Respiratory Failure

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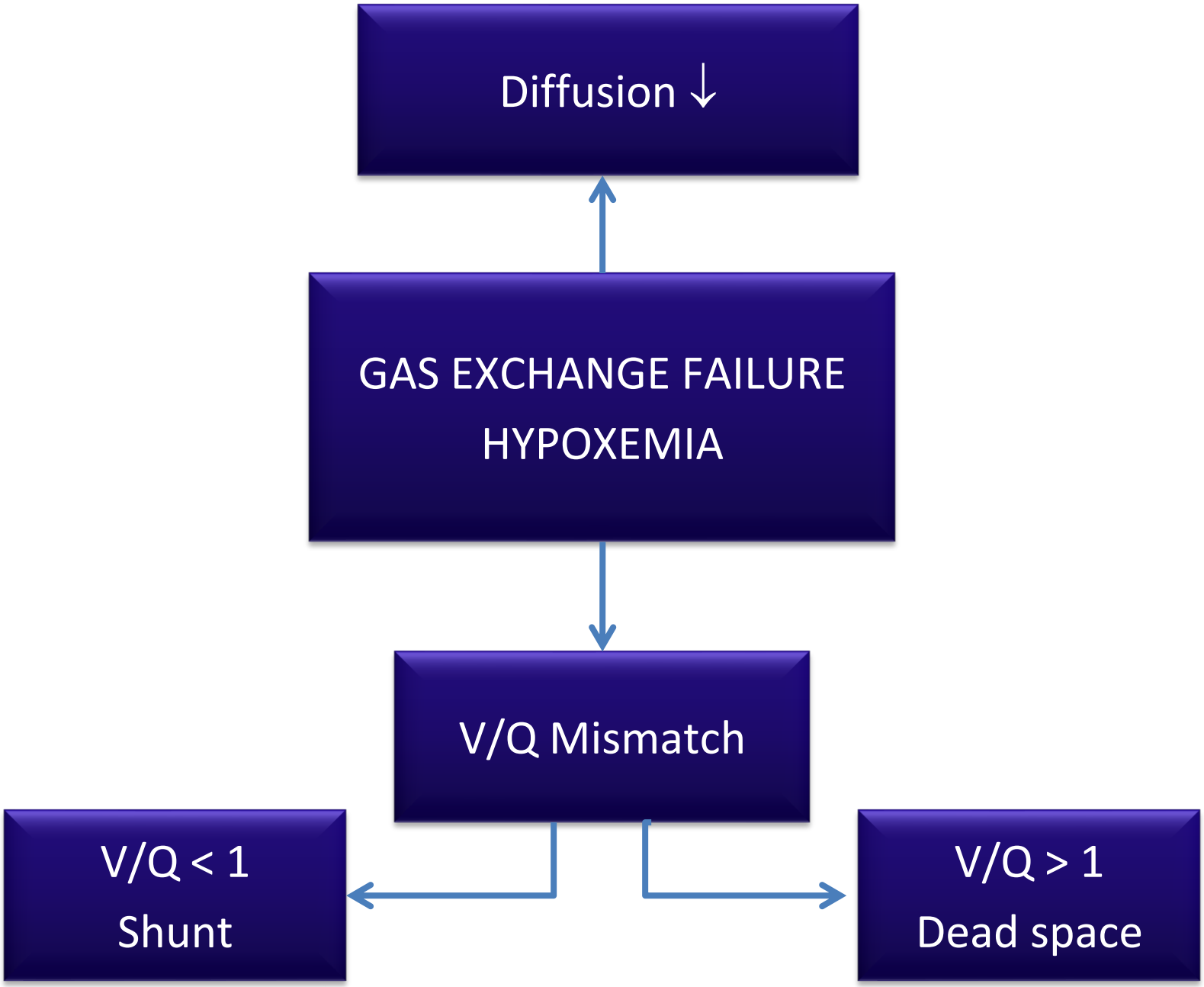
Definition

