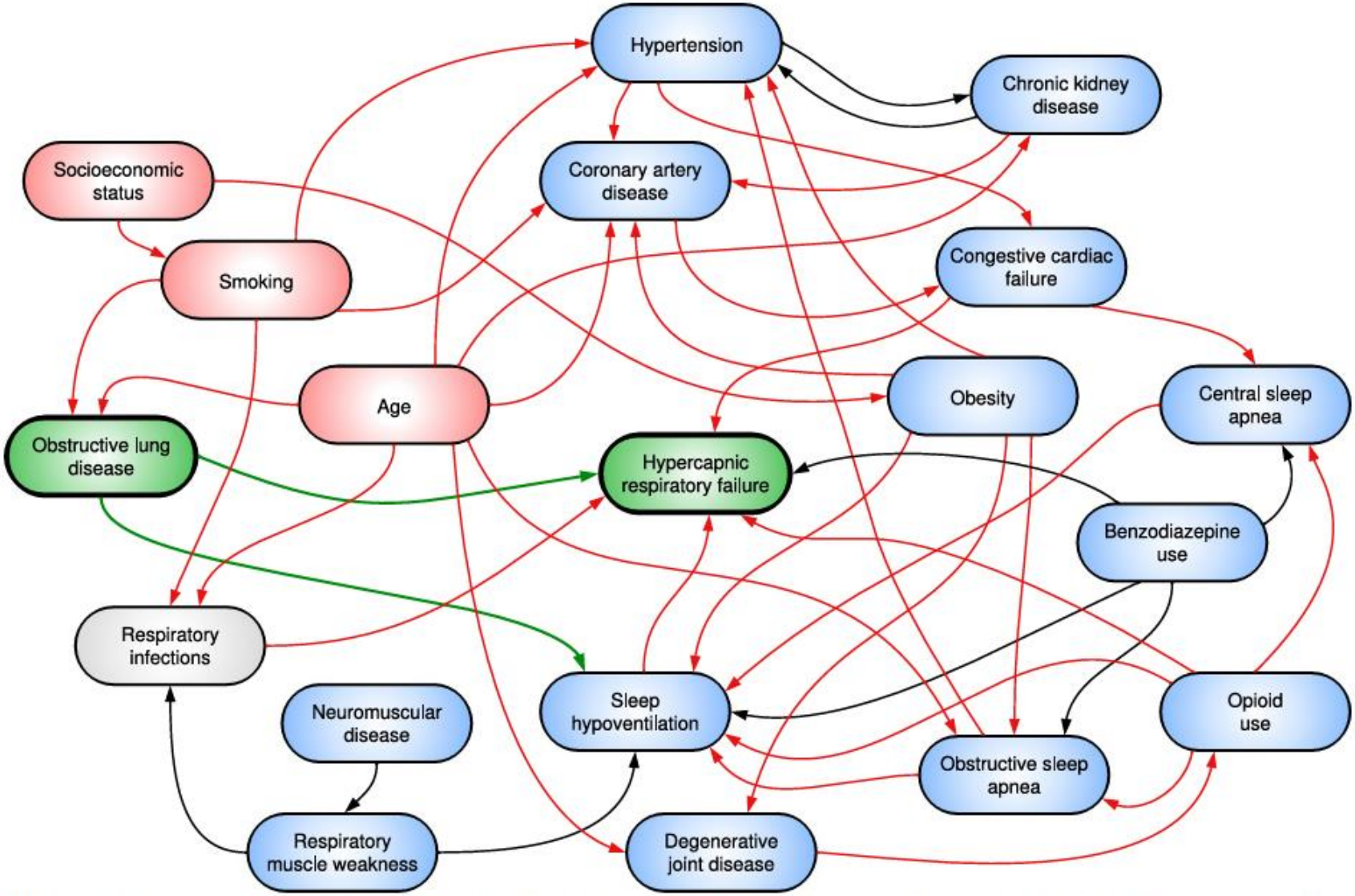
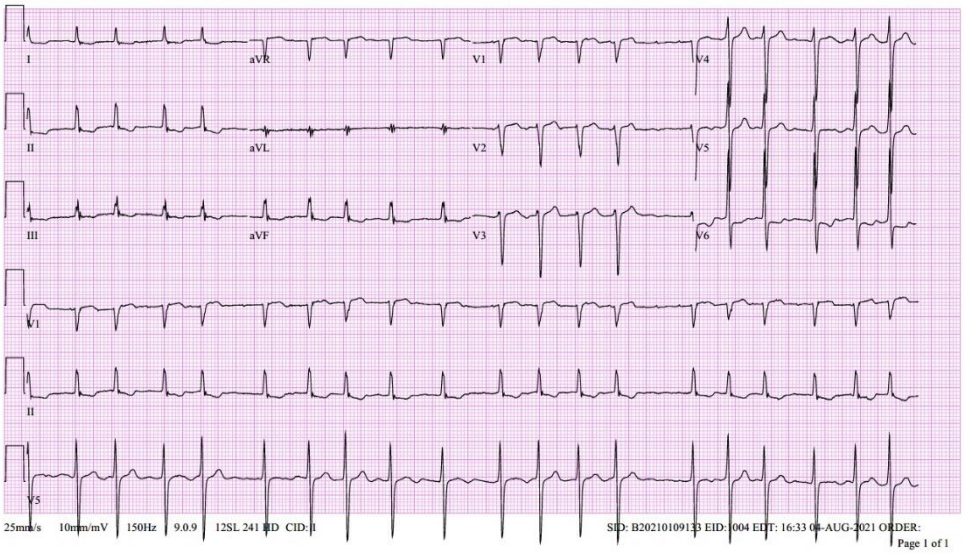



**Fig. 1** Causal diagram for hypercapnic respiratory failure. Directed acyclic graph illustrating assumed causal relationships between pre-specified exposure variables and the outcome of hypercapnic respiratory failure. In this case, obstructive lung disease has been selected as the exposure (green-shaded variable). Green arrows represent causal paths. Blue-shaded variables represent ancestors of the outcome and red-shaded variables represent ancestors of both the exposure and outcome. Red arrows represent biasing paths. Based on this diagram, the minimum adjustment set of variables to estimate the total effect of obstructive lung disease on hypercapnic respiratory failure are: age, smoking

*BMC Pulm Med 2023;23(1):347*

# 증례 1. **85세, 여자**



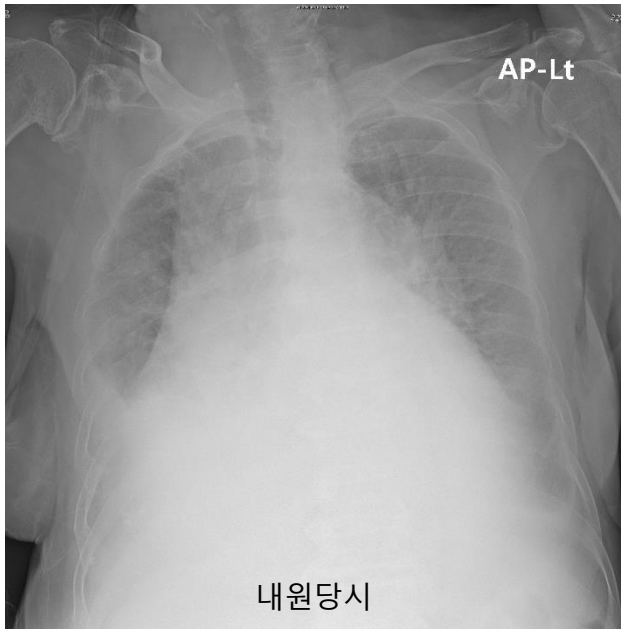

- **호흡곤란**으로 응급실

- **심방세동**, 고혈압, 당뇨
- BNP: 343.11 pg/mL
- 심초음파: Enlarged both atrium, EF: 65%

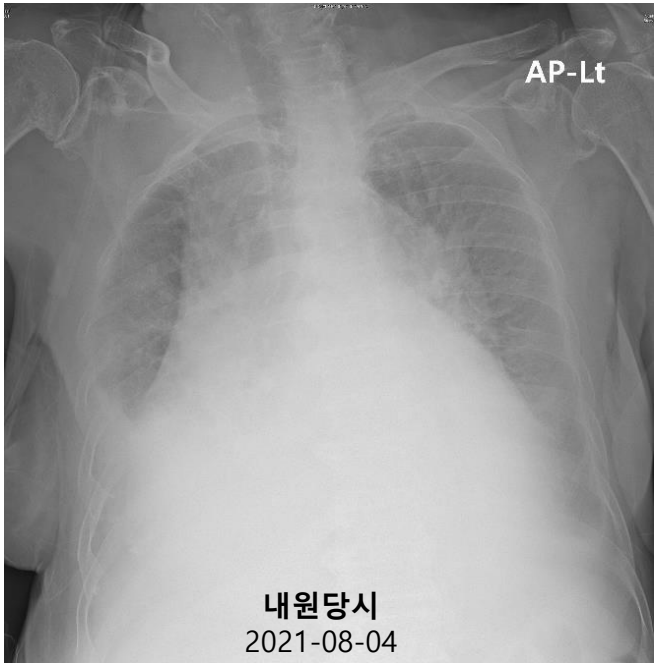
- 체질량지수=24.3 $kg/m^2$
  키: 153 cm
  몸무게: 57 kg

