Oxygen therapy in patients with chronic lung disease

최광용

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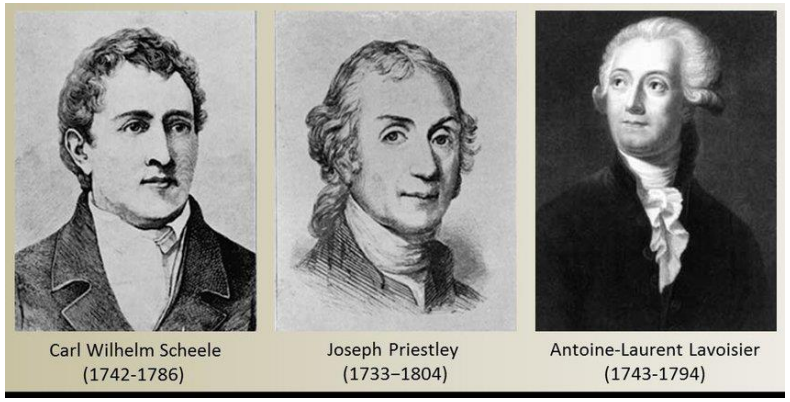
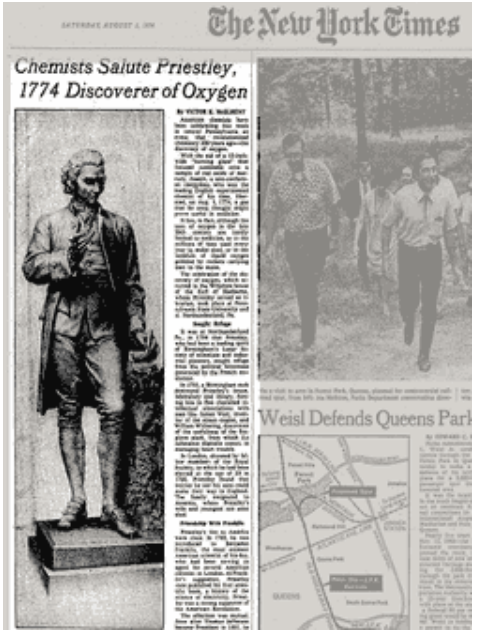
Table of Contents

Discovery of oxygen

- Carl Wilhelm Scheele (1842-1927) discovered oxygen in 1771
- Joseph Priestley (1733-1804) isolated oxygen in 1774
- Antoine Lavoisier (1743-1794) named oxygen in 1778: “vital air”




The New York Times

Chemists Salute Priestley, 1774 Discoverer of Oxygen

Weisl Defends Queens Parl

BBC Science Focus

Who really discovered oxygen?

Although Joseph Priestley was the first to publish his findings on the important element, was he the first to discover the gas?

React Oxyg Species (Apex). 2016 Jan;1(1):1-8.
https://www.nytimes.com
https://www.sciencefocus.com

Early clinical use of oxygen

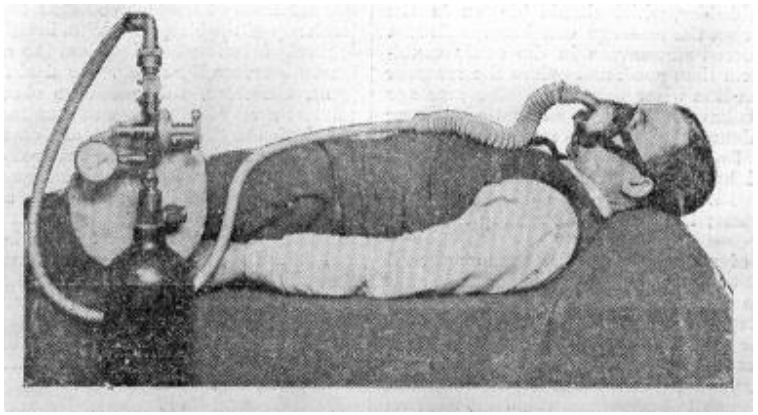
- Alvan Barach (1895-1977), John Scott Haldane (1860-1936) and others introduced and developed oxygen therapy in 1900s to 1920s

The Journal of the
American Medical Association
Published Under the Auspices of the Board of Trustees
VOL. 79, NO. 9 CHICAGO, ILLINOIS AUGUST 26, 1922

THE THERAPEUTIC USE OF OXYGEN *

ALVAN L. BARACH, M.D.
NEW YORK

previously poor cardiac and respiratory responses to effort. These results constitute an instance in which effective treatment with oxygen accomplished definite improvement and cure. Shufflebotham and Sowry treated more than 100 patients in their oxygen chamber,



JAMA. 1922;79(9):693-699.
https://www.facebook.com/columbiasurgery
https://asthmahistory.blogspot.com

Experiments of John Scott Haldane

THE ACTION OF CARBONIC OXIDE ON MAN. By JOHN HALDANE, M.A., M.D., *Lecturer in Physiology, University of Oxford. Grocers' Company Research Scholar.* (Three Figures in Text.)

(*From the Physiological Laboratory, Oxford.*)

Experiments on Man.

The accompanying diagram shows the arrangement employed for enabling the subject to breathe for any required time air containing a definite percentage of carbonic oxide. In all the experiments I was myself the subject.

J Physiol. 1895 Nov 16;18(5-6):430–462.

After 43 min.	Feeling decidedly "abnormal." Slight hyperpnœa and marked throbbing.
„ 45 „	Pulse 104. Breathing distinctly deeper.
„ 54 „	Feel very decidedly abnormal. Vision seems not so good. Slight feeling of giddiness.
„ 59 „	Hyperpnœa more distinct. Beginning to look pale and yellowish, and "as if ill."
„ 61 „	Blood taken again. Pinker than last specimen. *Saturation* 44·5 %.
„ 63 „	Feel worse shortly after making any movement in my chair.
„ 65 „	Hyperpnœa marked, and slight confusion of mind.
„ 71 „	Blood taken. Very pink tint, slightly more so than last specimen. *Saturation* 49 %. Stopped experiment. Vision dim. Limbs weak. Had some difficulty in getting up or walking without assistance, movements being very uncertain.

J Physiol. 1895 Nov 16;18(5-6):430–462.

Oxygen therapy and John Scott Haldane

- During World War I, John Scott Haldane designed the first gas masks and oxygen therapy equipment for victims.

- He recommended up to 41% oxygen administration “continuously” for hypoxic patients.

- He criticized intermittent therapy
  - ‘intermittent oxygen therapy was like brining a drowning man to the surface of the water – occasionally’

Indian J Anaesth. 2014 May-Jun;58(3):350–352.

Oxygen therapy and John Scott Haldane

THE THERAPEUTIC ADMINISTRATION OF OXYGEN.

By J. S. HALDANE, M.D., F.R.S.,
OXFORD.

Where, in lung affections, an addition of oxygen to the inspired air is needed in order to combat want of oxygen, it is evidently desirable to continue the administration over long periods. It was shown by Paul Bert that oxygen at a pressure of about three atmospheres is capable of producing convulsions and rapid death; but Lorrain Smith found that, apart altogether from this action on the nervous system, pure oxygen at high pressures produces pneumonia pretty rapidly, and even at ordinary atmospheric pressure acts slowly on the lungs, ultimately producing fatal pneumonia after several days in animals. This effect was even occasionally produced in about four days by a mixture containing only 80 per cent. of oxygen. It is evidently desirable, therefore, to keep the oxygen percentage as low as possible during long administrations, and to know roughly what percentage is being breathed.

Br Med J. 1917 Feb 10;1(2928):181-3.

History of oxygen therapy

- Early 1960s: Oxygen therapy was contraindicated in COPD
- 1967: Levine BE et al. reported benefit of long-term oxygen administration in patients with chronic airway obstruction with hypoxemia
- 1980s: Randomized trials (NOTT in 1980, MRC in 1981) demonstrated survival benefit of long-term oxygen therapy (LTOT) in COPD

Ann Intern Med. 1967 Apr;66(4):639-50.
Ann Intern Med 1980; 93:391.
Lancet 1981; 1:681.

Comparison of NOTT and MRC

TABLE 1 Inclusion and exclusion criteria of the Medical Research Council (MRC) study and Nocturnal Oxygen Treatment Trial (NOTT) [29, 30]

Trial	Inclusion criteria	Exclusion criteria
MRC [29]	Stable individuals with chronic bronchitis or emphysema with FEV_1 <1.2 L, aged <70 years P_{aO_2} 40–60 mmHg (5.3–8.0 kPa) when breathing room air, repeated after 3 weeks One or more episodes of ankle oedema	Restrictive disorders, pulmonary embolism, systemic hypertension, coronary artery disease
NOTT [30]	Stable participants P_{aO_2} <55 mmHg (7.3 kPa) (at least two occasions) P_{aO_2} <59 mmHg (7.9 kPa) (at least two occasions) plus one of the following: oedema, haematocrit >55%, or P pulmonale on ECG Lung function: FEV_1/FVC <70% after bronchodilator TLC >80% pred Age >35 years	Previous LTOT Other diseases that may be expected to influence mortality

FEV_1: forced expiratory volume in 1 s; FVC: forced vital capacity; LTOT: long-term oxygen therapy; P_{aO_2}: arterial oxygen tension; TLC: total lung capacity.

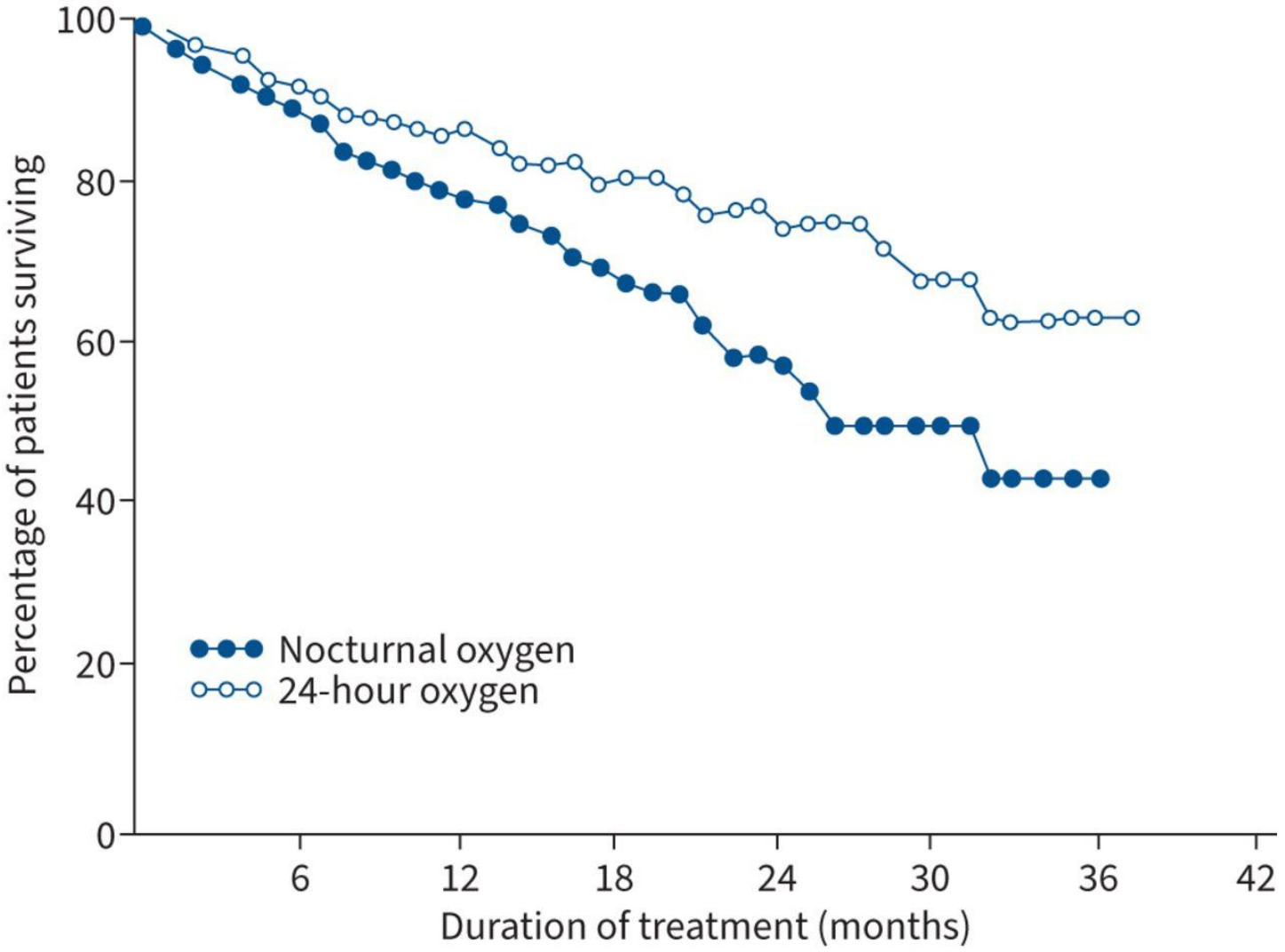
Eur Respir Rev. 2023 Mar 22;32(167):220159.

Comparison of NOTT and MRC

	NOTT 1980[24]	MRC 1981[25]
Age, y	> 35	42–69
Patients, *n*	203	87
Male, %	73–80	76
Baseline FEV_1	29% predicted	0.58–0.75 L
Baseline P_{aO_2}, mm Hg	51	49–52
Baseline P_{aCO_2}, mm Hg	43	55–60
Baseline mean pulmonary artery pressure, mm Hg	30	32–35
Intervention	Nocturnal oxygen vs continuous oxygen	No oxygen vs oxygen > 15 h/d including during sleep
Average hours of oxygen per day	12 ± 2.5 vs 17.7 ± 4.8	0 vs 15
Smoking status, %	Not reported	25–52
Outcomes	Mortality Quality of life Hemodynamics: right atrial pressure, right-ventricular stroke volume index, pulmonary artery pressure, pulmonary vascular resistance, pulmonary wedge pressure, cardiac index, stroke volume index	Mortality 5-year died: 19/42 oxygen 30/45 no oxygen FEV_1 FVC P_{aO_2} P_{aCO_2}

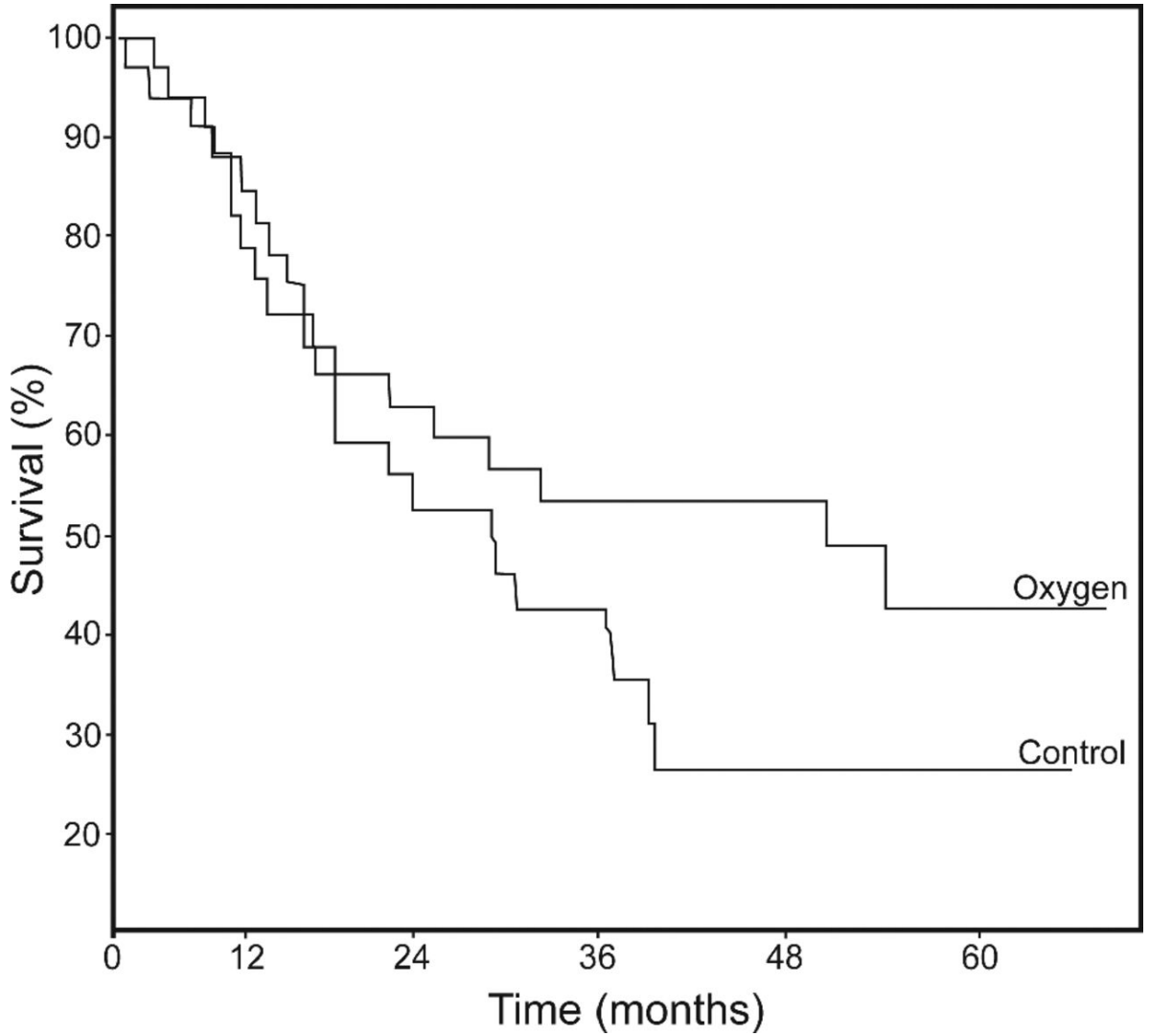
Respir Care. 2013 Jan;58(1):18-31.