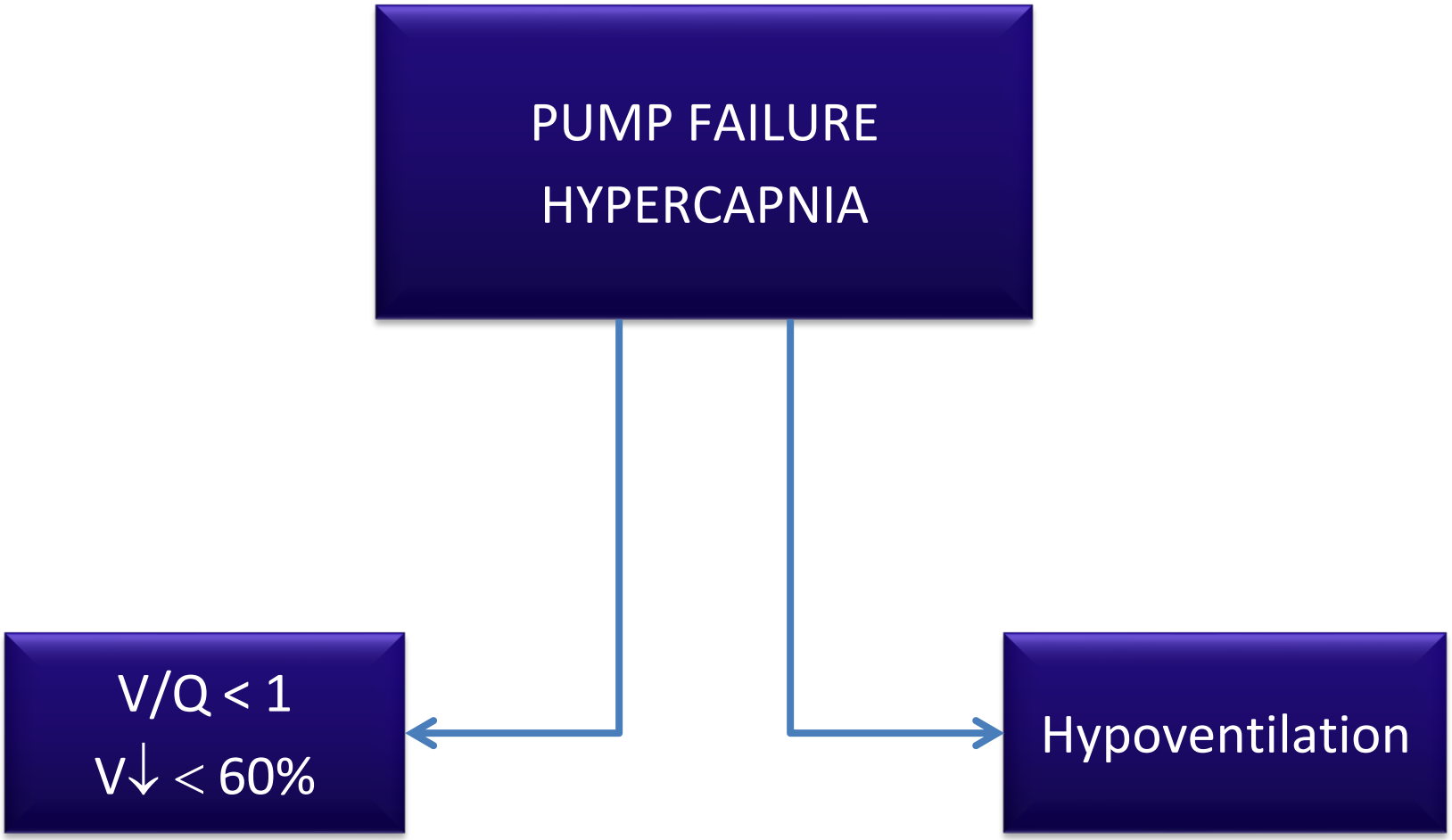
Respiratory failure syndrome

Inability (failure) of lung to ensure the gas exchange between air and blood.

PaO_2 **<60** mmHg or $PaCO_2$ **>45** mmHg

Pathogenesis


Diffusion ↓
GAS EXCHANGE FAILURE
HYPOXEMIA
V/Q Mismatch
V/Q < 1
Shunt
V/Q > 1
Dead space


PUMP FAILURE
HYPERCAPNIA
V/Q < 1
V↓ < 60%
Hypoventilation

Classification of RF

Type of disturbance of gas exchange

Type 1

- Hypoxemic RF
- $PaO_2 < 60$ mmHg
- normal or ↓ $PaCO_2$

Type 2

- Hypercapnic RF
- $PaCO_2 > 50$ mmHg
- Hypoxemia is common

Classification of RF

Speed of development

Acute RF

- Develops over minutes to hours
- ↓ pH quickly to <7.2

Chronic RF

- Develops over days
- ↑ in HCO3
- ↓ pH slightly

Classification of RF

Severity of Hipoxemia

- **Grade I** PaO2 **60-79** mm Hg; SaO2 ≥ **90-94%**
- **Grade II** PaO2 **40-59** mm Hg; SaO2 ≥ **75-89%**
- **Grade III** PaO2 **< 40** mm Hg; SaO2 **< 75%**

Clinical assessment of RF

RF - patient assessment

- History
- Physical exam
  - cyanosis, dyspnea, conscience impairment
  - compensatory CV signs,
  - manifestations of cor pulmonale (acute or chronic)

- Test: Rx, HRCT, ECG, EcoCG, Spirometry, DLCO, etc.

RF - patient assessment

- SaO2 assessment
    - SaO2< 90-92%
- Gas exchange assessment
    - PaO2, PaCO2
- Assessment of acid - base and electrolytes disturbances
    - pH, HCO3-, Na+, Cl-
- Assesment of complications

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Gas exchange assessment

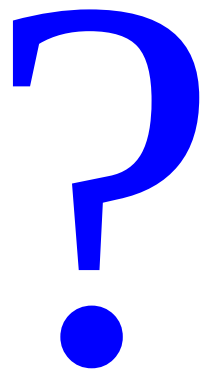
Case 1 PaO_2 = 70 mm Hg; $PaCO_2$ = 60 mm Hg

Case 2 PaO_2 = 69 mm Hg; $PaCO_2$ = 40 mm Hg

Case 3 PaO_2 = 50 mm Hg; $PaCO_2$ = 20 mm Hg

Case 4 PaO_2 = 50 mm Hg; $PaCO_2$ = 50 mm Hg

Case 5 PaO_2 = 48 mm Hg; $PaCO_2$ = 42 mm Hg



Gas exchange assessment

Alveolar-arterial oxygen gradient

- $P_{A\text{-}aO_2}=[(P_B - P_{H_2O})*Fi_{O_2} - P_{aCO_2}/R] - P_aO_2$
  - P_B – barometric pressure
  - P_{H_2O} - Partial pressure of H_2O vapors
  - Fi_{O_2} Fraction of O_2 în inhaled air
  - R- respiratory coeficient (≈ 0,8)

Gas exchange assessment

"130" rule

$PaO_2+PaCO_2=130$ ($FiO_2=0,21$; at see level)

$P_{A\text{-}aO_2} = 130 - (PaO2 + PaCO2)$

Normal value $P_{A\text{-}aO_2}$ < 15 mmHg
< 20 mmHg (old person)

Gas exchange assessment

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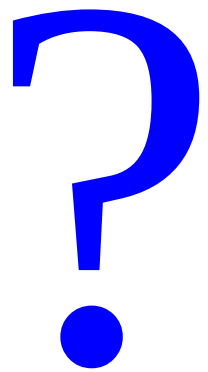

Gas exchange assessment

- Comparing of ABG obtained at different FiO_2
- PaO_2/FiO_2
- $PaO_2/FiO_2 < 200 \rightarrow$ ARDS

RF - patient assessment

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- Assessment of complications

