Akut Hipoksemik Solunum Yetmezliği: YANK&NİV

Nur Aleyna Yetkin

Sunum Planı

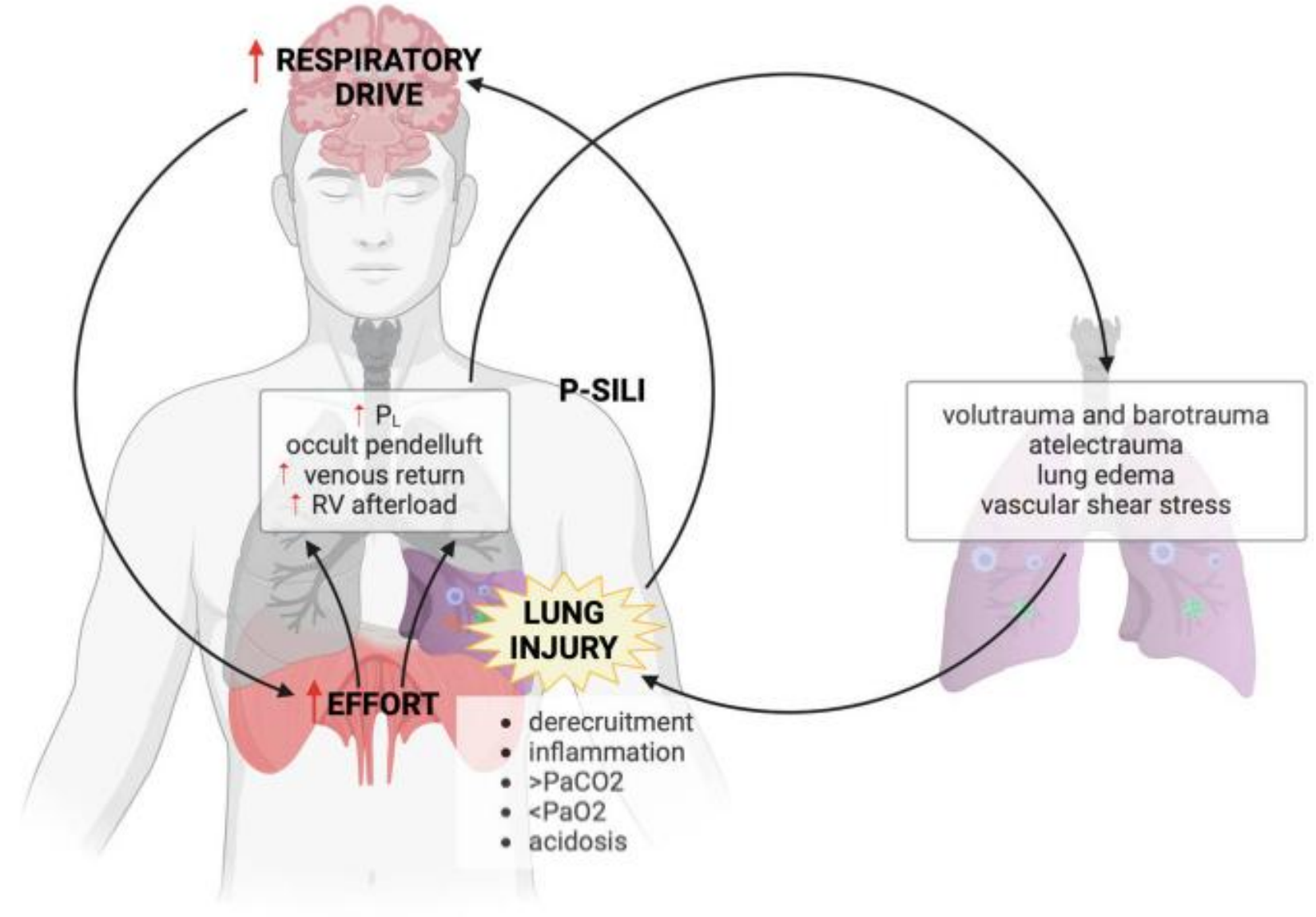
- Hipoksemik Solunum Yetmezliği Tanımı
- HSY Patofizyolojisi
- Noninvaziv Ventilasyon Yöntemlerin Etki anizmaları
- Noninvaziv Ventilasyon Yöntemlerin Seçimi
- Tedavi Başarısında kullanılan Ölçütler

Dünya genelinde yoğun bakıma yatışların önemli bir bölümü (%20-40)* LUNG-SAFE

Değişken solunum dinamikleri → P-SILI artış

Hem AHRF hem ARDS açısından aynı spektrumun parçasıdır.

*JAMA. 2016 Jul 19;316(3):350. PMID: 26903337.


↑ RESPIRATORY DRIVE
P-SILI
↑ P_L
occult pendelluft
↑ venous return
↑ RV afterload
volutrauma and barotrauma
atelectrauma
lung edema
vascular shear stress
LUNG INJURY
↑ EFFORT
• derecruitment
• inflammation
• >PaCO2
• <PaO2
• acidosis

Ketcham *et al. Critical Care* (2020) 24:391
https://doi.org/10.1186/s13054-020-03108-w

Critical Care

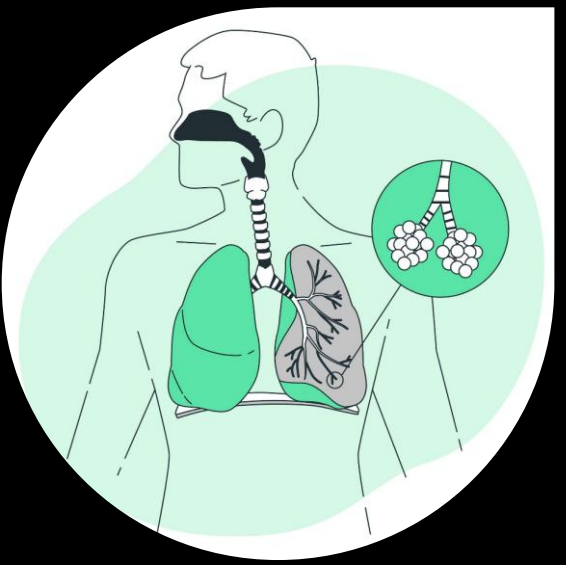
RESEARCH Open Access

Causes and characteristics of death in patients with acute hypoxemic respiratory failure and acute respiratory distress syndrome: a retrospective cohort study

Sepsis (%26),
Pulmoner disfonksiyon (%22)
Nörolojik disfonksiyon (%19)

ARDS ve non ARDS arasında fark yok

AKCİĞER



Oksijenizasyon

Pompa/Ventilasyon

Hipoksemik Solunum Yetmezliği

CO_2

PaO_2<60 mmHg

$PaCO_2$ ≥45 mmHg

SpO_2 ölçümü, genelde güvenilir.

Ama yalnızca Hb satürasyonunu ölçer.

AKG gereklidir.

Normal A-a gradyan

Artmış A-a gradyan

AKG/VKG?

pH ~0.03

PCO_2 : 5-7 mmHg

PO_2 için benzer korelasyon yok

Normal A-a gradyan

Artmış A-a gradyan

Azalmış alveoler ventila **A-a gradyanı** ğişimindeki bir bozulma?