NOTT: Survival benefit of LTOT (vs. nocturnal O_2) in COPD



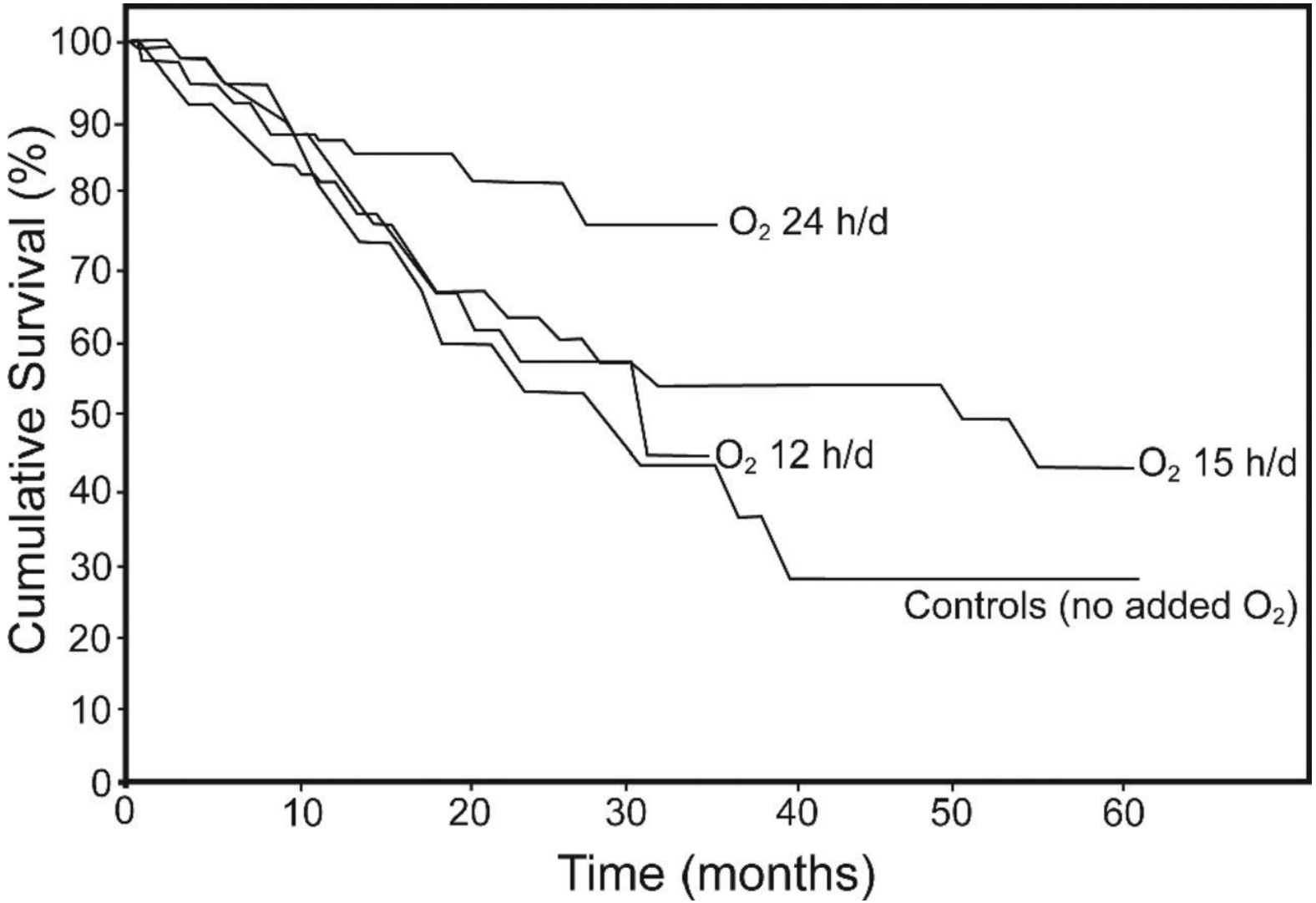
Eur Respir Rev. 2023 Mar 22;32(167):220159.

MRC: Survival benefit of LTOT in COPD



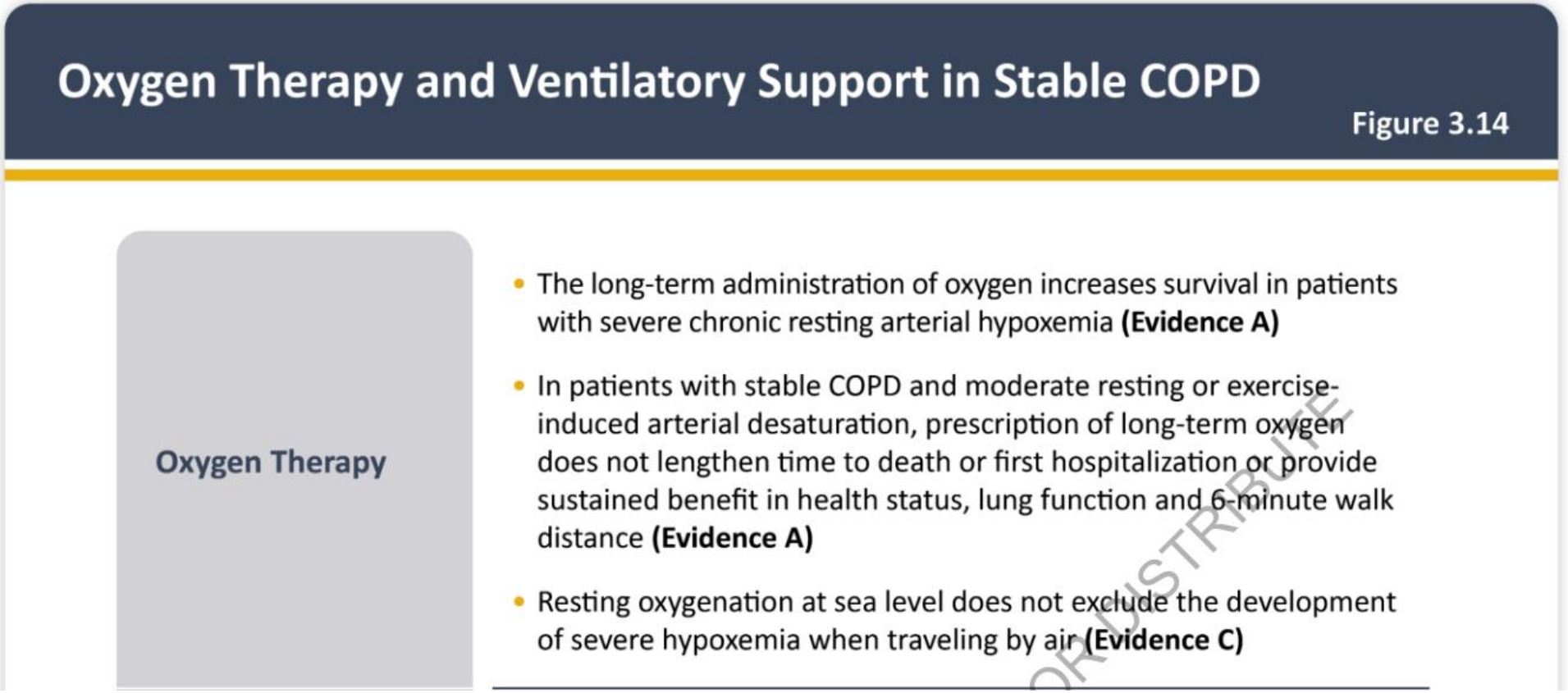
Respir Care. 2013 Jan;58(1):18-31.

NOTT and MRC: Survival benefit of LTOT in COPD



Respir Care. 2013 Jan;58(1):18-31.

2025 GOLD Report



Oxygen Therapy and Ventilatory Support in Stable COPD

Figure 3.14

Oxygen Therapy

- The long-term administration of oxygen increases survival in patients with severe chronic resting arterial hypoxemia **(Evidence A)**
- In patients with stable COPD and moderate resting or exercise-induced arterial desaturation, prescription of long-term oxygen does not lengthen time to death or first hospitalization or provide sustained benefit in health status, lung function and 6-minute walk distance **(Evidence A)**
- Resting oxygenation at sea level does not exclude the development of severe hypoxemia when traveling by air **(Evidence C)**

Prescription of Supplemental Oxygen to COPD Patients

Figure 3.15

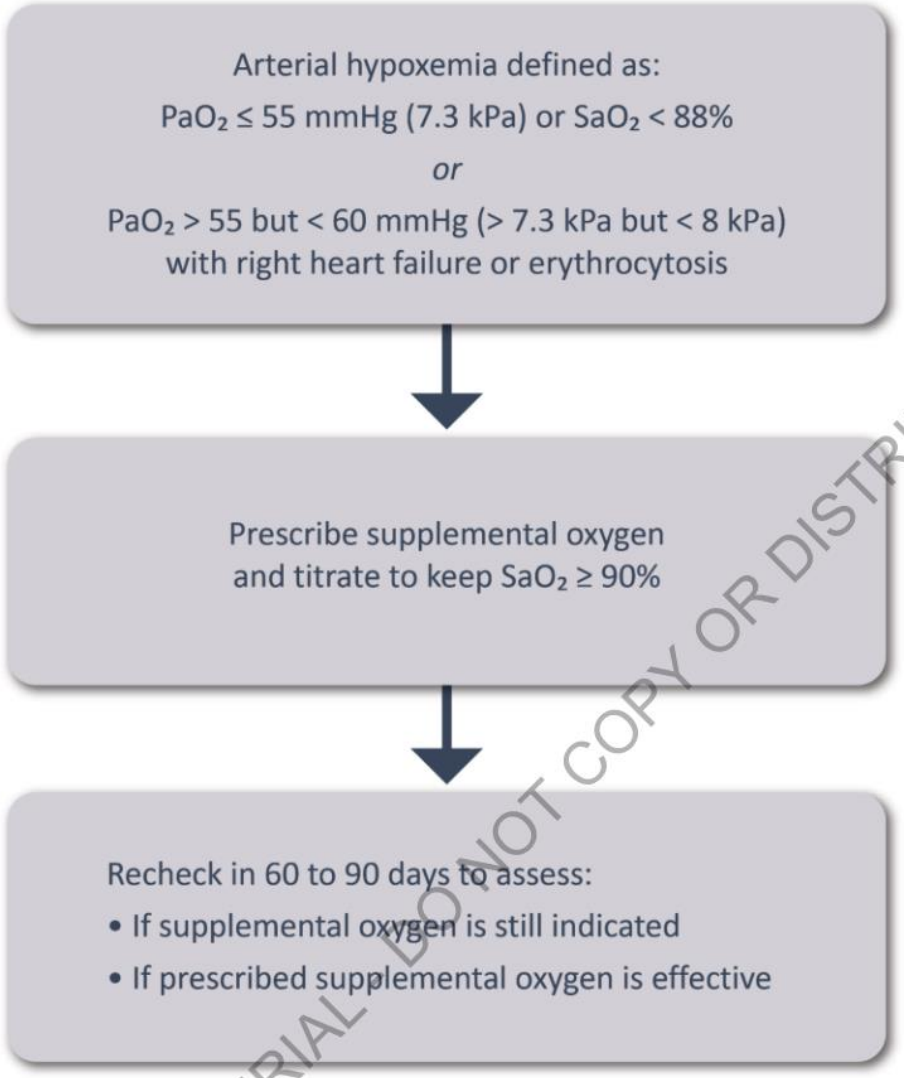


Table 4. Summary of ATS Recommendations

Question	ATS Recommendation	Strength of Recommendation and Level of Evidence
COPD		
Question 1: Should long-term oxygen be prescribed for adults with COPD who have severe* chronic resting room air hypoxemia?	In adults with COPD who have severe chronic resting room air hypoxemia, we recommend prescribing LTOT for at least 15 h/d.	Strong recommendation, moderate-quality evidence
Question 2: Should long-term oxygen be prescribed for adults with COPD who have moderate† chronic resting room air hypoxemia?	In adults with COPD who have moderate chronic resting room air hypoxemia, we suggest not prescribing LTOT.	Conditional recommendation, low-quality evidence
Question 3: Should ambulatory oxygen be prescribed for adults with COPD who have severe exertional room air hypoxemia?	In adults with COPD who have severe exertional room air hypoxemia, we suggest prescribing ambulatory oxygen.	Conditional recommendation, low-quality evidence
ILD		
Question 4: Should long-term oxygen be prescribed for adults with ILD who have severe chronic resting room air hypoxemia?	For adults with ILD who have severe chronic resting room air hypoxemia, we recommend prescribing LTOT for at least 15 h/d.	Strong recommendation, very-low-quality evidence
Question 5: Should ambulatory oxygen be prescribed for adults with ILD who have severe exertional room air hypoxemia?	For adults with ILD who have severe exertional room air hypoxemia, we suggest prescribing ambulatory oxygen.	Conditional recommendation, low-quality evidence
Liquid oxygen		
Question 6: Should portable liquid oxygen be provided for adults with chronic lung disease who are prescribed continuous oxygen flow rates of >3 L/min during exertion?	In patients with chronic lung disease who are mobile outside of the home and require continuous oxygen flow rates of >3 L/min during exertion, we suggest prescribing portable liquid oxygen.	Conditional recommendation, very-low-quality evidence
Education		
Education and safety for patients and caregivers	For all patients prescribed home oxygen therapy, we recommend that the patient and their caregivers receive instruction and training on the use and maintenance of all oxygen equipment and education on oxygen safety, including smoking cessation, fire prevention, and tripping hazards.	Best-practice statement

Am J Respir Crit Care Med. 2020 Nov 15;202(10):e121-e141.