Normal values

- pH 7,35-7,45
- PaO_2 >80 mmHg
- $PaCO_2$ 35-45 mmHg
- HCO_3 22-28 mmol/l

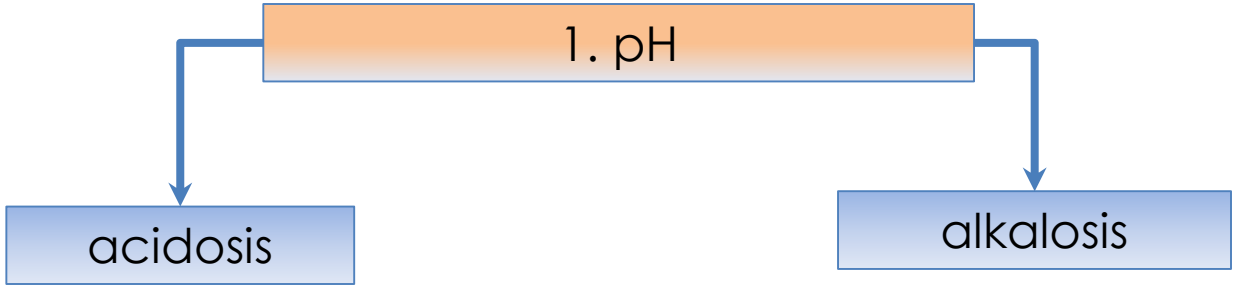
71 years old male – clinical case

- pH 7.25
- CO_2 31
- HCO_3^- 13

- P_aO_2 62
- SpO2 91% la 4L O_2

- Na+ 143 K- 4.2 Cl- 113

ABD assessment algorithm



ABD assessment algorithm

1. Assess pH

pH < 7.35

pH > 7.45

pH normal

- pH 7.25
- CO_2 31
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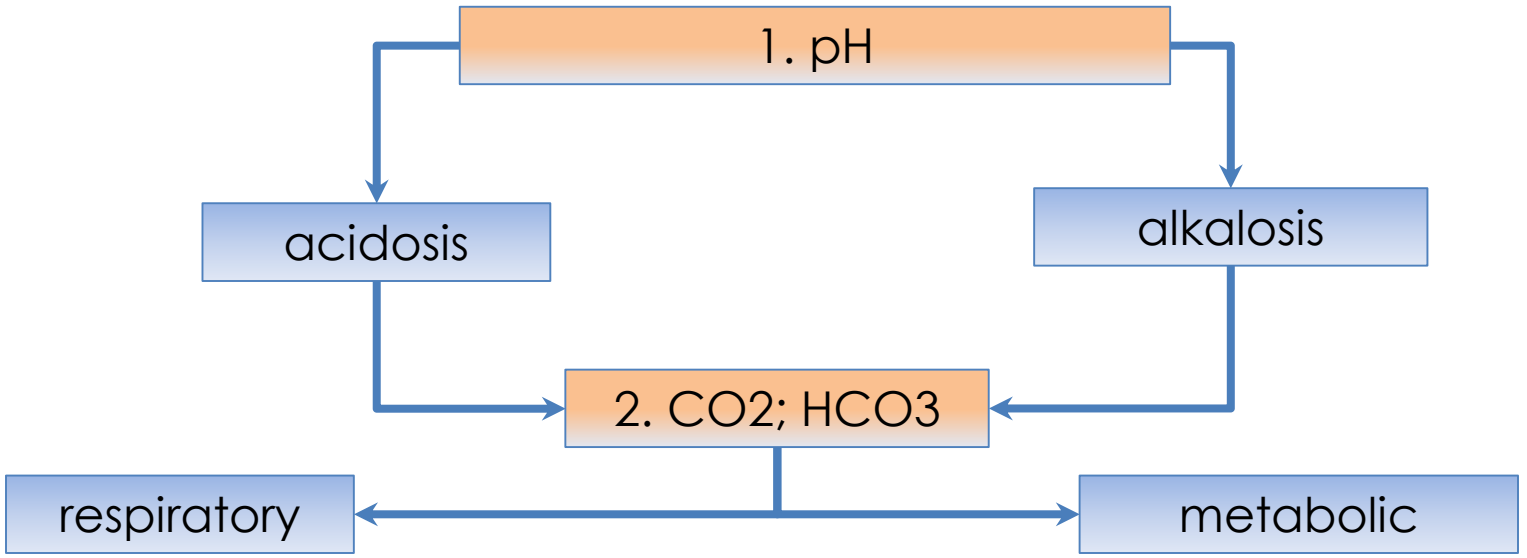
ABD assessment algorithm