- 동맥혈가스검사: 7.194- **87.0**- 91.0- 32.8

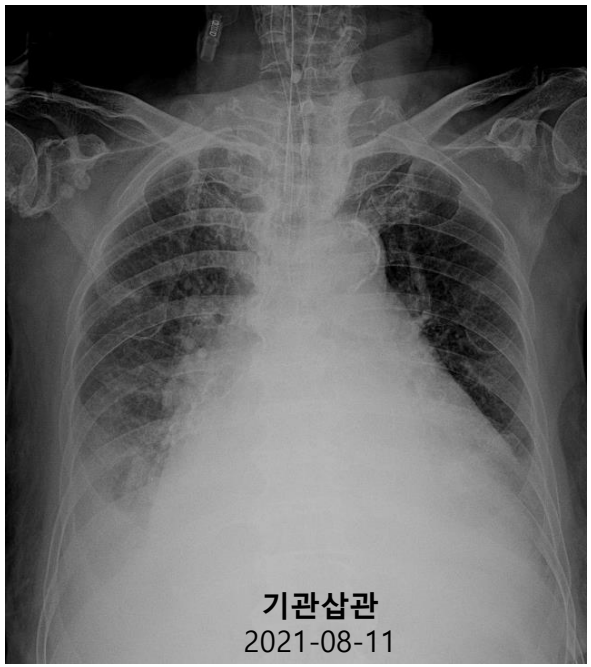
- **Hypercapnia**



# 심장내과 협진 요청




**내원당시**
2021-08-04



**기관삽관**
2021-08-11


**전과**
2021-08-18

| 검사명 | 2021-08-04 1720 | 2021-08-04 1843 | 2021-08-04 2000 | 2021-08-04 2106 | 2021-08-04 2217 |
|---|---|---|---|---|---|
| pH_Blood | 7.194 | 7.250 | 7.205 | 7.171 | 7.365 |
| PCO2_B | 87.0 | 79.2 | 84.5 | 93.0 | 51.7 |
| PO2_Blood | 91.0 | 114.6 | 92.8 | 156.6 | 94.9 |
| PaO/2FiO2 | 206.8 | 318.3 | 441.9 | 261.0 | 215.7 |
| BE_ECF | 4.6 | 6.7 | 4.7 | 4.7 | 3.5 |
| BE_B | 1.7 | 4.0 | 2.0 | 1.4 | 2.4 |
| HCO3_St | 25.9 | 28.1 | 26.2 | 25.7 | 26.6 |
| HCO3_Blood | 32.8 | 34.0 | 32.7 | 33.2 | 28.9 |
| TCO2 | 35.5 | 36.4 | 35.3 | 36.1 | 30.5 |
| O2_Sat | 95.2 | 97.9 | 95.8 | 98.4 | 96.9 |
| O2_Cont | 19.1 | 18.8 | 18.4 | | |
| A-aDO2 | 104.9 | 37.7 | < 0 | 159.3 | 142.3 |

| 2021-08-11 1116 | 2021-08-11 1320 | 2021-08-11 1545 | 2021-08-11 1711 | 2021-08-11 1942 | 2021-08-11 2125 |
|---|---|---|---|---|---|
| 7.202 | 7.233 | 7.201 | 7.227 | 7.164 | 7.416 |
| 107.5 | 101.4 | 105.1 | 96.6 | 113.5 | 53.6 |
| 76.4 | 61.1 | 62.6 | 79.9 | 80.9 | 120.3 |
| 254.7 | 218.2 | 173.9 | 199.8 | 183.9 | 200.5 |
| 13.3 | 14.3 | 12.2 | 11.7 | 11.3 | 9.1 |
| 8.4 | 9.6 | 7.6 | 7.5 | 6.5 | 7.4 |
| 32.1 | 33.0 | 31.1 | 31.1 | 30.2 | 31.2 |
| 41.3 | 41.8 | 40.2 | 39.3 | 39.9 | 33.7 |
| 44.6 | 44.9 | 43.5 | 42.2 | 43.4 | 35.3 |
| 91.0 | 85.0 | 84.8 | 92.6 | 91.5 | 98.3 |
| | | | | | |
| 9.2 | 17.7 | 69.6 | 90.3 | 100.0 | 242.0 |

| 2021-08-18 1416 | 2021-08-18 1513 | 2021-08-18 1643 | 2021-08-18 2014 | 2021-08-18 2140 | 2021-08-19 0243 |
|---|---|---|---|---|---|
| 7.181 | 7.212 | 7.247 | 7.342 | 7.345 | 7.434 |
| 105.6 | 95.0 | 84.3 | 65.6 | 66.6 | 54.6 |
| 101.4 | 137.1 | 89.2 | 124.0 | 120.8 | 126.5 |
| 405.6 | 391.7 | 297.3 | 413.3 | 402.7 | 421.7 |
| 10.3 | 9.5 | 8.6 | 9.0 | 9.8 | 11.5 |
| 5.9 | 5.6 | 5.2 | 6.5 | 7.2 | 9.8 |
| 29.7 | 29.5 | 29.1 | 30.4 | 31.1 | 33.6 |
| 38.6 | 37.3 | 35.9 | 34.8 | 35.5 | 35.8 |
| 41.9 | 40.2 | 38.5 | 36.8 | 37.6 | 37.4 |
| 95.6 | 98.0 | 94.9 | 98.2 | 98.1 | 98.5 |
| | | | | | 16.6 |
| < 0 | < 0 | 17.6 | 5.2 | 6.3 | 8.3 |

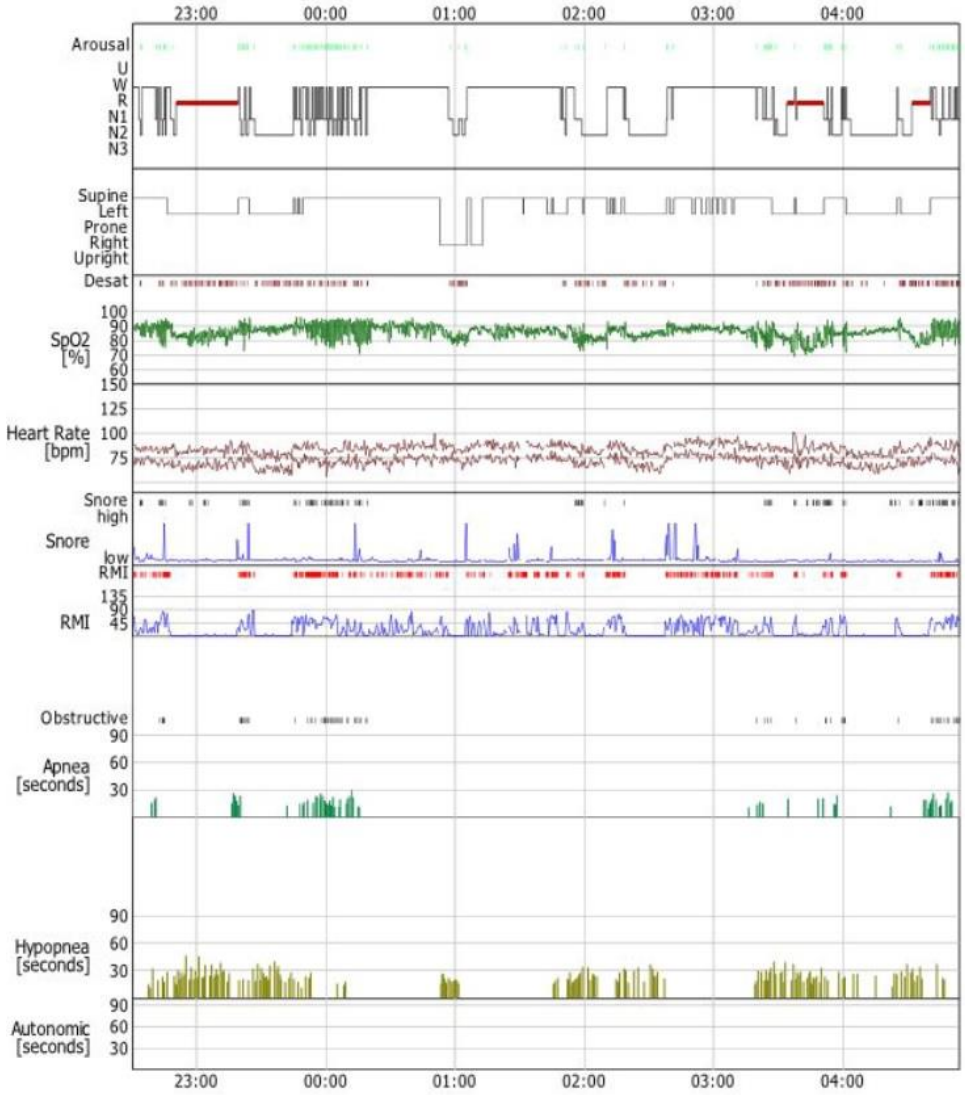
**7.194**- **87.0**- 91.0- **32.8**

**7.202**- **107.5**- 76.4- **41.3**

**7.181**- **105.6**- 101.4- **38.6**

# 수면다원검사

2021-09-06




경과기록 (2021-09-06) : 전자서명 기록일시 : 2021-09-06 10:15

**경과**

## Curent Diagnosis

Acute Respiratory Failure on HMV (21.8.11-)
R/O Hypoventilation SD
R/O Obstructive sleep apnea syndrome

HFpEF(EF65%)
Atrial fibrillation
Pericardial effusion
HTN
DM (6.9%)

High Risk Permission (DNR)

#1. R/O Obstructive sleep apnea syndrome

BMI : 24.3 kg/m2

코골이(+), 수면중 목격된 무호흡(+), 과도한 주간졸림(+), 피로감(+)
야간뇨(+), 운동시 호흡곤란(-/+, 잘 안움직임)
Modified Mallampati Score: class (4)
고혈압(+), 심혈관질환(+), 뇌혈관질환(-), 당뇨(+)
흡연력:-

일반병실 전실 후 섬망 호전되는 추세이고 경구식이 시에도 흡인증상 없음.
전신상태 호전추세로 금일 산소투여 중단하고 수면다원검사 시행 계획임.

