Demystifying mechanical ventilators: what’s under the hood?

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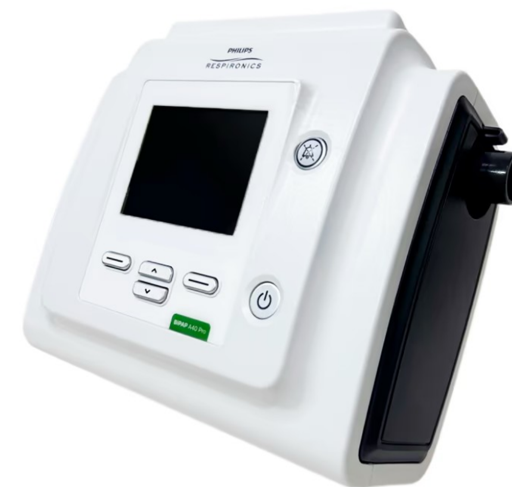
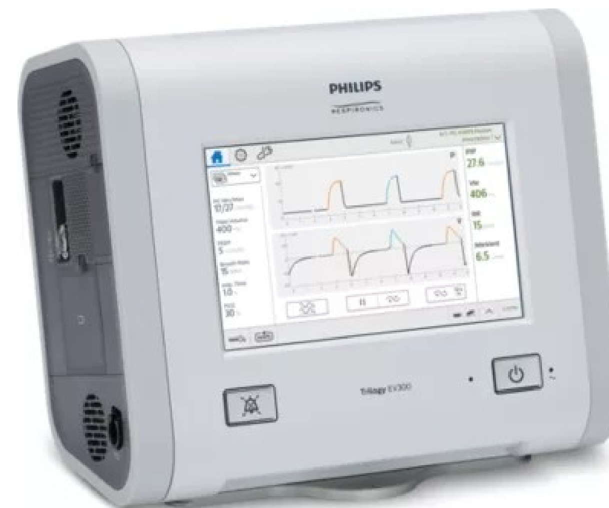
ASV
25
7.0
435
16




PHILIPS

Conflicts of interest disclosure

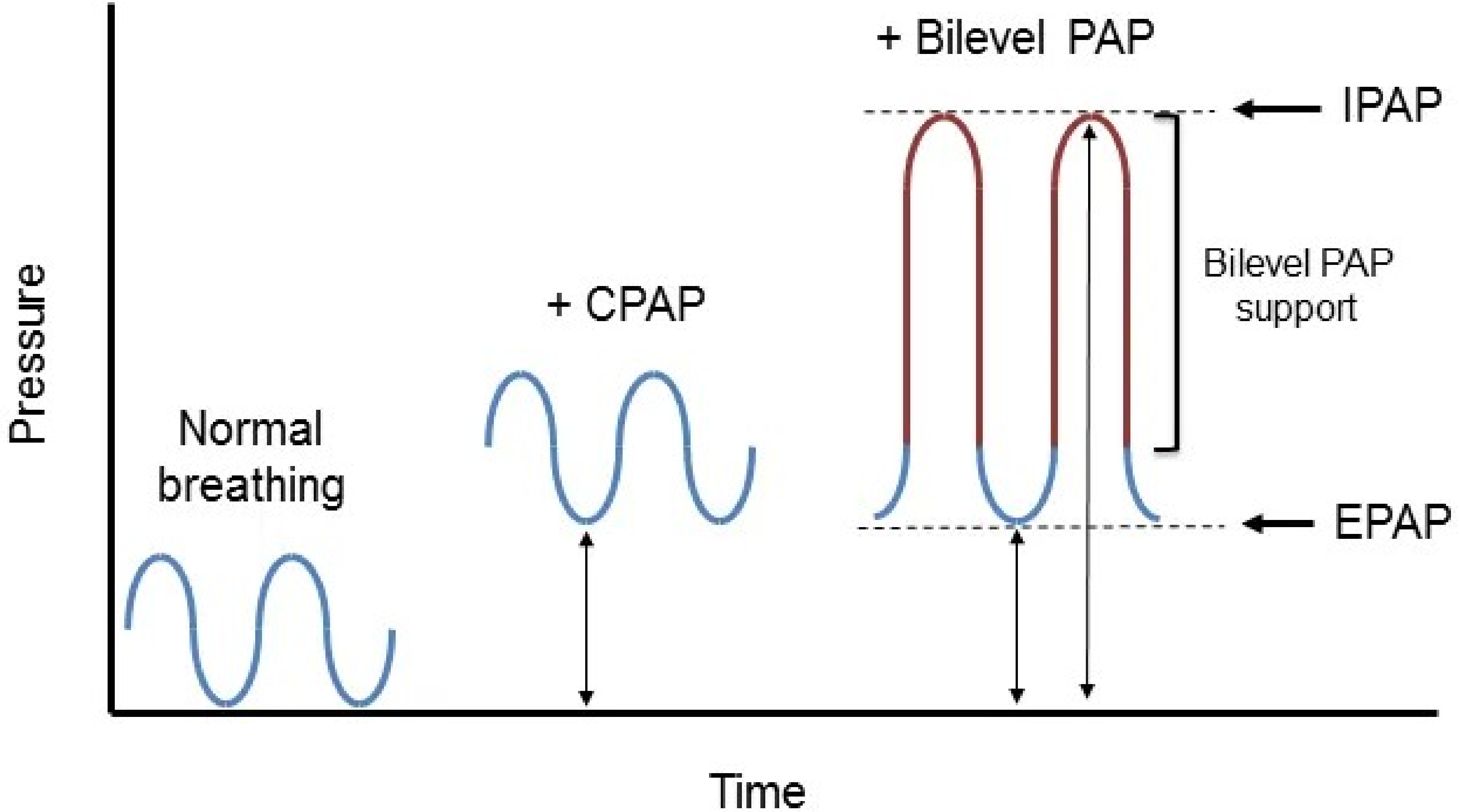
- I have no real or perceived conflicts of interest relating to this presentation