LOTT trial (2016)

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 OCTOBER 27, 2016 VOL. 375 NO. 17

A Randomized Trial of Long-Term Oxygen for COPD with Moderate Desaturation

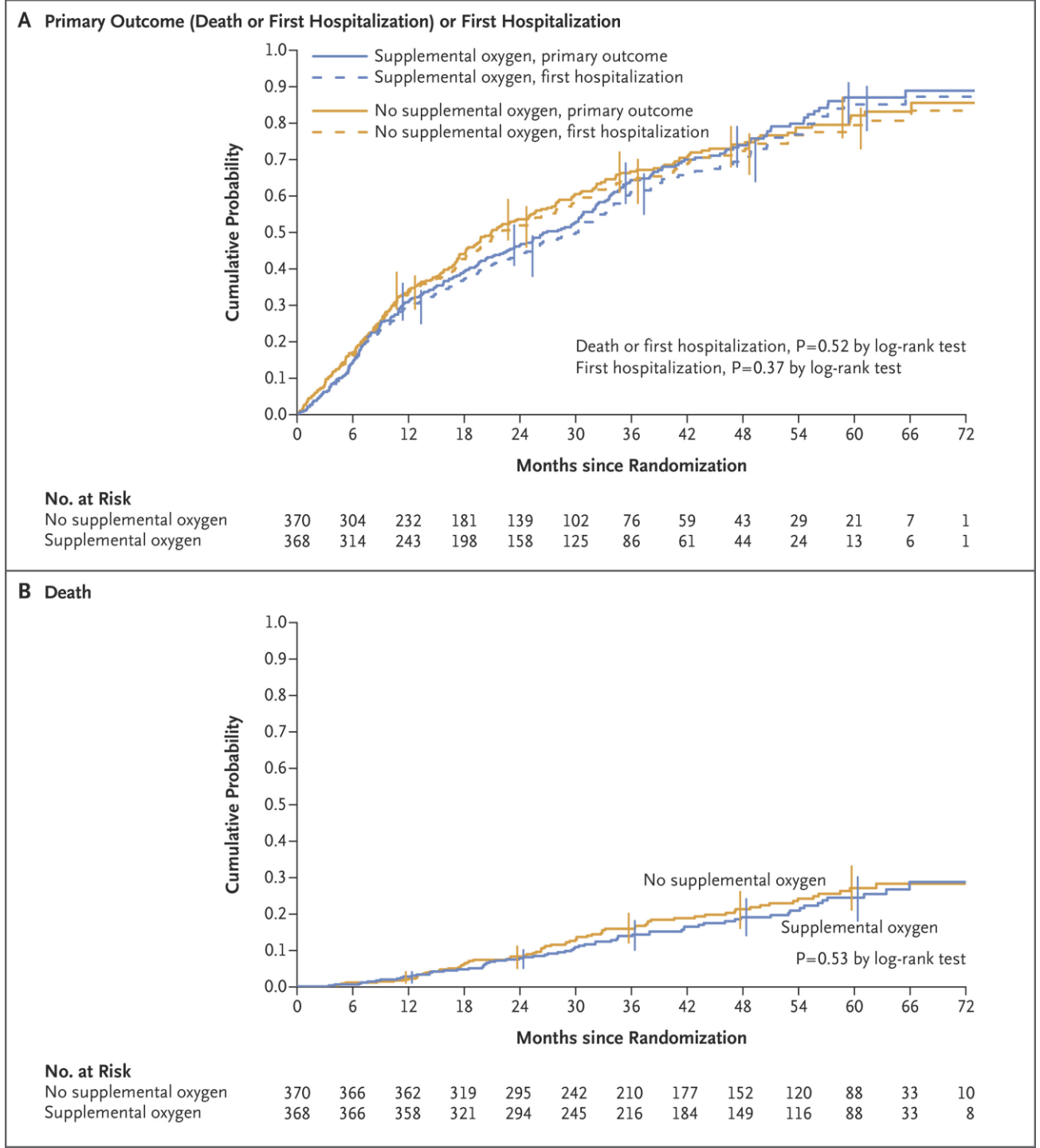
The Long-Term Oxygen Treatment Trial Research Group*

- Long-term Oxygen Treatment Trial (LOTT)
- Patients: stable COPD and resting or exercised induced moderate desaturation (N = 738, 42 centers)
  - Resting moderate desaturation: SpO_2 89 – 93%
    → 24-hour oxygen vs. no oxygen
  - Exercised induced moderate desaturation: during 6-minute walk test (6MWT), SpO_2 ≥80% for 5 minutes and SpO_2 <90% for 10 seconds
    → Oxygen during sleep and exercise vs. no oxygen

- No significant difference in
  - Time to death or first hospitalization
  - Rates of all hospitalizations, COPD exacerbations, COPD-related hospitalizations, quality of life measurements, lung function, 6MWT

N Engl J Med. 2016 Oct 27;375(17):1617-1627.

LOTT trial



N Engl J Med. 2016 Oct 27;375(17):1617-1627.

INOX trial (2020)

ORIGINAL ARTICLE

Randomized Trial of Nocturnal Oxygen in Chronic Obstructive Pulmonary Disease

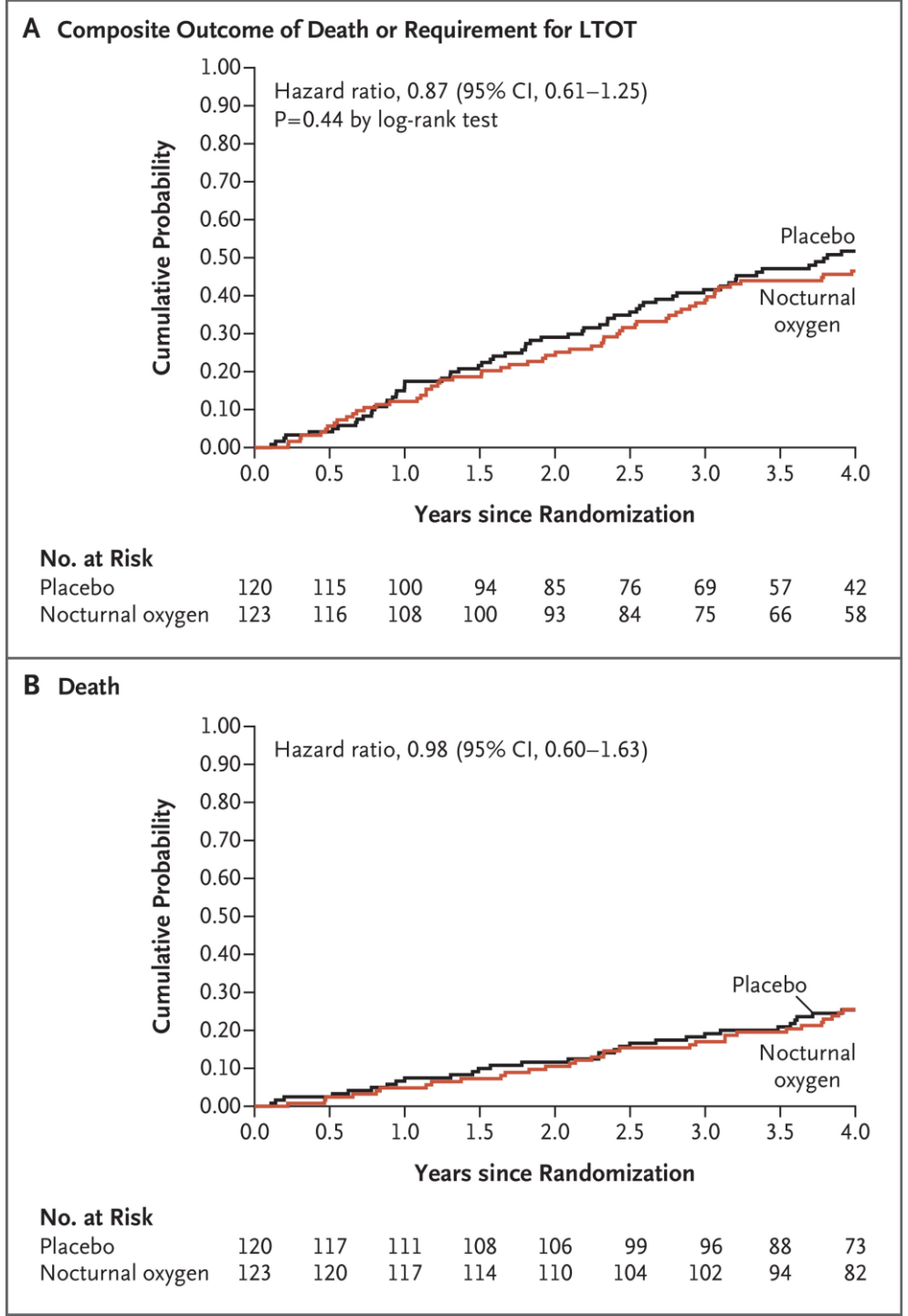
- International Nocturnal Oxygen (INOX) trial

- Patients: COPD with nocturnal desaturation (N = 243, 28 centers)
  - Nocturnal home oximetry recording: SpO_2 <90% at least 30% of the time in bed
  - Excluded severe daytime hypoxemia, sleep apnea

  → Nocturnal oxygen vs. placebo (ambient air from a sham concentrator)

N Engl J Med. 2020 Sep 17;383(12):1129-1138.

INOX trial



N Engl J Med. 2020 Sep 17;383(12):1129-1138.

INOX trial

Table 3. Exacerbation and Hospitalization Rates.

Variable	Nocturnal Oxygen	Placebo	Rate Ratio (95% CI)
Total person-yr of follow-up	366.1	340.3	
Acute exacerbations treated at home			
No. of events	473	396	
Rate per person-yr (95% CI)	1.29 (1.07–1.56)	1.16 (0.94–1.43)	1.11 (0.84–1.47)
Hospitalizations for any cause			
No. of events	144	156	
Rate per person-yr (95% CI)	0.39 (0.31–0.50)	0.46 (0.36–0.58)	0.86 (0.61–1.21)
Hospitalizations for respiratory conditions			
No. of events	104	104	
Rate per person-yr (95% CI)	0.28 (0.21–0.37)	0.31 (0.23–0.40)	0.93 (0.64–1.36)

N Engl J Med. 2020 Sep 17;383(12):1129-1138.

REDOX trial (2024)

- Registry-Based Treatment Duration and Mortality in Long-Term Oxygen Therapy (REDOX) trial

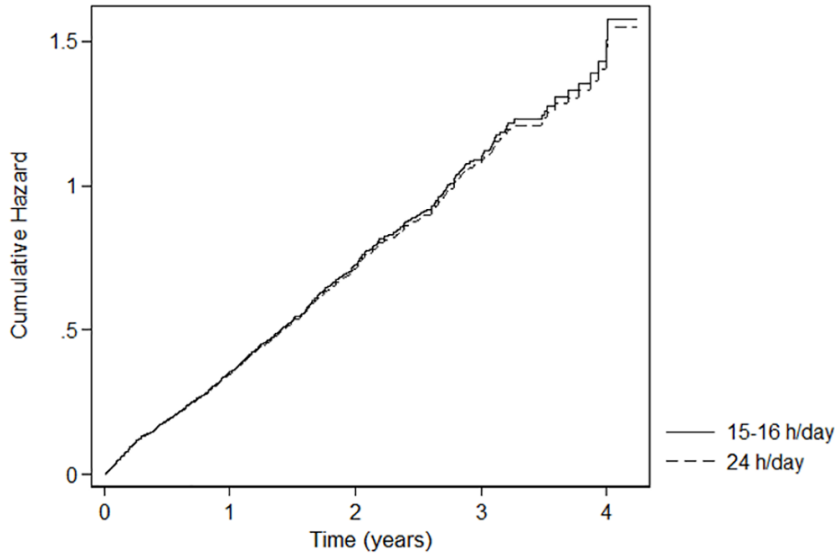
- Patients: 18 years or older who met established criteria for the receipt of long-term oxygen therapy for chronic severe hypoxemia (N = 241)
  - COPD 71%, pulmonary fibrosis 14%

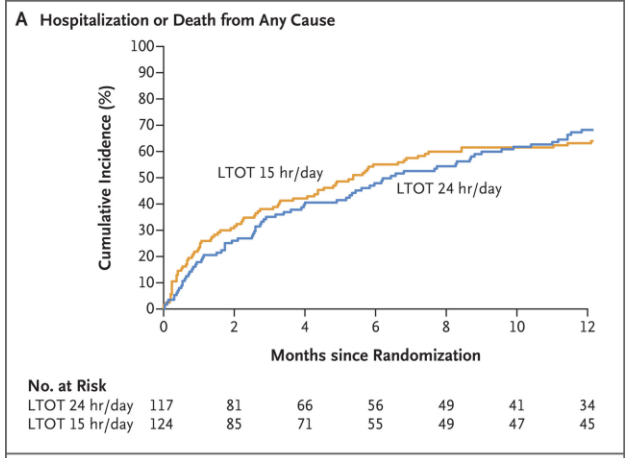
→ LTOT 24hr/day vs. 15hr/day, "the more hours oxygen, the better"?

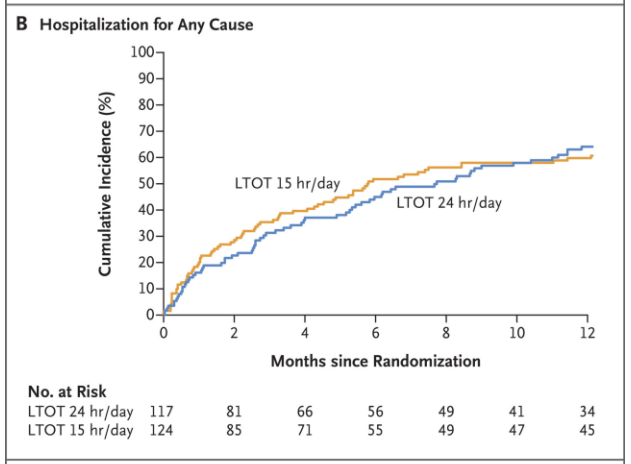
N Engl J Med. 2024 Sep 19;391(11):977-988.

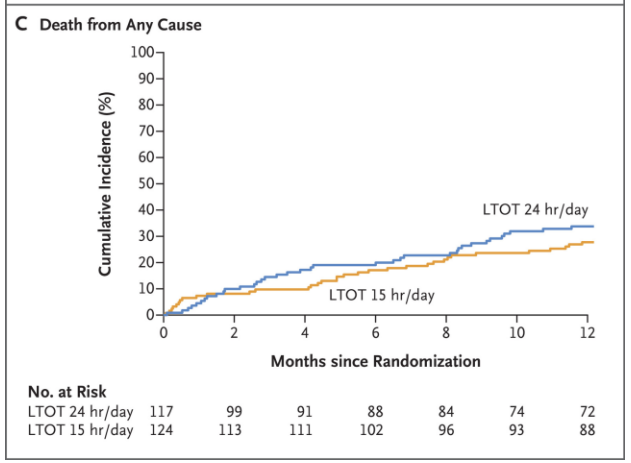
LTOT of 24 hours a day, not better

- REDOX trial (2024) showed no significant difference in mortality, hospitalization
- A Swedish COPD cohort study showed no significant difference in mortality rate. (N = 2,249)









N Engl J Med. 2024 Sep 19;391(11):977-988.
PLoS One. 2016 Sep 20;11(9):e0163293.

AmbOx trial (2018)

The Lancet Respiratory Medicine
Volume 6, Issue 10, October 2018, Pages 759-770

Articles

Effect of ambulatory oxygen on quality of life for patients with fibrotic lung disease (AmbOx): a prospective, open-label, mixed-method, crossover randomised controlled trial

- Patients: Fibrotic ILD, not hypoxic at rest, SpO_2 ≤88% on 6MWT (N = 74)
- Intervention: Ambulatory oxygen vs. placebo air
- Primary outcome: health-related quality-of-life (HRQoL) assessed by King's Brief ILD questionnaire (K-BILD)

Lancet Respir Med. 2018 Oct;6(10):759-770.

AmbOx trial

Table 3a. Quality of life scores after two weeks on and two weeks off ambulatory oxygen

PRIMARY OUTCOME	On oxygen	No Oxygen	Mean between treatment difference	P value
K-BILD* (N=74)				
Total score	55.5 (13.8)	51.8 (13.6)	3.7 (1.8 to 5.6)	<0.0001
Breathlessness and Activities score	44.4 (22.6)	35.8 (20.4)	8.6 (4.7 to 12.5)	<0.0001
Chest Symptoms score	65.5 (25.2)	57.9 (29.2)	7.6 (1.9 to 13.2)	0.009
Psychological Symptoms score	55.2 (19.6)	52.8 (19.6)	2.4 (-0.6 to 5.5)	0.12

Data are adjusted mean (SD) and mean difference (95% CI) for order of treatment KBLD=King's Brief Interstitial Lung Disease Questionnaire. *Higher scores reflect better quality of life. Recently reported minimal clinically important difference estimates for the KBILD scores are: total score: 4 (range 3.7-4.2); breathlessness and activities: 6 (5.6 – 6.5); psychological: 5.4 (4.6-6.9). and chest symptoms: 0.5SD:8.9 (34)

Lancet Respir Med. 2018 Oct;6(10):759-770.