기록자 김상하

Apnea-Hypopnea Index: **67.1**, Nadir $SaO_2$: **69.0**%

**Acute hypercapnic respiratory failure** with **severe OSA**

# CPAP

외래재진기록 (2022-03-15) : 전자서명 기록일시 : 2022-03-15 11:18

진료과 호흡기내과 주치의 김상하

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 혈압 | / | mmHg | | 맥박 | 회/분 | 체온 | ℃ |
| 키 | 153.3cm | 몸무게 | kg | BSA | 0.00m2 | BMI | 0.0kg/㎡ |
| 산소포화도 | | % | | ACT | 점 | CAT | 점 |

**진단명** 폐쇄성수면무호흡증후군, 중증(AHI=67.1, SaO2=69.0%)
적정압력: 13 cmH2O

급성호흡부전으로 입원했다가 퇴원하심 (호전됨)

4시간 이상 사용: 95 --> 97 --> 84%
AHI 2.7 --> 1.6 --> 1.1

자기전에 오관(화투)하면서 쓰고 있기도..

**PAP titration**: 13 $cmH_2O$ with full-face mask

2021-09-07

→ **Good compliance**

# 증례 2. **70세, 남자**

- **호흡곤란**으로 응급실

- 산소포화도 88 → **50**%

- BNP증가, **심부전** 소견

입원기록 (2021-07-07) : 전자서명 ID: 98291829 기록일시 : 2021-07-07 13:08

| | | | |
|---|---|---|---|
| 입원일자 | 2021-07-07 | 입원과 | 호흡기내과 |
| 입원주치의 | 김상하 | 입원결정의사 | 일반진료 |

**주호소**

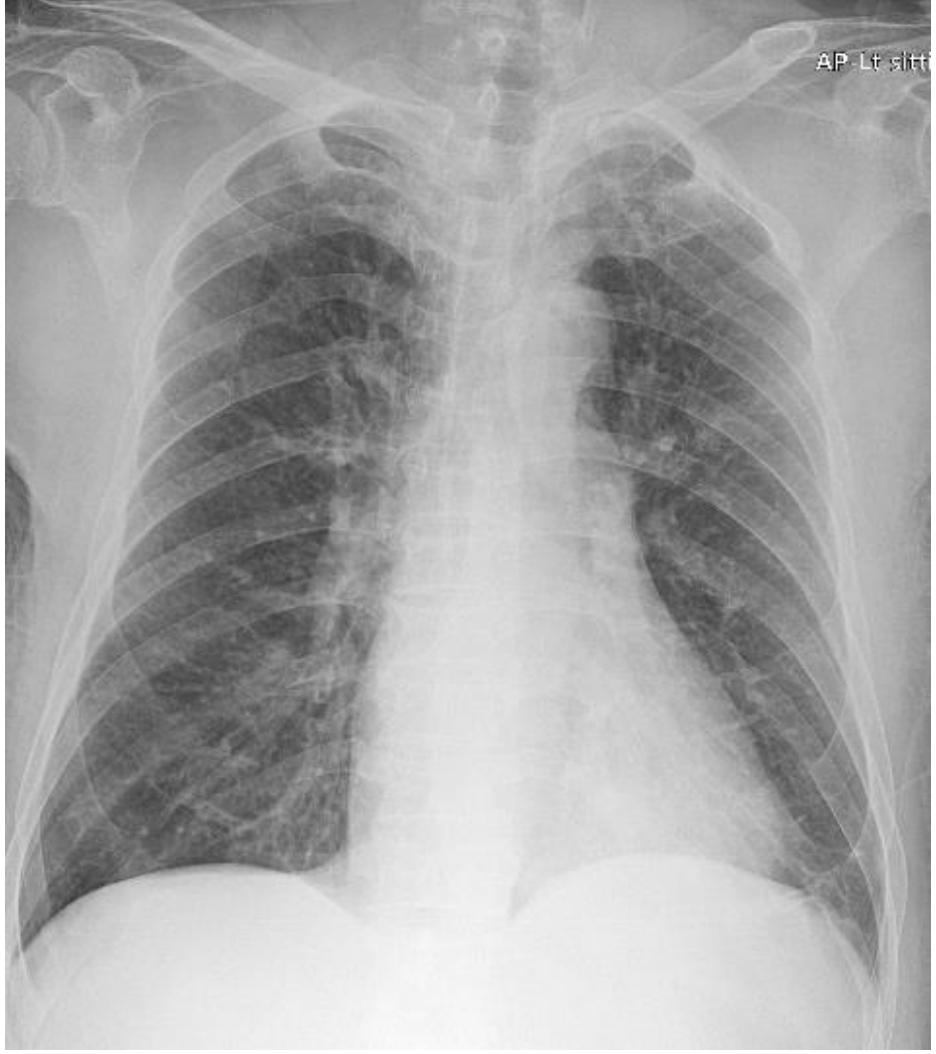
| | 주호소 | 기간 |
|---|---|---|
| 1 | Dyspnea | |
| 2 | | |
| 3 | | |

**현재질병상태** 본 70세 남환 내원 당일 08:00경 dyspnea 발생하여 타병원 내원하여 시행한 검사 결과 BNP 상승, HF aggravation 의심소견으로 본원 전원함.

++ 소견서(명지병원)
만성골수염(좌측대퇴부) 원주기독 f/u하시는 자로 내원일 08:00am 부터 dyspnea 있어 내원하였습니다. initial SaO2 88% -> 50%
혈액검사상 Na 121, NT-pro BNP 1181로 hyponatremia, CHF소견 보입니다. cardio evaluation 필요하여 본원 사정상 유선으로 연락후 전원 드립니다. 감사합니다.
**제천 명지병원 투약이력: Lasix 1@, NTG fluid 5cc/hr

검사결과 BNP 391
CRP 1.35
ABG: pH 7.223 / PO2 133.5 / PCO2 88.1 / HCO3 35.5
Na 125

- 인근병원서 호흡곤란, 산소포화도 50%로 감소
  → **hypoxemia**




**회진 중 또는 언제라도 수면 중**

**코골이**(+),

**수면중 목격된 무호흡**(+),

**잠에 취해 있는 듯**..(보호자)

Modified Mallampati Score: **IV**

**Vital signs**

BP: **141/91** mmHg, PR: **77**/min,
RR: **22**/min, BT: **36.8**℃

# 동맥혈가스검사

응급실
내원 당시

| 검사명 | 참고치 | 2021-07-06 2135 | 2021-07-06 2254 | 2021-07-06 2355 | 2021-07-07 0056 | 2021-07-07 0158 | 2021-07-07 0256 |
|---|---|---|---|---|---|---|---|
| pH_Blood | 7.35~7.45 | 7.223 | 7.226 | 7.279 | 7.283 | 7.297 | 7.292 |
| PO2_Blood | 72.0~104.0 | 133.5 | 91.8 | 106.2 | 100.9 | 92.8 | 162.6 |
| PCO2_B | 35.0~48.0 | 88.1 | 90.5 | 75.7 | 74.4 | 75.4 | 75.1 |
| BE_ECF | -2~2 | 7.8 | 9.1 | 7.9 | 7.7 | 9.5 | 8.9 |
| BE_B | -2~3 | 4.0 | 5.4 | 5.0 | 4.9 | 6.5 | 5.9 |
| HCO3_St | 21.0~28.0 | 28.1 | 29.3 | 29.0 | 28.8 | 30.3 | 29.9 |
| HCO3_Blood | 22.0~26.0 | 35.5 | 36.7 | 34.7 | 34.4 | 36.0 | 35.5 |
| TCO2 | 22.0~28.0 | | | | | | |
| TCO2 | 23.0~31.0 | 38.2 | 39.5 | 37.0 | 36.7 | 38.3 | 37.8 |
| O2_Sat | 95.0~98.0 | 98.4 | 95.0 | 97.0 | 96.7 | 96.0 | 98.8 |