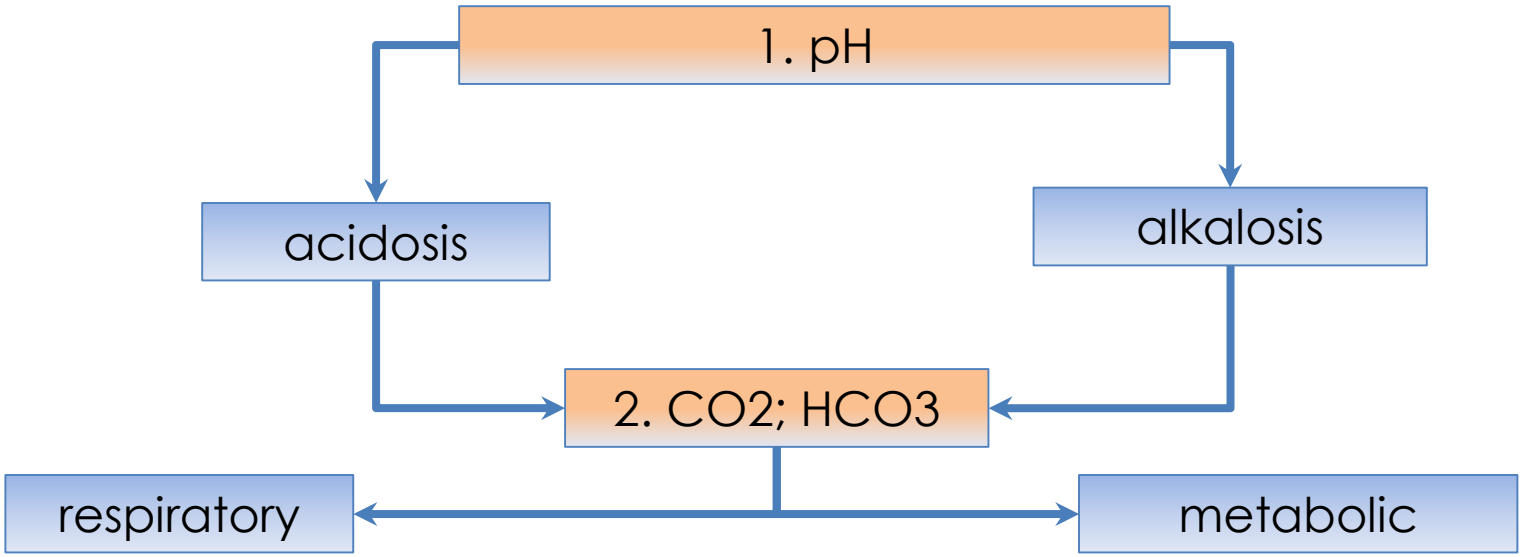
ABD assessment algorithm

2. Assess PaCO2, HCO3-

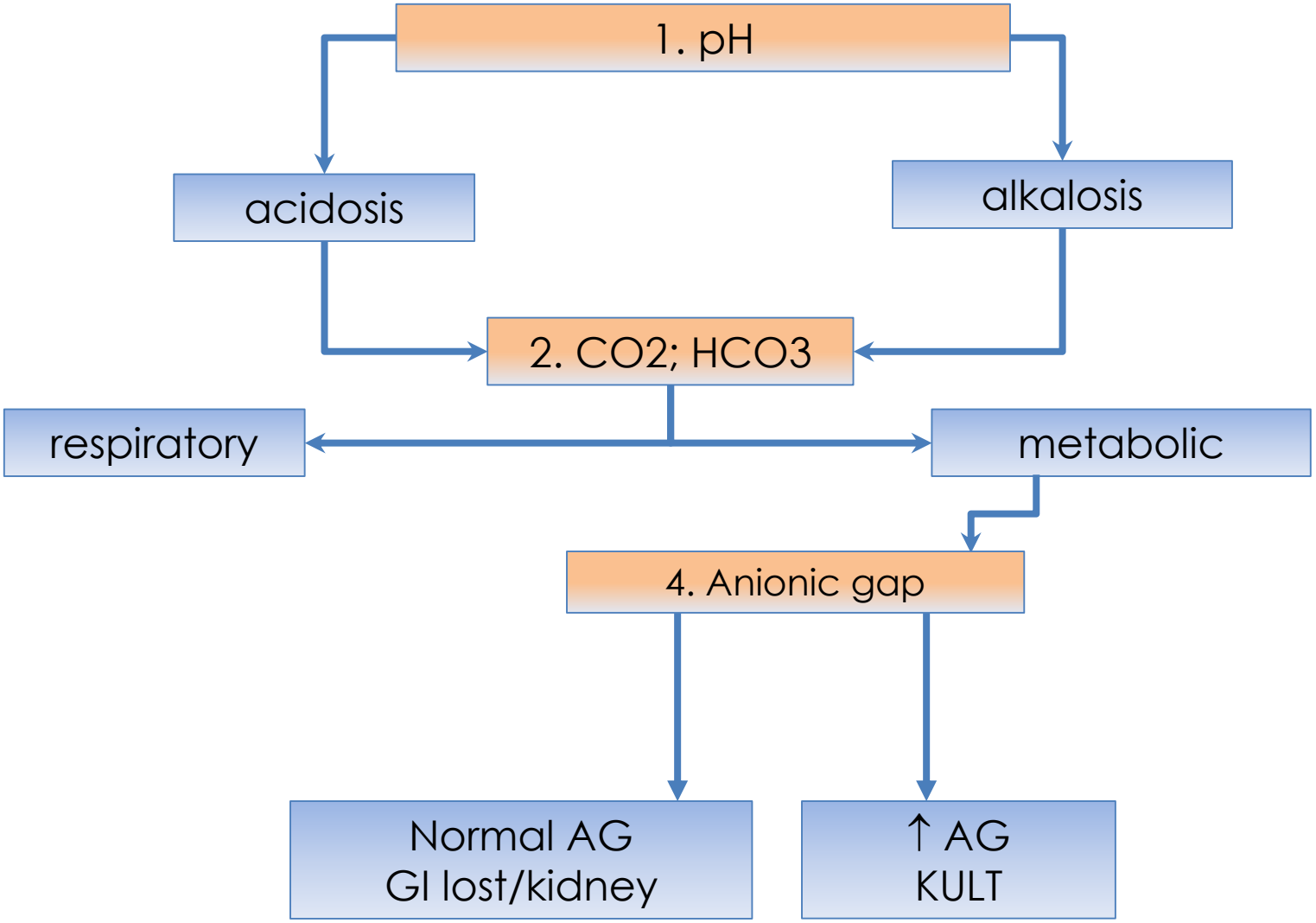
- If PaCO2 is changed in direction of pH-ului DEAB than ABD is respiratory
- If HCO3- is changed in direction of pH-ului DEAB than ABD is metabolic

- pH 7.25
- CO_2 31
- HCO_3^- 13
- P_aO_2 62
- SpO2 91% la 4L O_2
- Na+ 143 K- 4.2 Cl- 113

ABD assessment algorithm



ABD assessment algorithm



Evaluarea DEAB

5. If Metabolic acidosis assess Anion gap

Anion gap = [Na] – ([Cl-] + [HCO3-])

- GA > 16
  Ketoacidosis, Uremia,
  Lactic acidosis, Toxins

- GA - normal, - diarrhea, RTA

- pH 7.25
- CO_2 31
- HCO_3^- 13

- P_aO_2 62
- SpO2 91% la 4L O_2

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- Assessment of complications

RF complications acute/chronic

- Pulmonary hypertension
- Cor pulmonale
- Polycythemia
- Cachexia
- Respiratory muscle dysfunction
- Death by RF

RF Management

- Treatment of the cause
  - Bronchial permeability - Bronchodilators (β-agonists, Xantines, GCS)
  - Infection control- antibiotics
  - Right heart failure – diuretics
- Removing and prevenion of hypoxemia
- Control of $PaCO_2$ and respiratory acidosis
- Monitoring and treatment of CV and CNS manifestations

Removing of Hypoxemia

- Increasement of FiO2 (Oxigenotherapy)
  - Lower V/Q less efficient O2-therapy
- Recruitment of ventilatory space
  - CPAP, NIV (BIPAP), IMV

P_aCO_2 Control

- Augmentation of minute volume (assisted ventilation- V, P ,FR)
  - Noninvasive ventilation with negative pressure
  - Noninvasive ventilation with positive pressure (NIV)
  - Invasive ventilation with positive pressure (IMV)