Terminology

NIV
NIMV
NIPPV/NPPV
BiPAP/BPAP

IMV
MV
IPPV

CPAP
(PEEP)


Pressure
Time
Normal breathing
+ CPAP
+ Bilevel PAP
IPAP
EPAP
Bilevel PAP support

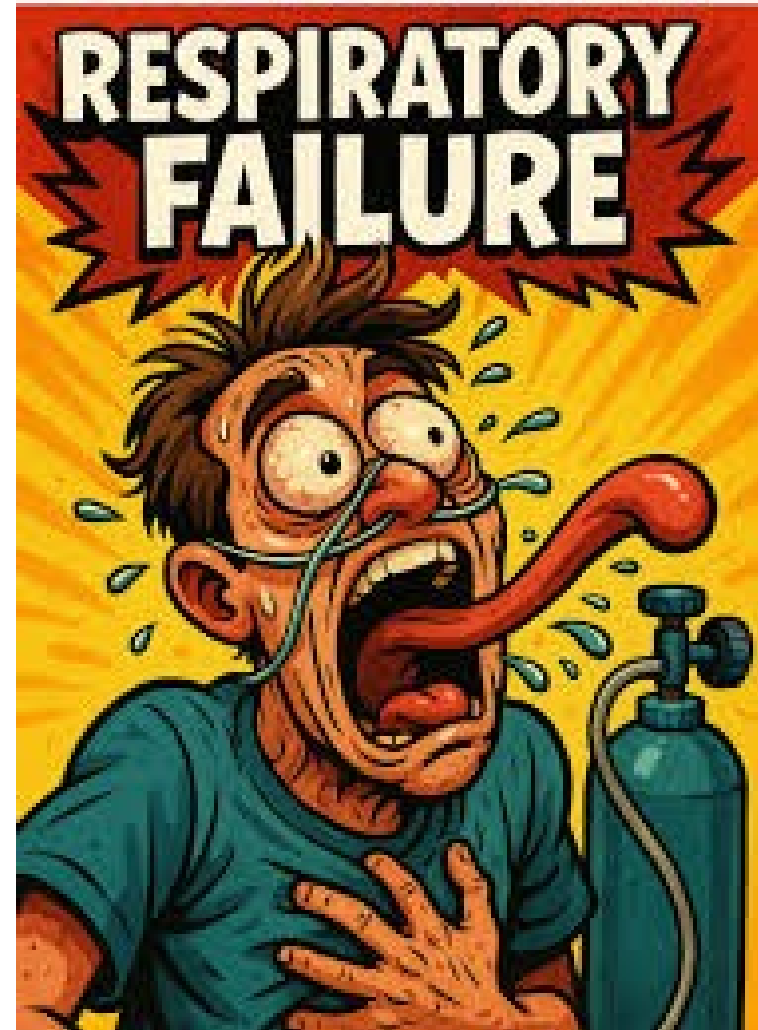
Typical clinical use

NIV → Ventilatory support

- Acute or chronic hypercapnic respiratory failure ('ventilatory failure')
- COPD
- Obesity hypoventilation syndrome
- Chest wall deformity
- Neuromuscular disease