Summary of key or recent trials in LTOT

Study (Year)	Population	O_2 Therapy vs Control	Key Outcomes	Findings
NOTT & MRC Trials (1980–81)	Severe hypoxemia, COPD (PaO_2 ≤55 mmHg)	LTOT ≥15 h/day vs no oxygen (or nocturnal)	Mortality	**LTOT demonstrated mortality reduction.** ; established LTOT standard of care.
LOTT Trial (2016)	Moderate hypoxemia, COPD (SpO_2 89–93% or exercise desaturation)	Long-term O_2 (continuous or during exercise/nocturnal) vs none	Composite: time to death or first hospitalization; QoL	**No significant benefit** – oxygen did not improve survival, time to hospitalizations, or QoL in moderate hypoxemia or exercise desaturation.
INOX Trial (2020)	COPD with isolated nocturnal desaturation (normal daytime oxygenation)	Nocturnal O_2 during sleep vs placebo air	Composite: death or need for LTOT; exacerbations, QoL	**No significant benefit** – nocturnal-only oxygen showed no effect on progression to LTOT or survival, and no improvement in exacerbations or QoL.
Lancet Meta-analysis (2022)	COPD with moderate hypoxemia and/or isolated nocturnal desaturation – 5 RCTs, N=1002	Home oxygen (LTOT or nocturnal) vs control	3-year Mortality	**No mortality benefit** – oxygen had little or no effect on 3-year survival in moderate hypoxemia and/or isolated nocturnal desaturation in COPD.
REDOX Trial (2024)	Chronic severe hypoxemia	LTOT of 24hr/day vs 15hr/day	Mortality; hospitalization	**No significant difference** between LTOT of 24hr/day and 15hr/day.
AmbOx Trial (2018)	Fibrotic ILD with exertional hypoxemia (resting SpO_2 >94%)	Ambulatory O_2 during activity vs no oxygen (crossover design)	Health-related QoL (K-BILD questionnaire)	**Improved HRQoL** – ambulatory O_2 was associated with better QoL scores and patient-reported mobility.
SOPHA Trial (2024)	Precapillary PH (PAH or CTEPH) with mild hypoxemia at rest and during exercise	Oxygen ≥16hr/day for 12 weeks vs no oxygen	6-minute walk distance; QoL	**Improved exercise capacity** – O_2 users had +42 m greater 6MWD vs controls, with signals of improved exertional symptoms.

Types of oxygen devices

Am J Respir Crit Care Med. 2020 Nov 15;202(10):e121-e141.

Table 5. Characteristics of Portable Oxygen Devices

	Metal Oxygen Cylinders	POCs	LOX
Size and weight	Available in multiple sizes from 2.5 to 9 kg (E cylinder in United States, which requires a trolley)*	Vary in weight (1.5–10 kg), noise, battery life, oxygen purity (87–95%), maximum breath rates, and settings (pulse flow, continuous flow, or both)†‡	Medium to large canister ranges between 2.5 and 4 kg
Filling	Some stationary concentrators allow patients to fill smaller oxygen cylinders in their home, (home-fill units), but these last <1 h on continuous-flow rates >3 L/min and therefore are inadequate for high-flow patients	No filling; POCs "concentrate" oxygen by extracting nitrogen from ambient air. They run off of a battery and can be recharged	Patients refill portable canisters from a larger home reservoir of LOX One liter of LOX expands to 860 L of gaseous oxygen
Pulse setting or continuous-flow capacity§	Oxygen-conserving devices using pulse-flow technology can be attached to metal cylinders to prolong the duration of supply by releasing oxygen only during inspiration Because of differences in an individual patient's ability to trigger a pulse dose of oxygen, and the volume delivered with each pulse at different respiratory rates, they may be insufficient for patients who require continuous oxygen with exertion at >3 L/min, such as those with interstitial lung disease, lung transplantation candidates, and others with severe hypoxemia	At a given pulse-flow setting, POCs differ as to the volume of oxygen (ml) per pulse, inspiratory time, and triggering sensitivity and may not consistently sense patients' inspiratory efforts to trigger the device* Pulse settings are based on an oxygen volume unique to each device, not a standardized L/min methodology	Portable LOX technology allows delivery of continuous-flow oxygen up to 15 L/min via a lighter and longer-duration device
Duration of supply	A single E tank with a stroller will last approximately 1.9 h on 6 L/min. Multiple cylinders are needed for high-flow (>3 L/min) patients to be out of the home >2–4 h‖	All POCs depend on a battery supply that depletes more rapidly with higher settings, higher respiratory rates, and the use of continuous-flow settings	A medium LOX canister will last 3 h at 6 L/min of continuous flow
Cost	Metal oxygen cylinders range from US$50 to US$100; additional costs for a regulator or oxygen-conserving device. Commonly supplied by U.S. DME companies	In the United States, many DME companies offer POCs as a portable option together with a stationary concentrator; individuals can also purchase them for US$2,000–4,000	Cost estimates are approximately four times higher per patient compared with POCs or metal-cylinder options because of the requirements for DME companies to access and store LOX, use specially outfitted delivery trucks, and provide weekly refill servicing¶
Travel	Metal cylinders not allowed for air travel	POCs are the only carry-on portable oxygen device allowed by the Federal Aviation Administration for air travel; some airlines may provide oxygen cylinders for emergency in-flight use only**	Liquid oxygen not allowed for air travel

Future directions for LTOT?

(1) High-flow nasal cannula (HFNC)

Table 1. Summary of the physiologic mechanisms and the resulting clinical benefits of high-flow nasal therapy (HFNT) in stable chronic obstructive pulmonary disease (COPD) patients.

Physiologic Mechanism	Clinical Benefit
Nasopharyngeal dead-space clearance	Reduction in dead-space ventilation and possible improvement of hyperinflation
Decrease in minute ventilation	Improvement in work of breathing
Provides positive end-expiratory pressure	Alveolar recruitment and improvement in gas exchange
Reduction in inspiratory effort	Improvement in work of breathing
Delivery of warm and humidified oxygen	Improvement in mucociliary clearance

J Clin Med. 2020 Nov 26;9(12):3832.

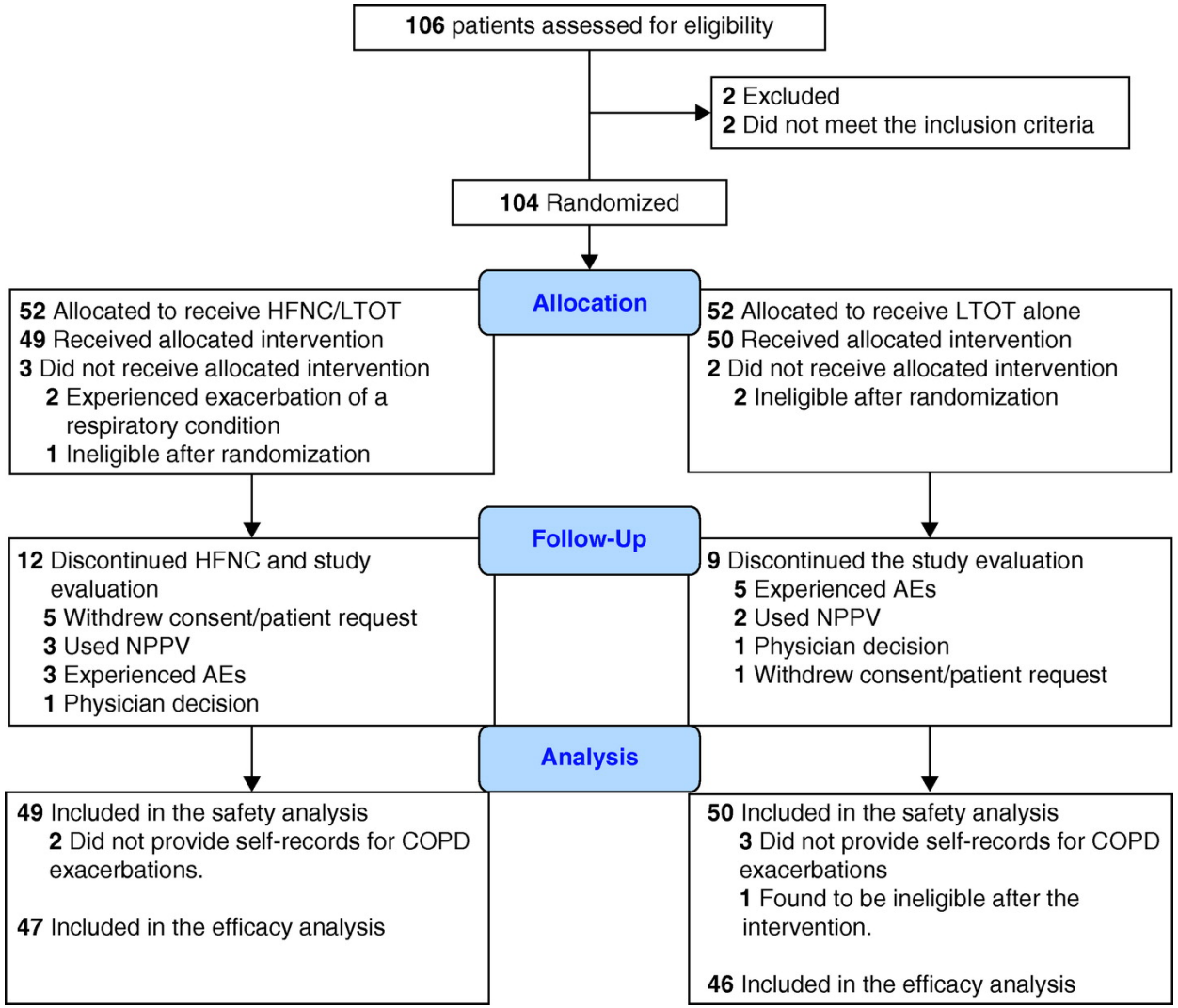
(1) High-flow nasal cannula (HFNC)

Table 2. Benefits and drawbacks of HFNT.

Benefits	Drawbacks
Improvement in dyspnea	Intolerance of noise, especially with higher flow
Dead space clearance	Abdominal distension
Can titrate FiO_2	Avoid use in facial trauma/surgery
Improved work of breathing	Decreased mobility
Improved gas exchange	Increased risk of aspiration
Delivery of warm and humidified oxygen	May cause epistaxis
Can be used at home	Can cause nasal discomfort

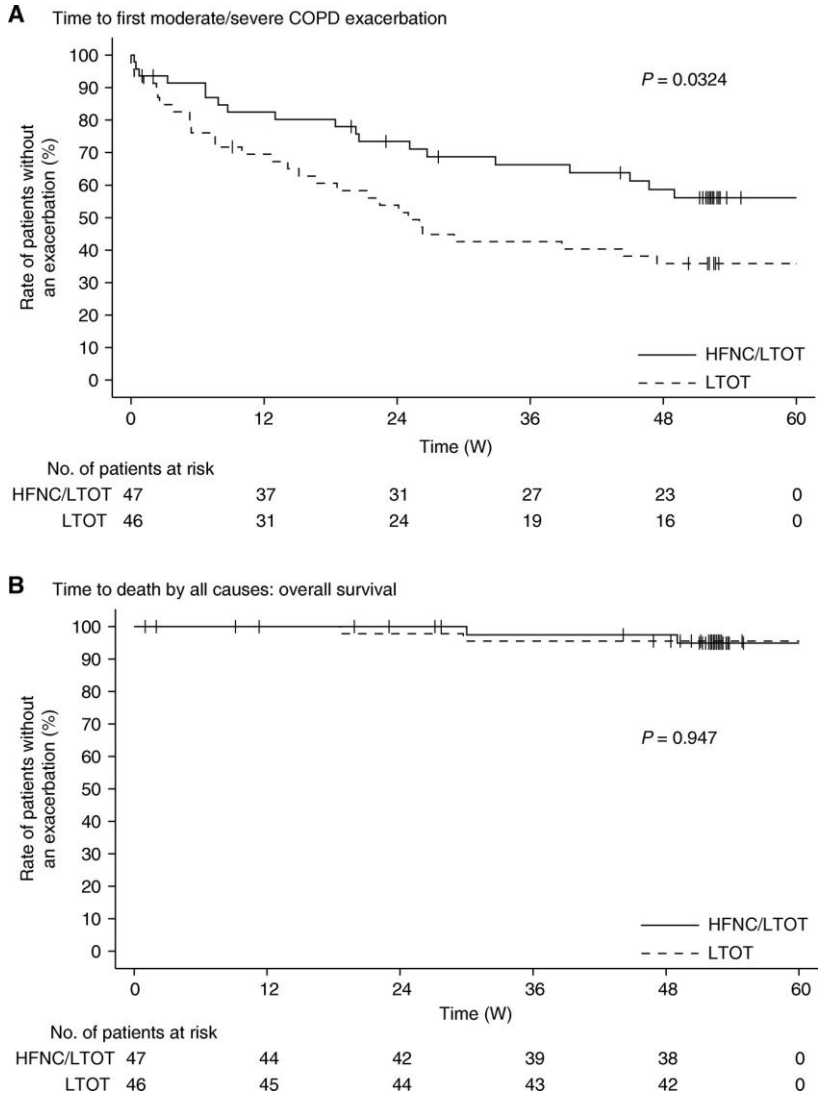
J Clin Med. 2020 Nov 26;9(12):3832.

(1) High-flow nasal cannula (HFNC)



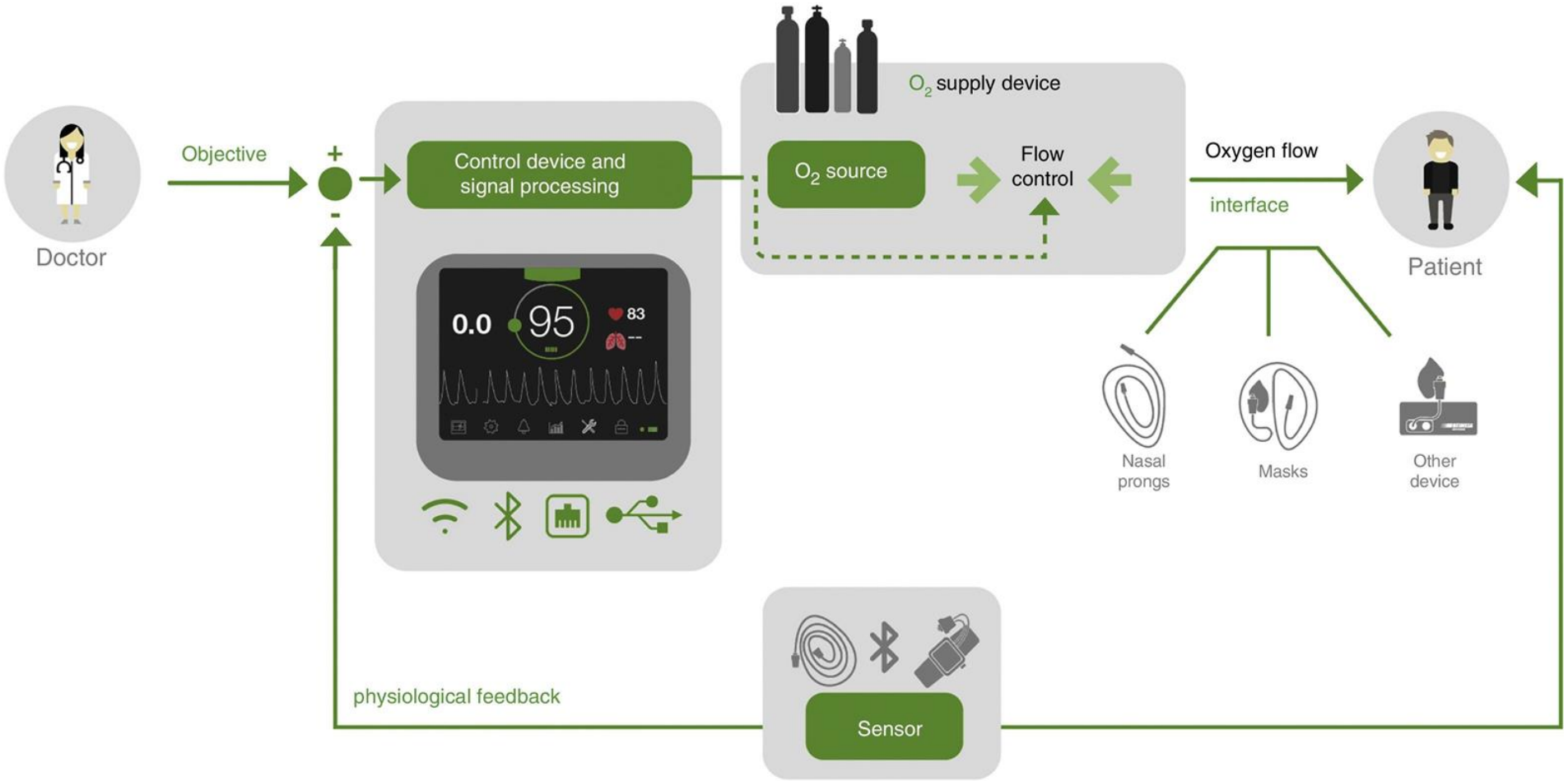
Am J Respir Crit Care Med. 2022 Dec 1;206(11):1326-1335.

