Noninvasive Oxygen Delivery Methods

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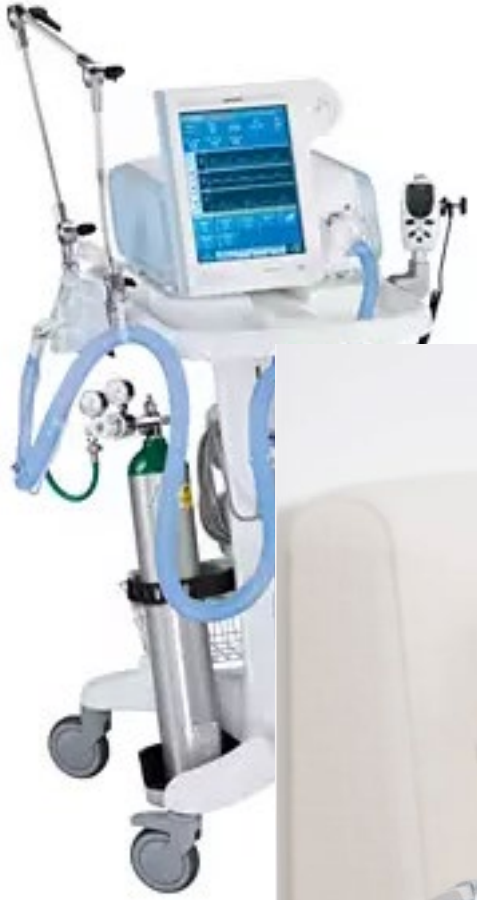
Pulmonary, Critical Care and Sleep Medicine

OBJECTIVES

- Define noninvasive ventilation (NIV)
- Discuss mechanisms of dyspnea and assessment
- Identify modes/methods of NIV
- Discuss data and indications

DISCLOSURES

- I HAVE NO DISCLOSURES RELEVENT TO THIS PRESENTATION



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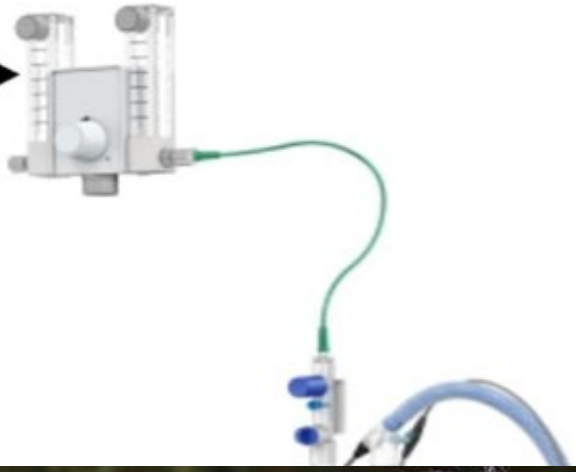
Oxygen/air blender →



Heated hu

Soft nasal prongs

Dyspnea

- “A term used to characterize a *subjective experience* of breathing discomfort that comprises *qualitatively distinct* sensations that vary in *intensity*. The experience derives from interactions among multiple *physiological, psychological, social and environmental* factors, and may induce *secondary physiological behavioral* responses”

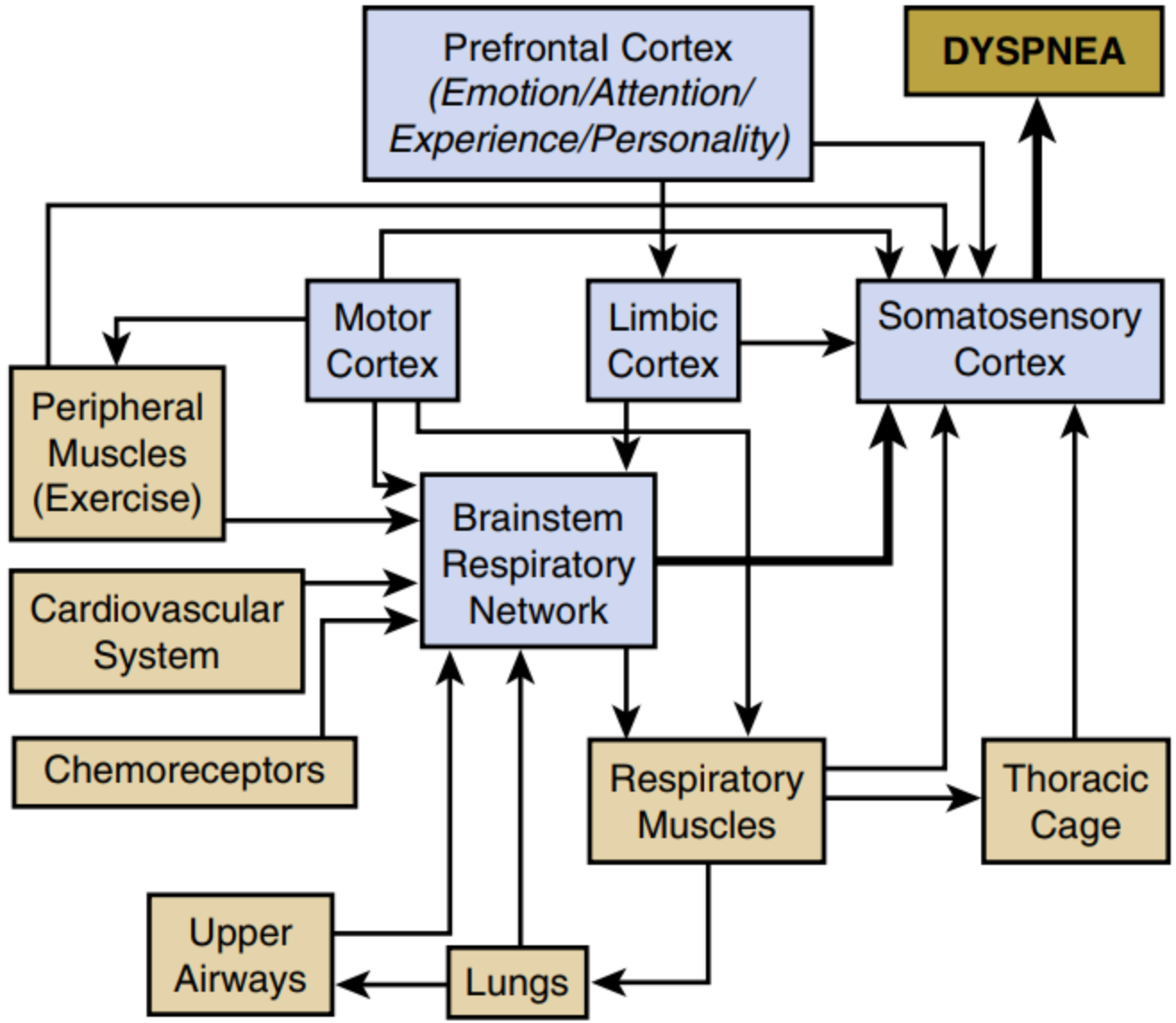
  -American Thoracic Society (ATS) consensus statement

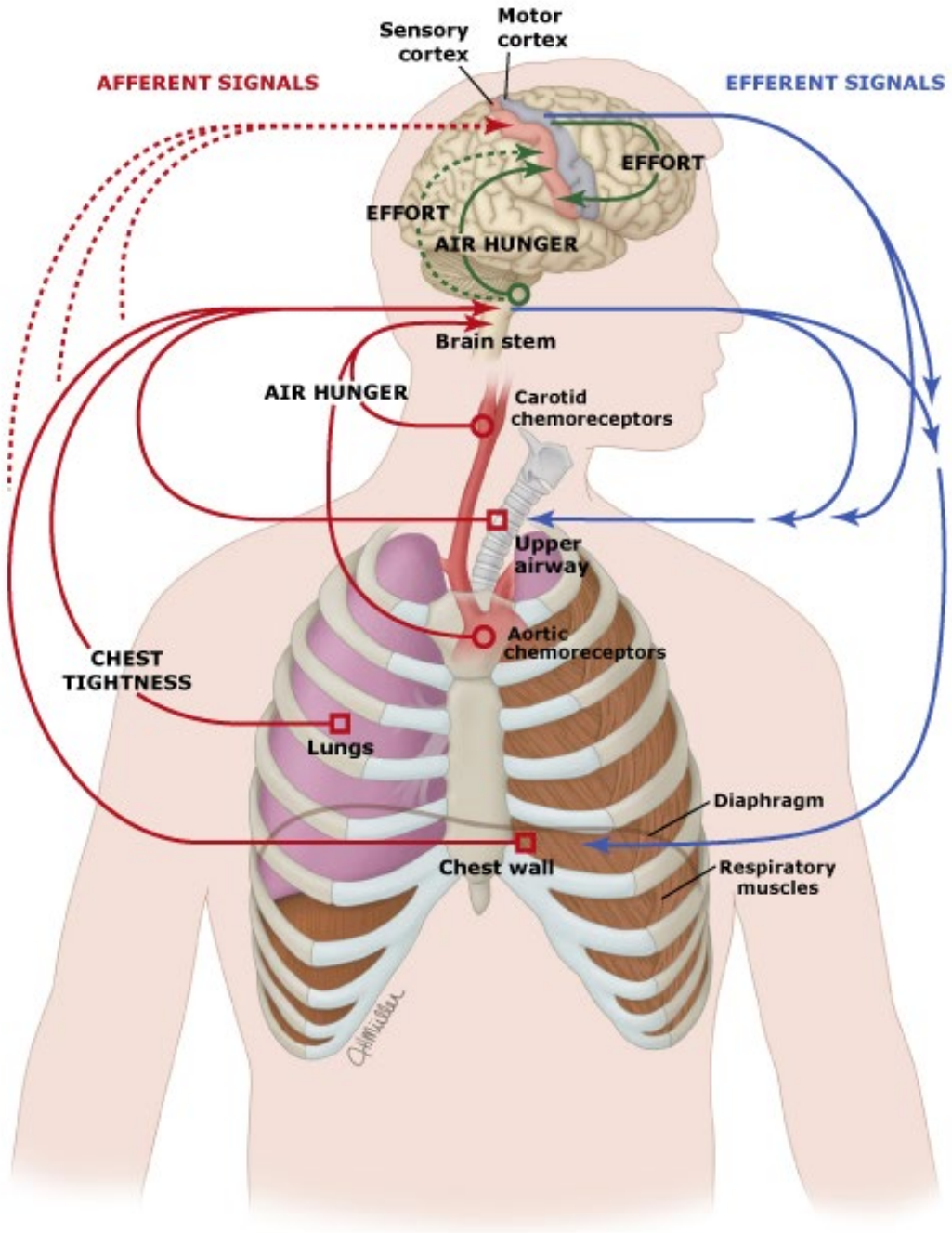
- Uncomfortable or unpleasant sensation associated with breathing

- Frequent component of QOL questionnaires

How do patients describe this?