Normal A-a gradyan

Artmış A-a gradyan

$$PAO_2 = (Patm - PH_2O) \times FiO_2 - (PaCO_2 / RQ)$$

37°C'de su buharı parsiyel basıncı = 47 mmHg

Solunum katsayısı

Hipokseminin Değerlendirilmesi

Normal A-a gradyan

Artmış A-a gradyan

$$PAO_2 = 150 - (PaCO_2 / 0.8)$$

Hipokseminin Değerlendirilmesi

Normal A-a gradyan

Artmış A-a gradyan

A-a gradyanı = 150 – ($PaCO_2$ / 0.8) – PaO_2

Hipokseminin Değerlendirilmesi

Normal A-a gradyan

Artmış A-a gradyan

A-a gradyanı =5-25 mm Hg

Normal A-a gradyanı = (Yaş + 10) / 4

Hipokseminin Değerlendirilmesi

Normal A-a gradyan

Artmış A-a gradyan

Düşük FiO_2 ile solunum

Alveoler hipoventilasyon

Difüzyon Bozukluğu

Ventilasyon/Perfüzyon uyumsuzluğu

Şant

Hipoksemik Solunum Yetmezliği

Hipokseminin Değerlendirilmesi

Normal A-a gradyan

Artmış A-a gradyan

1-Düşük FiO_2 ile solunum

2-Alveoler hipoventilasyon

3-Difüzyon Bozukluğu

4-Ventilasyon/Perfüzyon uyumsuzluğu

5-Şant

Hipoksemik Solunum Yetmezliği

Hipokseminin Değerlendirilmesi

Normal A-a gradyan

Artmış A-a gradyan

1-Düşük FiO_2 ile solunum
Yüksek irtifa, toxic gaz inhalasyonu

2-Alveoler hipoventilasyon

3-Difüzyon Bozukluğu

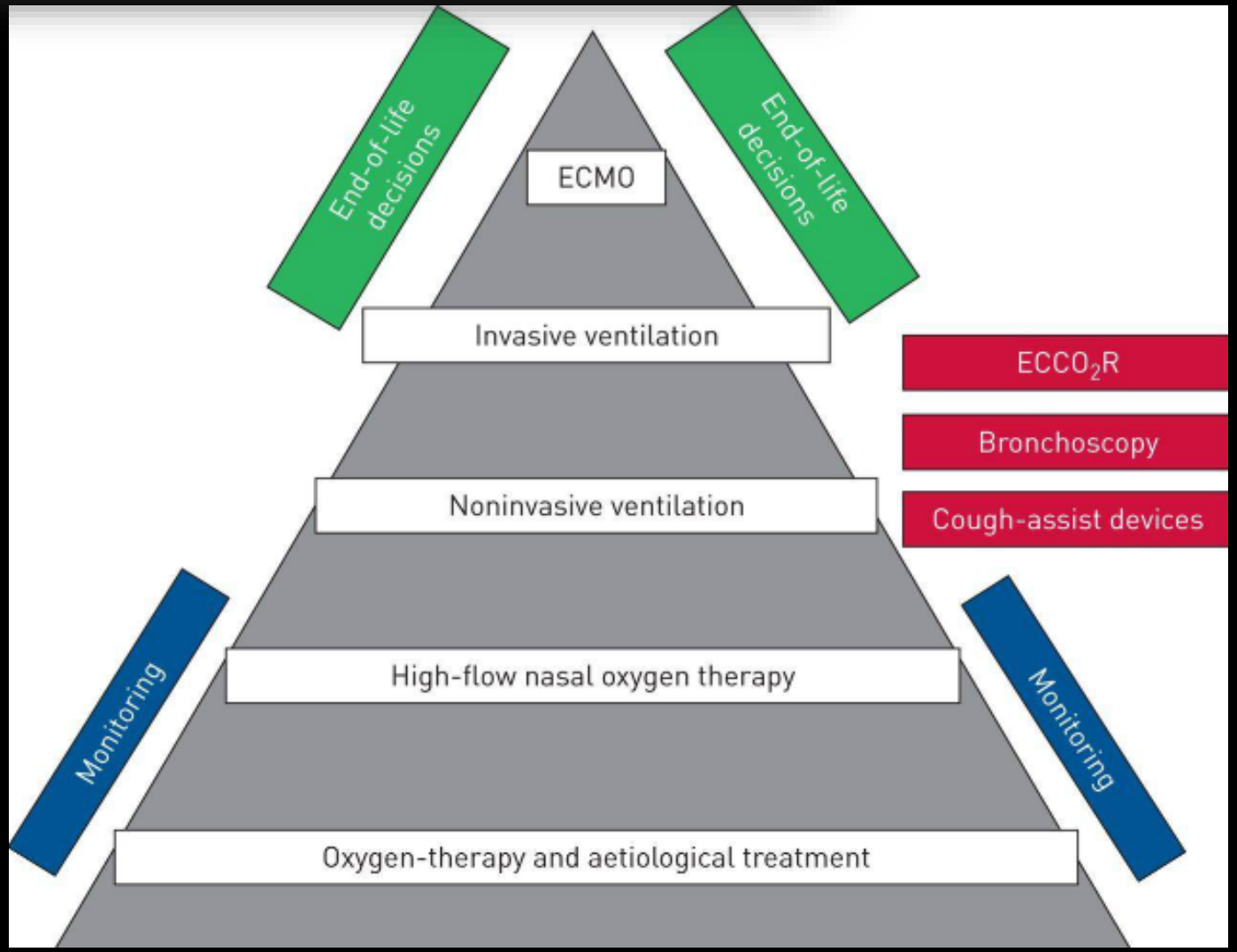
4-Ventilasyon/Perfüzyon uyumsuzluğu

5-Şant

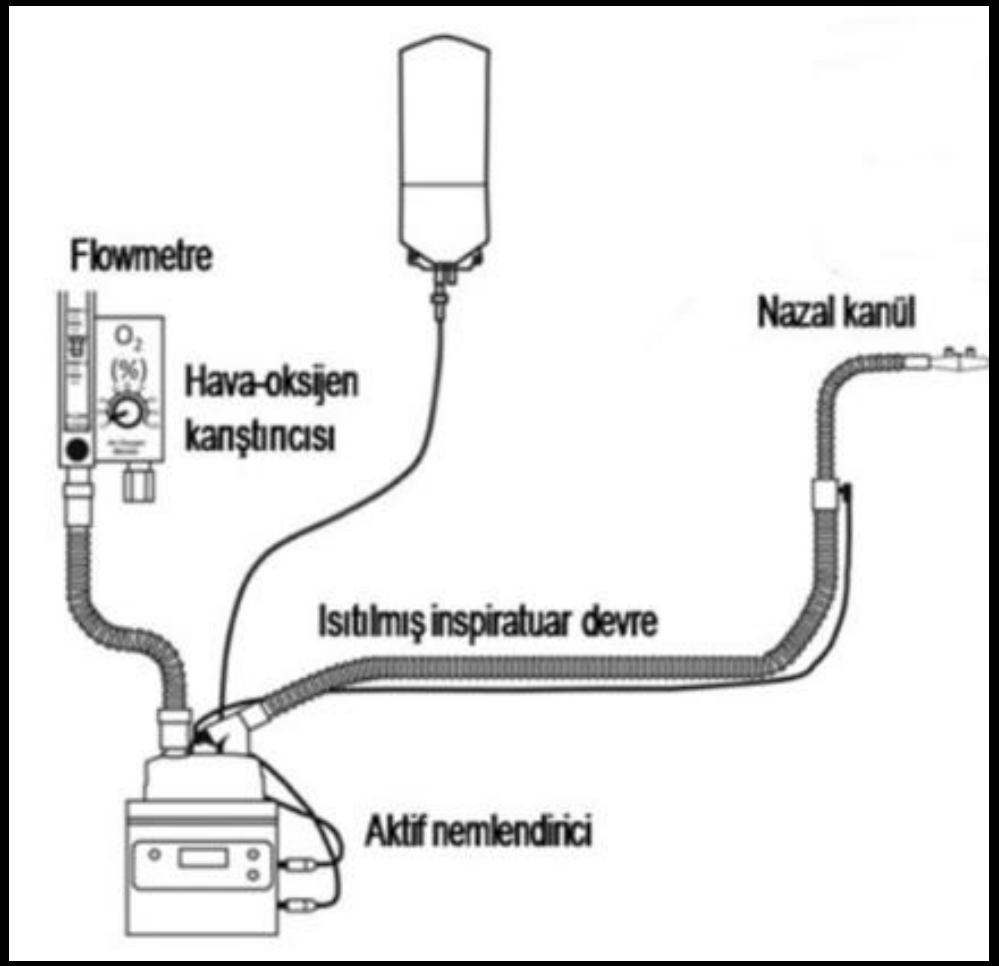
Hipoksemik Solunum Yetmezliği

Highlights in acute respiratory failure

Raffaele Scala[1] and Leo Heunks[2]



Yüksek Akışlı Nazal Kanül (YANK)