CPAP → Oxygenation and/or airway patency

- OSA
- Acute pulmonary oedema
- (COVID)



Contraindications to NIV

- Absolute
  - Facial deformity or burns
  - Fixed upper airway obstruction
  - Undrained pneumothorax
- Relative
  - pH <7.15 (or pH <7.25 with an additional adverse feature)
  - Factors affecting compliance of wearing the face mask
  - Unprotected airway / GCS <8
  - Copious respiratory secretions

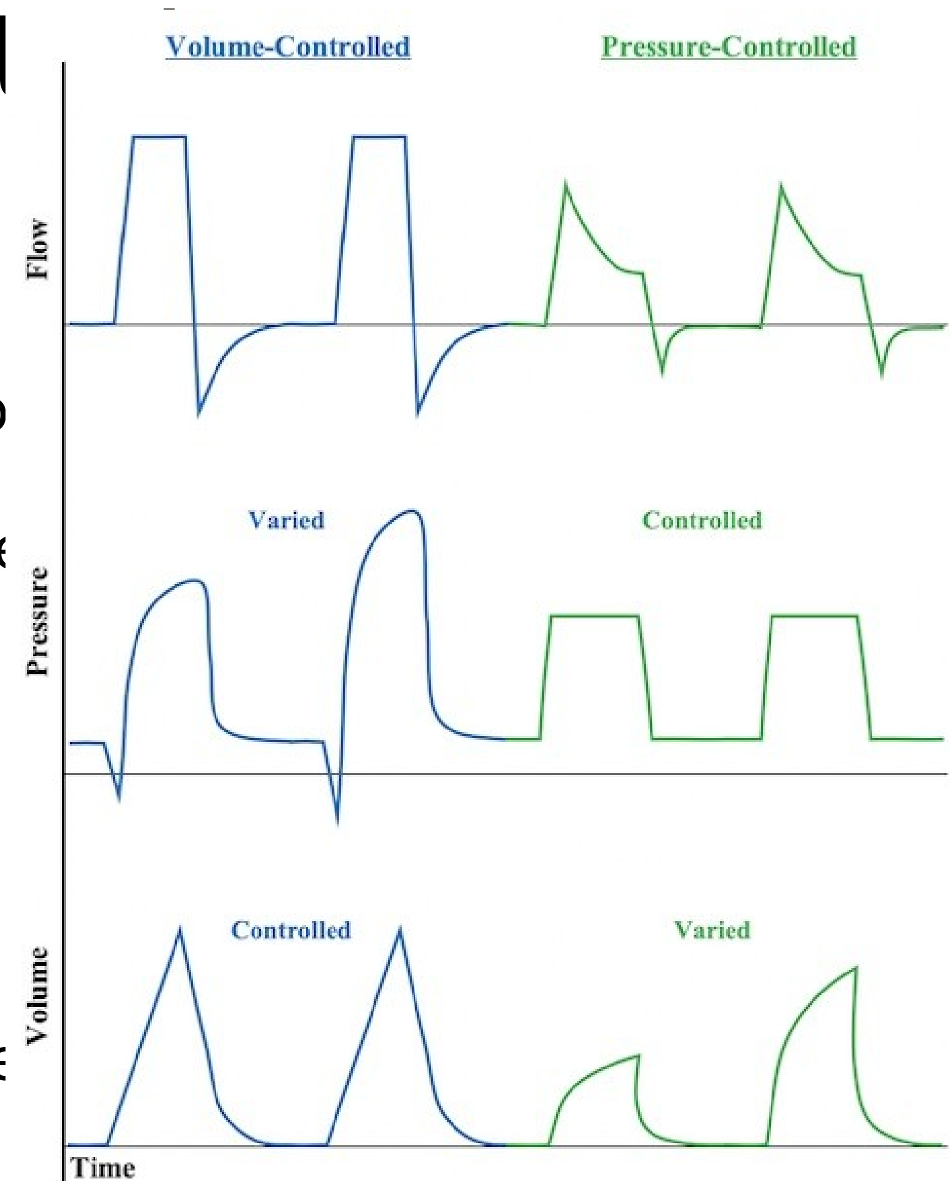
NIV set-up

- Equipment
  - Ventilator
  - Filter
  - Circuit (single v dual limb)
  - Mask
  - (Oxygen supply)
  - (Nebuliser T-piece)