**BPAP I:E=14:6** | **BPAP I:E=15:6** | **BPAP I:E=20:6** | **BPAP I:E=20:6**

보호자 제공

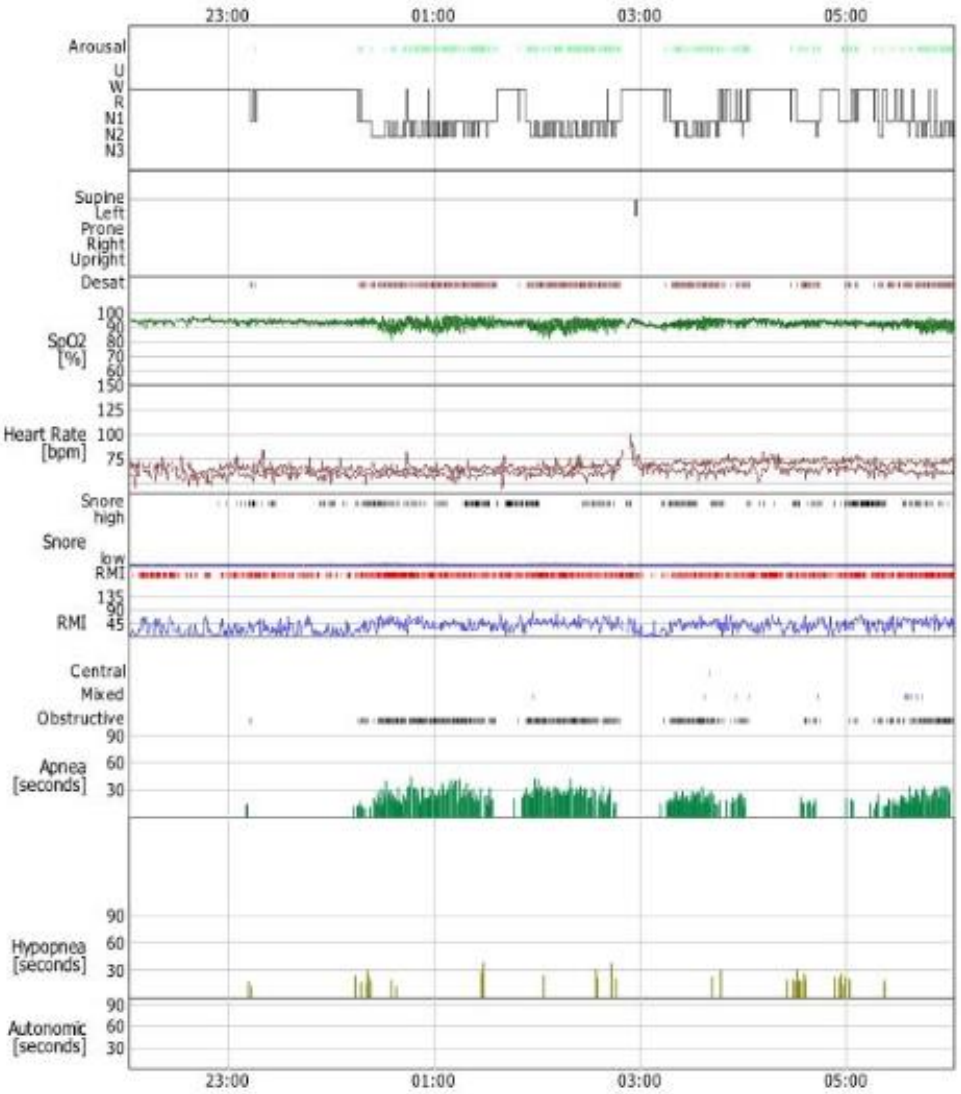
# 기타혈액검사

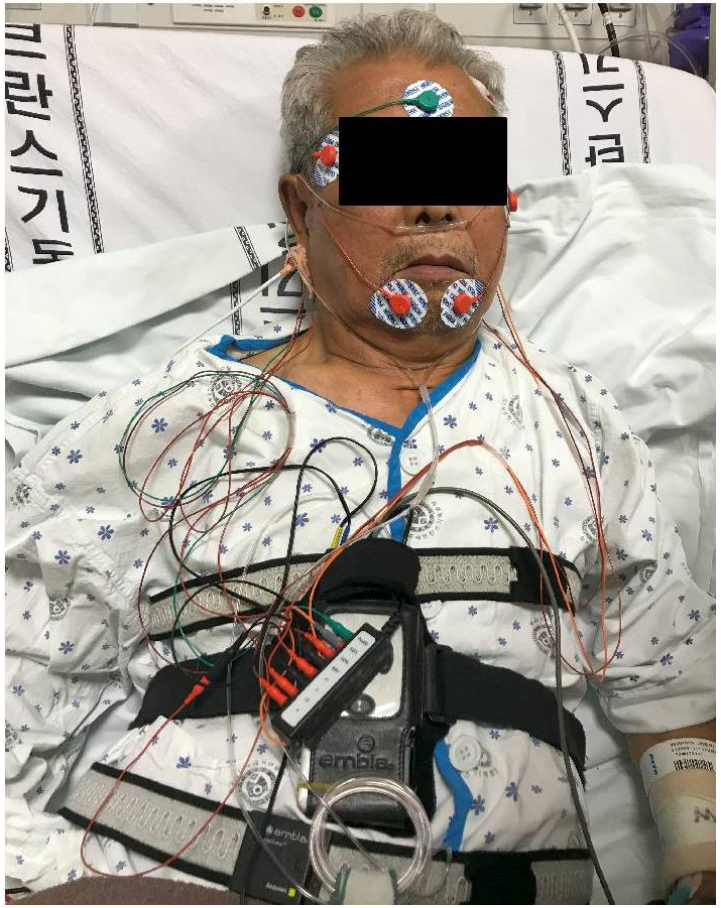
BNP: **391.95** pg/mL, Hb: **15.8** g/dL

CRP: **1.35** mg/dL, Hct: **53.8**%

# 수면다원검사 (level II)

2021-07-12



보호자 제공

Apnea-Hypopnea Index: **94.2**, Nadir $SaO_2$: **80.0**%

**Acute hypercapnic respiratory failure** with **severe OSA**

# Effective NIV ?

- Appropriate mask fit: oronasal or full-face masks
- Monitor and minimize leak

- Initial BPAP settings: **IPAP : EPAP = 10 : 5** $cmH_2O$
- Tidal volume: **6- 8** mL/kg ideal body weight

- Supplemental oxygen: Saturation **90- 93**%
- Reassess at least every 30 min during the initial phase
- In-lab PSG/PAP titration: **1- 3 months** after discharge

*Chest 2012;141(3)798-808*

# PAP titration

2021-07-15

| Device Mode | Pressure /cmH2O | Duration /min | OA # | CA # | MA # | All H # | AHI /h | RERA # | All Resp # | RDI /h | SpO2 Min % | SpO2 Mean % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPAP | 4.0 | 57.0 | - | - | - | 1 | 131 | - | 1 | 131 | 90 | 93 |
| CPAP | 5.0 | 6.9 | 6 | - | - | 3 | 100 | - | 9 | 100 | 87 | 92 |
| CPAP | 6.0 | 6.1 | 4 | - | - | 5 | 106 | - | 9 | 106 | 85 | 91 |
| CPAP | 7.0 | 18.8 | 13 | - | - | 13 | 85 | - | 26 | 85 | 85 | 92 |
| CPAP | 8.0 | 8.0 | - | - | - | 9 | 90 | - | 9 | 90 | 88 | 93 |
| CPAP | 9.0 | 8.8 | - | - | - | 11 | 85 | - | 11 | 85 | 86 | 92 |
| CPAP | 10.0 | 7.7 | - | - | - | 8 | 67 | - | 8 | 67 | 89 | 93 |
| CPAP | 11.0 | 7.5 | - | - | - | 8 | 64 | - | 8 | 64 | 88 | 92 |
| CPAP | 12.0 | 17.1 | - | - | - | 16 | 56 | - | 16 | 56 | 87 | 92 |
| CPAP | 13.0 | 14.1 | - | - | - | 12 | 51 | - | 12 | 51 | 88 | 92 |
| CPAP | 14.0 | 9.8 | - | - | - | 10 | 64 | - | 10 | 64 | 90 | 92 |
| CPAP | 15.0 | 13.5 | - | - | - | 14 | 65 | - | 14 | 65 | 89 | 92 |
| BiLevel | 12.0/8.0 | 26.0 | 3 | 1 | - | 7 | 74 | - | 11 | 74 | 90 | 93 |
| BiLevel | 13.0/9.0 | 7.5 | 1 | - | - | 8 | 94 | - | 9 | 94 | 89 | 93 |
| BiLevel | 14.0/9.0 | 5.7 | - | - | - | 6 | 82 | - | 6 | 82 | 89 | 93 |
| BiLevel | 15.0/9.0 | 26.9 | 2 | - | 1 | 10 | 91 | - | 13 | 91 | 91 | 94 |
| BiLevel | 15.0/10.0 | 34.8 | - | - | - | 10 | 85 | 2 | 12 | 102 | 88 | 93 |
| BiLevel | 16.0/10.0 | 32.7 | 3 | - | - | 13 | 102 | - | 16 | 102 | 89 | 94 |
| BiLevel | 16.0/11.0 | 6.2 | - | - | - | 2 | 120 | - | 2 | 120 | 94 | 95 |
| BiLevel | 17.0/11.0 | 11.4 | - | - | - | 6 | 107 | - | 6 | 107 | 88 | 94 |
| BiLevel | 18.0/11.0 | 8.8 | 4 | - | - | 4 | 116 | - | 8 | 116 | 88 | 94 |
| BiLevel | 18.0/12.0 | 8.0 | - | - | - | 4 | 80 | - | 4 | 80 | 92 | 95 |
| BiLevel | 19.0/12.0 | 26.7 | 2 | - | - | 5 | 105 | - | 7 | 105 | 89 | 94 |
| BiLevel | 20.0/12.0 | 9.3 | 2 | - | 1 | 3 | 103 | - | 6 | 103 | 90 | 94 |
| BiLevel | 12.0/8.0 | 2.2 | - | - | - | 3 | 94 | - | 3 | 94 | 89 | 93 |
| BiLevel | 13.0/8.0 | 3.8 | - | - | - | 4 | 103 | - | 4 | 103 | 91 | 94 |
| BiLevel | 14.0/8.0 | 3.6 | - | - | - | 3 | 69 | - | 3 | 69 | 90 | 94 |
| BiLevel | 15.0/8.0 | 3.6 | 3 | - | - | 1 | 76 | - | 4 | 76 | 76 | 89 |
| BiLevel | 16.0/9.0 | 3.6 | 1 | - | - | 1 | 34 | - | 2 | 34 | 68 | 84 |
| BiLevel | 17.0/9.0 | 2.3 | - | - | - | 2 | 53 | - | 2 | 53 | 73 | 83 |
| BiLevel | 18.0/9.0 | 3.4 | - | - | - | 3 | 57 | - | 3 | 57 | 80 | 88 |
| BiLevel | 19.0/9.0 | 3.4 | - | - | - | - | - | - | - | - | - | - |