Peak Inspiratory Flow

PEEP

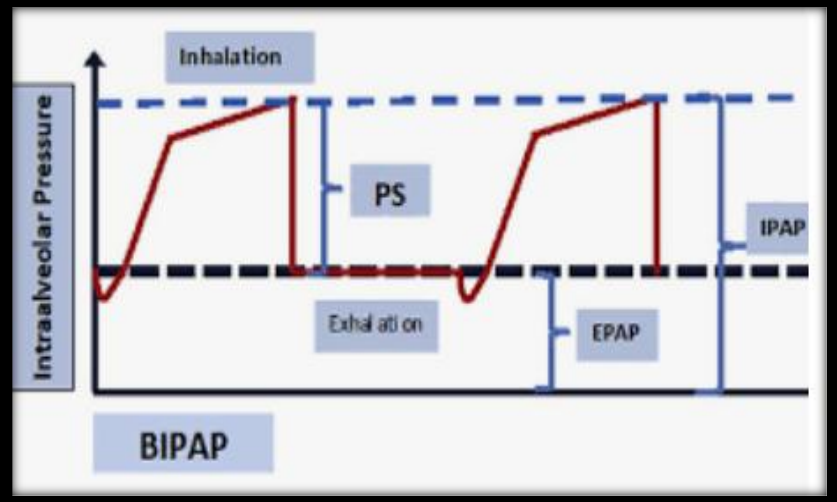
CO_2 washout

Stabil FiO_2

Nemlendirme

P-SILI azalması

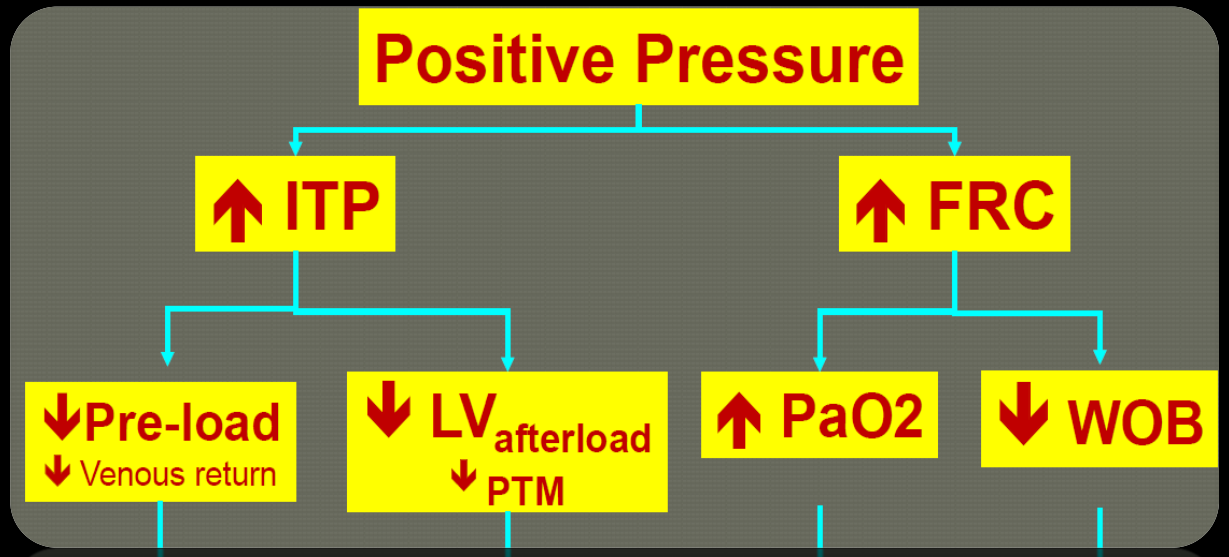
NIV



CPAP ve BiPAP/Pressure Support

Maske / Helmet

P-SILI riski



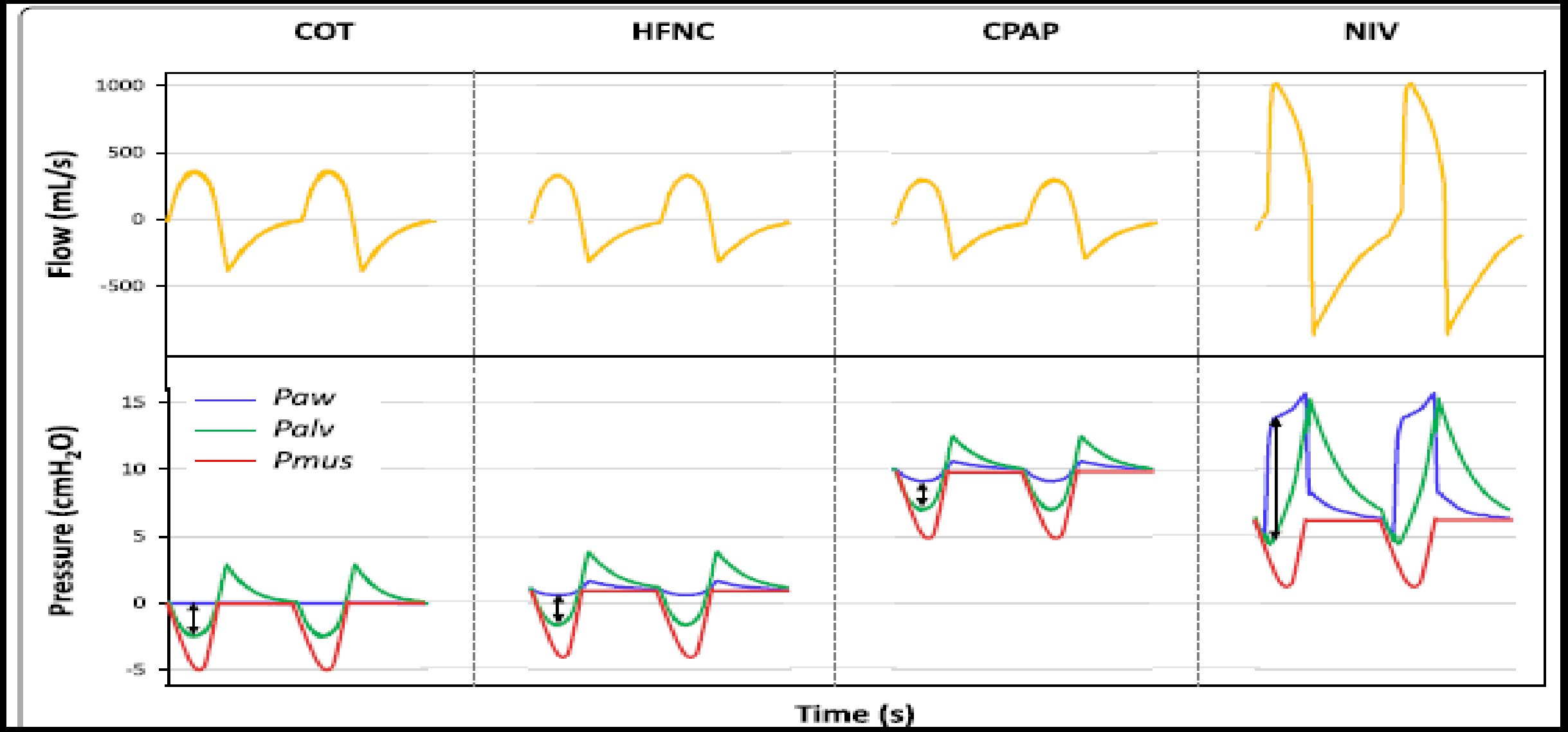
Haudebourg et al. Annals of Intensive Care (2023) 13:116
https://doi.org/10.1186/s13613-023-01200-2