Pressure v. volume cont

- Pressure-controlled:
  - Set pressures delivered (mitigates leak)
  - Ensures adequate pressure achieved (avo barotrauma) but variable volume → risk of hypoventilation if compliance change
  - Typically adopted in practice

- Volume-controlled:
  - Set volumes delivered
  - Ensures consistent tidal volume/minute ventilation, but risks high pressures (variab
  - More often adopted in ITU/strict control ne



Modes

- Pressure-driven:
  - BPAP/CPAP
  - S/T - spontaneous/timed (patient initiates, provides support, but also forces breath if patient fails to initiate)
  - e.g. NIV-ST, PC-BiPAP, PS-NIV, P-SIMV
- Volume-driven:
  - e.g. VAPS, VC-A/C, PRVC, SIMV
- Hybrid
  - e.g. AVAPS (average volume assured pressure support) – adapts to changing lung mechanics

Settings

- IPAP
- EPAP
- ΔPinsp
- Back up rate
- Ti
- Te
- Trigger sensitivity (detection of patient effort)
- P-ramp (speed at which pressure is reached)

Indications for NIV

COPD
pH <7.35
pCO2 >6.5
RR>23
If persisting after bronchodilators and controlled oxygen therapy

Neuromuscular disease
Respiratory illness with RR > 20 if usual VC <1L even if pCO2<6.5
Or
pH < 7.35 and pCO2>6.5

Obesity
pH <7.35, pCO2>6.5, RR>23
Or
Daytime pCO2> 6.0 and somnolent

NIV Not indicated
Asthma/Pneumonia
Refer to ICU for consideration IMV if increasing respiratory rate/distress
or
pH <7.35 and pCO2 >6.5

Contraindications for NIV

Absolute
Severe facial deformity
Facial burns
Fixed upper airway obstruction

Relative
pH<7.15
(pH<7.25 and additional adverse feature)
GCS <8
Confusion/agitation
Cognitive impairment (warrants enhanced observation)

Indications for referral to ICU
AHRF with impending respiratory arrest

NIV failing to augment chest wall movement or reduce pCO2

Inability to maintain Sao2 > 85-88% on NIV

Need for IV sedation or adverse features indicating need for closer monitoring and/or possible difficult intubation as in OHS, DMD.

NIV SETUP

Mask
Full face mask (or own if home user of NIV)

Initial Pressure settings
EPAP: 3 (or higher if OSA known/expected)

IPAP in COPD/OHS/KS 15 (20 if pH <7.25)

Up titrate IPAP over 10-30 mins to IPAP 20—30 to achieve adequate augmentation of chest/abdo movement and slow RR

IPAP should not exceed 30 or EPAP 8* without expert review

IPAP in NM 10 (or 5 above usual setting)

Backup rate
Backup Rate of 16-20. Set appropriate inspiratory time

I:E ratio
COPD 1:2 to 1.3
OHS, NM & CWD 1:1

Inspiratory time
0.8-1.2s COPD
1.2-1.5s OHS, NM & CWD

Use NIV for as much time as possible in 1st 24hours.
Taper depending on tolerance & ABGs over next 48-72 hours

SEEK AND TREAT REVERSIBLE CAUSES OF AHRF

*** Possible need for EPAP > 8**
Severe OHS (BMI >35), lung recruitment eg hypoxia in severe kyphoscolios, oppose intrinsic PEEP in severe airflow obstruction or to maintain adequate PS when high EPAP required

NIV Monitoring

Oxygenation
Aim 88-92% in all patients

Note: Home style ventilators CANNOT provide > 50% inspired oxygen.

If high oxygen need or rapid desaturation on disconnection from NIV consider IMV.