| Device Mode | Pressure /cmH2O | Duration /min | OA # | CA # | MA # | All H # | AHI /h | RERA # | All Resp # | RDI /h | SpO2 Min % | SpO2 Mean % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BiLevel | 20.0/10.0 | 2.5 | - | - | - | 1 | 41 | - | 1 | 41 | 81 | 87 |
| BiLevel | 21.0/11.0 | 4.5 | - | - | - | 3 | 40 | - | 3 | 40 | 70 | 86 |
| BiLevel | 22.0/12.0 | 5.8 | - | - | - | 5 | 56 | - | 5 | 56 | 77 | 88 |
| BiLevel | 23.0/13.0 | 5.9 | - | - | - | 4 | 41 | - | 4 | 41 | 77 | 88 |
| BiLevel | 24.0/14.0 | 7.1 | - | - | - | 7 | 59 | - | 7 | 59 | 78 | 87 |
| BiLevel | 25.0/15.0 | 7.5 | - | - | - | 14 | 112 | - | 14 | 112 | 77 | 87 |
| BiLevel | 26.0/16.0 | 11.4 | - | - | - | 15 | 79 | - | 15 | 79 | 85 | 90 |
| BiLevel | 27.0/17.0 | 24.9 | - | 2 | - | - | 5 | - | 2 | 5 | 91 | 94 |

| Device Mode | Pressure /cmH2O | TST /min | REM /min | Non-REM /min | Wake /min | Arousal # | Arousal /h | LM/RR LM # | LM/RR LM /h | PLM # | PLM /h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BiLevel | 20.0/10.0 | 1.4 | 1.4 | 0.0 | 1.0 | - | - | - | - | - | - |
| BiLevel | 21.0/11.0 | 4.5 | 4.5 | 0.0 | 0.0 | 2 | 27 | - | - | - | - |
| BiLevel | 22.0/12.0 | 5.3 | 5.3 | 0.0 | 0.5 | 5 | 56 | - | - | - | - |
| BiLevel | 23.0/13.0 | 5.9 | 5.9 | 0.0 | 0.0 | 3 | 31 | - | - | - | - |
| BiLevel | 24.0/14.0 | 7.1 | 7.1 | 0.0 | 0.0 | 1 | 8 | - | - | - | - |
| BiLevel | 25.0/15.0 | 7.5 | 7.5 | 0.0 | 0.0 | 2 | 16 | - | - | - | - |
| BiLevel | 26.0/16.0 | 11.4 | 11.4 | 0.0 | 0.0 | 6 | 32 | - | - | - | - |
| BiLevel | 27.0/17.0 | 22.4 | 17.4 | 5.0 | 2.5 | 7 | 19 | - | - | - | - |

**BPAP** apply with full-face mask

IPAP=**27.0** $cmH_2O$, EPAP=**17.0** $cmH_2O$

# BPAP titration

- **General recommendations**
  - uncomfortable or intolerant of high pressure on CPAP

    continued obstructive respiratory events at 15 $cmH_2O$
  - starting with an IPAP and EPAP of **8 and 4 $cmH_2O$**

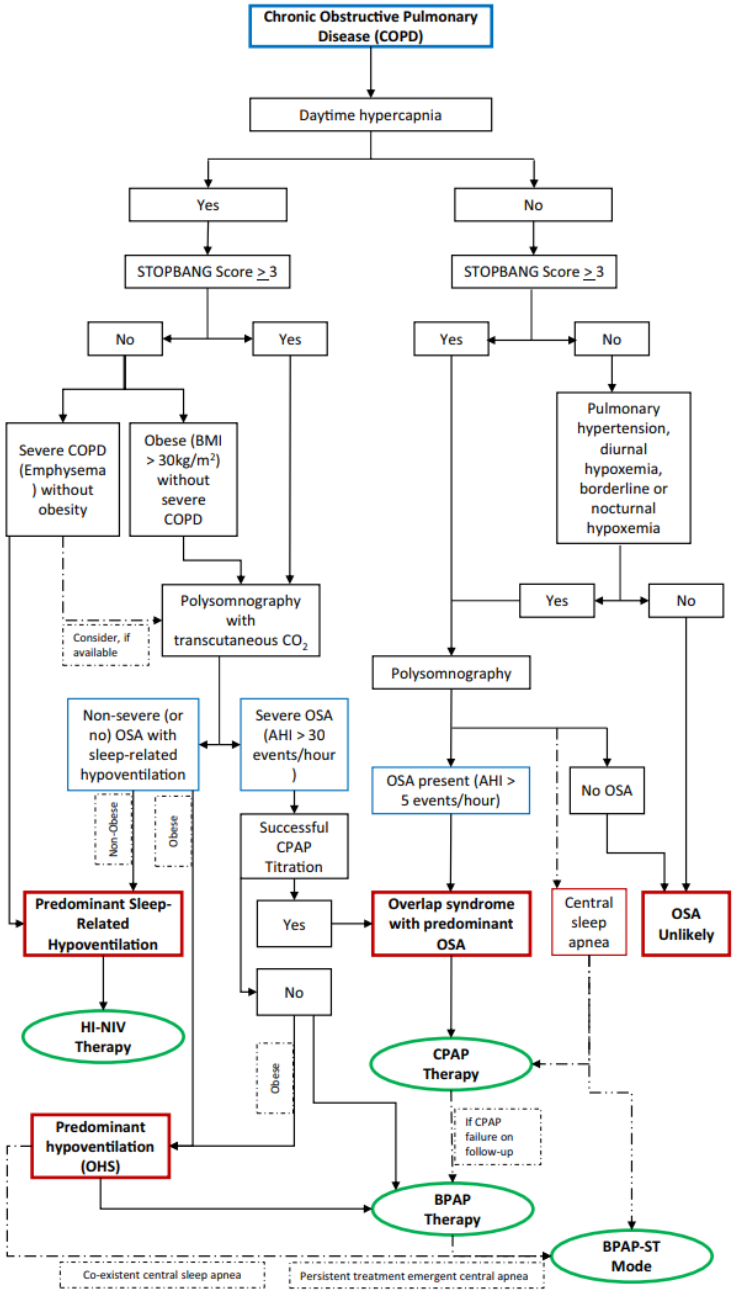
    **IPAP and EPAP** ≥ 1 $cmH_2O$ for ≥ **2** obstructive apneas

    **IPAP** ≥ 1 $cmH_2O$ for ≥ **3** hypopneas, or ≥ **5** RERAs, or

    ≥ (**3** min of loud or unambiguous snoring)
  - maximum IPAP: **30 $cmH_2O$**

    maximum pressure support: **10 $cmH_2O$**

*J Clin Sleep Med 2008;4(2):157-71*




# [Supplemental Oxygen]

- awake supine $SpO_2$ while breathing room air is **≤88%**
- when $SpO_2$ is **≤88% for ≥5 minutes** in the absence of obstructive respiratory events

↓

- introduced at 1 L/min and titrated upwards to achieve a target $SpO_2$ between **88% and 94%** (Consensus)

- O2 rate should be increased by 1 L/min, **with an interval no shorter than 15 min**, until $SpO_2$ is between 88% and 94% (Consensus)

FASEB Bioadv 2021;3:683-93

## Adult Sleep Related Breathing Disorders in the ICSD3 (ICD-9) [ICD-10]

### Obstructive Sleep Apnea Disorders

Obstructive Sleep Apnea, Adult (327.23) [G47.33]

### Central Sleep Apnea Disorders*

Central Sleep Apnea with Cheyne-Stokes Breathing (786.04) [R06.3]

Central Sleep Apnea Due to a Medical Disorder without Cheyne-Stokes Breathing (327.27) [G47.37]

Central Sleep Apnea Due to High Altitude Periodic Breathing (327.22) [G47.32]

Central Sleep Apnea Due to a Medication or Substance (327.29) [G47.39]

Primary Central Sleep Apnea (327.21) [G47.31]

Treatment-Emergent Central Sleep Apnea (327.29) [G47.39]

### Sleep-Related Hypoventilation Disorders

Obesity-Hypoventilation Syndrome (278.03) [E66.2]

Idiopathic Central Alveolar Hypoventilation (327.24) [G47.34]

Sleep Related Hypoventilation Due to Medication or Substance (327.26) [G47.36]

Sleep Related Hypoventilation Due to a Medical Disorder (327.26) [G47.36]

### Sleep Related Hypoxemia Disorders

Sleep-Related Hypoxemia (327.26) [G47.36]