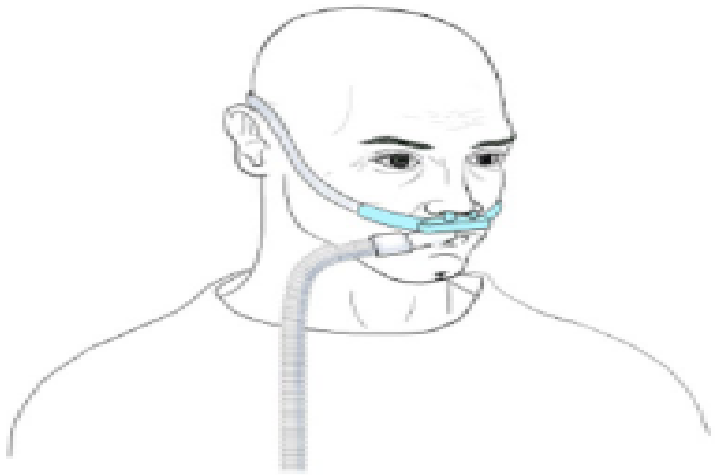
Annals of Intensive Care

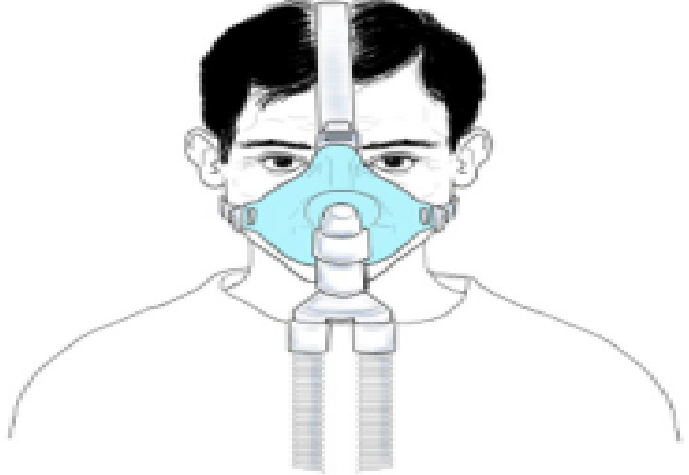
RESEARCH Open Access

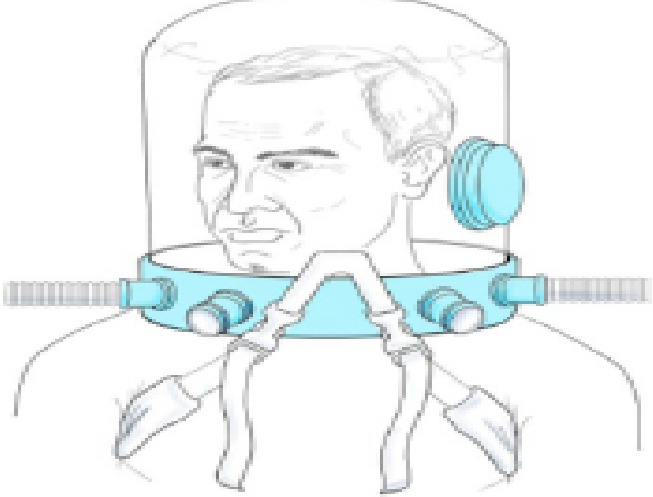
Influence of different noninvasive oxygenation support devices on tidal volume

İnspiratuar basınç gradyanı









Settings

- FiO_2: 0.21-1
- Gas flow: 40-60 lpm
- Temperature: 31-37°C

Pitfalls

- Small amount of PEEP delivered

Settings

Helmet NIV, maskeye göre hem entübasyon oranını hem de mortaliteyi azalttı*

Daha düşük entübasyon oranı sağladı ancak 28-gün respiratuvar desteksiz gün sayısında fark yoktu**

*JAMA, 315(22), 2435-2441
**JAMA, 325(17), 1731-1743

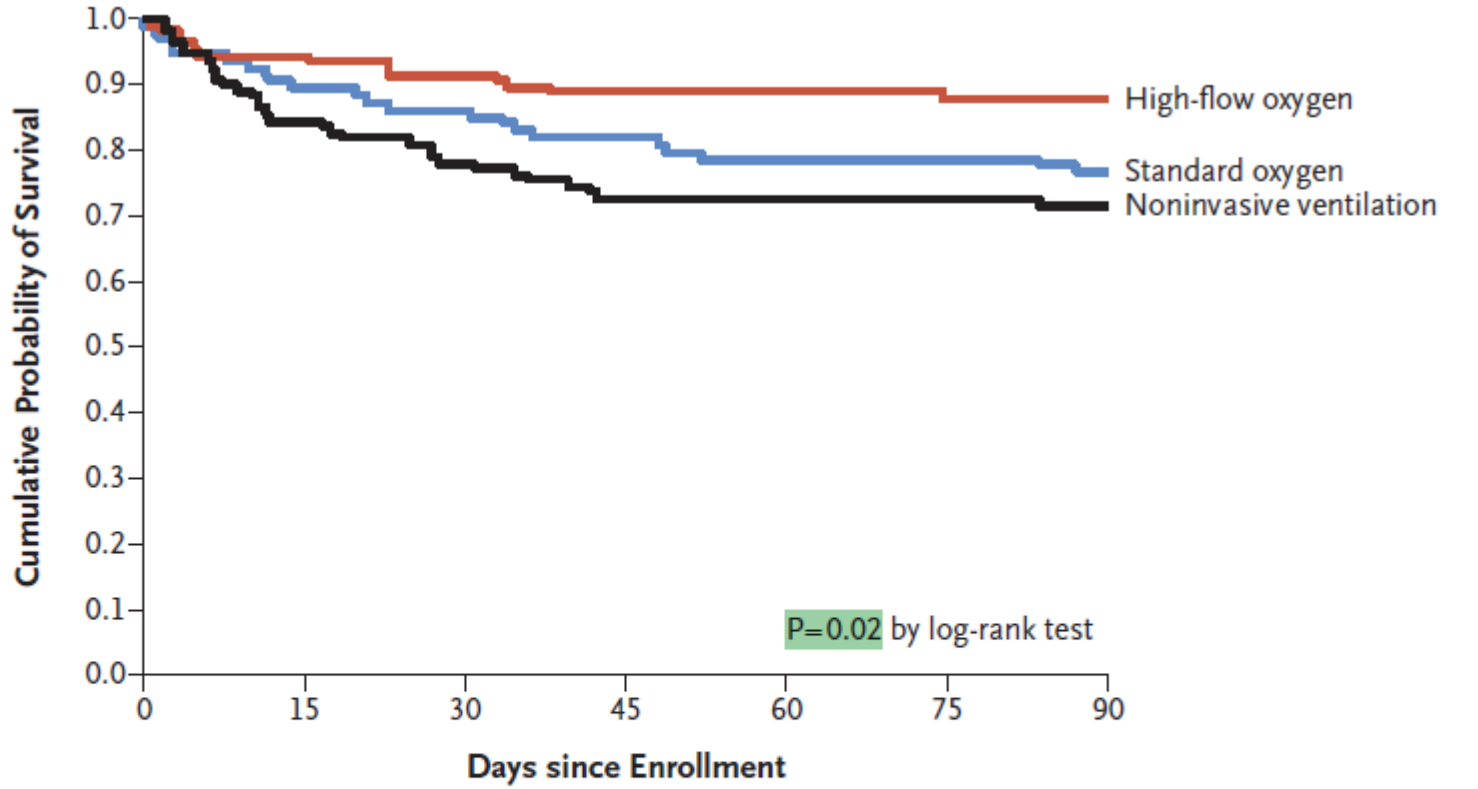
- Poor tolerability: need for treatment interruptions

Settings

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 JUNE 4, 2015 VOL. 372 NO. 23

High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure

A Overall Populatior



No. at Risk							
High-flow oxygen	106	100	97	94	94	93	93
Standard oxygen	94	84	81	77	74	73	72
Noninvasive ventilation	110	93	86	80	79	78	77

Figure 3. Kaplan–Meier Plot of the Probability of Survival from Randomization to Day 90.

Intensive Care Med (2019) 45:563–572
https://doi.org/10.1007/s00134-019-05590-5

SYSTEMATIC REVIEW

High flow nasal cannula compared with conventional oxygen therapy for acute hypoxemic respiratory failure: a systematic review and meta-analysis

- **9 RKÇ, n= 2093**
- **Mortalitede fark yok**
- **Entübasyon ihtiyacını azaltır**

ventilation in either group) favouring HFNC-treated patients (RR 0.71, 95% CI 0.51–0.98), although certainty in both outcomes was low due to imprecision and issues related to risk of bias. HFNC had no effect on intensive care unit length of stay (mean difference [MD] 1.38 days more, 95% CI 0.90 days fewer to 3.66 days more, low certainty), hospital length of stay (MD 0.85 days fewer, 95% CI 2.07 days fewer to 0.37 days more, moderate certainty), patient reported comfort (SMD 0.12 lower, 95% CI 0.61 lower to 0.37 higher, very low certainty) or patient reported dyspnea (standardized mean difference [SMD] 0.16 lower, 95% CI 1.10 lower to 1.42 higher, low certainty). Complications of treatment were variably reported amongst included studies, but little harm was associated with HFNC use.