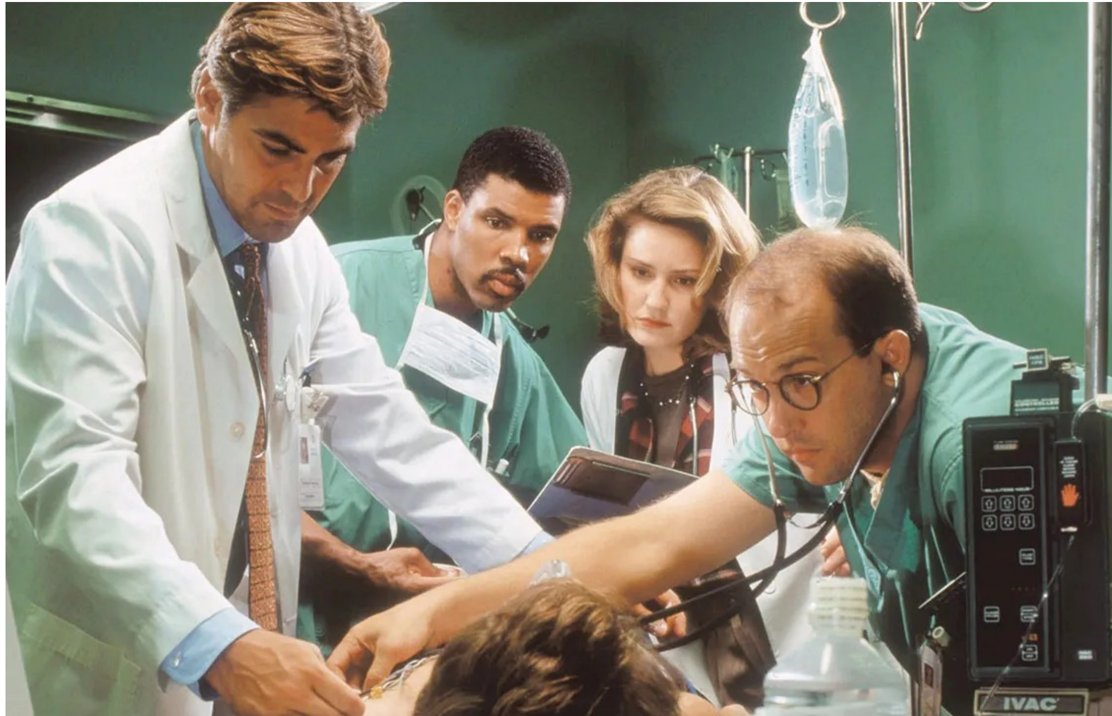
Red flags
pH <7.25 on optimal NIV
RR persisting > 25
New onset confusion or patient distress

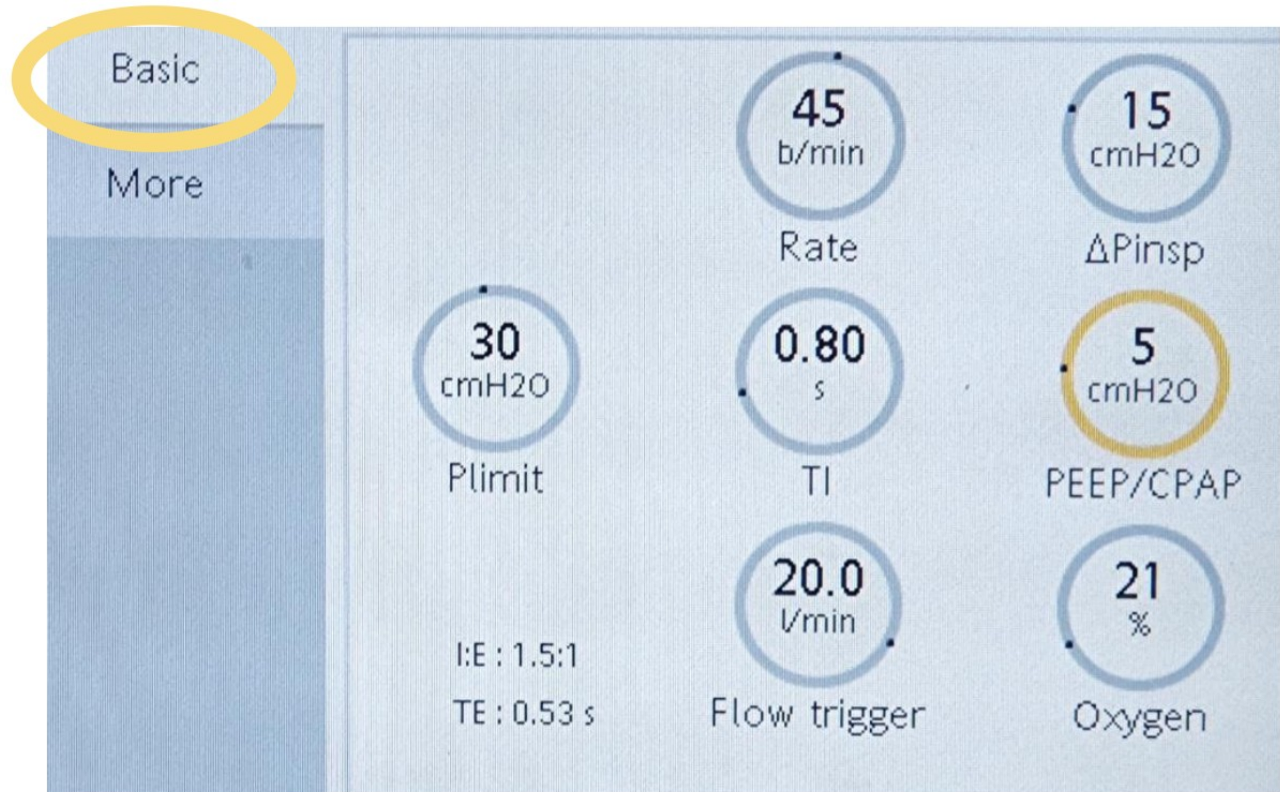
Actions
Check synchronisation, mask fit, exhalation port : give physiotherapy/bronchodilators, consider anxiolytic