- Can’t catch my breath
- I feel winded
- I feel like I am Suffocating
- I feel fatigued
- I am exhausted
- My breathing is heavy
- My chest feels tight
- Air hunger
- I have increased effort to breath
- Cannot get a deep breath
- Breathing feels unsatisfying


Prefrontal Cortex
(Emotion/Attention/
Experience/Personality)
DYSPNEA
Motor
Cortex
Limbic
Cortex
Somatosensory
Cortex
Peripheral
Muscles
(Exercise)
Brainstem
Respiratory
Network
Cardiovascular
System
Chemoreceptors
Respiratory
Muscles
Thoracic
Cage
Upper
Airways
Lungs



HYPOXIA

HYPERCAPNIA

RESPIRATORY CONTROLLER

ACIDOSIS

DRUGS

NERVE STIMULATION

RESISTIVE WORK OF BREATHING

BONES/CHEST WALL

VENTILATORY PUMP

AFFERENT SIGNALS

MUSCLES

ILD/LUNG TISSUE

GAS EXCHANGER

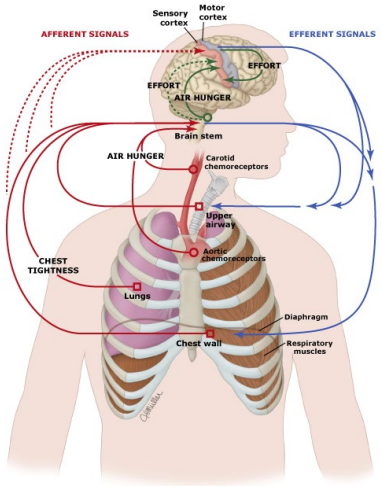
INTERSTITIUM

ALVEOLI

VESSELS

Curr Opin Support Palliat Care. 2014;8(3):225–233

UpToDate: approach to the patient with dyspnea



DYSPNEA

ANTICIPATION

ANXIETY

PAIN OR DISCOMFORT

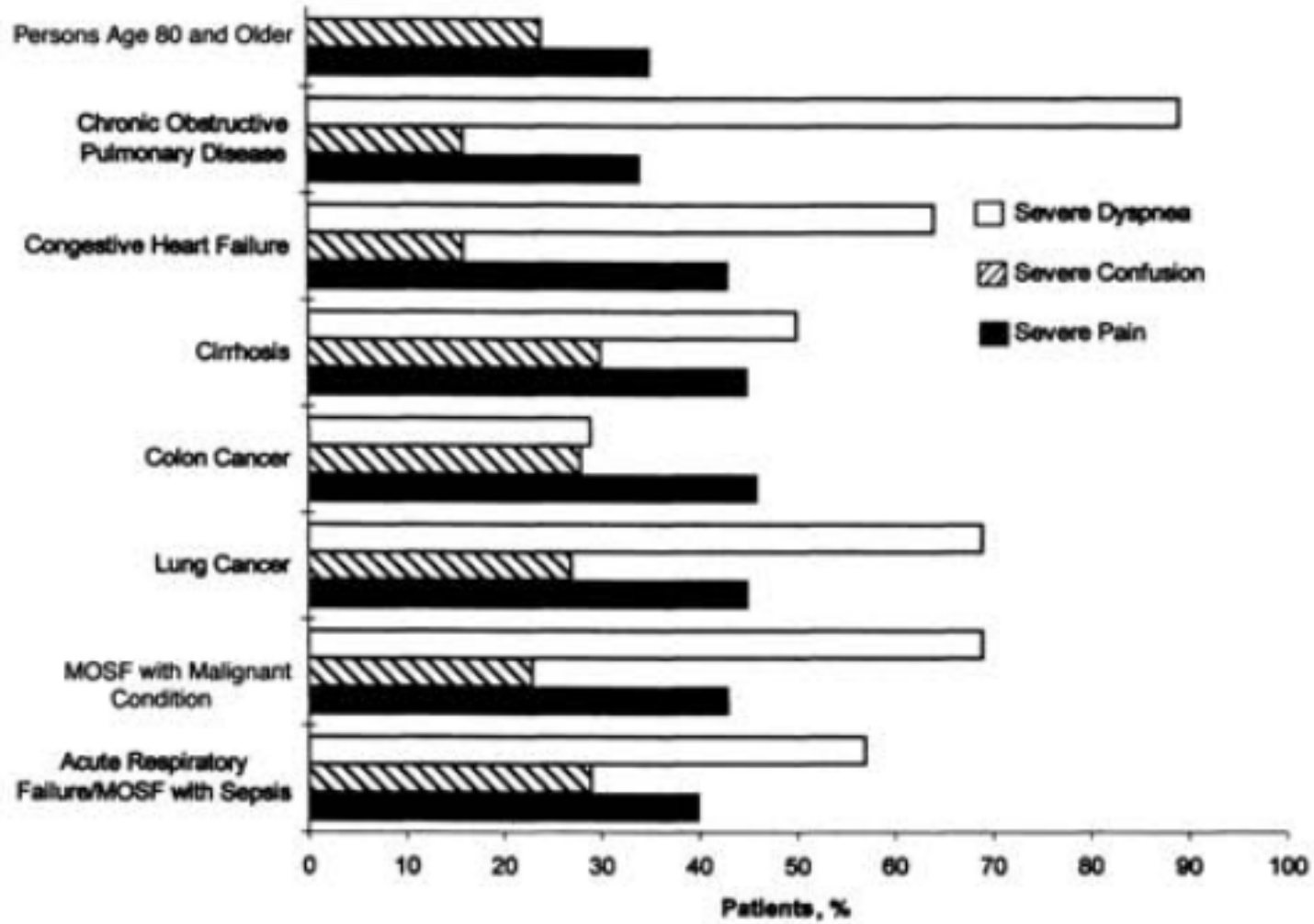
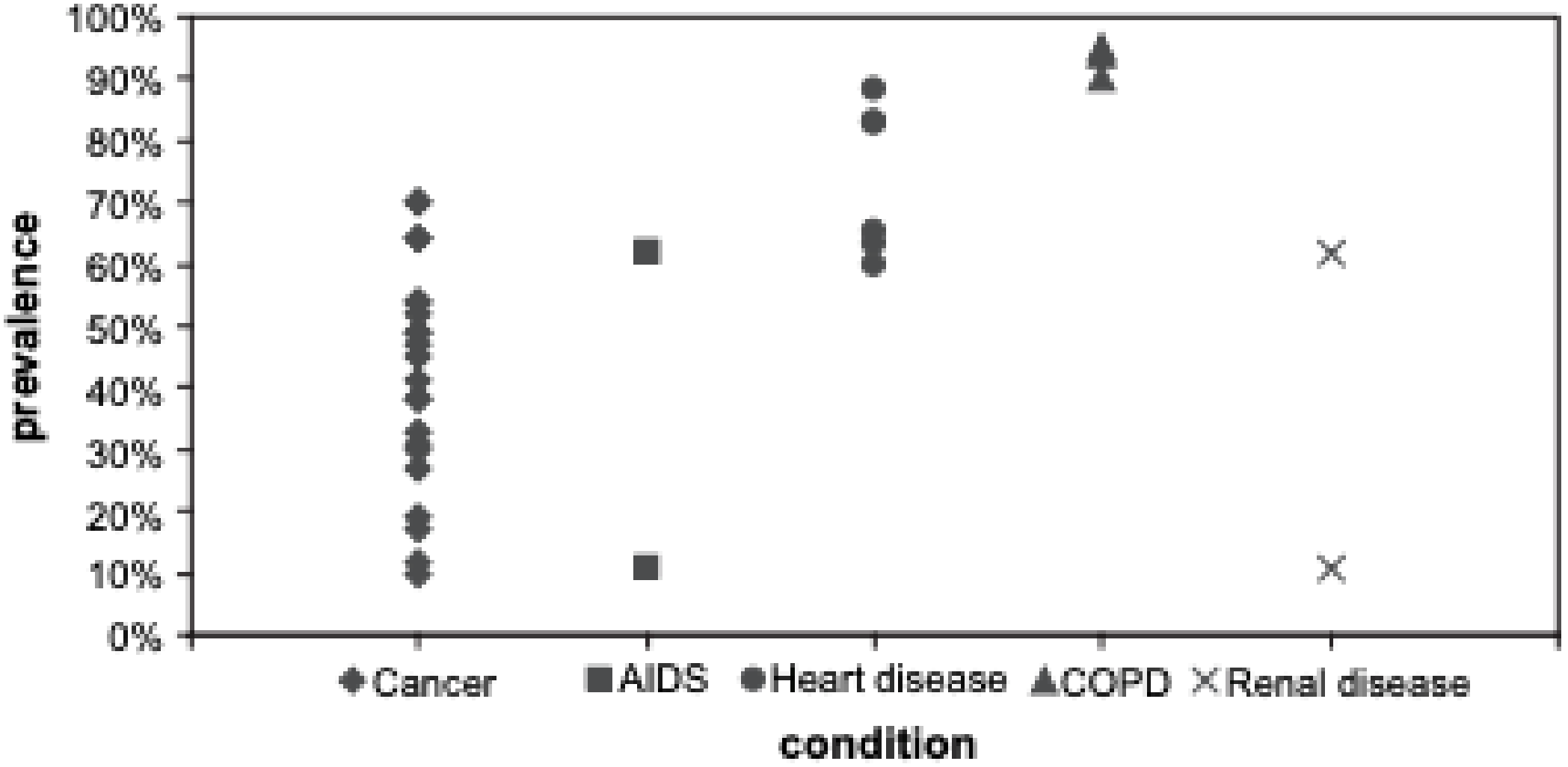


Figure 2. Rates of severe symptoms in patients 3 days before death, as reported by family members. Family members of elderly patients were not asked about dyspnea. MOSF = multiple organ system failure.