(1) High-flow nasal cannula (HFNC)



Am J Respir Crit Care Med. 2022 Dec 1;206(11):1326-1335.

(2) Automatic oxygen titration



Arch Bronconeumol (Engl Ed). 2019 Jun;55(6):319-327.

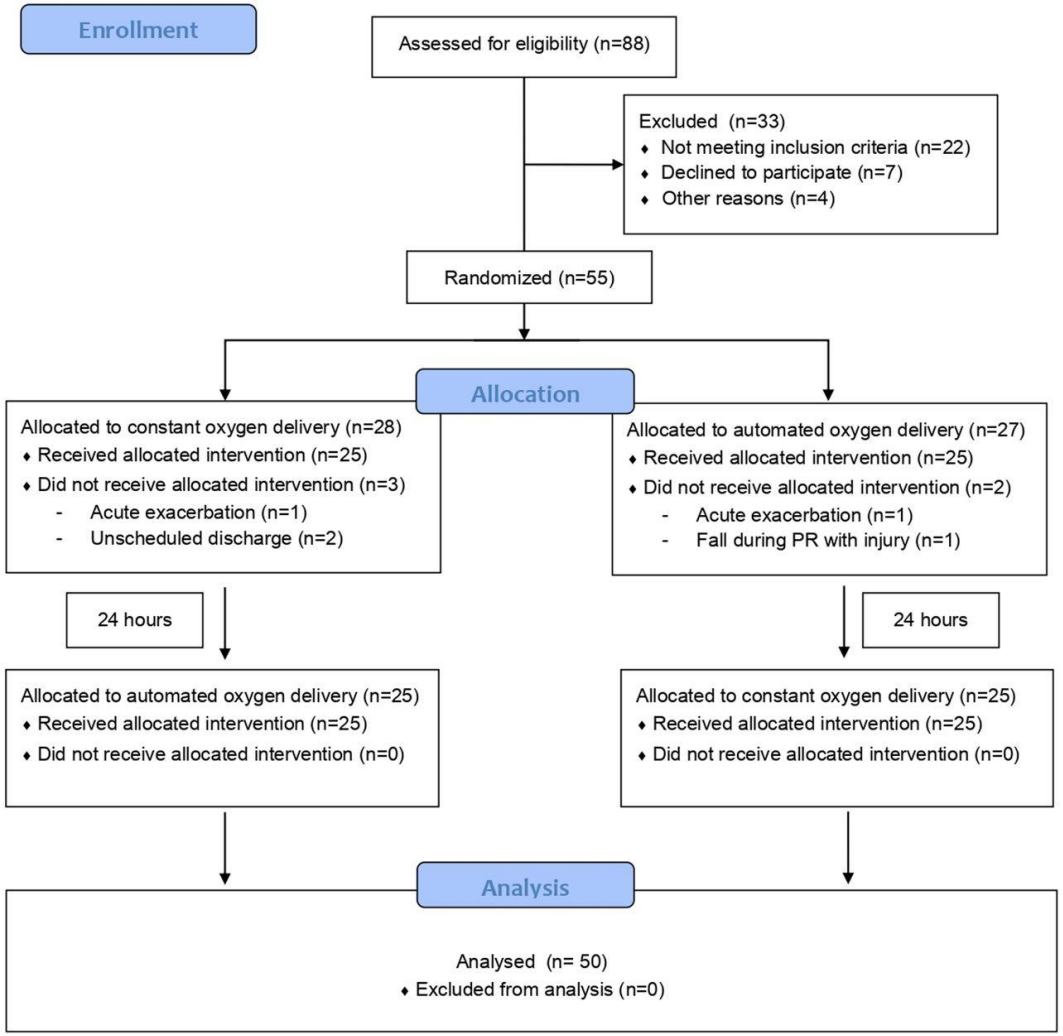
(2) Automatic oxygen titration

Original research

Automatic oxygen titration versus constant oxygen flow rates during walking in COPD: a randomised controlled, double-blind, crossover trial

Thorax. 2023 Apr;78(4):326-334.

(2) Automatic oxygen titration



Thorax. 2023 Apr;78(4):326-334.

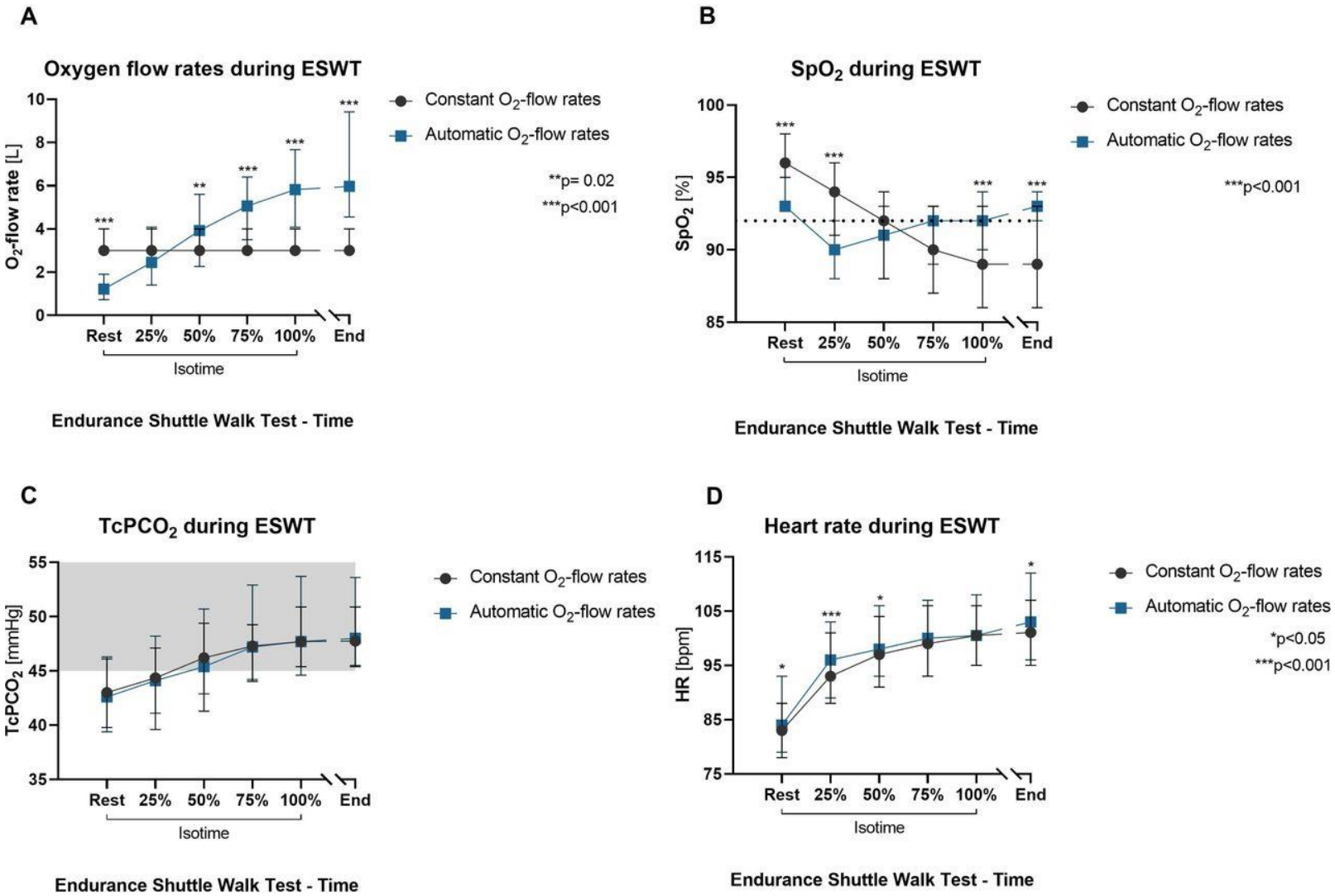
(2) Automatic oxygen titration

Table 2 Results

	Constant O_2-flow, CFOS, n=50	Automatic O_2-flow, ATOS, n=50	P value[x)]	Median effect (95% CI) automatic—constant
Primary outcome				
ESWT Time, s	333.50 (214, 581)	522.5 (277, 1200)	$1.203E^{-04}$	144.5 (54 to 241.5)
Secondary outcomes				
ESWT Distance, m	310 (200, 620)	465 (200, 1030)	$2.602E^{-04}$	150 (60 to 31)
Oxygen Mean O_2-flow rate	3.0 (3.0, 4.0)	4.5 (3.2, 6.1)	$1.000E^{-05}$	1.34 (0.68 to 2.14)

Thorax. 2023 Apr;78(4):326-334.

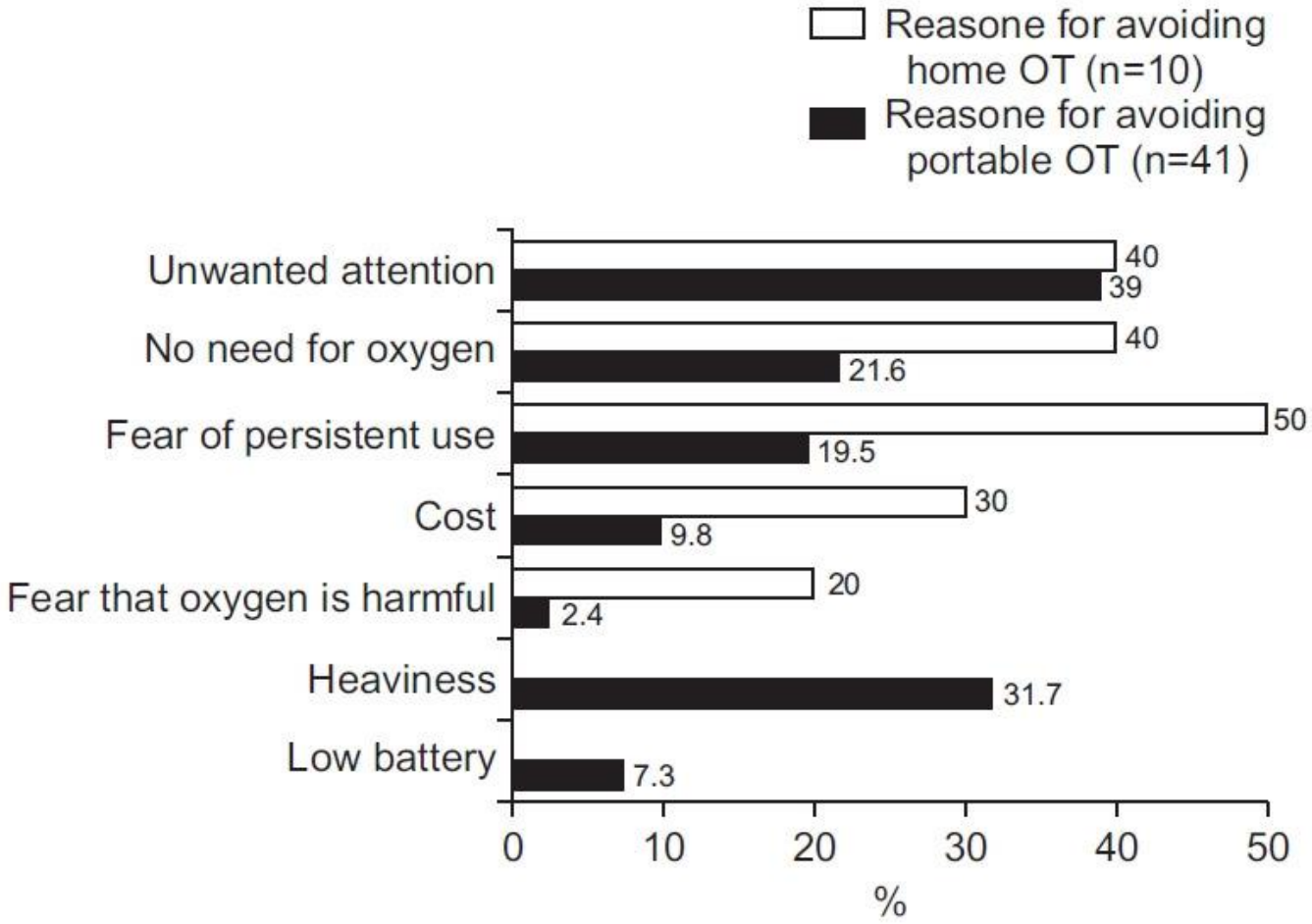
(2) Automatic oxygen titration



한림대학교의료원
한림대학교성심병원

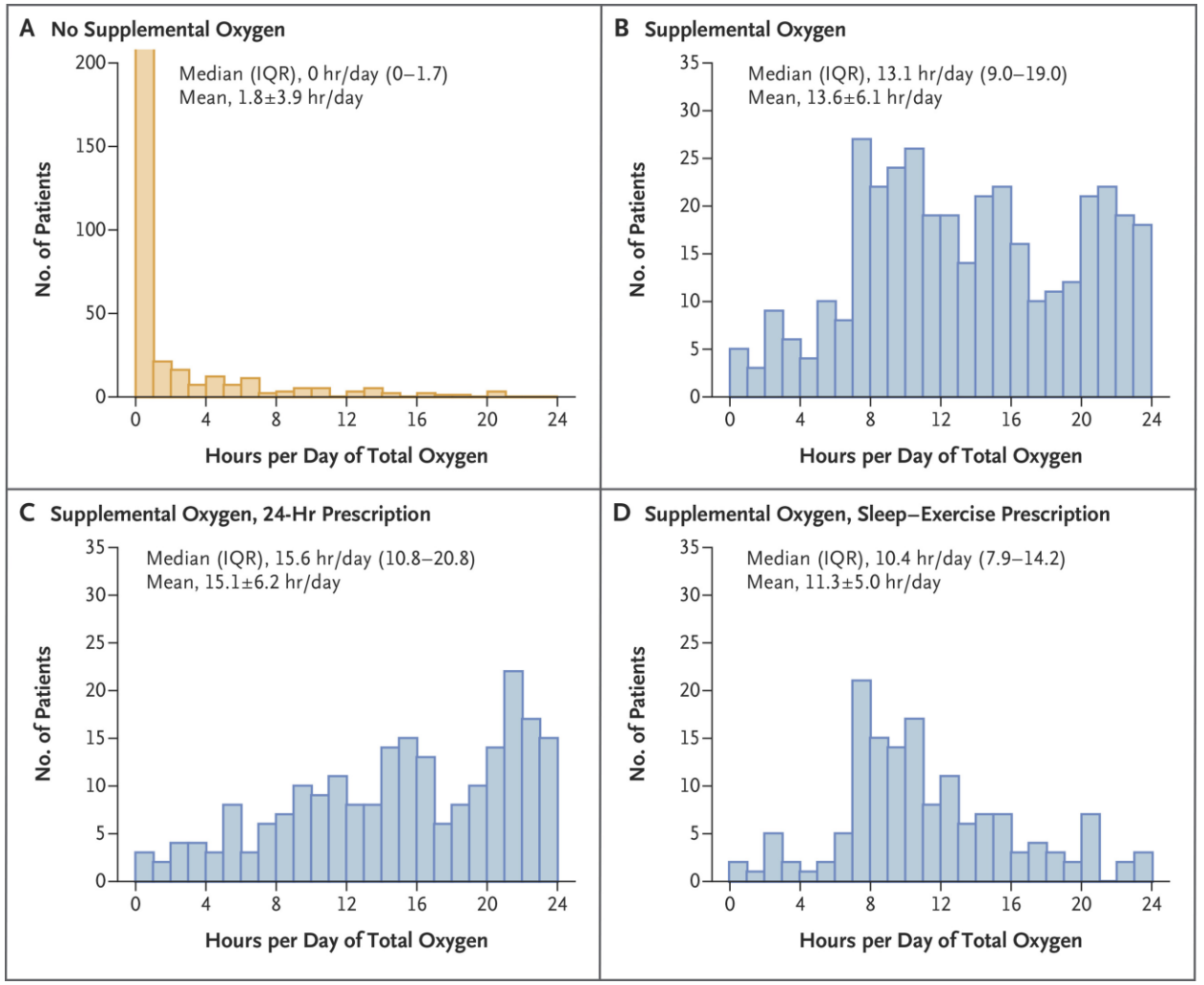
Thorax. 2023 Apr;78(4):326-334.