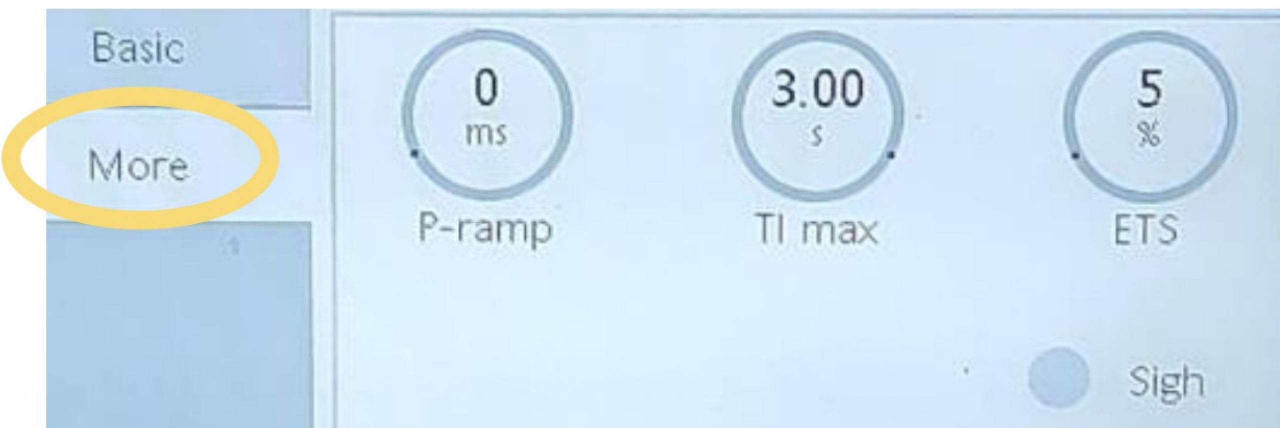
CONSIDER IMV

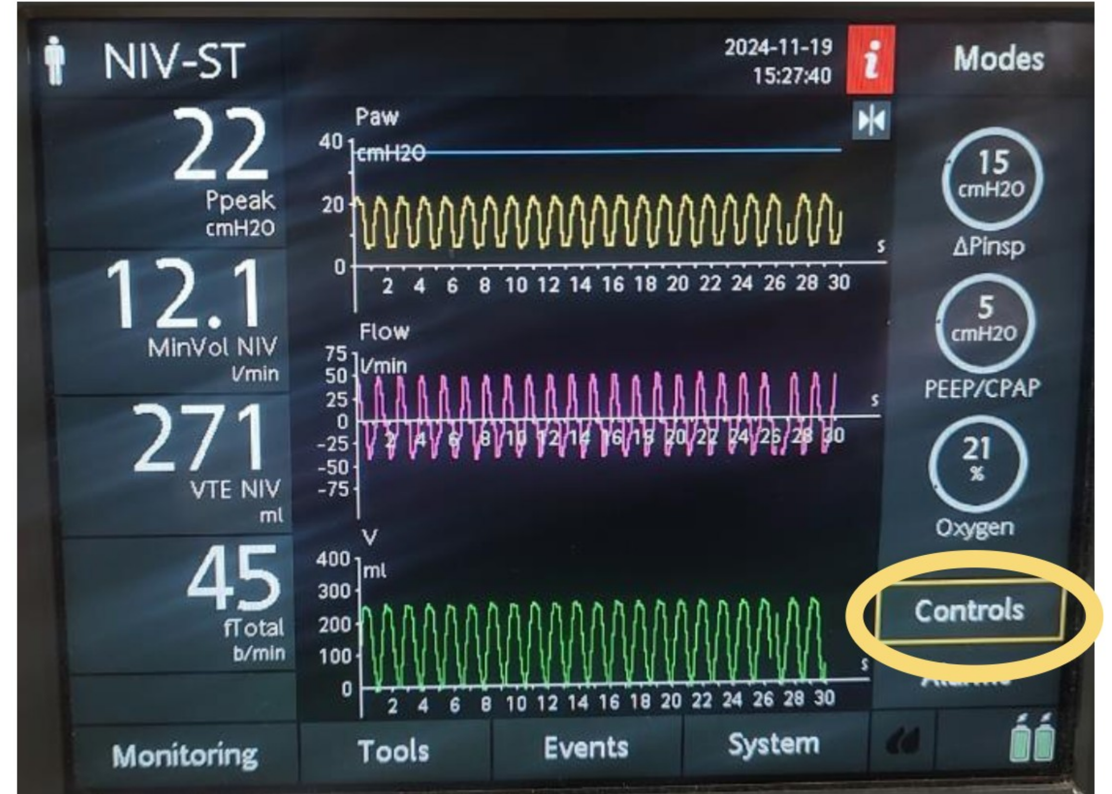
Translation to radiotherapy use

- NIV systems originally designed to provide ventilatory support can be utilized to control and regularize breathing characteristics in the absence of ventilatory failure
- Timed breathing rate → can drive respiration independent of patient effort
- No longer using as a ‘back-up rate’, but to dictate frequency/depth of breaths by NIV - ‘ventilator-led breathing’

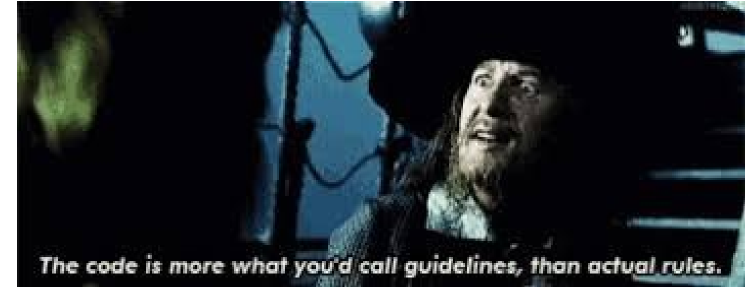

IVAC

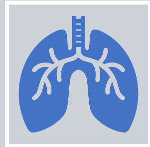

Basic
More
45
b/min
Rate
15
cmH2O
ΔPinsp
30
cmH2O
Plimit
0.80
s
TI
5
cmH2O
PEEP/CPAP
20.0
l/min
Flow trigger
21
%
Oxygen
I:E : 1.5:1
TE : 0.53 s


Basic
More
0
ms
P-ramp
3.00
s
TI max
5
%
ETS
Sigh


NIV-ST
2024-11-19
15:27:40
Modes
22
Ppeak
cmH2O
12.1
MinVol NIV
l/min
271
VTE NIV
ml
45
fTotal
b/min
Paw
Flow
V
15
cmH2O
ΔPinsp
5
cmH2O
PEEP/CPAP
21
%
Oxygen
Controls
Monitoring
Tools
Events
System

Take-home messages





Use here is to minimize respiratory motion, not for treatment of ventilatory failure

Can be safely delivered by appropriately trained staff - **does not need to be a clinician**

Protocols are a generic starting-point – adapt to individual according to tolerability (akin to what is done in practice)