Ann Intern Med 1997;126(2): 97-106.



J Pain Symptom Manage. 2006 Jan;31(1):58-69

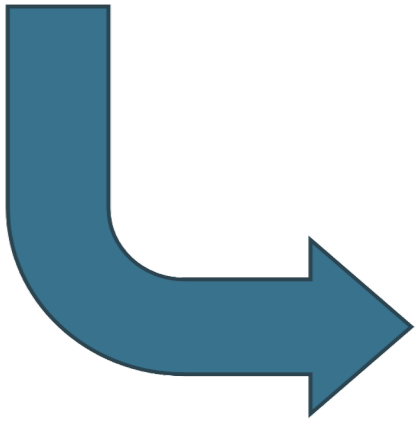
EXAM FEATURES

- Tachypnea
- Accessory muscle use
- Tripod position
- Abdominal paradox
- Abdominal contraction
- Pursed lip breathing
- Cyanosis
- Pulmonary exam – crackles, wheezes, rhonchi, NOTHING

DYSPNEA HAS BEEN IDENTIFIED

Modified Medical Research Council (MRC) (Grade 0-4)

Borg (range 6-20)



WHAT IS THE CAUSE?

CAN IT BE ASSESSED ‘OBJECTIVELY’?

Modified Borg (0-10)

INTERVENTIONS

1. Decrease respiratory drive
   -supplemental 02, flow/blow cool air, chest wall vibration, inhaled furosemide, etc

2. Reduce respiratory effort or improve muscle function
   -Pursed lip breathing, breathing/diaphragm training, NIV, HFNC

3. Alter central perception
   -desensitization, opiates, anxiolytics (?)
   -psychosocial support/counseling

AIRFLOW

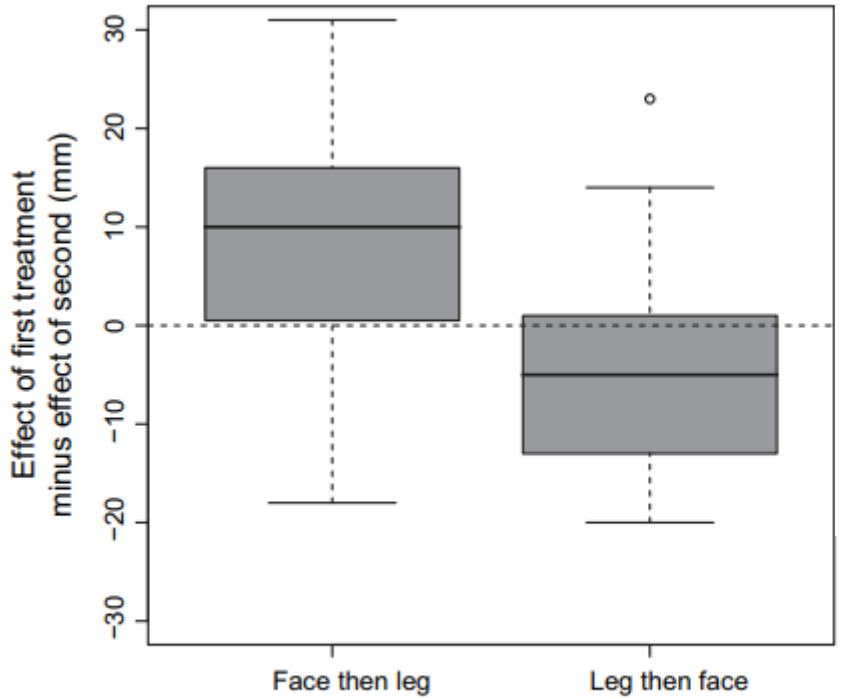


Fig. 2. The effects of fan directed to the face and fan directed to the leg.

Diagnosis	Recruited Patients Total $n = 50$
COPD	26
Primary or secondary lung cancer	11
Asthma	8
Heart disease	15
Bronchiectasis	7
Pneumonitis	4
Other	20
Multiple diagnoses (up to 4 in any one patient)	26

Table 2

Percentage and Millimeter Changes in VAS After the Use of Fan

VAS Decrease After Use of the Fan and During Washout Period	Fan to Face First 27 Patients	Fan to Leg First 22 Patients
VAS median (IQR) mm decrease after five minutes' use of fan	7.0 (1.5 to 14.5)	1.5 (−2.0 to 7.0)
VAS median (IQR) % decrease after five minutes' use of fan	29 (6 to 50)	2 (−6 to 27)
VAS median (IQR) mm decrease including 10-minute washout period	10.0 (3.5 to 17)	1.0 (−4.5 to 12.0)
VAS median (IQR) % decrease including 10-minute washout period	40 (15 to 57)	3 (−12 to 25)

IQR = interquartile range.

J Pain Symptom Manage 39(5):831-838.

Fear of suffocating; “Once I lose it, it’s kind of hard to catch it. That’s what scares me”

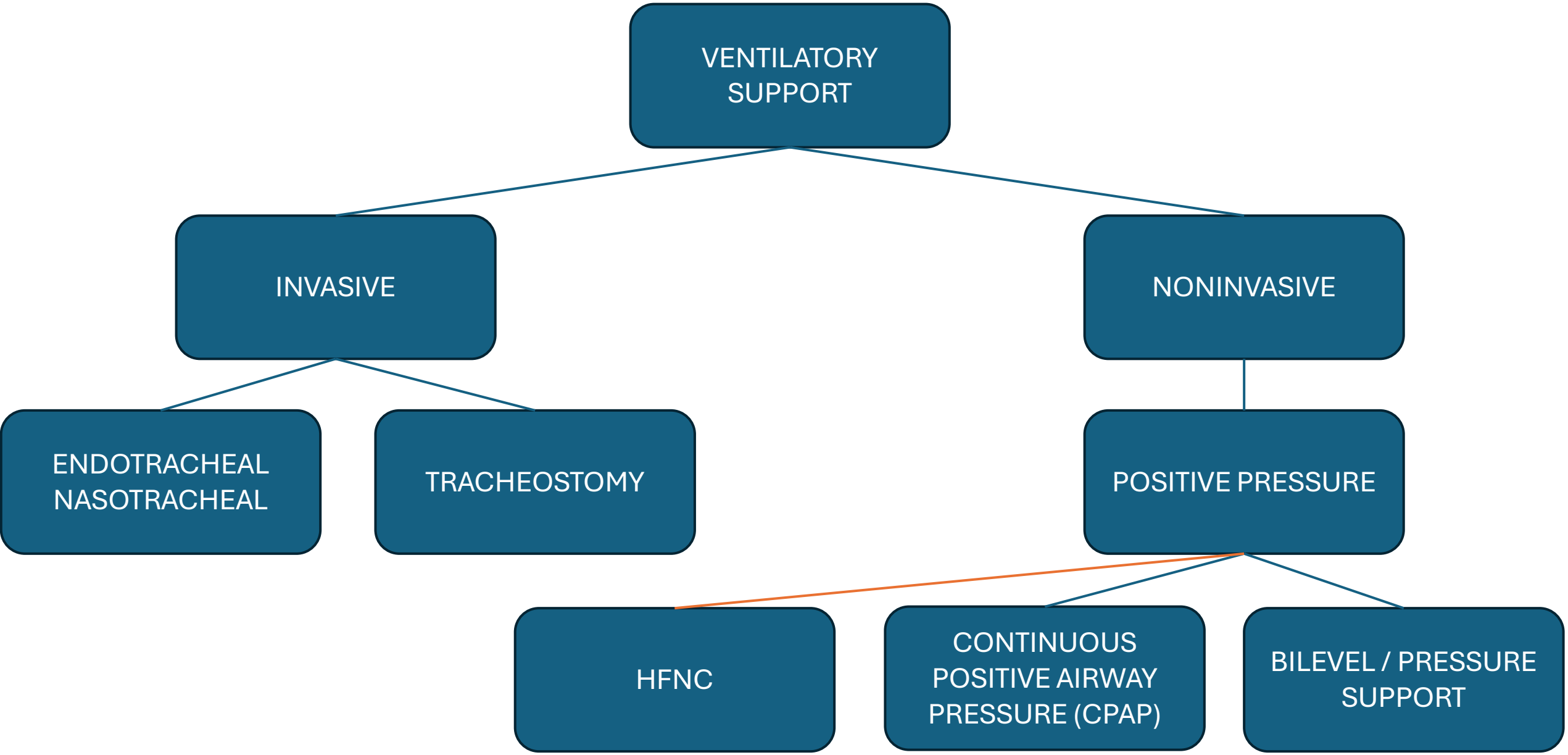
Hall S. Int J Palliat Nurs. 2010;16(9):451–457
Luce JM JAMA. 2001;285(10):1331–1337
Am J Respir Crit Care Med. 2008;177(8):912–927