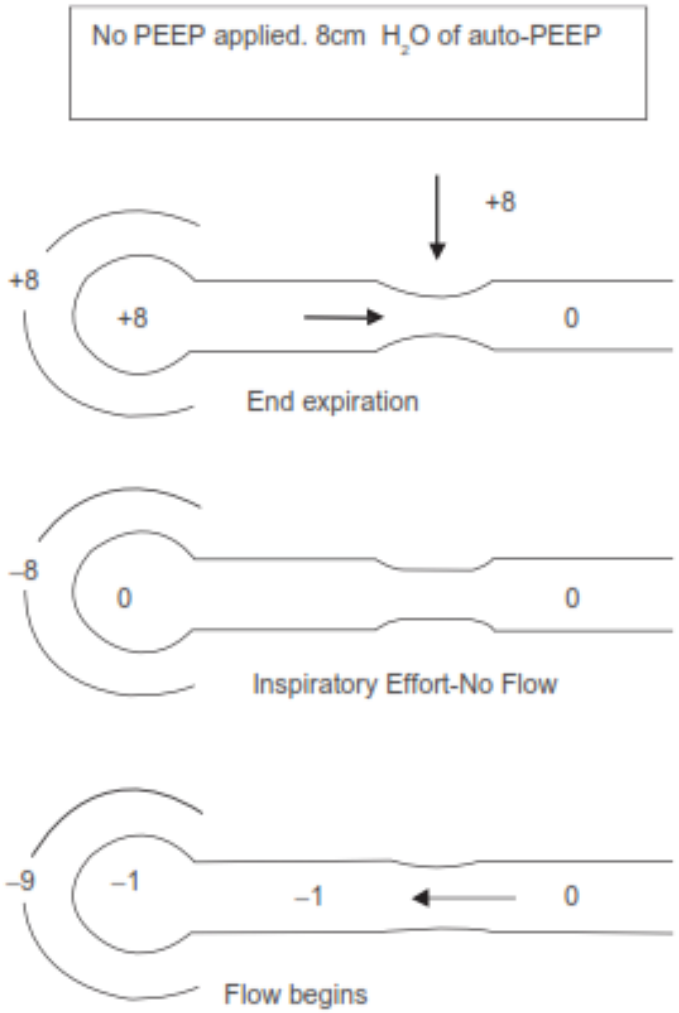
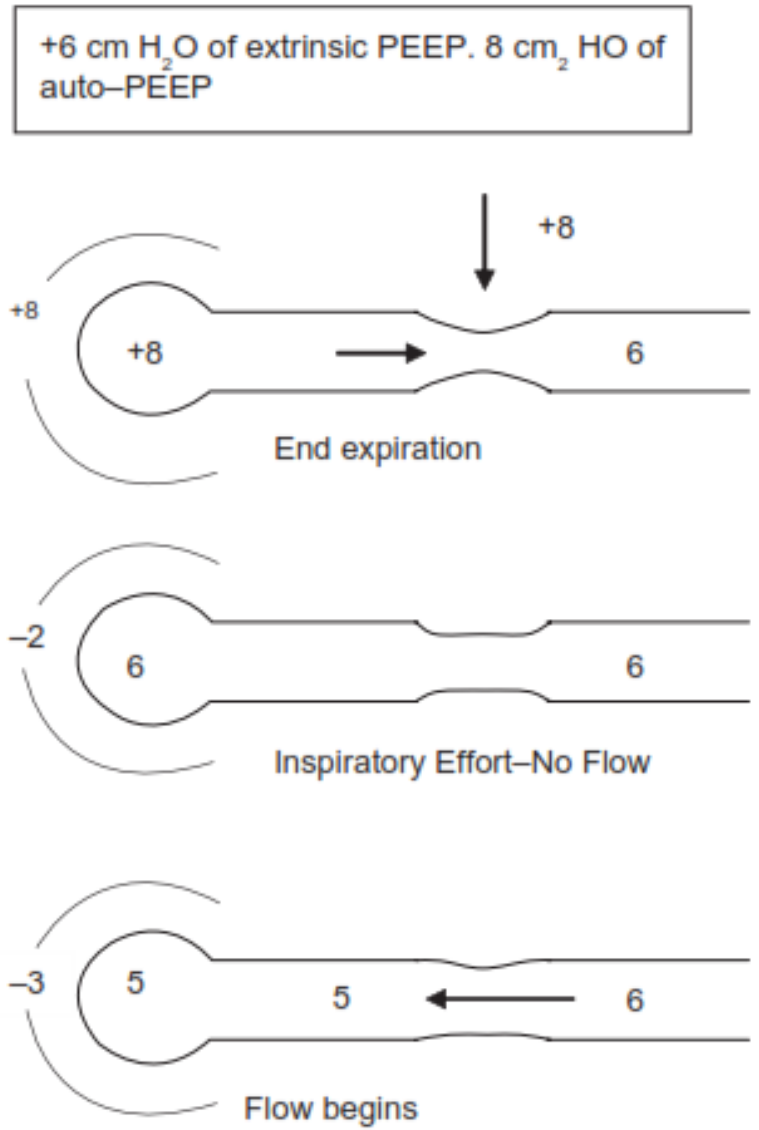


Figure 2A Effect of auto-PEEP on work of breathing (WOB). In the presence of airflow obstruction the alveoli remain inflated at end expiration. This results in alveolar pres-



Oxygen-therapy in Acute respiratory failure or Acute on chronic

O_2 în acute RF

All hypoxemic patients
Oxygen is a treatment for hypoxemia not for breathless

- SaO_2 target - 94-98%,

  (simple mask, cannula, in critical patients - reservoir mask)
- Risk for hypercapnia SaO2 target - 88-92%, (Ventrui mask - 28%)
  - Excepting critical patients,
  - Excepting prior episodes of IR tip II, NIV, IPPV
- Assess ABG
- If hypercapnia or acidosis ventilatory support
- Assess ABG after 30-60 min
- Reduced O_2 in stable patients with satisfactory SaO_2