Intensive Care Med (2020) 46:2226–2237
https://doi.org/10.1007/s00134-020-06312-y

CONFERENCE REPORTS AND EXPERT PANEL

The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline

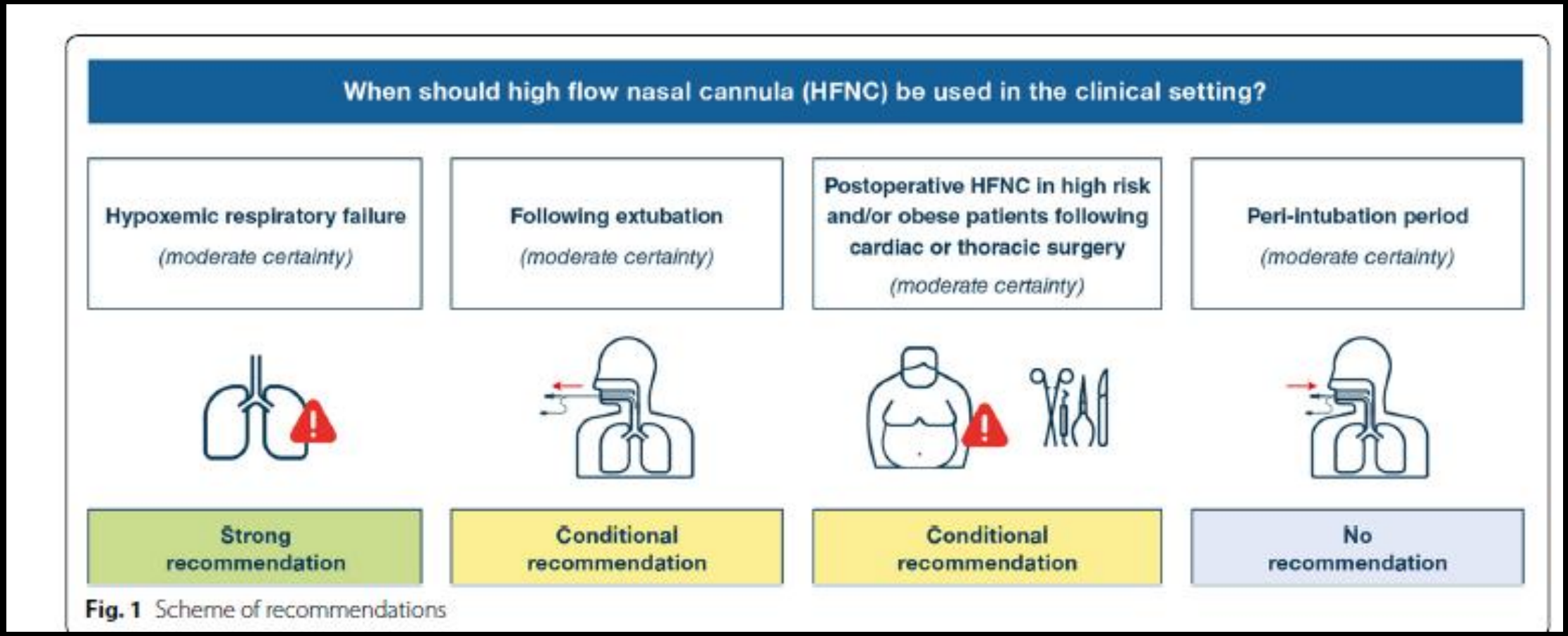


Fig. 1 Scheme of recommendations

ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure

Eur Respir J 2022; 59: 2101574

COT yerine YANK tedavisi: koşullu öneri, orta düzeyde kanıt

Entübasyon riskini azaltabilir (0.89)

NIV'e eskalasyon gereksinimi YANK ile biraz daha düşük

28 & 90 günlük mortalitede fark yok

ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure

Eur Respir J 2022; 59: 2101574

Kanıtlarda:

& aralıklı uygulama

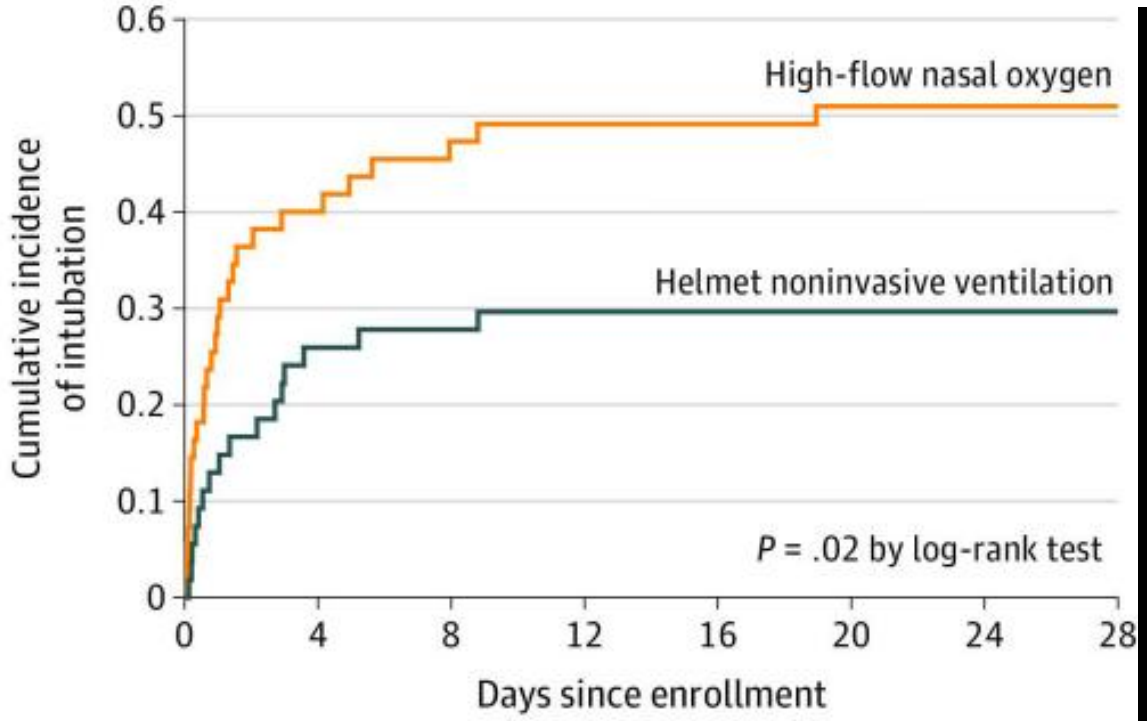
Entübasyon gereksinimini azaltma eğilimindedir (0.84, düşük kesinlik)

Hospitalizasyonda fark yok

JAMA. 2021 Mar 25;325(17):1–13. doi: 10.1001/jama.2021.4682

Effect of Helmet Noninvasive Ventilation vs High-Flow Nasal Oxygen on Days Free of Respiratory Support in Patients With COVID-19 and Moderate to Severe Hypoxemic Respiratory Failure

The HENIVOT Randomized Clinical Trial



No. at risk								
High-flow nasal oxygen	55	34	30	28	28	27	27	27
Helmet noninvasive ventilation	54	41	39	38	38	38	38	38

28 gün içinde entübasyon: Helmet-NIV %30 vs YANK %51, mutlak risk azalması ≈ %21

İnvaziv mekanik ventilasyondan bağımsız gün sayısı: Helmet-NIV'de daha yüksek

Mortalite: Fark yok

High-Flow Nasal Oxygen vs Noninvasive Ventilation in Patients With Acute Respiratory Failure

The RENOVATE Randomized Clinical Trial

JAMA 2025 Mar 11;333(10):875-890.

Noninferiority tasarımlı, RKÇ

Brezilya- 33 merkez

Nonimmünsüprese hastalar, immünsüprese hastalar, solunumsal asidozlu KOAH alevlenmesi, akut kardiyojenik pulmoner ödem, COVID-19

Birincil sonlanım: 7 günde entübasyon / ölüm

High-Flow Nasal Oxygen vs Noninvasive Ventilation in Patients With Acute Respiratory Failure

The RENOVATE Randomized Clinical Trial

JAMA 2025 Mar 11;333(10):875-890.

n=1766

Nonimmünsüprese (n=485)
Solunumsal asidozlu KOAH alevlenmesi (n=77)

Akut kardiyojenik pulmoner ödem (n=272)
COVID-19 (n=882)

Entübasyon veya Ölümde YANK NIV'e non-inferior

High-Flow Nasal Oxygen vs Noninvasive Ventilation in Patients With Acute Respiratory Failure

JAMA

T

A Analysis of the primary outcome[a]

Patients with acute respiratory failure	No./total (%) High-flow nasal oxygen	No./total (%) Noninvasive ventilation	Model-fitted median odds ratio (95% credible interval)[b]	Posterior probability[c] Noninferiority[d]	Posterior probability[c] Superiority[e]
Nonimmunocompromised with hypoxemia	81/249 (32.5)	78/236 (33.1)	1.02 (0.81-1.26)	0.999	0.433
Immunocompromised with hypoxemia				989	0.334
Chronic obstructive p disease exacerbatio respiratory acidosis					0.375
Acute cardiogenic p					0.575
Hypoxemic COVID-					0.136