# Hypoventilation *during* ***sleep***

**≥10 minutes,**
**>55 mmHg** $PaCO_2$ (or end-tidal $PCO_2$ / transcutaneous $PCO_2$) **증가**

**≥10 minutes,**
**>50 mmHg** 초과하여
**≥10 mmHg** $PaCO_2$ (or end-tidal $PCO_2$ / transcutaneous $PCO_2$) **증가**

Principles and Practice of Sleep Medicine, 6th Ed., p.1037

Patients

# Surviving (AHRF) acute hypercapnic respiratory failure

*Coexistence of*

**COPD**
**Obesity**
**OSA**
**Cardiac failure**

**Poor prognosis**

**Frequent readmissions**

*Am J Respir Crit Care Med 2017;196:200-7*

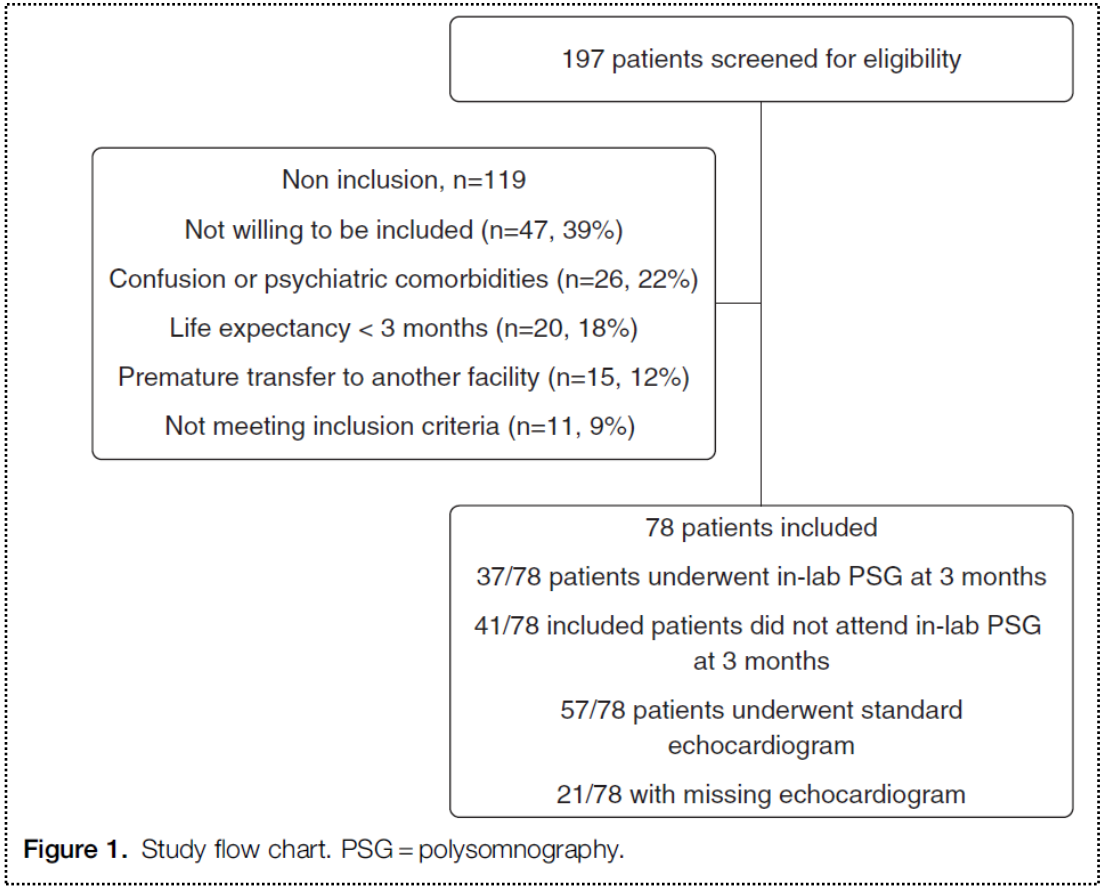



**Figure 1.** Study flow chart. PSG = polysomnography.

## [Study protocol]

- *15 days after*
  - Complete PFT
  - Echocardiography
- *3 months after & 2 days after NIV/CPAP withdrawal*
  - In-laboratory PSG

## [Exclusion criteria]

- < 18 years old
- Neuromuscular disease
- Pregnancy
- Iatrogenic respiratory failure
- Life expectancy < 3 months
- Confusion
- Major psychiatric disease

## [Inclusion criteria]

- **$PaCO_2$ > 50 mmHg**
- **Invasive or noninvasive mechanical ventilation in the ICU**

*Am J Respir Crit Care Med 2017;196:200-7*

**Table 2.** Pulmonary Function Test Data

| | Study Population (*n* = 78) | COPD (*n* = 52) | Non-COPD (*n* = 26) | *P* Value |
|---|---|---|---|---|
| $FEV_1$, % of predicted | 50.0 ± 18.9 | 43.5 ± 15.3 | 62.9 ± 19.2 | <0.001 |
| Residual volume, % of predicted | 123.5 ± 55.9 | 140 ± 60.4 | 91 ± 24.8 | <0.001 |
| TLC, % of predicted | 87.6 ± 28.0 | 95.9 ± 29.7 | 72.1 ± 15.5 | <0.001 |
| RV/TLC, % of predicted | 132.8 ± 24.7 | 140.2 ± 24.8 | 118.9 ± 17.7 | <0.001 |
| $D_{LCO}$, % of predicted | 60.2 ± 23.1 | 56.9 ± 22.1 | 66.6 ± 24.2 | 0.062 |
| Kco, % of predicted | 92.8 ± 28.0 | 88.9 ± 30.1 | 99.8 ± 22.8 | 0.062 |

*Definition of abbreviations*: COPD = chronic obstructive pulmonary disease; $D_{LCO}$ = diffusion capacity of the lung for carbon monoxide; RV = residual volume; TLC = total lung capacity.
Data are given as mean ± SD.

**Table 3.** Polysomnographic Data of the Study Population

| | COPD (*n* = 25) | No COPD (*n* = 12) | *P* Value |
|---|---|---|---|
| N1 + N2 sleep stage, % | 69.1 (58.6–83.4) | 78.7 (72.6–96.4) | 0.211 |
| N3 stage sleep stage, % | 18.3 (6.4–24.5) | 12.1 (0.2–21.7) | 0.397 |
| REM sleep stage, % | 12.2 (2.5–17.4) | 6 (0.1–10.2) | 0.090 |
| Total sleep time, min | 365 (259–441) | 393 (343.2–406.5) | 0.746 |
| Sleep efficiency, % | 74.0 (54.8–83.8) | 75.6 (60.8–80.0) | 0.910 |
| AHI, $h^{-1}$ | 31.9 (14.3–45.6) | 66.0 (48.0–83.8) | 0.014 |
| HI, $h^{-1}$ | 27.6 (11.9–39.9) | 44.7 (21.7–64.3) | 0.101 |
| MA, $h^{-1}$ | 45 (31–55) | 54.0 (48.0–74.8) | 0.060 |
| Mean $Pt_{CO_2}$ during sleep, kPa | 6.6 (5.9–7.0) | 6.6 (6.2–7.0) | 0.783 |
| Maximum $Pt_{CO_2}$ during sleep, kPa | 7.2 (6.7–7.6) | 7.3 (7.0–7.7) | 0.515 |
| Increase in $Pt_{CO_2}$ during sleep, kPa | 0.4 (0.3–0.6) | 0.5 (0.3–0.7) | 0.537 |

*Definition of abbreviations*: AHI = apnea–hypopnea index; COPD = chronic obstructive pulmonary disease; HI = hypopnea index; MA = microarousals; N1 = non-REM stage 1; N2 = non-REM stage 2; N3 = non-REM stage 3.
Data are given as median (interquartile range).

**COPD: 67%**

**Moderate-Severe OSA**
with COPD: 66%
without COPD: **94%**

**Severe OSA**
with COPD: 51%
without COPD: **81%**

**Heart failure with preserved EF: 44%**

**Hypertension: 67%**

*Am J Respir Crit Care Med 2017;196:200-7*

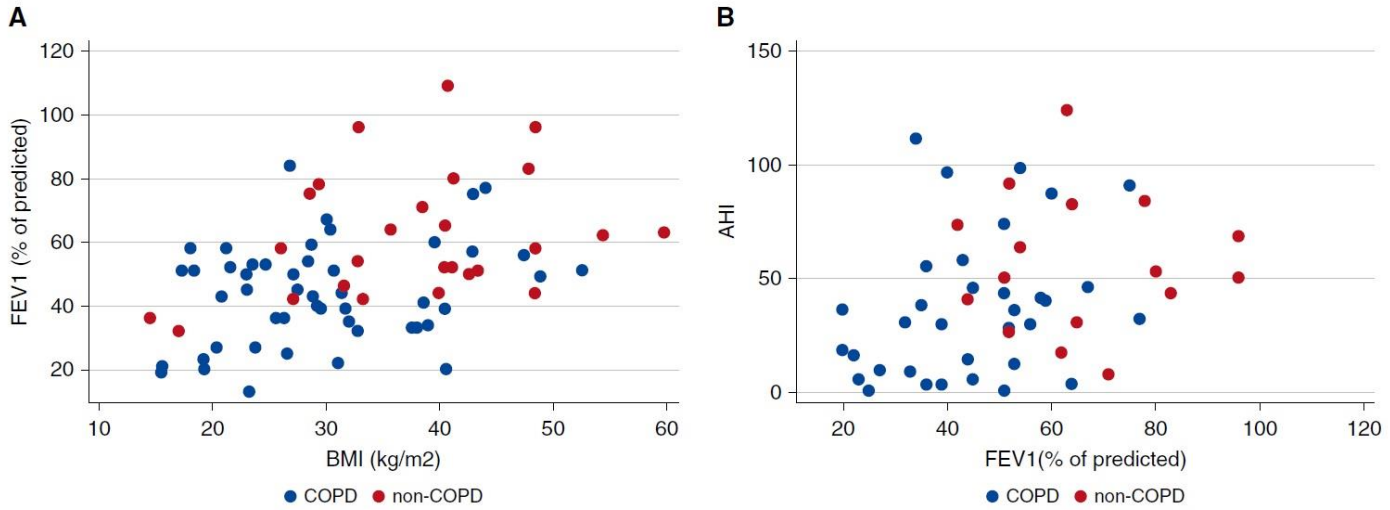
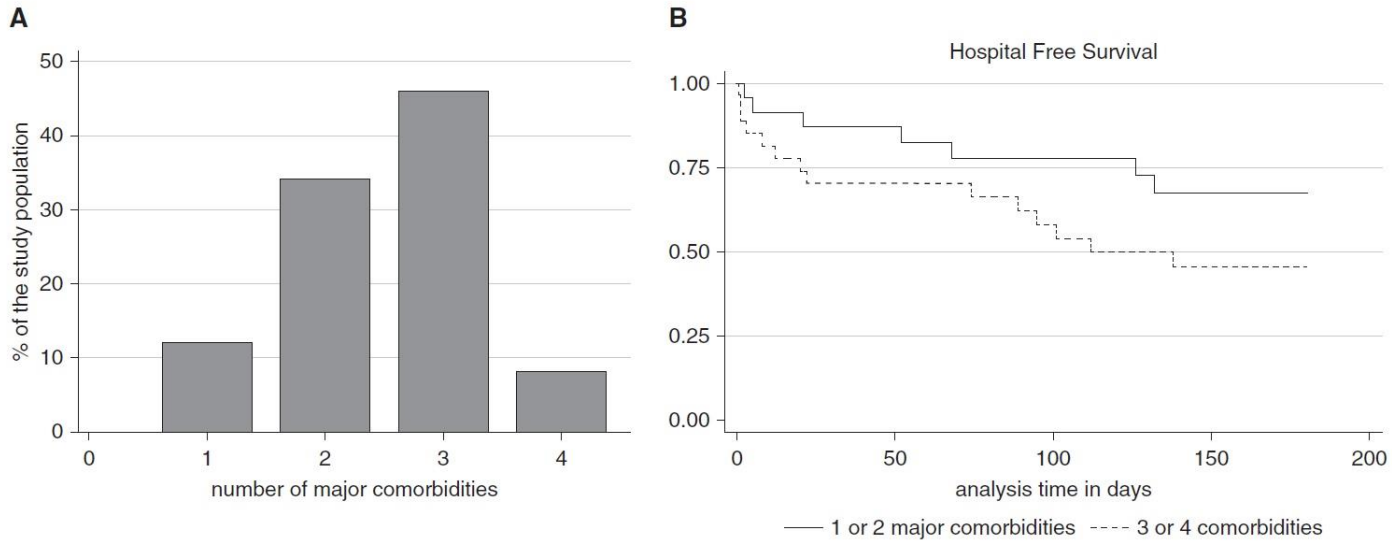