Patients at risk for hypercapnia

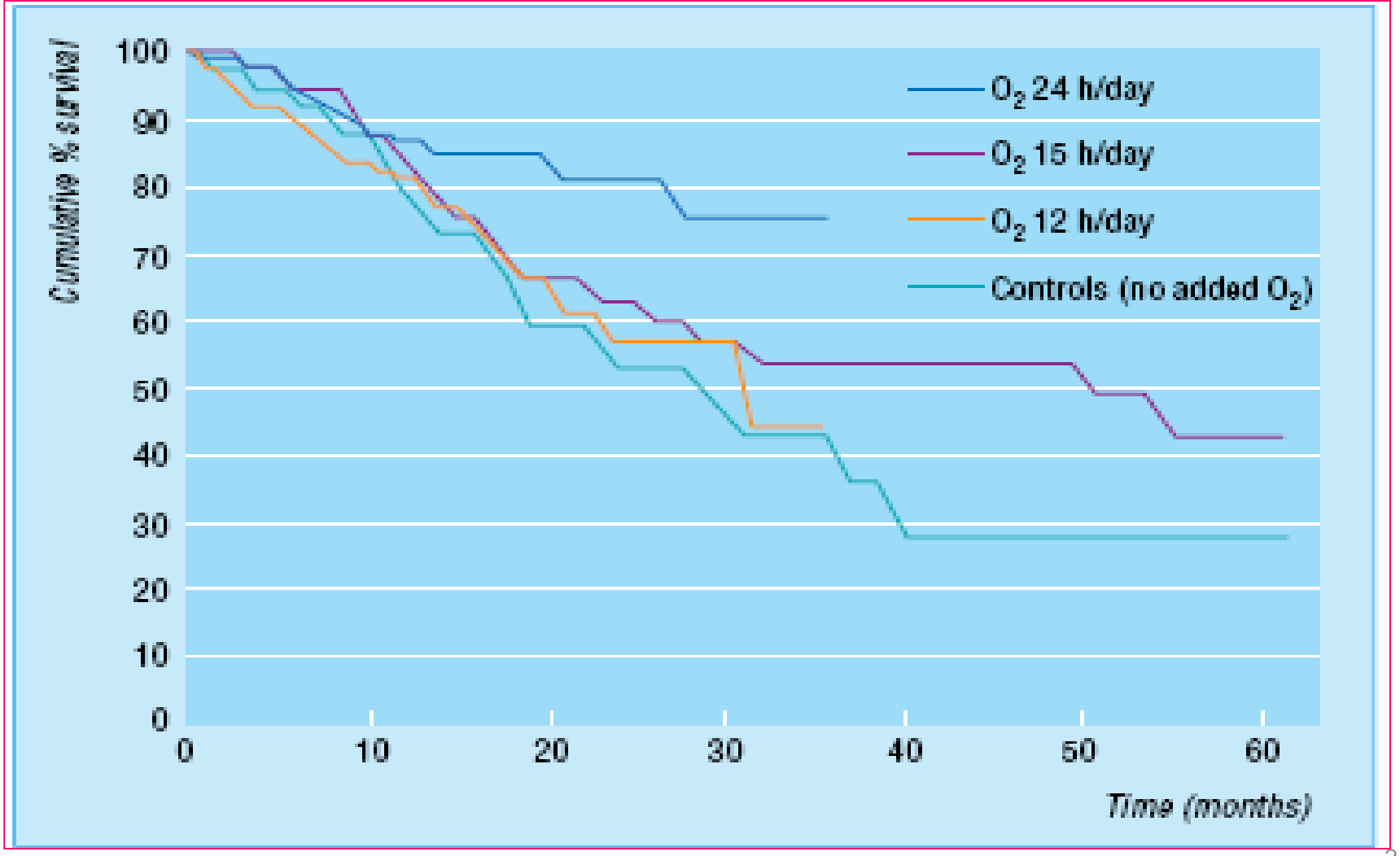
- COPD
- Exacerbation of cystic fibrosis
- Chronic neuromuscular diseases
- Diseases of chest wall or spine
- Morbid obesity

Oxygen-therapy in Chronic RF

Long term oxygentherapty

- 10-12h at night-for paradoxical sleep dessaturation
- Daily after meals up to 15h
- Use exercise
- Improvement: exercise tolerance, life expectancy, intellectual performance

British Medical Research Council Domiciliary (BMRCD)



Indications for LOT

At rest

- **PaO_2 <55 mmHg or SaO_2 < 88%**

- PaO_2 56-59 mmHg or SaO_2 - 89% şi
  - Right heart failure
  - Hronic cor pulmonale
  - Polycitemia (Ht > 56%)

At rest

- **PaO_2 >59% mmHg or SaO_2 > 89%**

BUT

- During sleep
  - SaO_2 < 90% , for 30% of the entire duration of sleep (improved by O2)

- At exertion
  - SaO_2 < 90%, during 6MWT, (improved by O2)

CPAP in acute RF

- Acute Pulmonary Edema
- Decompensated obstructive sleep apnoea
- Patients with chest wall trauma who remain hypoxic despite adequate regional anaesthesia and high flow oxygen (only in ICU)
- CAP who remain hypoxic despite maximum medical treatment oxygen (only in ICU)

NIV Acute RF

Patients

- COPD
- Chest wall deformity, neuromuscular disorder,
- Decompensated OSA
- Cardiogenic pulmonary oedema, unresponsive to CPAP

Blood gases

- Respiratory acidosis (pH<7,35; PaCO2>35 mm Hg) which persists despite maximal medical treatment and appropriate controlled oxygen therapy
- patients with pH <7.25 respond less well and should be managed in an HDU/ICU).
- Low A±a oxygen gradient (patients

managed by tracheal intubation)