Dyspnea in Critical Illness

TABLE 3. GUIDELINES FOR TREATMENT OF DYSPNEA

Mild Dyspnea	Moderate Dyspnea	Severe Dyspnea
Treat underlying disease*	Treat underlying disease	Treat underlying disease
Treat psychosocial factors†	Treat psychosocial factors	Treat psychosocial factors
	Pulmonary rehabilitation‡ Consider anxiolytic	Pulmonary rehabilitation Facial cooling (by use of fan) Anxiolytics Opioids§ Noninvasive ventilation (88)

Am J Respir Crit Care Med. 2008;177(8):912–927


VENTILATORY SUPPORT
INVASIVE
NONINVASIVE
ENDOTRACHEAL NASOTRACHEAL
TRACHEOSTOMY
POSITIVE PRESSURE
HFNC
CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)
BILEVEL / PRESSURE SUPPORT

One continuous pressure (i.e. 5 CWP)

Acts to increase airway pressure

Two pressures (inspiratory + expiratory)

Acts to increase airway pressure AND augments ventilation

INDICATIONS

- *Common* reasons to initiate NIV
  - Bronchospasm (asthma, COPD), cardiogenic pulmonary edema, atelectasis
  - Acute +/- chronic hypercapnia
  - Increased work of breathing or decreased muscle strength (*)

Contraindications

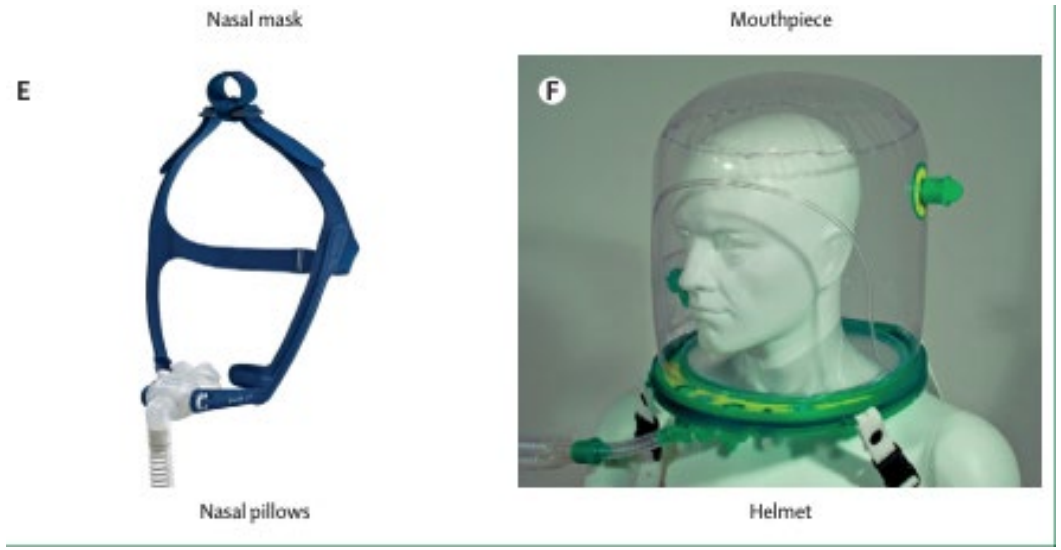
Absolute

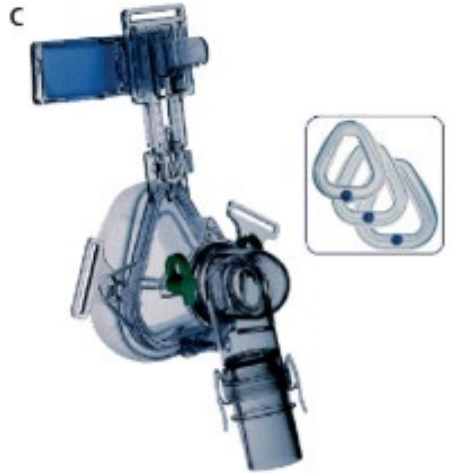
- Respiratory arrest
- Unable to fit mask

Relative

- Medically unstable—hypotensive shock, uncontrolled cardiac ischaemia or arrhythmia, uncontrolled copious upper gastrointestinal bleeding
- Agitated, uncooperative
- Unable to protect airway
- Swallowing impairment
- Excessive secretions not managed by secretion clearance techniques
- Multiple (ie, two or more) organ failure
- Recent upper airway or upper gastrointestinal surgery

Lancet. 2009 Jul 18;374(9685):250-9





Nasal mask

Mouthpiece

Full face mask

Total face mask

Lancet. 2009 Jul 18;374(9685):250-9

Recommendations based on levels of evidence[21]

Level 1 evidence

Systematic reviews (with homogeneity) of RCTs and individual RCTs (with narrow CIs)

Evidence of use (favourable)

- COPD exacerbations
- Facilitation of weaning/extubation in patients with COPD
- Cardiogenic pulmonary oedema
- Immunosuppressed patients

Evidence of use (caution)

- None

Lancet. 2009 Jul 18;374(9685):250-9

Level 2

Systematic reviews (with homogeneity) of cohort studies—individual cohort studies (including low quality RCTs; eg, <80% follow-up)

Evidence of use (favourable)

- Do-not-intubate status
- End-stage patients as palliative measure
- Extubation failure (COPD or congestive heart failure) (prevention)
- Community-acquired pneumonia in COPD
- Postoperative respiratory failure (prevention and treatment)
- Prevention of acute respiratory failure in asthma

Evidence of use (caution)

- Severe community acquired pneumonia
- Extubation failure (prevention)

Lancet. 2009 Jul 18;374(9685):250-9

Level 3

Systematic reviews (with homogeneity) of case–control studies, individual case-control study

Evidence of use (favourable)

- Neuromuscular disease/kyphoscoliosis
- Upper airway obstruction (partial)
- Thoracic trauma
- Treatment of acute respiratory failure in asthma

Evidence of use (caution)

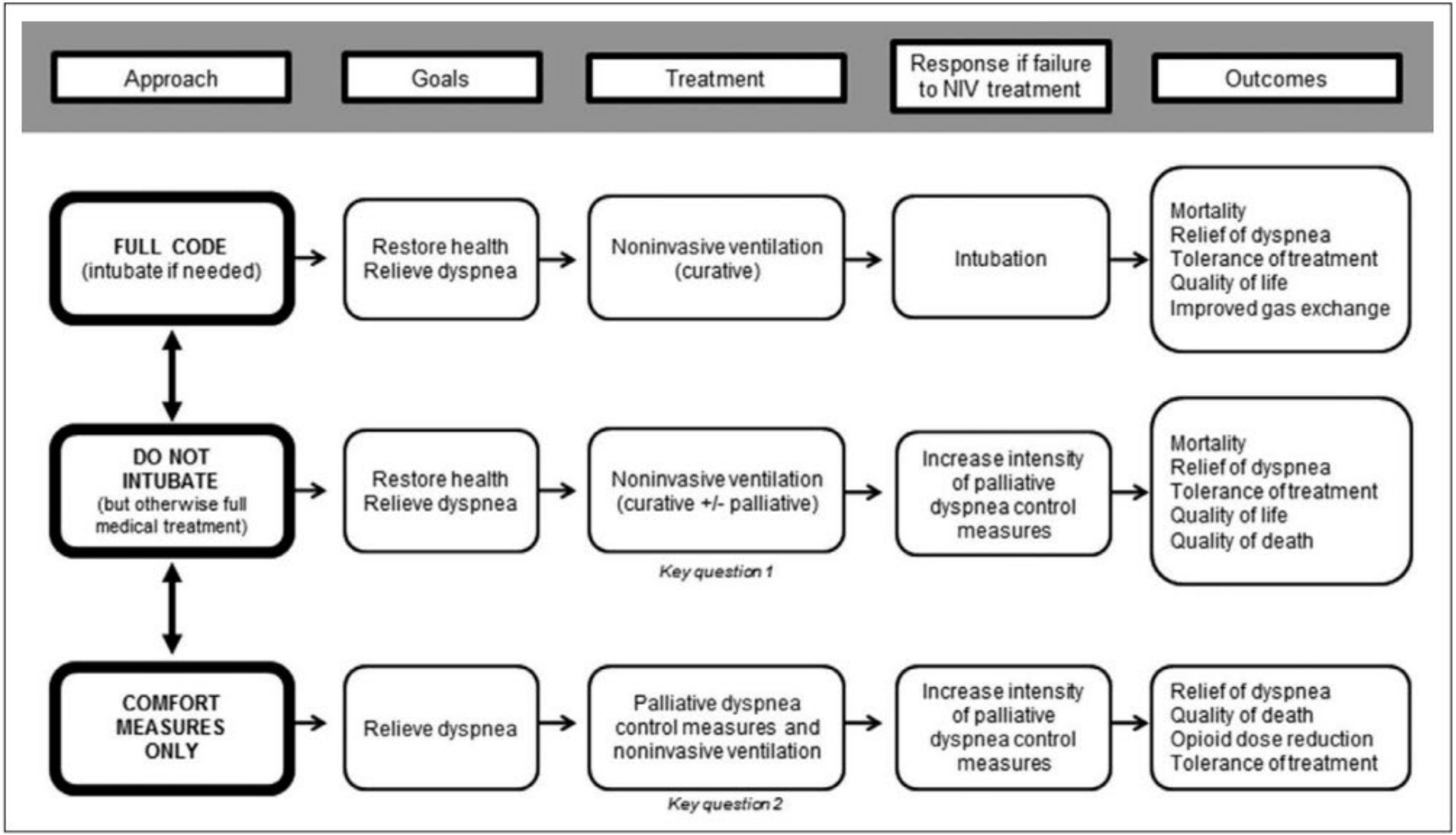
- Severe acute respiratory syndrome

Lancet. 2009 Jul 18;374(9685):250-9

Table 1. Overview of the three-category approach to using noninvasive positive pressure ventilation (NPPV) for acute respiratory failure