High-flow nasal oxygen better | Noninvasive ventilation better

Noninferiority margin

B Post hoc analy

Patients with acute respiratory failure	r probability[c] iority[d]	Superiority[e]
Nonimmunocompro with hypoxemia		0.542
Immunocompromis with hypoxemia		0.023
Chronic obstructive disease exacerbatic respiratory acidosis		0.192
Acute cardiogenic pu		0.970
Hypoxemic COVID-19		0.111

Model-fitted median odds ratio (95% credible interval)[b]

28 &90 günlük mortalite
28 günde MV'siz gün sayısı
28 günde YB'sız gün sayısı

YANK / NIV fark yok

<u>İmmünsupresif grup</u>: Entübasyon /ölüm YANK %57.1, NIV %36.4

Intensive Care Med (2025) 51:731–741
https://doi.org/10.1007/s00134-025-07890-5

ORIGINAL

Outcomes in immunocompromised patients with acute hypoxemic respiratory failure treated by high-flow nasal oxygen

RESPIR-OH, IVNICTUS, HIGH ve retrospektif (EFRAIM) birleştirilmiştir.

n=986

28 günde IMV gereksinimi

28-gün mortalite ve ROX indeksinin öngörüsü

HFNO sonrası IMV oranı %46, 28-gün mortalite %33
ROX için AUC ≈ 0.67
İmmünkompromize AHSY hastalar heterojen
SOT'lı hastalar en iyi sonuçlara sahipken, hematolojik ve özellikle miyeloid malignitelerde HFNO başarısızlığı ve mortalite yüksektir.

Is there still a place for noninvasive ventilation in acute hypoxemic respiratory failure?

Intensive Care Med (2018) 44:2248–2250

Table 1 Benefit–risk ratio assessment in favor or against NIV use in hypoxemic ARF patients

Indications for NIV use
Acute exacerbation of COPD
Acute cardiogenic pulmonary edema
Hypoxemia post-abdominal surgery
Chest trauma
Preoxygenation before intubation
Against NIV use
(Late or moderate–severe) ARDS
High tidal volumes during the NIV session
Leaks during the NIV session despite changes of interface
Lack of patient adherence
Dyspnea during NIV sessions
Impossibility of close monitoring
Absence of rapid clinical improvement (signs of respiratory distress including elevated respiratory rate) and gas exchange improvement after 1 h of NIV session

5 günden uzun NIV uygulaması sonrası entübasyon mortaliteyi %75'e yükseltmiştir.*

TV>9–9.5 mL/kg PBW olması başarısızlık öngörücüsü

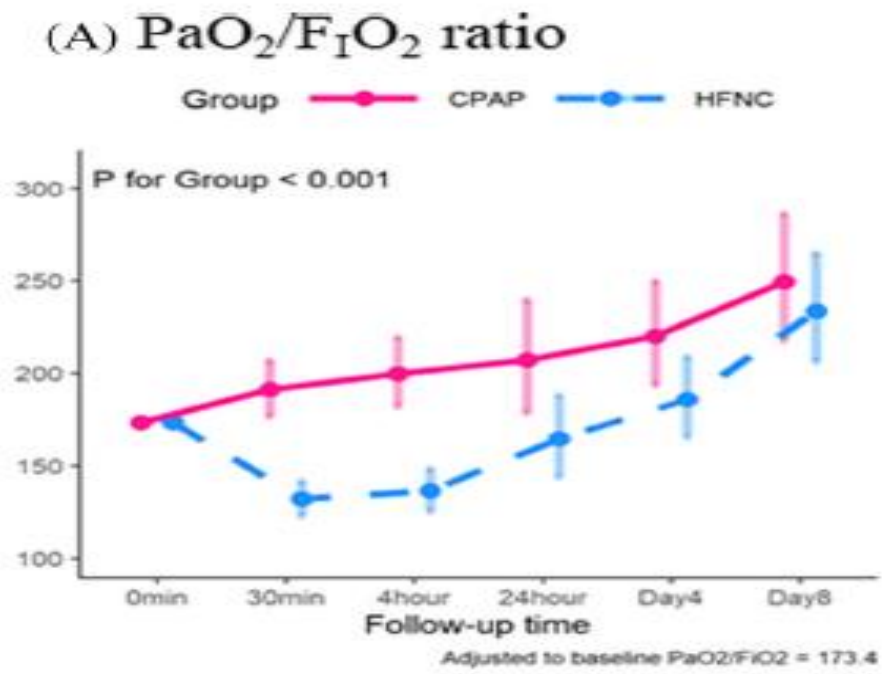
*Pneumologie. 2021 Jun;75(6):424-431. German. Epub 2021 May 11. PMID: 33975371.

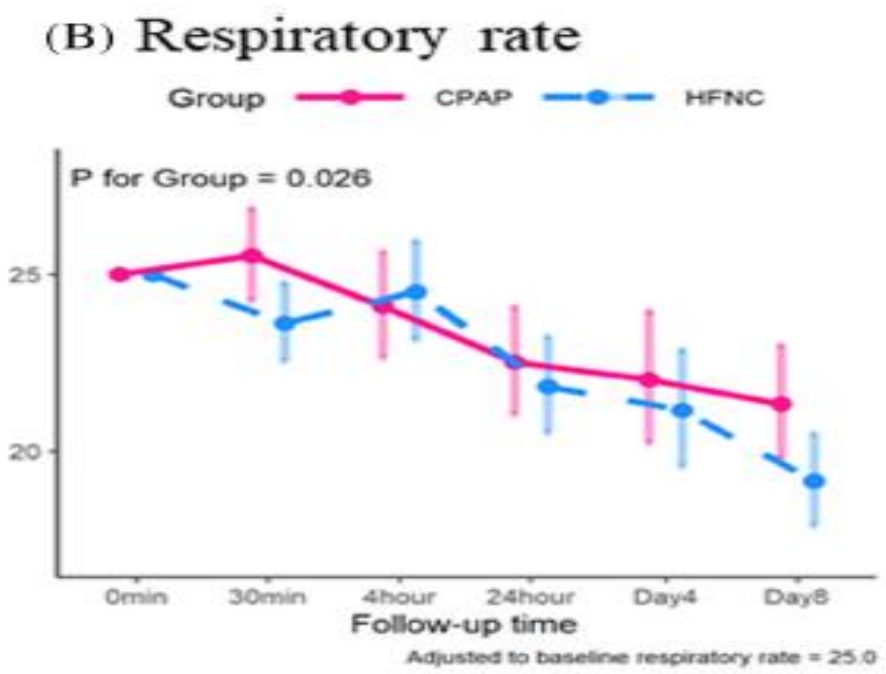
Received: 1 February 2023 | Accepted: 16 August 2023
DOI: 10.1111/resp.14588