**Figure 2.** Positive correlation between body mass index and $FEV_1$ (*A*) and apnea–hypopnea index (*B*). AHI = apnea–hypopnea index; BMI = body mass index; COPD = chronic obstructive pulmonary disease.



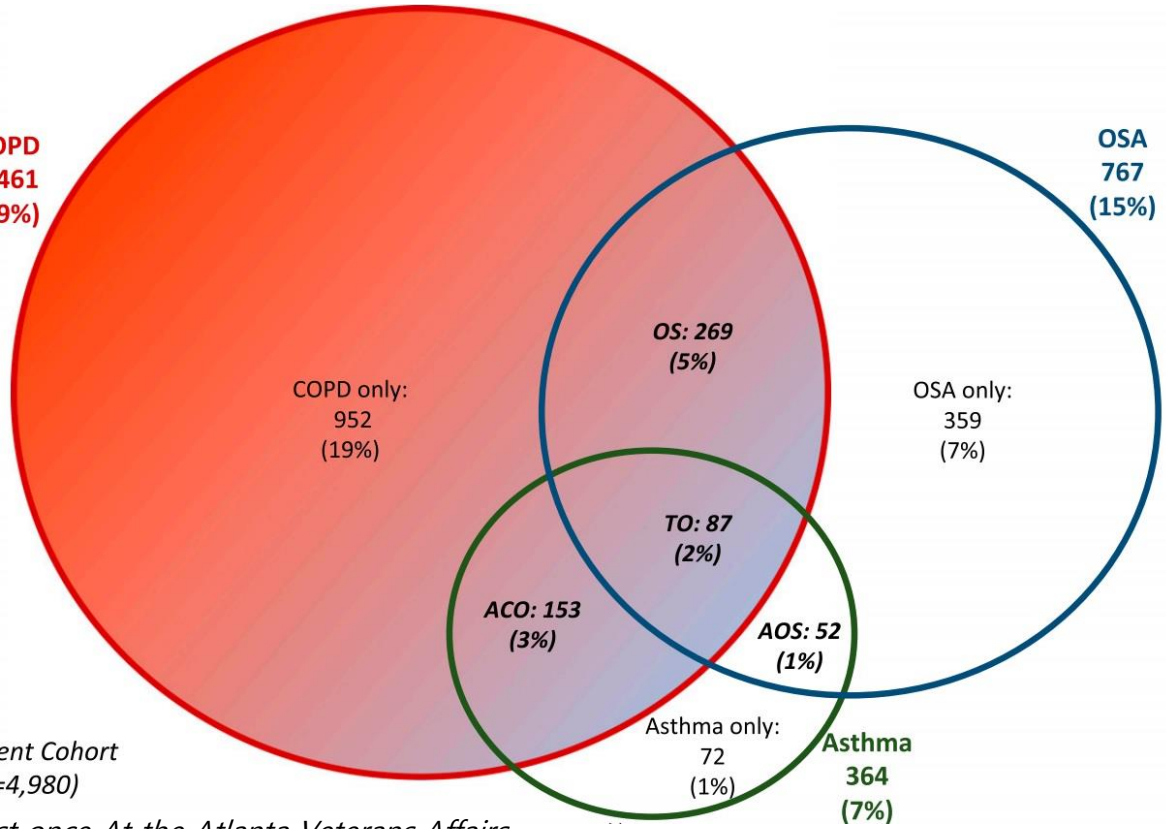

ICU discharge 후
3.5 개월 동안
46% 환자가
재입원 또는 사망

**Figure 3.** (*A*) Number of objectively identified comorbidities. (*B*) Kaplan-Meier survival curves according to hospital-free survival in higher and lesser comorbid patients ($P = 0.127$).

*Am J Respir Crit Care Med 2017;196:200-7*

***Obstructive Lung Disease and Obstructive Sleep Apnea (OLDOSA)*** *cohort study*

**24.4%**




**46.4%**

*: All patients **hospitalized** at least once At the Atlanta Veterans Affairs Medical Center during calendar year 2008*

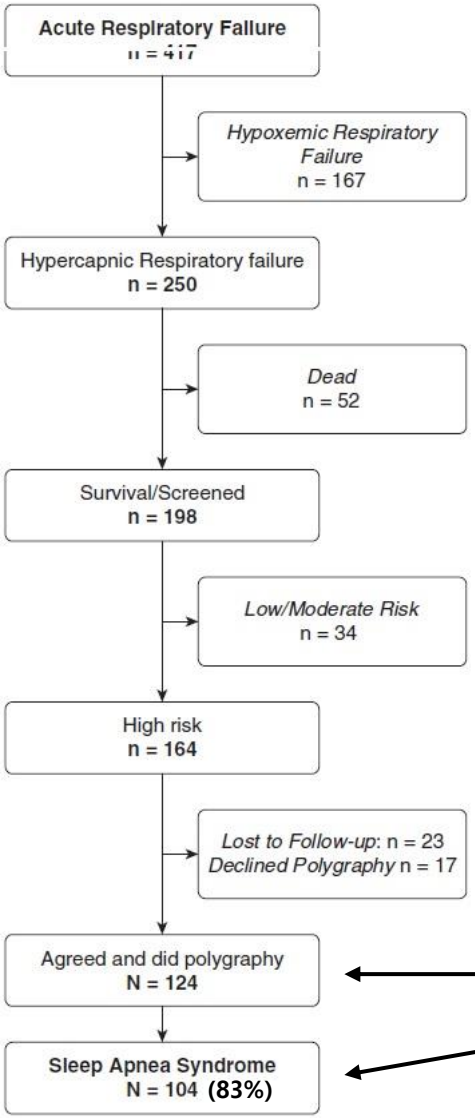
# **OSA** in **COPD** : **11~45**%

# **COPD** in **OSA** : **9~41**%

J Clin Sleep Med 2020;16:267-77
FASEB Bioadv 2021;3:683-93

# Diagnosis of Sleep Apnea Syndrome

## Survivors of acute hypercapnic respiratory failure




**STAOP-Bang** questionnaire

*at the day of ICU discharge*

High risk: score ≥3 (total 0-8)

**Home sleep apnea testing** (SOMNOlab 2)

*within 3 weeks* following the ICU discharge

Level III test

**OSA 86%, Mixed apnea 14%**

*Ann Am Thorac Soc 2021;18(4):727-9*

**Figure 1.** Flow chart of the patients included in the study.

**Table 1.** Signs and symptoms suggestive of OSA syndrome

| Clinical Features | Frequency [*n* (%)] |
|---|---|
| STOP-Bang components | |
| Snoring | 98 (94) |
| Daytime tiredness | 79 (76) |
| Observed apneic events | 42 (41) |
| Hypertension | 68 (66.3) |
| Body mass index >35 kg/m$^2$ | 65 (60) |
| Age >50 yr | 95 (91) |
| Neck circumference, cm (>43 in men, >41 in women) | 52 (50) |
| Sex, M | 44 (42) |
| Other clinical features | |
| Repeated nocturnal awakening | 65 (62) |
| Nocturia | 62 (60) |
| Nonrestorative sleep | 62 (60) |
| Altered concentration | 65 (62) |
| Cardiac arrythmia | 36 (35) |

*Definition of abbreviation*: OSA = obstructive sleep apnea.
Number and frequency relate to the cohort of patients diagnosed with OSA ($n$ = 104).