(3) The issue of adherence: the need for telemonitoring?



Tuberc Respir Dis (Seoul). 2023 Nov 29;87(1):100–114.

(3) The issue of adherence: the need for telemonitoring?



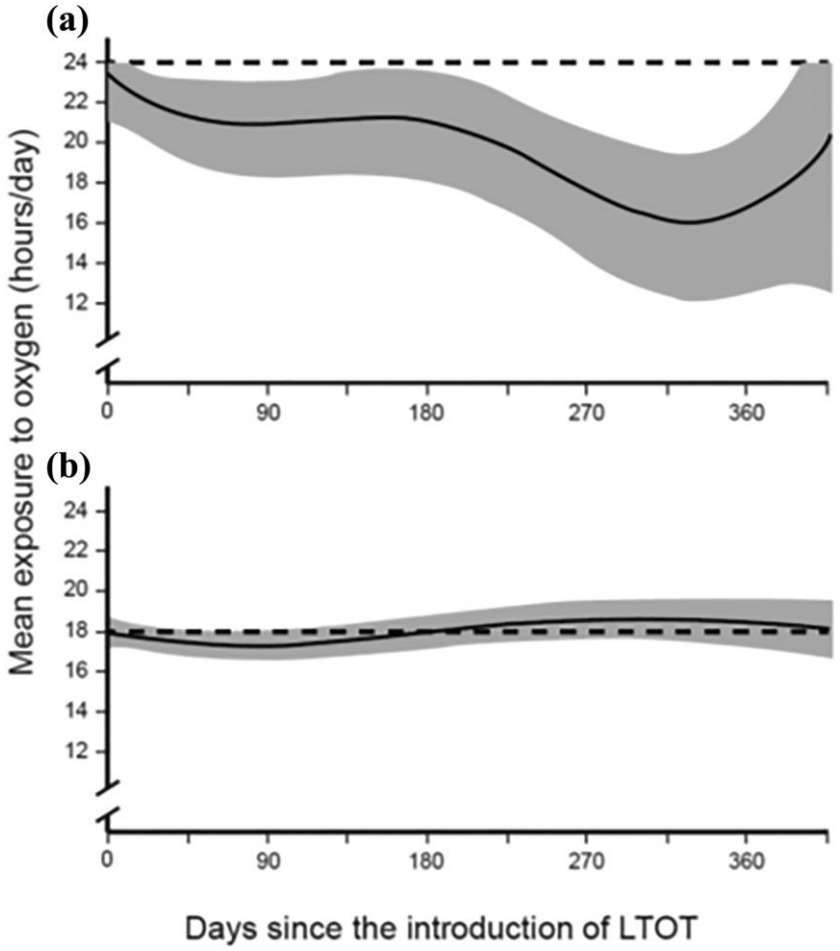
N Engl J Med. 2016 Oct 27;375(17):1617-1627.

(3) The issue of adherence: the need for telemonitoring?

Table 3. Daily exposure and compliance to home oxygen therapy.

Prescription	Number of patients	Daily exposure to oxygen (hours/day), mean (SD)[a]	Number of adherent patients (%)
All patients	115	17.8 (5.5)	69 (60)
≥15 hours/day	12	11.9 (5.4)	2 (17)
≥16 hours/day	3	12.4 (2.3)	0 (0)
≥18 hours/day	84	18.1 (5.1)	57 (68)
24 hours/day	16	21.4 (4.1)	10 (63)
Between-group comparison		$p < 0.0001$	$p = 0.0007$

SD: Standard deviation.
[a]Adjusted for portable oxygen utilizations and hospitalizations.



Chron Respir Dis. 2019 Jan-Dec:16:1479972318767724.

Table 5. Studies of compliance to oxygen therapy in COPD that used objective measures.

Reference	Population/sample size	Eligibility criteria to LTOT	Time since the introduction of LTOT[a]	Method for compliance measurement	Results
Evans et al.[5]	14 patients with COPD; 10 (71%) current smokers	Not specified	All patients presumably studied from prescription over 12 months	Every 3 months technical staff visited the patients' home to read the hidden clock	Mean daily use of concentrator: 13.3 hours (SD: 2.0); 14% used LTOT for ≥15 hours/day
Walshaw et al.[6]	61 patients, including 55 (90%) with COPD; 12 patients (20%) current smokers	Not specified	12 months (SD: 6.4; range: 4–22)	Oxygen concentrator meter readings	Mean daily use of concentrator: 14.7 hours (SD: 5.3); 28 patients (46%) ran their concentrator for at least 15 hours a day
Restrick et al.[7]	176 patients, including 148 (84%) with COPD; 34 patients (19%) current smokers	Absolute indications: FEV_1 < 1.5 liters; FVC < 2 liters; PaO_2 < 7.3 kPa; $PaCO_2$ > 6.0 kPa; peripheral edema	Median: 19 months (range: 1–64)	Meter readings	Median daily use of concentrator: 15 hours; 74% used LTOT for >12 hours/day
Morrison et al.[8]	519 patients, including 410 (79%) with COPD; 14% current smokers at prescription	Absolute indications: FEV_1 < 1.5 liters; PaO_2 < 7.3 kPa; $PaCO_2$ > 6.0 kPa; edema, clinically stable, repeated measures, optimal therapy, no smoking	Not specified	Three monthly oxygen concentrator meter readings	Mean daily use of concentrator: 14.9 hours (SD: 6.0); 56% used LTOT for ≥15 hours/day
Pépin et al.[9]	930 patients, all with COPD; 121 patients (13%) current smokers	Based on measured blood gas results in 72%; 23% were prescribed oxygen on the basis of severe disability	36 months (SD: 24; range: 6–144)	Two readings of the concentrator clock counter over a 3-month period	Mean daily use of concentrator: 14.5 hours (SD: 5); 419 (45%) used LTOT for ≥15 hours/day; 230 (25%) used LTOT for ≥12 hours/day
Peckham et al.[10]	Non-randomized comparison of two groups: total of 86 patients, including 75 (87%) with COPD; 7 (8%) current smokers; 45 patients received practical teaching about the use of oxygen; 41 served as controls	Teaching group: stable hypoxia with PaO_2 <7.3 kPa with stable spirometry on two separate occasions at least 3 weeks apart; control group: not specified	All patients studied from prescription over 6 months	Electrical meter recordings from the concentrator	82% of those who received practical teaching used LTOT for ≥15 hours/day (vs. 44% in the control group; $p < 0.0002$)
Ringbaek et al.[11]	182 patients, including 153 (84.1%) with COPD; 14.1% current smokers	Not specified	Median: 6.2 months (range: 0–112)	Oxygen concentrator meter readings and calculation of oxygen cylinders delivered	65% used LTOT for >15 hours/day
Katsenos et al.[12]	249 patients, including 186 (74.7%) with COPD; 25.7% current smokers	Not specified	22.3 months (SD: 30.11; range: 1–300)	Time counter attached to the concentrator	Mean daily use of concentrator: 9.7 hours (SD: 6.1); 27% used LTOT for ≥15 hours/day
Nasilowski et al.[13]	30 patients, including 23 (77%) with COPD; no data about smoking provided	PaO_2 < 55 mmHg or between 55 mmHg and 59 mmHg when radiological or electrocardiographical signs of pulmonary hypertension and/or secondary polycythemia (hematocrit > 55%) were present	All patients studied from prescription over 14 months	Concentrator counter reading performed by visiting nurses	Mean daily use of concentrator: 12.5 hours (SD: 4.6); 37% used LTOT for ≥15 hours/day; compliance diminished over time: 48% used LTOT for ≥15 hours/day in the first month of treatment; this proportion decreased to 25–33% in the following months

가정산소요법의 효과적인 관리를 위한 재택 모니터링 시스템 개발 및 적용

한림대학교 성심병원
교수 **황 용 일**

주관연구기관

한림대학교성심병원

공동연구개발기관

가톨릭대학교 서울성모병원 THE CATHOLIC UNIV. OF KOREA SEOUL ST. MARY'S HOSPITAL

한양대학교병원 HANYANG UNIVERSITY SEOUL HOSPITAL

SUDO Healthcare Inc

실증연구기관

강동성심병원 Kangdong Sacred Heart Hospital

건국대학교병원 KONKUK UNIVERSITY MEDICAL CENTER

SAMSUNG 삼성서울병원

SNUH 서울대학교병원운영 서울특별시보라매병원

동아대학교병원 Dong-A University Hospital

KNUH 강원대학교병원 Kangwon National University Hospital

한림대학교춘천성심병원

한림대학교동탄성심병원

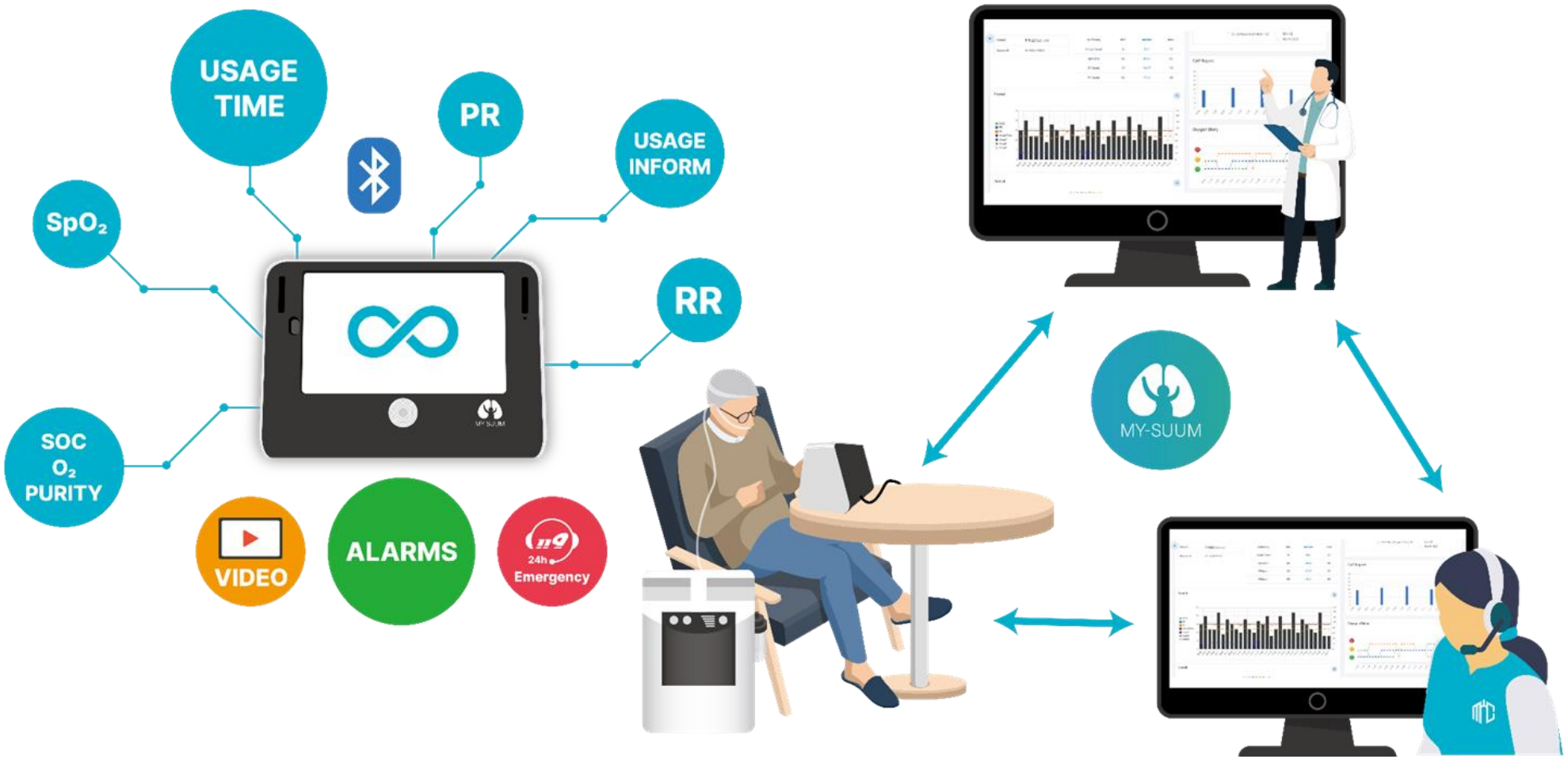
SMC 강북삼성병원

가톨릭대학교 의정부성모병원

울산대학교병원 ULSAN UNIVERSITY HOSPITAL

인제대학교일산백병원 INJE UNIVERSITY ILSAN PAIK HOSPITAL

마이숨:케어 서비스 시스템



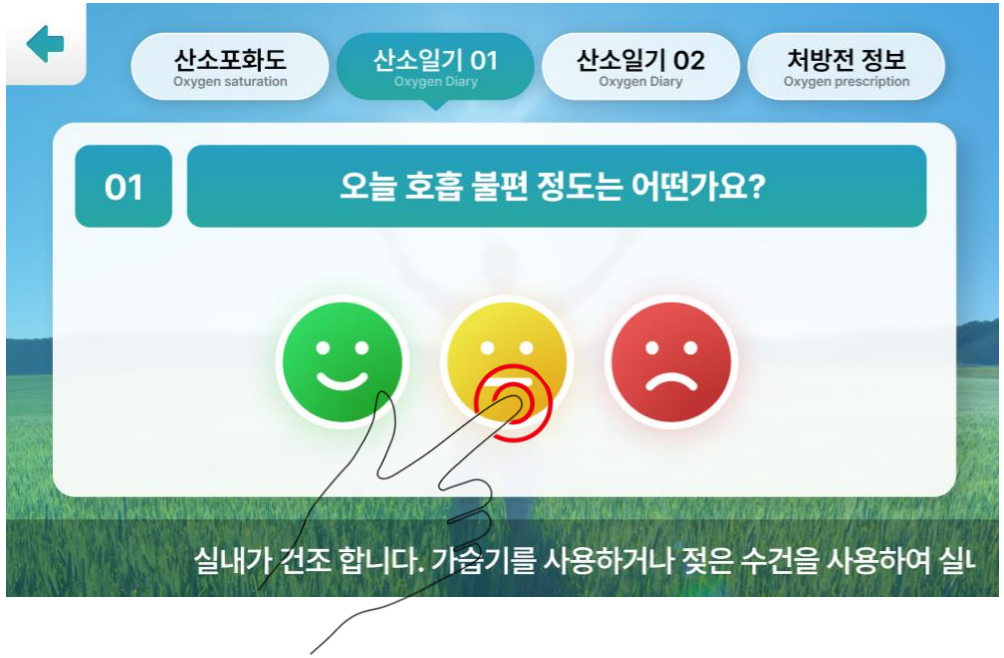
마이숨:케어 서비스 케어비전

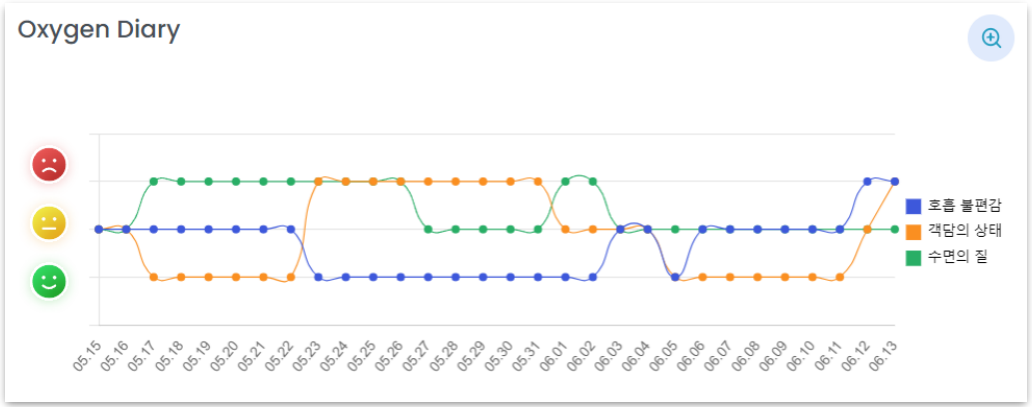
마이숨, 보호자1&2, 병원
서비스 공급 업체 24시간 콜센터, 주 보호자 1&2, 주 병원 응급실
버튼을 누르면 바로 통화 영상 통화 연결 가능