Approach	Category 1	Category 2	Category 3
Definition	Life Support Without Preset Limits	Life Support With Preset Limit (Do Not Intubate)	Comfort Measures Only
Primary goals of care	Assist ventilation and/or oxygenation Alleviate dyspnea Achieve comfort Reduce risk of intubation Reduce risk of mortality Avoidance of intubation	Includes same as category 1 except intubation declined Also could include briefly prolonging life for a specific purpose (e.g., arrival of family member)	Palliation of symptoms (relief of dyspnea)
Main goals to communicate with patient and family	Goal is to restore health and use intubation if necessary and indicated	Goal is to restore health without using endotracheal intubation and without causing unacceptable discomfort	Goal is to maximize comfort while minimizing adverse effects of opiates
Determination of success	Improved oxygenation and/or ventilation Tolerance of NPPV or minor discomfort that is outweighed by potential benefit	Improved oxygenation and/or ventilation Tolerance of NPPV or minor discomfort that is outweighed by potential benefit	Improved symptoms Tolerance of NPPV
Endpoint for NPPV	Unassisted ventilation adequately supporting life Intolerance of NPPV	Unassisted ventilation adequately supporting life Intolerance of NPPV	Patient is *not* more comfortable having NPPV on or wants NPPV stopped Patient becomes unable to communicate
Response to failure	Intubation and mechanical ventilation (if indicated)	Change to comfort measures only and palliate symptoms without NPPV	Palliate symptoms without NPPV
Likely location of NPPV	ICU but may include step-down unit or acute care bed in some hospitals with appropriately monitored setting and trained personnel	Variable but may include ICU or step-down unit or acute care bed	Acute care bed but could be applied in hospice by appropriately trained personnel

Crit Care Med. 2007 Mar;35(3):932-9



Crit Care Med . 2018 Aug;46(8):1209-1216

What is the goal? What is the disease?

(1) Life-sustaining measure (no preset limits)?

(2) Life-sustaining (time-limited trial) if deciding to forego IMV?

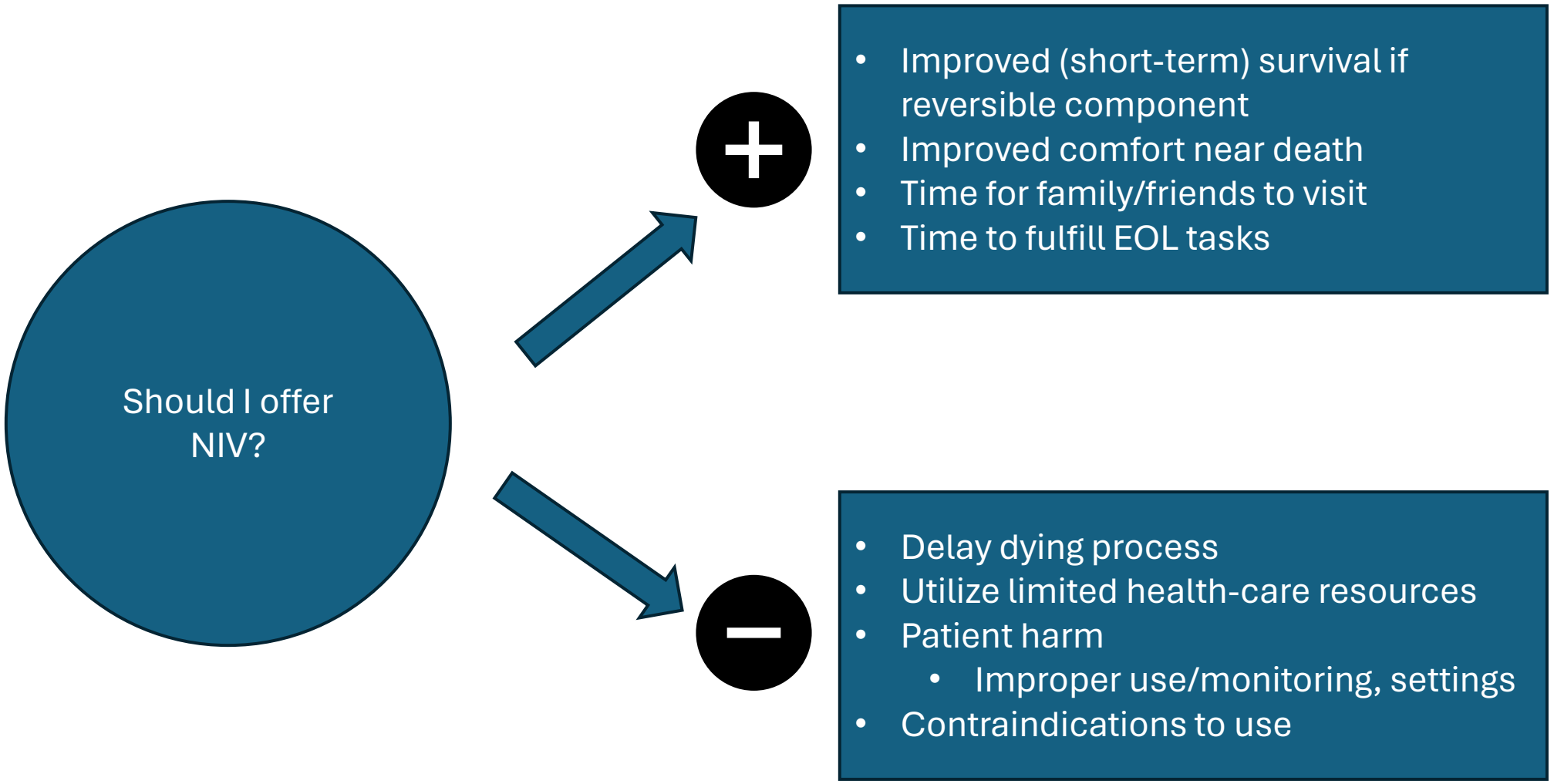
(3) Palliative measure if deciding to forego all life support → Comfort

Crit Care Med. 2007 Mar;35(3):932-9

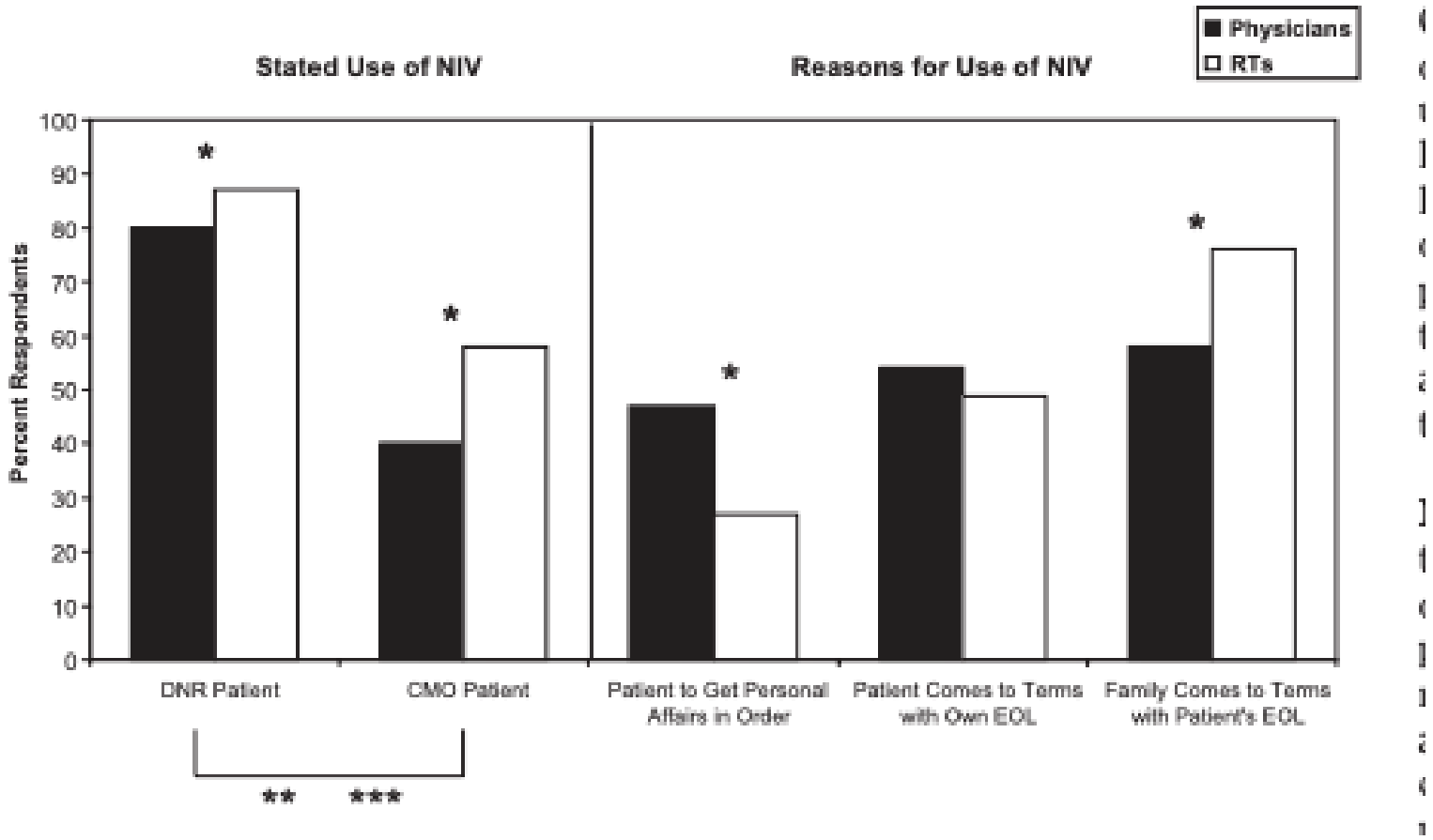
Intensive Care Med. 2011 Aug;37(8):1250-7

SETTING EXPECTATIONS

- Goals of therapy to be discussed BEFORE initiation
  - ‘patch’ not ‘cure’
- Discuss end-points/branch-points
- Discuss risks