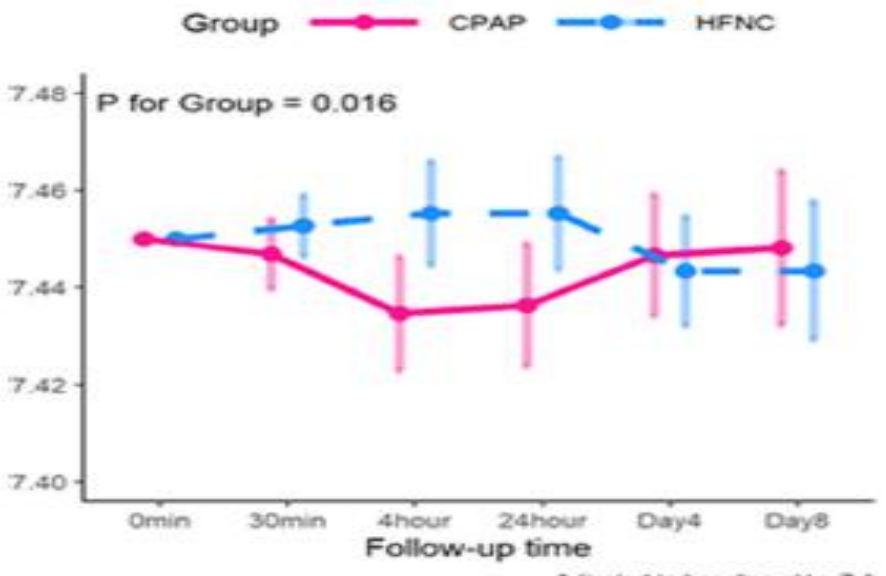
ORIGIN

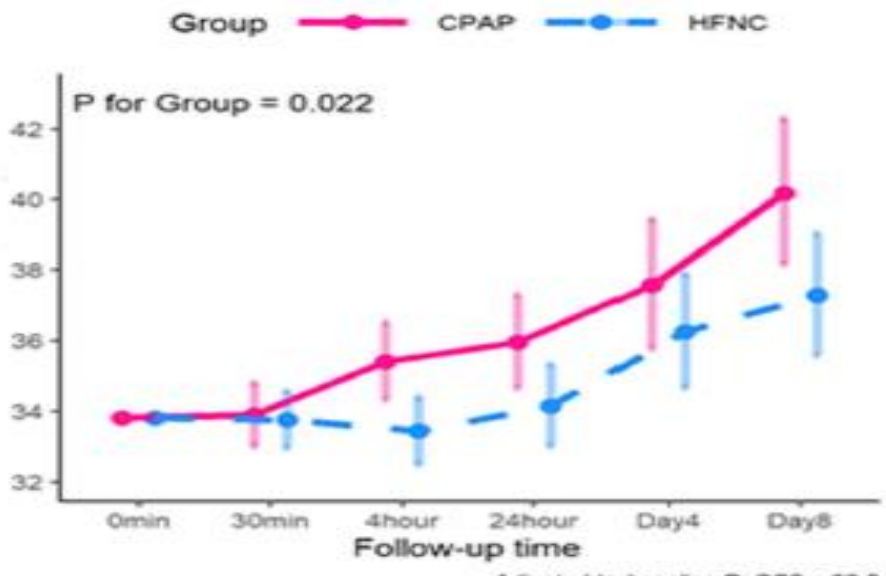
TABL

Outco								p-value
Prima								
Met th (N							4]	0.006
Secon								
Intuba							1]	0.385
Morta							3]	0.363
In-hos							4]	0.378
Ventil								0.744
Durati							9]	0.405
Durati							0]	0.741
Need f								-









Non-invasive ventilatory support and high-flow nasal oxygen as first-line treatment of acute hypoxemic respiratory failure and ARDS

Intensive Care Med (2021) 47:851–866

The role of non-invasive respiratory support (high-flow nasal oxygen and noninvasive ventilation) in the management of acute hypoxemic respiratory failure and acute respiratory distress syndrome is debated. The oxygenation improvement coupled with lung and diaphragm protection produced by non-invasive support may help to avoid endotracheal intubation, which prevents the complications of sedation and invasive mechanical ventilation. However, spontaneous breathing in patients with lung injury carries the risk that vigorous inspiratory effort, combined or not with mechanical increases in inspiratory airway pressure, produces high transpulmonary pressure swings and local lung overstretch. This ultimately results in additional lung damage (patient self-inflicted lung injury), so that patients intubated after a trial of noninvasive support are burdened by increased mortality. Reducing inspiratory effort by high-flow nasal oxygen or delivery of sustained positive end-expiratory pressure through the helmet interface may reduce these risks. In this physiology-to-bedside review, we provide an updated overview about the role of noninvasive respiratory support strategies as early treatment of hypoxemic respiratory failure in the intensive care unit. Noninvasive strategies appear safe and effective in mild-to-moderate hypoxemia ($PaO_2/FiO_2 > 150$ mmHg), while they can yield delayed intubation with increased mortality in a significant proportion of moderate-to-severe ($PaO_2/FiO_2 \leq 150$ mmHg) cases. High-flow nasal oxygen and helmet noninvasive ventilation represent the most promising

Klasik Parametrelerin Sınırları

- **Solunum sayısı, ROX indeksi ve HACOR skorları = inspiratuvar eforun dolaylı göstergesi**
- **Özefagus manometrisi (Δpe) altın standart**

ROX	
≥4.88	Little risk of intubation
3.85-4.87	close monitoring due to increased risk of intubation
2.85-3.84	Monitoring in the ICU if possible. Highly increased risk of intubation
<2.85	Consider intubation

Zhou et al. BMC Pulmonary Medicine (2022) 22:121
https://doi.org/10.1186/s12890-022-01914-2

BMC Pulmonary Medicine

RESEARCH Open Access

The ROX index as a predictor of high-flow nasal cannula outcome in pneumonia patients with acute hypoxemic respiratory failure: a systematic review and meta-analysis

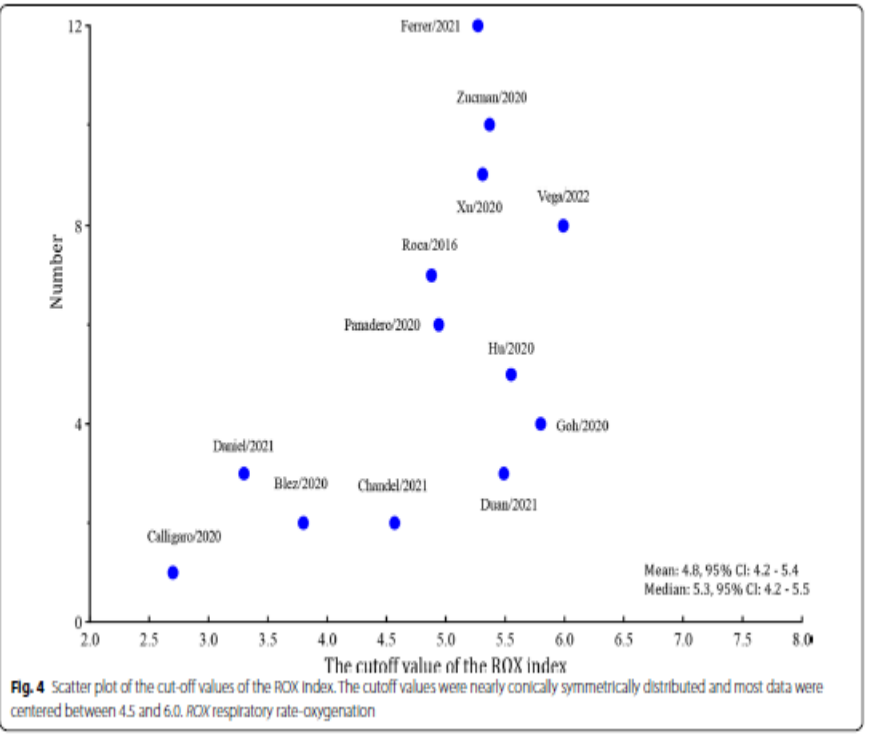


Fig. 4 Scatter plot of the cut-off values of the ROX index. The cutoff values were nearly conically symmetrically distributed and most data were centered between 4.5 and 6.0. *ROX* respiratory rate-oxygenation

6 prospektif, 7 retrospektif; n= 1751
10 çalışma COVID-19
ROX hem erken hem de 12 saate kadar benzer doğrulukta
ROX <4.2 → entübasyon düşün
4.2–5.4 → Dikkat
• >5.4 → iyi
•
AUHSROC = 0.81 (95% CI 0.77–0.84)
• Pooled sensitivite = %71
• Pooled spesifisite = %78
• Tanısal odds ratio (DOR) = 8.3

Liu et al. Respiratory Research (2024) 25:143
https://doi.org/10.1186/s12931-024-02771-9

Respiratory Research

RESEARCH Open Access

Association between the ROX index and mortality in patients with acute hypoxemic respiratory failure: a retrospective cohort study

ROX: ilk 24 saatin ortalaması alınmış- Fizyolojik?