산소수첩
매일 산소포화도 측정, 상태 설문지 작성
산소처방전 정보확인

나의일기
고령 환자의 나의 일상 화상 기록

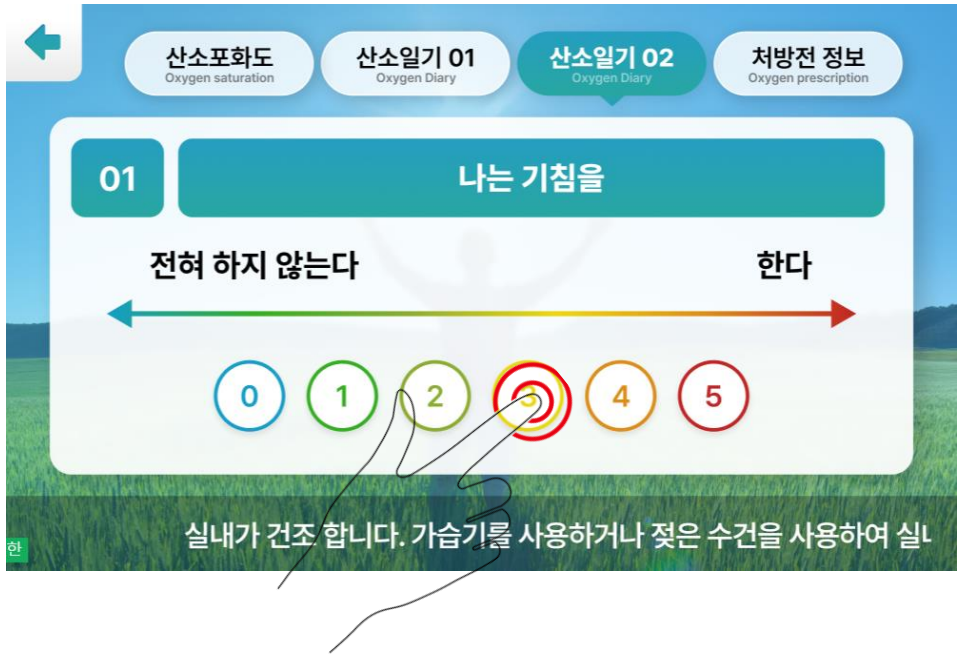
마이숨:케어 서비스 케어비전_산소수첩

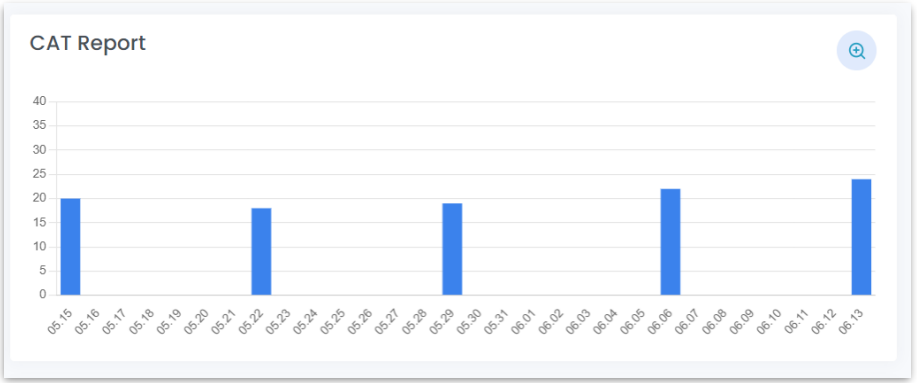




No	질문	답변
1	오늘 호흡 불편 정도는 어떤가요?	녹색: 1 (상태좋음) 노랑: 2 (보통) 빨간색: 3 (나쁨)
2	객담의 상태는 어떤가요?	
3	지난밤 잘 주무셨나요?	

마이숨:케어 서비스 케어비전_산소수첩





JKMA 만성폐쇄성폐질환 최신 진단지침

COPD Assessment Tool (CAT) (in Korean)

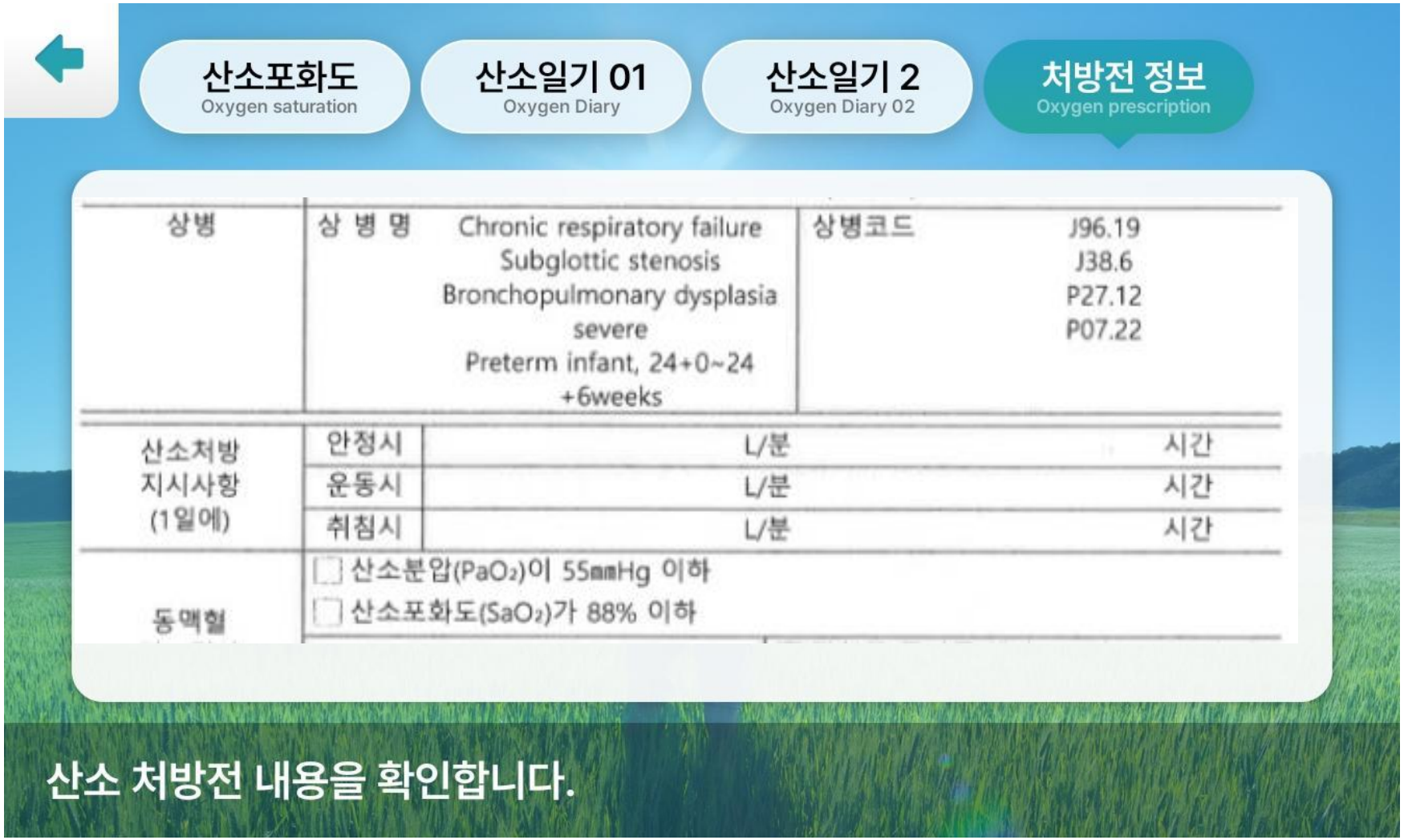
귀하의 만성폐쇄성폐질환(COPD)은 어떠십니까? 만성폐쇄성폐질환(COPD) 평가 검사 (CAT)를 해주십시오.

다음 질문들은 귀하와 담당 의료진이 만성폐쇄성폐질환(COPD)이 귀하의 육체적, 정신적 건강과 일상생활에 미치는 영향을 평가하기 위한 것입니다. 답안과 검사 점수는 만성폐쇄성폐질환(COPD) 관리를 정상시키고 치료 효과를 최대화하는데 사용될 수 있습니다.

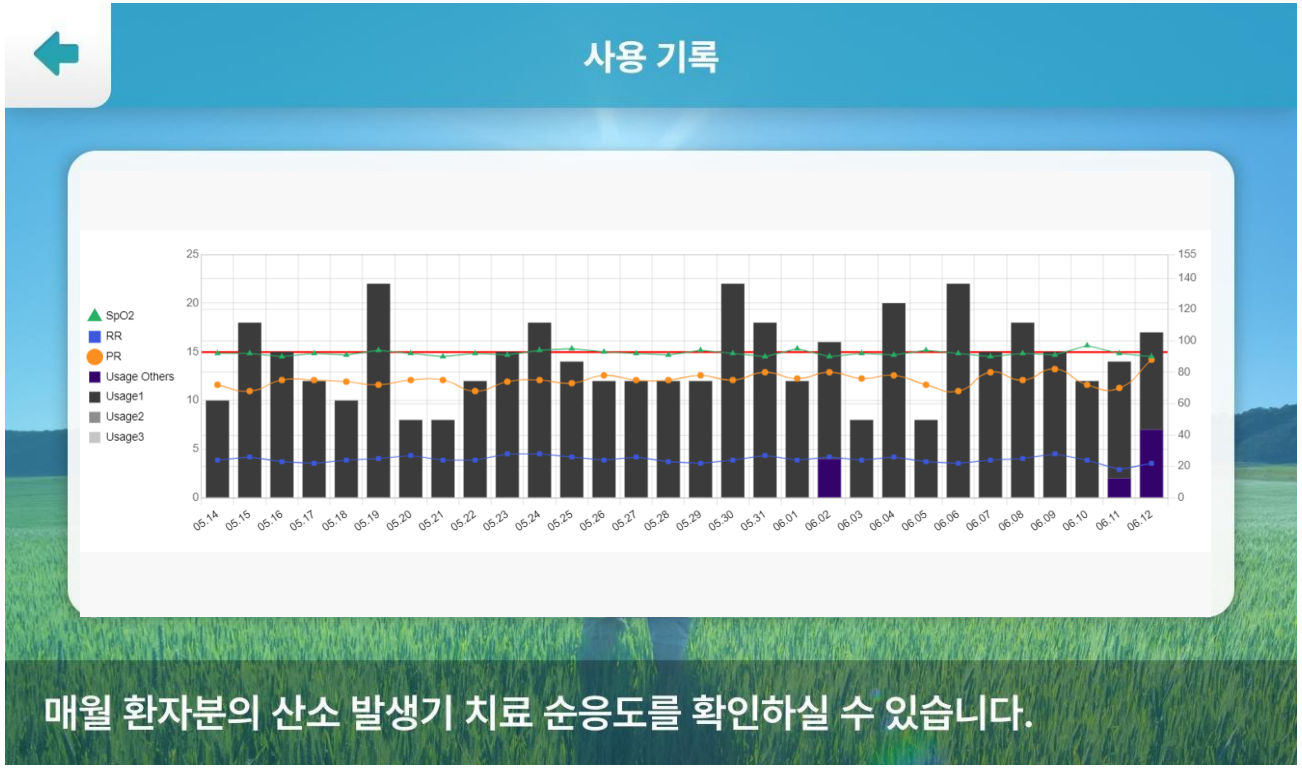
나는 기침을	전혀 하지 않는다	0 1 2 3 4 5	한다
나는 가슴에 가래가	전혀 없다	0 1 2 3 4 5	가득 차 있다
나는 가슴에 답답함을	느끼지 않는다	0 1 2 3 4 5	많이 느낀다
나는 언덕이나 계단을 오를 때 숨이	전혀 차지 않는다	0 1 2 3 4 5	많이 차다
나는 집에서 활동하는데 제약을	전혀 받지 않는다	0 1 2 3 4 5	많이 받는다
나는 폐질환에도 불구하고 외출하는데	자신이 있다	0 1 2 3 4 5	전혀 자신이 없다
나는 잠을	깊이 잔다	0 1 2 3 4 5	깊이 못 잔다
나는 기운이	왕성하다	0 1 2 3 4 5	없다

Reproduced from Korea Academy of Tuberculosis and Respiratory Diseases. Resource center: CAT [Internet]. Seoul: Korean Academy of Tuberculosis and Respiratory Disease; 2018. with permission from Korea Academy of Tuberculosis and Respiratory Diseases [14].

마이숨:케어 서비스 케어비전_산소수첩



마이숨:케어 서비스 케어비전_사용기록



환자 및 가족,
본사 방문 담당자와 함께
산소 사용 정보 및 상태 측정 값을
(이전 1개월의 산소 사용정보..)
통계자료로 확인하여
치료 순응도를 한눈에 확인 가능

MY-SU:M
마이숨케어 산소치료 순응 보고서

[redacted] (남) 80대
43[redacted]
한림대학교 평촌성심병원
SimplyGo Mini with Extended

2025-03-05 ~ 2025-04-04
Device ID : 602236110141

7 | 14 | 30 | 90

Compliance Summary

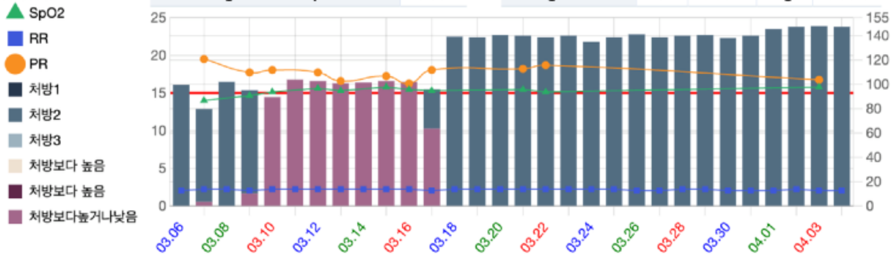
	MIN	MEDIAN	MAX
Usage(hour)	12.8	22.3	23.8
SpO2(%)	65	95	99
RR(bpm)	1	14	29
PR(bpm)	92	110	138

Last Prescription

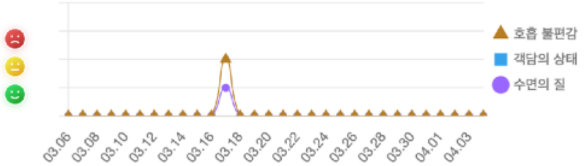
산소치료처방 지시사항(1일에)			
처방전 발행일 2024.10.07			
안정시	1-2	L/분	시간
운동시	2	L/분	시간
취침시	1	L/분	시간