Respiratory Care June 2019, 64 (6) 701-711



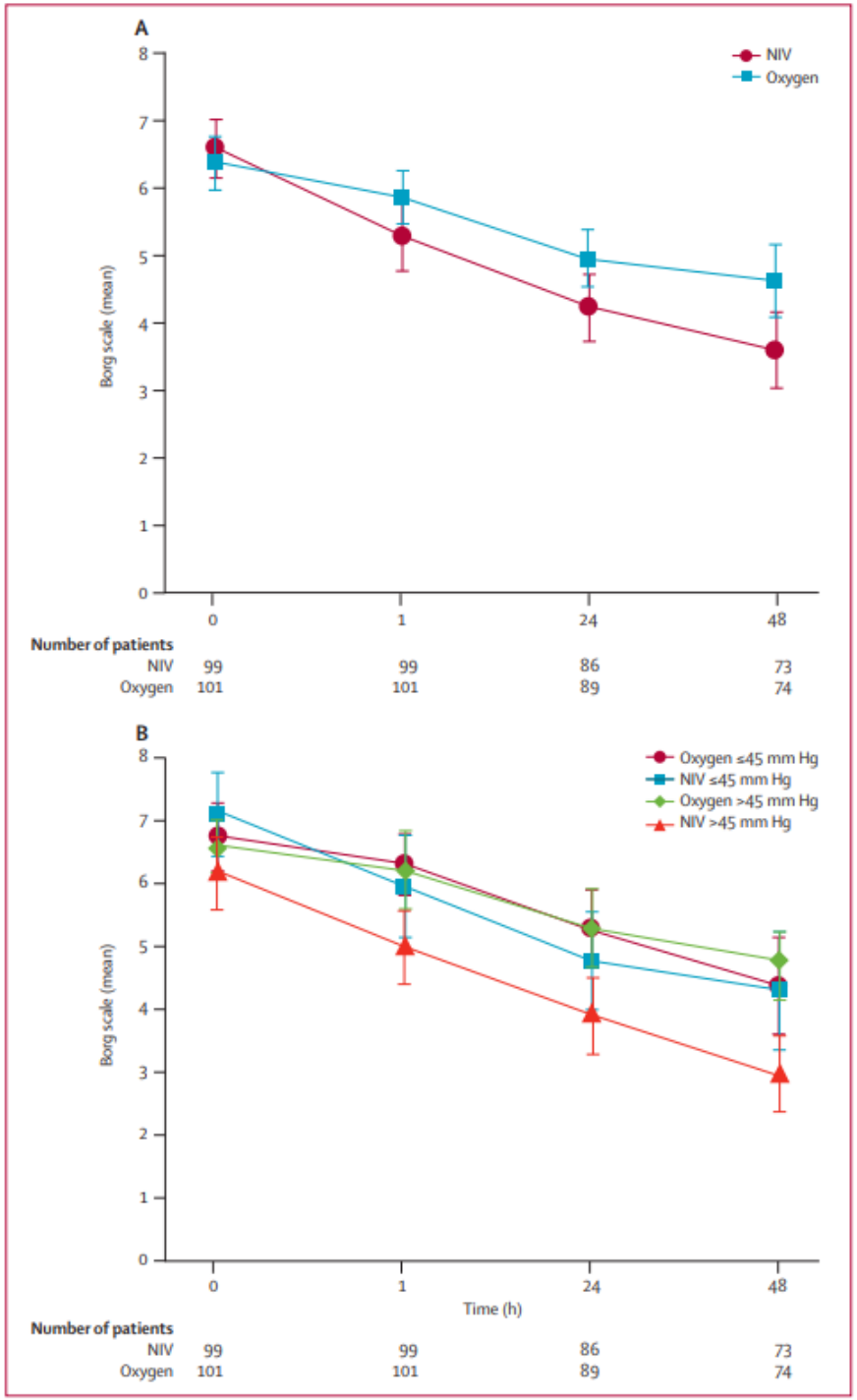
- 2/3 physicians included NIV in EOL discussion in DNR patients at least sometimes
- 87% RTs stated that NIV should be included in these discussions

- Comfort: ½ physicians reported including conversation; < ½ RTs felt these aught to be discussed

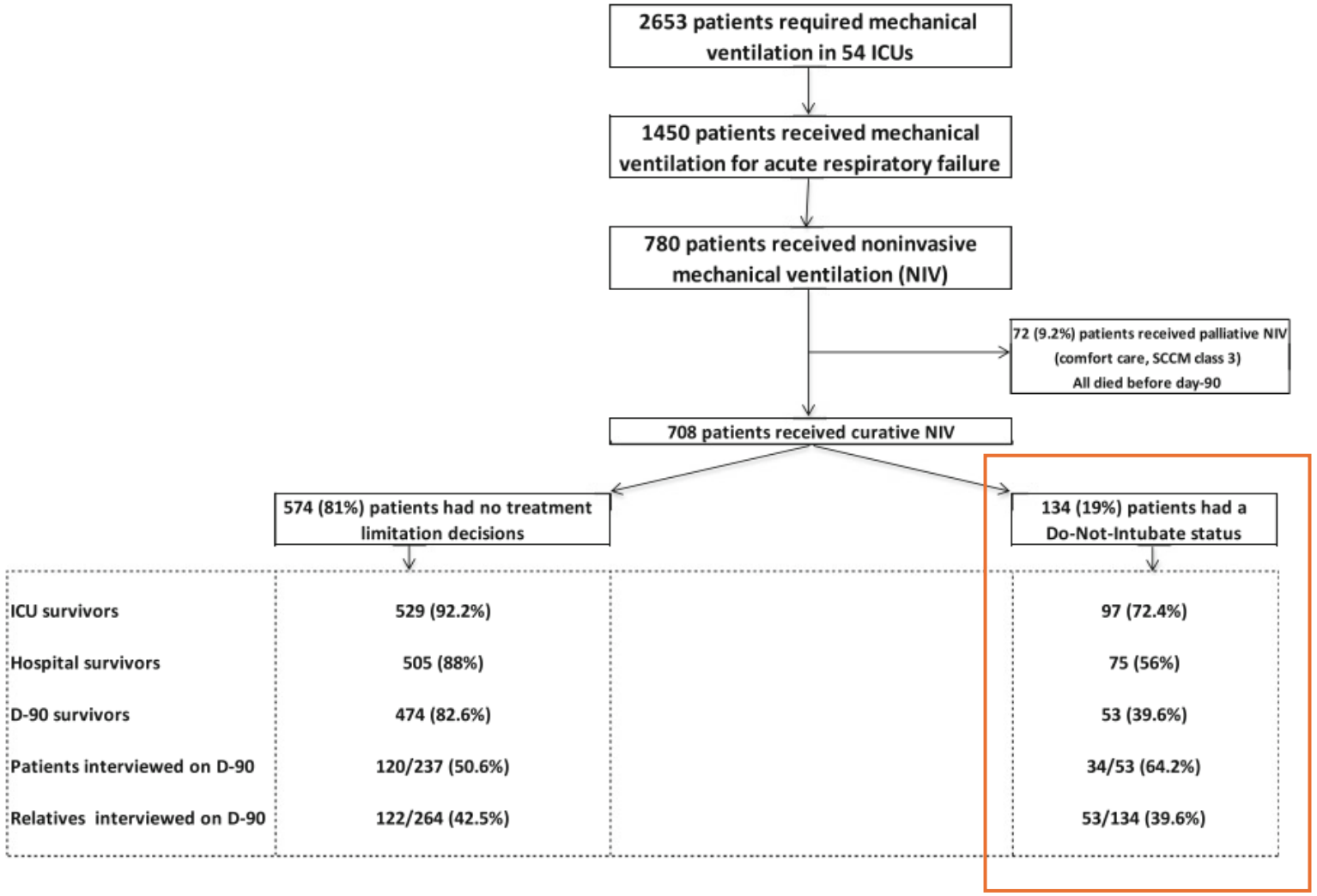
Crit Care Med.2008 Mar;36(3):789-94

NIV vs Oxygen therapy

- 99 NIV vs 101 Oxygen
- NIV: more rapid dyspnea score decrement
- Total morphine dose (N) 26.9 mg vs (0) 59.4 mg



Lancet Oncol . 2013 Mar;14(3):219-27



- DNI patients were: older, smokers/ drinkers, cancer and poor health status
  - More likely to have COPD as cause of resp status
- DNI: 44% hospital mortality
- DNI: 40% 90-day survival
  - No decrease in health-related QOL via phone interviews

Intensive Care Med . 2013 Feb;39(2):292-301

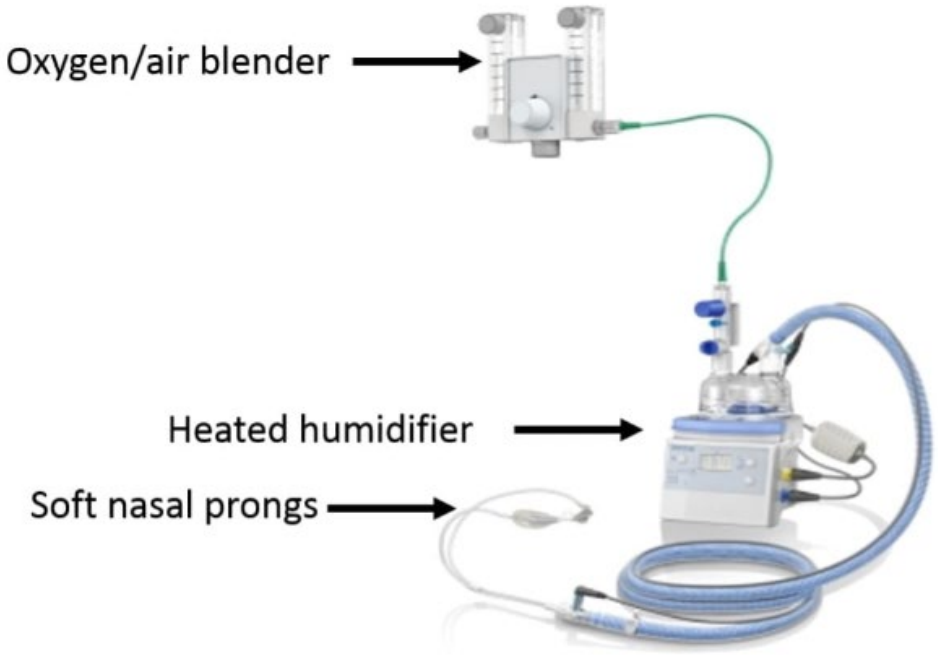
Noninvasive Ventilation in Patients With Do-Not-Intubate and Comfort-Measures-Only Orders: A Systematic Review and Meta-Analysis*