n= 813

28 günlük mortalite

3-6-12 ay mortalite, ICU ve hastane mortalitesi

Sonuç: nonlineer- güçlü ilişki
***ROX>8.28 ilişki kayboluyor.**

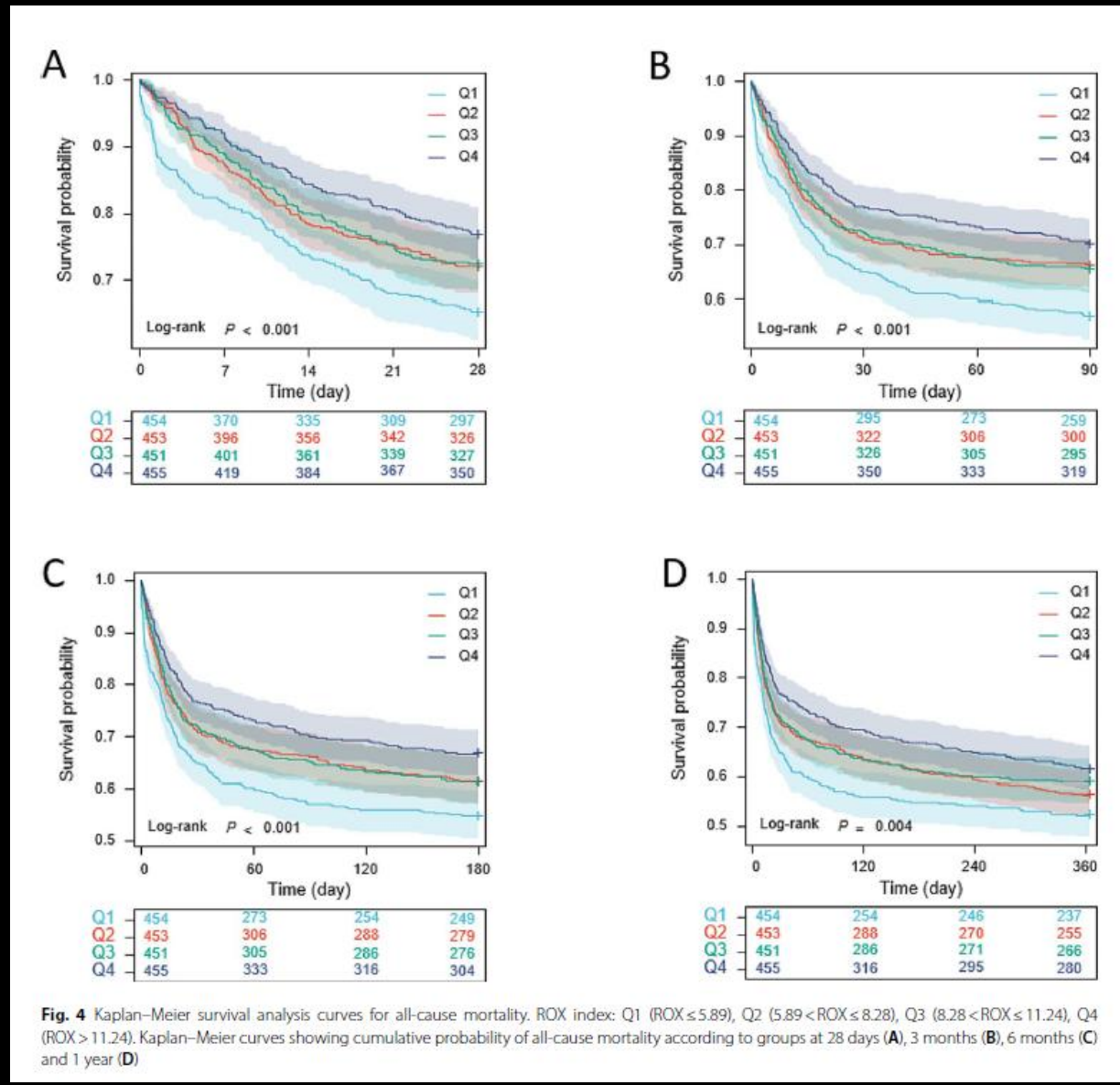


Fig. 4 Kaplan–Meier survival analysis curves for all-cause mortality. ROX index: Q1 (ROX ≤ 5.89), Q2 (5.89 < ROX ≤ 8.28), Q3 (8.28 < ROX ≤ 11.24), Q4 (ROX > 11.24). Kaplan–Meier curves showing cumulative probability of all-cause mortality according to groups at 28 days (**A**), 3 months (**B**), 6 months (**C**) and 1 year (**D**)

A Novel Index to Predict the Failure of High-Flow Nasal Cannula in Patients with Acute Hypoxemic Respiratory Failure: A Pilot Study

American Journal of Respiratory and Critical Care Medicine Volume 206 Number 7 | October 1 2022

$$\mathrm{VOX} = \frac{\mathrm{SpO_2/FiO_2}}{\mathrm{VT}}$$

Tek merkez, n=62

ROX ilk saatlerde yetersiz..

TV, YANK başarısız olan hastalarda başlangıçtan itibaren belirgin yüksek. Özellikle >10 ml/kg PBW!

A Novel Index to Predict the Failure of High-Flow Nasal Cannula in Patients with Acute Hypoxemic Respiratory Failure: A Pilot Study

American Journal of Respiratory and Critical Care Medicine Volume 206 Number 7 | October 1 2022

Table 1. Diagnostic Accuracy of Different Respiratory Variables at Different Time Points of Need for IMV in Patients Treated With HFNC

	Time (h)	AUROC	95% CI	*P* Value
Sp_{O_2}/Fi_{O_2}	0	0.76	0.64–0.89	<0.001
	2	0.82	0.71–0.93	<0.001
	6	0.84	0.73–0.95	<0.001
Respiratory rate	0	0.50**	0.35–0.64	0.944
	2	0.42**	0.28–0.56	0.271
	6	0.51**	0.36–0.66	0.893
ROX index	0	0.66**	0.52–0.80	0.034
	2	0.70*	0.56–0.85	0.006
	6	0.79**	0.68–0.91	0.001
VT (ml/kg of PBW)	0	0.83	0.71–0.94	<0.001
	2	0.87	0.77–0.97	<0.001
	6	0.87	0.76–0.98	<0.001
VOX index	0	0.84	0.75–0.94	<0.001
	2	0.88	0.79–0.97	<0.001
	6	0.93	0.86–0.99	<0.001

HACOR skoru

Variable	Value	Score
Heart rate (HR)	≤ 120	0
	> 120	1
Acidosis (pH)	≥ 7.35	0
	7.30 – 7.34	2
	7.25 – 7.29	3
	< 7.25	4
Consciousness (GCS)	15	0
	13 – 14	2
	11 – 12	5
	≤ 10	10
Oxygenation (PaO_2/FiO_2)	> 200	0
	176 - 200	2
	151 – 175	3
	126 - 150	4
	101 – 125	5
	≤ 100	6
Respiratory rate (RR)	≤ 30	0
	31 - 35	1
	36 – 40	2
	41 – 45	3
	> 45	4

>5

1 Saatte >5 Puan Yüksek Başarısızlık Riski Anlamına Gelir.

Bu eşik değer, farklı hasta gruplannda NiV başarısızlığını öngörmede etkilidir.

Duan et al. Critical Care (2022) 26:196
https://doi.org/10.1186/s13054-022-04060-7

Critical Care

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An updated HACOR score for predicting the failure of noninvasive ventilation: a multicenter prospective observational study

Variable	Value	Score
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	≤ 100	6
Respiratory rate (RR)	≤ 30	0
	31 - 35	1
	36 – 40	2
	41 – 45	3
	> 45	4

18 merkez, prospektif çalışma (n=2179)

Orijinal HACOR skoruna 6 NIV öncesi değişken eklenmiştir:

SOFA skoru
Pnömoni varlığı
Kardiyojenik pulmoner ödem
Pulmoner ARDS
İmmünsüpresyon
Septik şok

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Güncellenmiş HACOR skorunun NIV başladıktan 1–2 saat sonra hesaplanması, en güçlü sonuçları vermiştir.

AUC ≈ 0.85

≤ 7 puan → Düşük risk (%12)

7.5–10.5 → Orta risk (%38)

11–14 → Yüksek risk (%67)

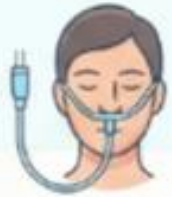
14 → Çok yüksek risk (%84)

Akut Hipoksemik Solunum Yetmezliği Tanısı Alan Hasta

Soru 1: PEEP ihtiyacı ön planda mı?

Hastanın oksijenasyonunu düzeltmek için ne kadar PEEP gerekli?

Düşük/Minimal PEEP Yeterli



YANK (Yüksek Akışlı Nazal Kanül)

YANK, iyi tolere edilir ve minimal PEEP desteği sağlar.

Yüksek PEEP Gerekli

Helmet CPAP / NIV

Oksijenasyon zayıfsa, Helmet CPAP veya basınç desteği daha etkilidir.

Soru 2: Solunumsal efor nasıl?

Hastanın kendi kendine akciğer hasarı (P-SILI) riski var mı?

Normal Efor

Konvansiyonel O_2 Terapisi / YANK

İlk seçenek konvansiyonel oksijen, yanıtsızsa ikinci seçenek YANK'tır.

Yüksek Efor

Helmet + Basınç Desteği (PS)

Bu kombinasyon, eforu ve pendelluft etkisini en aza indirerek akciğeri korur.

HENIVOT

Özel Hasta Gruplarında Dikkat Edilecekler RENOVATE

De Novo solunum yetmezliğinde YANK • İmmünsupreses hastalarda NIV öncelenek mi?

BAŞARISIZLIĞI ERKEN TANI!

Entübasyonun geciktirilmesi mortaliteyi önemli ölçüde artırabilir.


Teşekkürler