Trend

Percentage of use as prescribed	78.95%	Usage Others	Low	0.00%	High	0.00%



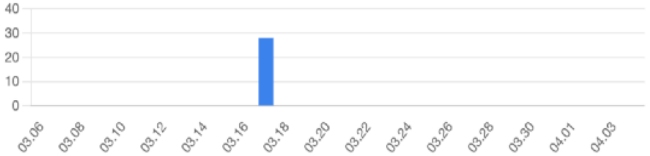
Oxygen Diary



항목	MIN	MEDIAN	MAX
호흡 불편감	2	2	2
객담의 상태	2	2	2
수면의 질	1	1	1

나쁨 3 보통 2 상태좋음 1

CAT Report



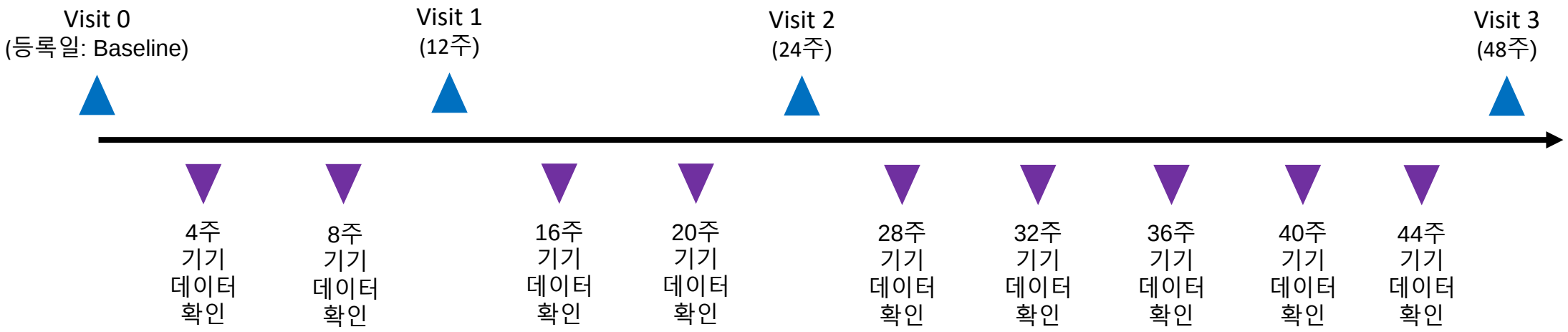
MIN	MEDIAN	MAX
28	28	28

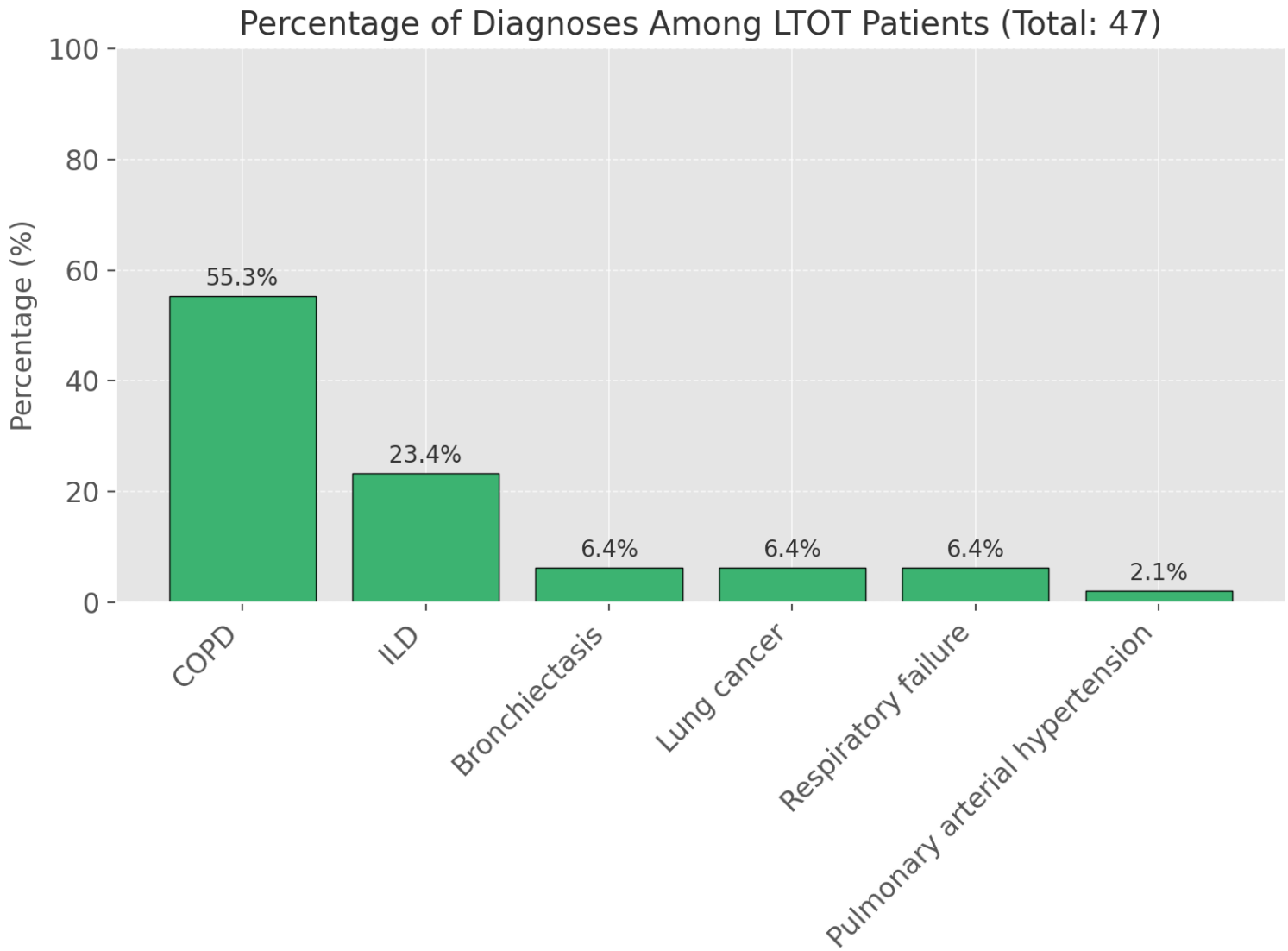
Physician Comment

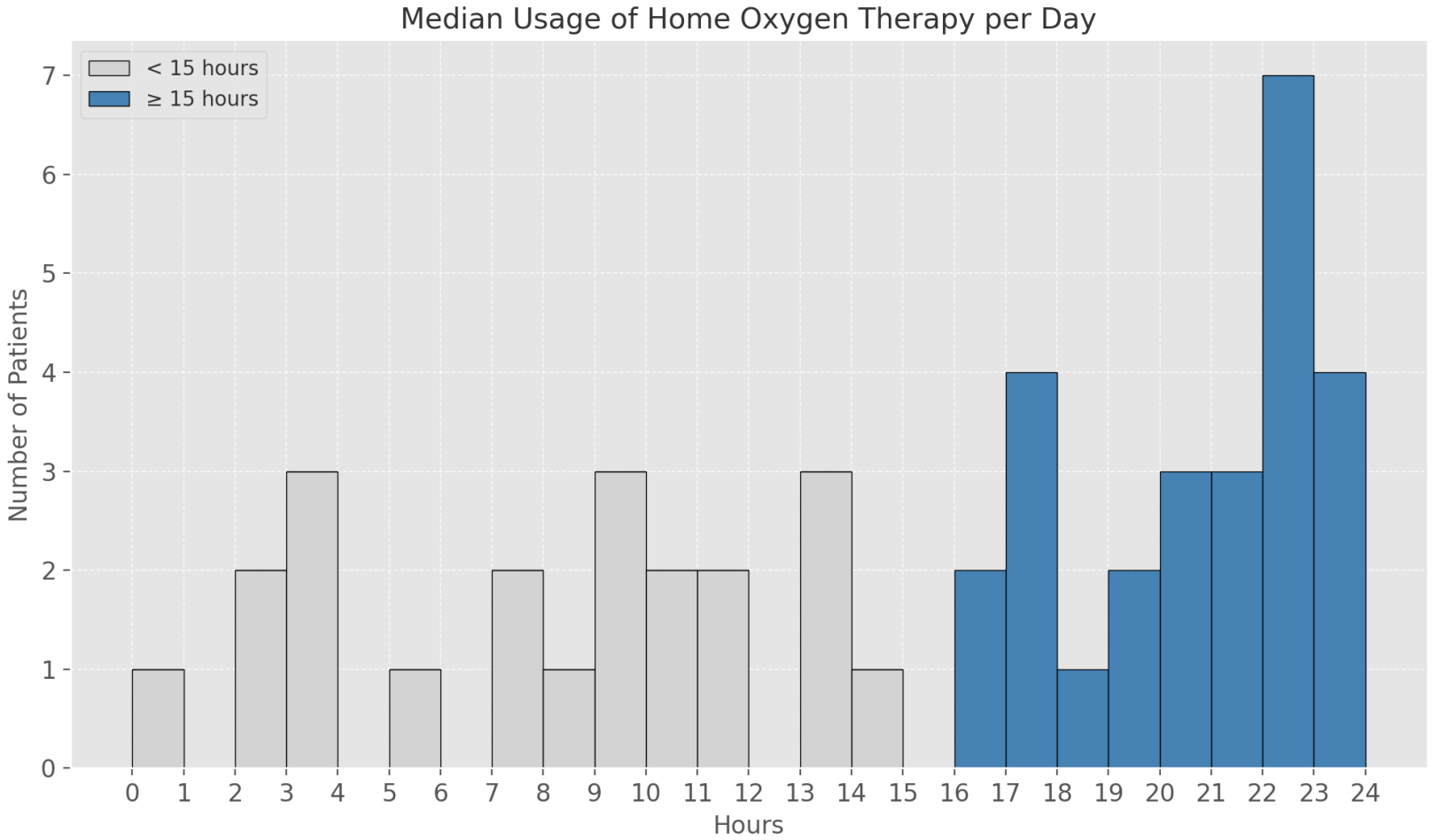
마이숨:케어
의료인 사이트

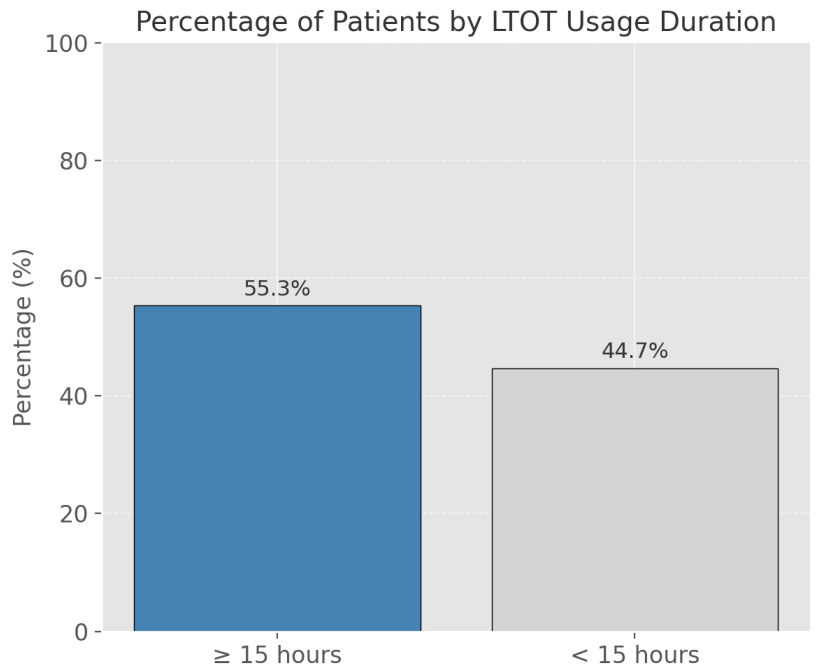
(주)멕헬스케어 mekhealthcare.co.kr TEL.1644-1537 / (주)위드메드 www.withmed.net TEL.1566-4423

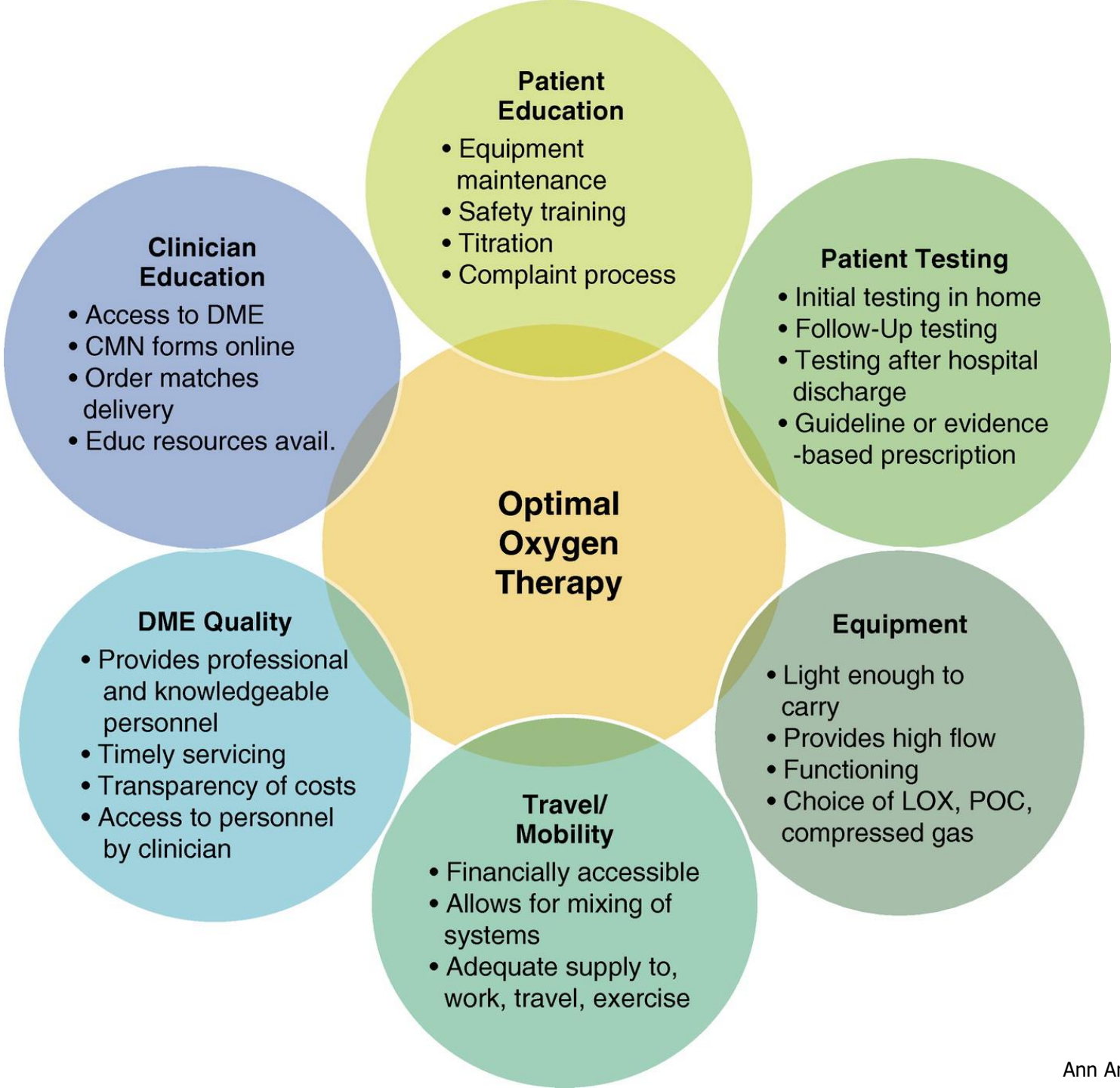
한림대학교의료원
한림대학교성심병원


Visit 0
(등록일: Baseline)
Visit 1
(12주)
Visit 2
(24주)
Visit 3
(48주)
4주 기기 데이터 확인
8주 기기 데이터 확인
16주 기기 데이터 확인
20주 기기 데이터 확인
28주 기기 데이터 확인
32주 기기 데이터 확인
36주 기기 데이터 확인
40주 기기 데이터 확인
44주 기기 데이터 확인


Percentage of Diagnoses Among LTOT Patients (Total: 47)
Percentage (%)
100
80
60
40
20
0
55.3%
23.4%
6.4%
6.4%
6.4%
2.1%
COPD
ILD
Bronchiectasis
Lung cancer
Respiratory failure
Pulmonary arterial hypertension


Median Usage of Home Oxygen Therapy per Day
< 15 hours
≥ 15 hours
Number of Patients
Hours
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Percentage of Patients by LTOT Usage Duration
Percentage (%)
55.3%
44.7%
≥ 15 hours
< 15 hours



Ann Am Thorac Soc. 2018 Dec;15(12):1369-1381.

Summary

- Long-term oxygen therapy (LTOT) is an established treatment for patients with severe hypoxemia (PaO2 ≤55 mmHg)
  - Improves morbidity and mortality, as well as quality of life

- Evidence is insufficient for moderate hypoxemia, nocturnal hypoxemia, or exercise desaturation

- Technological advancements can pave the way to improve the efficacy and alleviate the burdens of LTOT
  - HFNC
  - Automatic oxygen titration
  - Telemonitoring