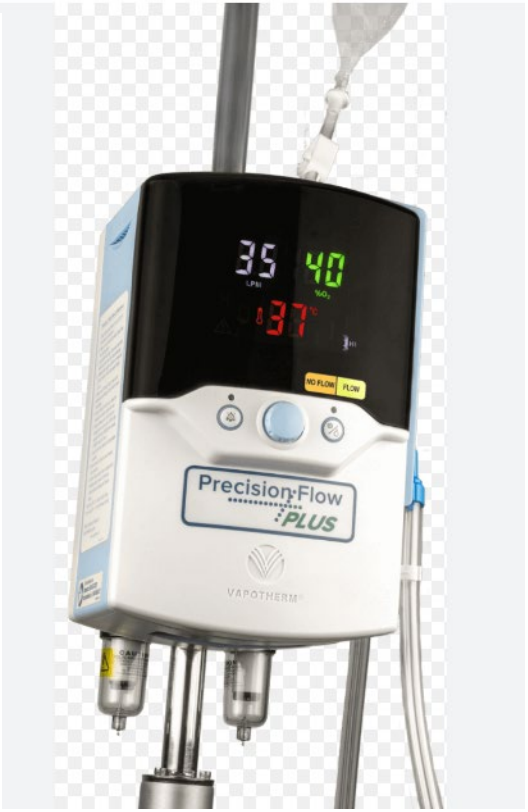
Michael E. Wilson, MD[1,2]; Abdul M. Majzoub, MD[1]; Claudia C. Dobler, MD, PhD[3]; J. Randall Curtis, MD, MPH[4,5]; Tarek Nayfeh, MD[6]; Bjorg Thorsteinsdottir, MD[2,7,8]; Amelia K. Barwise, MB, BCh, BAO[1,8]; Jon C. Tilburt, MD, MPH[7,8]; Ognjen Gajic, MD, MSc[1]; Victor M. Montori, MD, MSc[3,6]; M. Hassan Murad, MD, MPH[2,6]

- 27 studies, 2,020 patients with DNI
  - 3 studies, 200 patients with comfort-only
- 56% survival at discharge
  - 68% COPD, 68% CHF, 41% PNA, 37% malignancy
- 32% survival at 1 year
- No significant QOL reduction (limited data)

Crit Care Med . 2018 Aug;46(8):1209-1216

Heated Humidified High Flow Nasal Cannula (HHFNC) / High Flow Nasal Cannula (HFNC)





HFNC

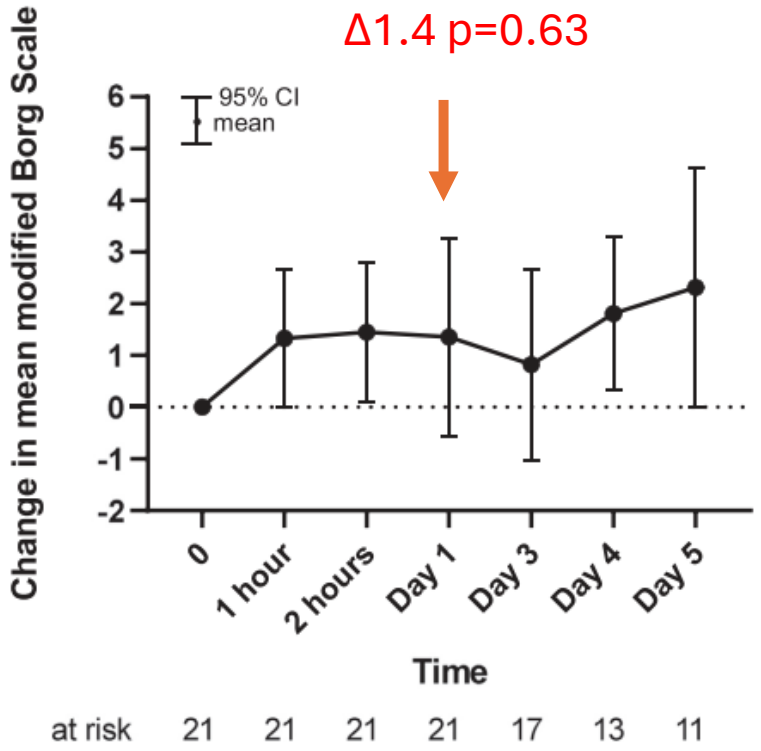
- Up to 60L/min of flow
- Independently adjust Fi02 (oxygen content) and Flow
- Heated and humidified (may thin secretions)
- High flow – flushes dead-space/C02
- Low level PEEP – estimates ~ 0.7 CWP/10L flow*

A Phase II Study of High-Flow Nasal Cannula for Relieving Dyspnea in Advanced Cancer Patients

Eri Takase, MD, Hiroaki Akamatsu, MD, PhD, Shunsuke Teraoka, MD, Keita Nakaguchi, MD, Masanori Tanaka, MD, Takahiro Kaki, MD, Katsuyuki Furuta, MD, Koichi Sato, MD, PhD, Eriko Murakami, MD, Takeya Sugimoto, MD, Ryota Shibaki, MD, Daichi Fujimoto, MD, PhD, Atsushi Hayata, MD, PhD, Nahomi Tokudome, MD, PhD, Yuichi Ozawa, MD, PhD, Yasuhiro Koh, MD, PhD, Masanori Nakanishi, MD, PhD, Kuninobu Kanai, MD, PhD, Toshio Shimokawa, PhD, and Nobuyuki Yamamoto, MD, PhD

Internal Medicine III (E.T., H.A., S.T., K.N., M.T., T.K., K.F., K.S., E.M., T.S., R.S., D.F., A.H., N.T., Y.O., Y.K., M.N., N.Y.), Wakayama Medical University, Wakayama, Japan; Center for Biomedical Sciences (Y.K.), Wakayama Medical University, Wakayama, Japan; Department of Respiratory Medicine (K.K.), Naga Municipal Hospital, Wakayama, Japan; Clinical Study Support Center (T.S.), Wakayama Medical University, Wakayama, Japan

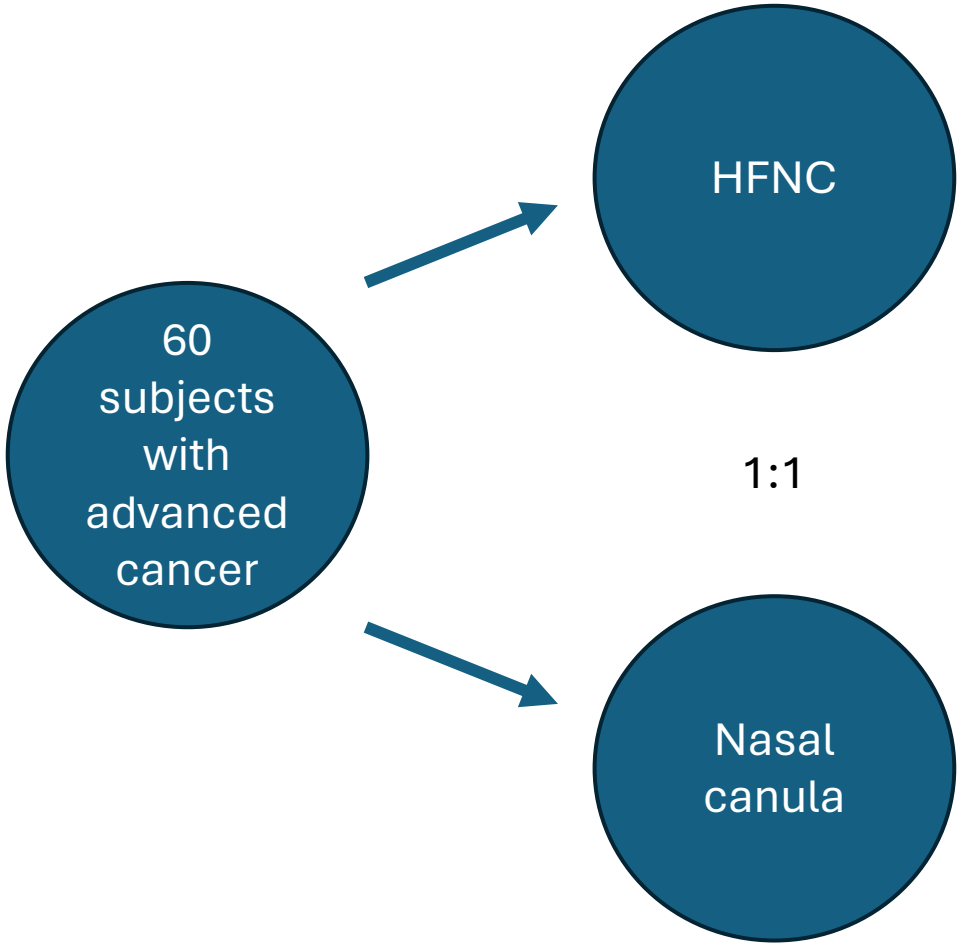
- 21 DNI patients with advanced cancer and ECOG 3 or 4 with NRS > 3 and hypoxia
- Mean age = 72, majority male, with lung cancer
- Mean Fi02 was 0.34
- Mean NRS = 5.2, mean mBorg = 5.9