**코골이, 주간졸음, 50세 이상**

**반복적으로 야간에 잠을 깸**
**야간뇨**

**Table 2.** Demographic and clinical characteristics of study patients

| Variable | Value |
|---|---|
| Demographics | |
| Age, yr | 66 ± 11 |
| Sex, M/F | 44/60 |
| Comorbidities | |
| Obesity (BMI ⩾30) | 83 (80) |
| Smoking | 66 (63) |
| COPD | 49 (48) |
| Obesity hypoventilation syndrome | 24 (23) |
| Hypertension | 68 (66.3) |
| Diabetes | 37 (35.6) |
| Coronary artery disease | 15 (14) |
| Cause of ICU admission | |
| Left ventricular failure | 80 (77) |
| COPD tracheobronchitis | 13 (12.5) |
| Community-acquired pneumonia | 11 (10.6) |
| Arterial blood gas | |
| pH | 7.29 ± 0.07 |
| $Pa_{O_2}$, kPa | 8.47 ± 2.5 |
| $Pa_{CO_2}$, kPa | 9.6 ± 3.4 |
| $CO_3H^-$, mmol/L | 32 ± 4 |
| $CO_3H^-$ ⩾27 mmol/L | 78 (75) |

*Definition of abbreviations*: BMI = body mass index; COPD = chronic obstructive pulmonary disease; ICU = intensive care unit; $Pa_{CO_2}$ = arterial carbon dioxide tension/pressure; $Pa_{O_2}$ = arterial oxygen tension/pressure.
Data are shown as mean ± standard deviation or $n$ (%).

*Ann Am Thorac Soc 2021;18(4):727-9*

# Clinical Evaluation

- **STOPBANG** questionnaire (2008)

  To assess the risk of OSA as a part of preoperative assessments of surgical patients

  **S**noring, **T**iredness, **O**bserved apnea, high blood **P**ressure, high **B**MI, **A**ge, **N**eck circumference, male **G**ender

  >35 kg/m$^2$ >50

  Male: >43 cm, Female: > 41 cm

- **Low** risk : 0~2

  **Intermediate** risk : **3**~4

  **High** risk : 5~8

# Screening tools of Sleep Apnea Syndrome

## Survivors of acute hypercapnic respiratory failure

**Table 1. Patient characteristics.**

| | Overall (n = 53) | Moderate-to-severe OSA (n = 36) | No or mild OSA (n = 17) | p-value |
|---|---|---|---|---|
| Gender, female/male | 22/31 | 15/21 | 7/10 | 1.000 |
| Age (yrs) | 67 (62–74) | 66 (62–72) | 71 (64–75) | 0.311 |
| COPD, n (%) | 37 (70) | 23 (64) | 14 (82) | 0.296 |
| FEV1, % of predicted value | 50 (39–58) | 54 (44–64) | 39 (27–45) | 0.001 |
| FEV1/FVC, % | 57 (46–73) | 65 (51–76) | 51 (39–67) | 0.073 |
| TLC, % of predicted value | 84 (67–104) | 85 (65–98) | 83 (68–113) | 0.641 |
| RV, % of predicted value | 111 (81–143) | 99 (81–140) | 120 (101–176) | 0.092 |
| RV/TLC, % of predicted value | 130 (114–150) | 121 (112–138) | 149 (139–162) | 0.002 |
| AHI,n /h | 36 (17–58) | 48 (36–76) | 9 (5–16) | <0.001 |
| BMI, kg/m2 | 33 (26–41) | 33 (29–41) | 27 (23–39) | 0.042 |
| Neck circumference, cm | 43 (38–46) | 43 (40–47) | 41 (37–46) | 0.211 |
| Hypertension, n (%) | 33/53(62) | 22/36 (61) | 11/17 (65) | 1.00 |
| Epworth Sleepiness Scale | 7 (4–12) | 7 (4–12) | 7 (5–9) | 0.709 |

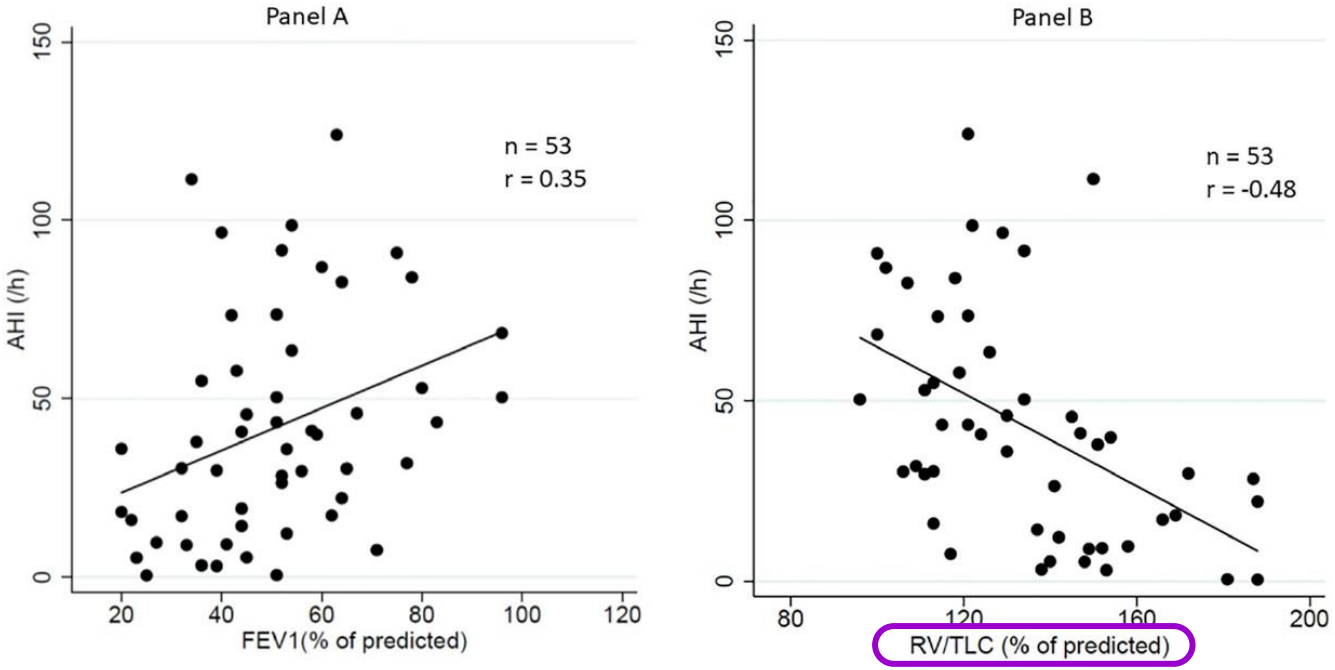
**67.9%**

OSA: obstructive sleep apnea; COPD: chronic obstructive lung disease; FEV1: forced expiratory volume in 1 sec.; FVC: forced vital capacity; RV: residual volume; TLC: total lung capacity; AHI; apnea-hyponea index; BMI: body mass index

Single-center, prospective, cohort study
Geneva University Hospitals from 2012-2015

197 patients (ICU discharge) − meeting exclusion criteria ➔ 78 patients
➔ 53 patients who completed an overnight PSG

*PLoS One 2018;13(10):e0205669*




**Static Hyperinflation (RV/TLC):**

***Negative*** association with **AHI**

**Fig 1.** Panel A: Positive correlation between FEV1 (% of predicted) and the apnea-hypopnea index. Panel B: Negative correlation between residual volume/total lung capacity (% of predicted) and the apnea-hypopnea index. FEV1: forced expiratory volume in 1 sec;.

**Table 3. Performance of classic screening tools for obstructive sleep apnea and our 3 variables model.**

| | Sensitivity (95% CI) | Specificity (95% CI) | Positive predictive value (95% CI) | Negative predictive value (95% CI) | Area under the curve (95% CI) |
|---|---|---|---|---|---|
| Simplified penalized regression model with RV/TLC | 0.97 (0.85–1) | 0.20 (0.04–0.48) | 0.74 (0.59–0.86) | 0.75 (0.19–0.99) | 0.78 (0.65–0.91) |
| Simplified penalized regression model with FEV1 | 0.97 (0.85–1) | 0.20 (0.04–0.48) | 0.74 (0.59–0.86) | 0.75 (0.19–0.99) | 0.75 (0.60–0.89) |
| NoSAS | 0.89 (0.72–0.96) | 0.24 (0.08–0.50) | 0.71 (0.55–0.83) | 0.50 (0.18–0.83) | 0.65 (0.50–0.81) |
| STOP BANG | 0.78 (0.60–0.89) | 0.41 (0.19–0.67) | 0.74 (0.57–0.86) | 0.47 (0.22–0.73) | 0.58 (0.42–0.75) |

RV: residual volume; TLC: total lung capacity; FEV1: forced expiratory volume in 1 sec.

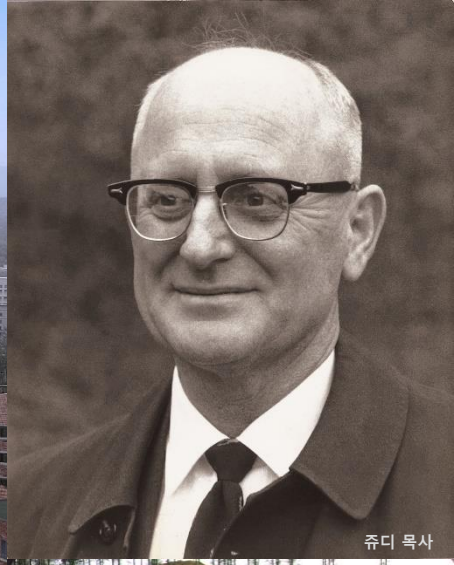
*PLoS One 2018;13(10):e0205669*

# 요 약 (1)

- AHRF로 ICU에 입원했다가 살아서 퇴원한 환자의 약 67~75%에서 중등도 이상의 OSA가 있다.
- COPD는 67%가 있으며, 동반되지 않은 경우에서는 OSA가 더 많다.

# 요 약 (2)

- AHRF로 ICU에 입원했던 환자에서 OSA를 예측하기 위해서는 RV/TLC, STOP-Bang 설문지를 사용한다.
- 진단은 3개월 이내에 overnight PSG를 시행한다.



쥬디 목사


기공식
1957. 11. 15


모례리 박사

# 2024년
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