Clinical state

Sick but not moribund

· Able to protect airway

· Conscious and cooperative

· Haemodynamically stable

· No excessive respiratory secretions

· Few co-morbidities

Contraindications excluded

· Facial burns/trauma/recent facial or upper airway surgery

· Vomiting

· Fixed upper airway obstruction

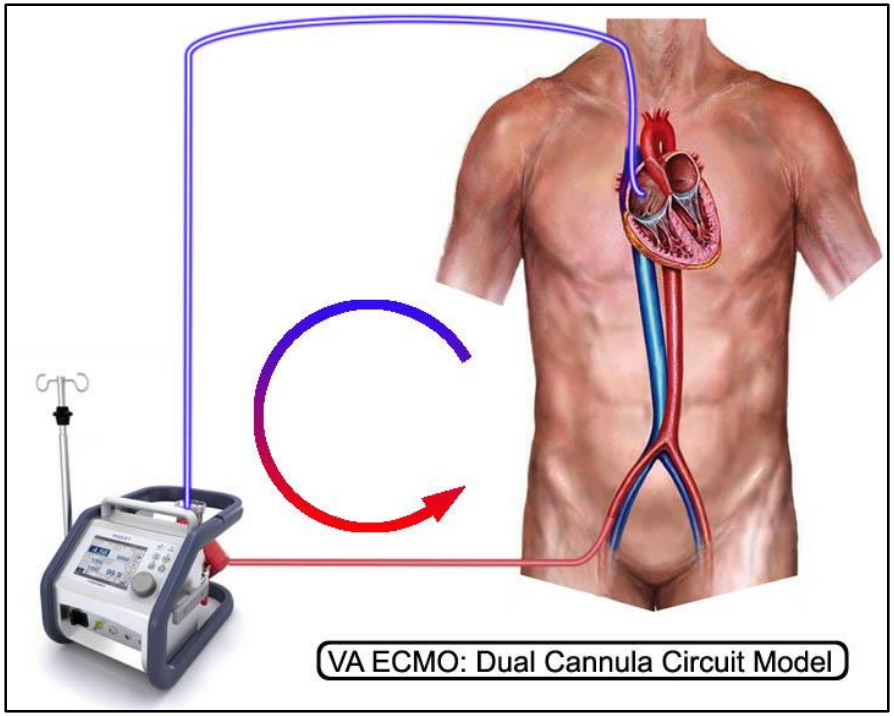
· Undrained pneumothorax

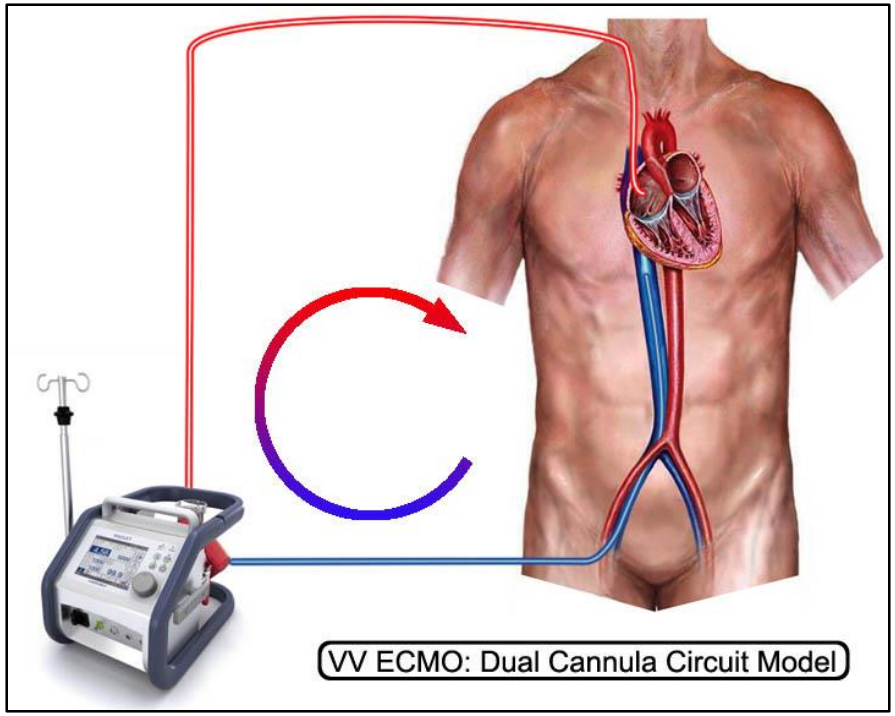
No efficacy after 1-2 hours → intubation

Indication for IMV

- Respiratory failure
  - pH: <7.25
  - $PaCO_2$: >50 mmHg
  - PaO_2: <50mmHg
- Fixed upper airway obstruction (also potential)
- Inefficient respiratory movement
- Impaired conscience