J Pain Symptom Manage. 2024 Mar;67(3):204-211.e1

Effect of heated humidified high-flow nasal cannula (HFNC) oxygen therapy in dyspnea patients with advanced cancer, a randomized controlled clinical trial

Zhaoning Xu[1,2] · Pingping Li[2] · Chi Zhang[3] · Dedong Ma[4]



SRSS score		
Before	After 3 days	*P*
36.97 ± 2.04	37.47 ± 2.39	0.247
36.27 ± 2.00	30.27 ± 2.05	< 0.001
0.192	< 0.001	

Degree of dryness of mouth score		
Before	After 3 days	*P*
6.50 ± 1.50	8.13 ± 1.20	< 0.001
6.07 ± 1.55	6.47 ± 1.55	0.056
0.276	< 0.001	

Group	VAS score		
	Before	After 3 days	*P*
Control group	8.57 ± 1.10	8.77 ± 1.38	0.415
Intervention group	8.23 ± 1.36	6.80 ± 0.48	< 0.001
P	0.301	< 0.001	

HFNC VS NIV (PAP)

Table 1. Subject Characteristics (n = 50)

Male	25
Female	25
Age, mean y	73
Age range, y	27–96
Diagnosis for hypoxemic respiratory failure, no. (hospital mortality %)	
Pulmonary fibrosis	15 (73.3)
Pneumonia	15 (46.7)
COPD	12 (33.3)
Congestive heart failure	3 (33.3)
Solid malignancy	7 (57)
Hematologic malignancy	7 (71.4)
Sepsis	2 (50)
Pulmonary embolism	2 (50)
Myocardial infarct	1 (0)
Hemorrhage	1 (100)

Table 2. Outcome of High-Flow Nasal Oxygen in 50 Subjects* With Do-Not-Intubate Status

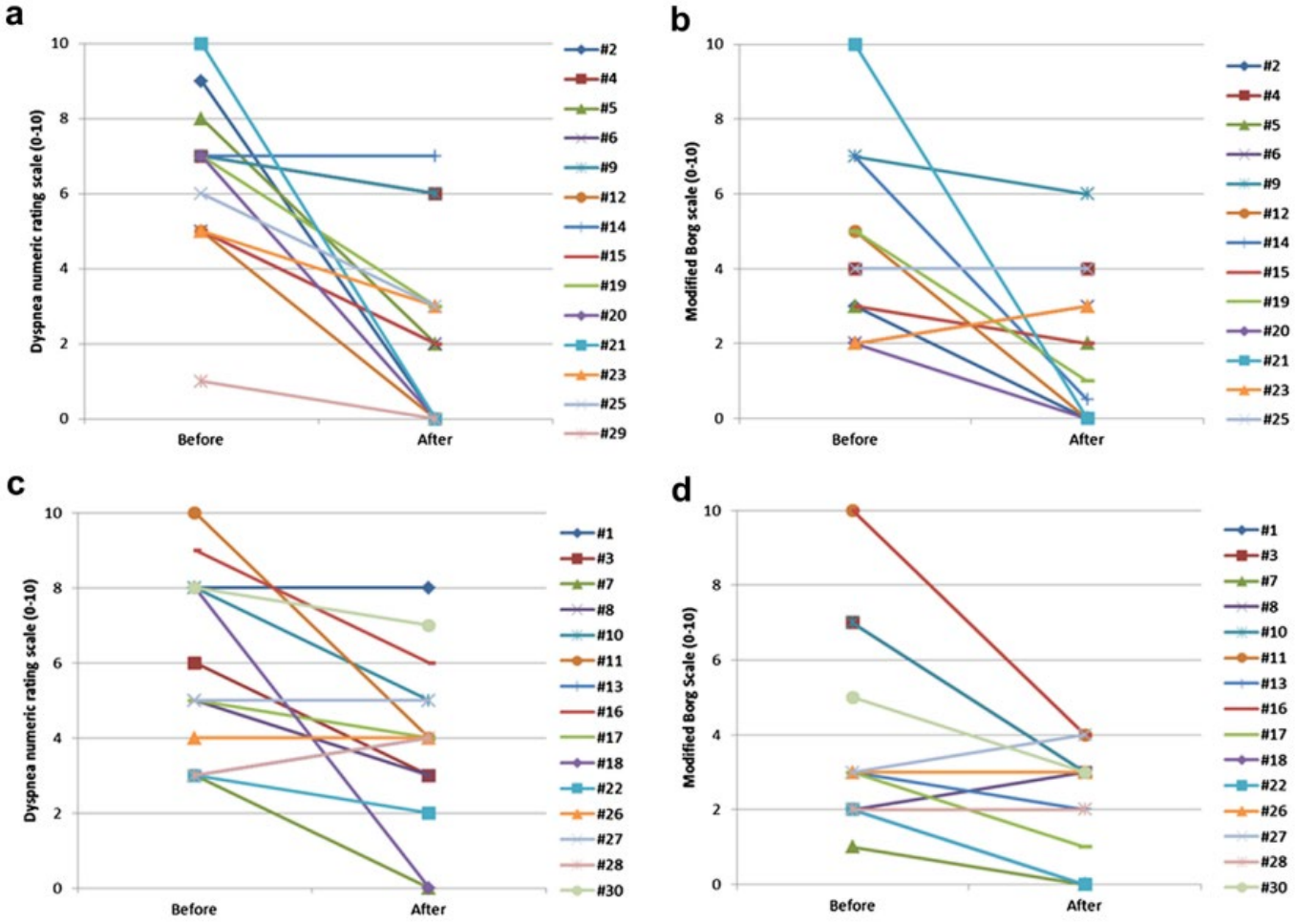
	Pre-HFNC	Post-HFNC	P
Breathing frequency, breaths/min	30.6	24.7	< .001
O_2 saturation	89.1	94.7	< .001

* 41/50 (82%) were maintained on high-flow nasal cannula (HFNC). 9/50 (18%) escalated to noninvasive ventilation. Overall hospital mortality was 60%. The mean HFNC F_{IO_2} was 0.67 (range 0.3–1.0). The mean HFNC flow was 42.6 L/min (range 30–60 L/min).

9/50 escalated to NIV
39/50 maintained on HFNC

Respir Care 2013;58(4):597-600

HFNC VS NIV (PAP)



Patients with advanced cancer

J Pain Symptom Manage 2013;46(4):463-473.

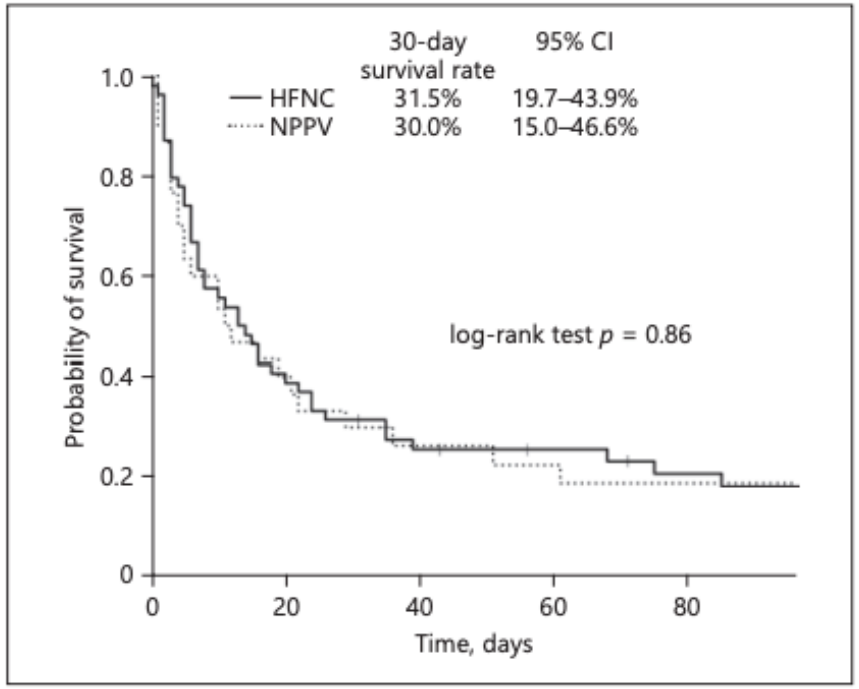


Table 2. Outcomes in patients with hypoxemic respiratory failure associated with interstitial lung disease

Outcome	HFNC group (n = 54)	NPPV group (n = 30)	p value
In-hospital mortality	43 (79.6)	25 (83.3)	0.78
Temporary interruption at the patient's request	2 (3.7)	7 (23.3)	0.009
Discontinuation at the patient's request	0 (0)	3 (10.0)	0.043
Adverse events	1 (1.9)	7 (23.3)	0.003
Number of days from the last meal to death	2 (1–5) (n = 43)	4 (2–8) (n = 25)	0.037
Number of days from the last conversation to death	1 (1–2) (n = 43)	2 (1–4) (n = 25)	0.042

Patients with ILD

Respiration 2018;96(4):323-329.

WHICH ONE?

- Absolute (or relative) contra-indications
- Patient preference or ability to tolerate
- Disease process
  - Hypoxia, hypercapnia, both
  - Natural history
- Staff comfort and availability of interface
- Severity of symptoms
- Do no harm

BARRIERS

- Anxiety/claustrophobia
- Gastric distension
- Noise, mask fit, pressure sores
- Unable to deep suction
- Physician
  - Reluctance to discuss end-of-life decisions
  - Poor understanding of disease trajectory
  - *Perceived* lack of understanding among patients/relatives

TO SUMMARIZE

- Noninvasive ventilation is a form of positive pressure ventilation / ventilatory assistance that does not utilize an artificial airway
- Understand indications AND contraindications
- NIV can demonstrate mortality benefit in acute exacerbations of COPD or CHF
- In end-stage diseases it may have benefit as a bridge to a goal and to treat symptoms

QUESTIONS?