Extracorporeal Membrane Oxygenation
ECMO



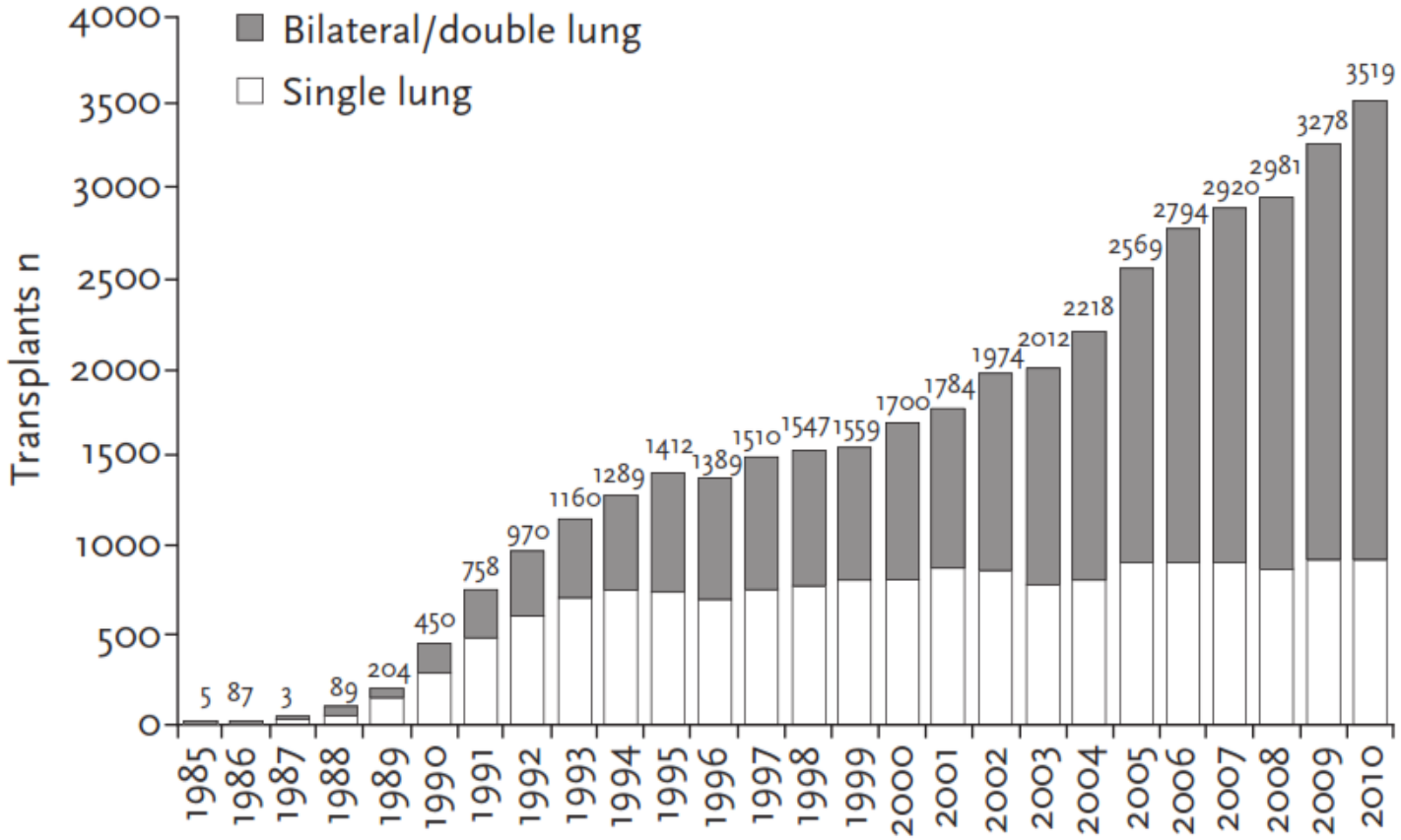


NIV in chronic RF

- Hypercapnic respiratory failure secondary to:
  - Spinal cord lesion
  - Neuromuscular diseases
  - Chest wall deformity (e.g. scoliosis, thoracoplasty)
  - Morbid obesity (BMI >30)

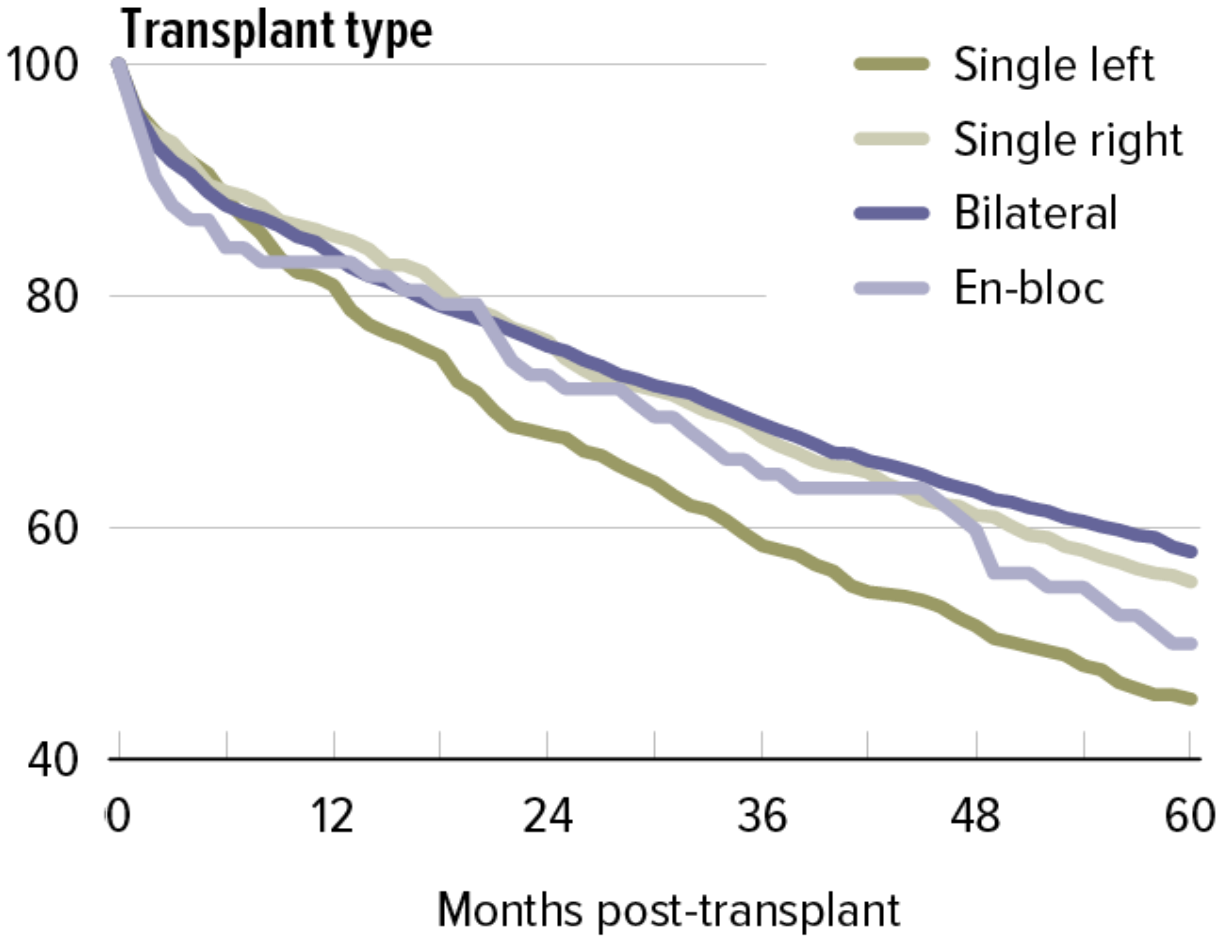
- COPD with:
  - Recurrent AHRF (>3 episodes) requiring treatment with NIV
  - Intolerance of supplementary oxygen (because of CO_2 retention) with symptomatic sleep disturbance
- Failure to wean from NIV

Pulmonary transplant



- Unipulmonar Bipulmonar Cardiopulmonar

Supravieţuirea posttransplant



Thank you