UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

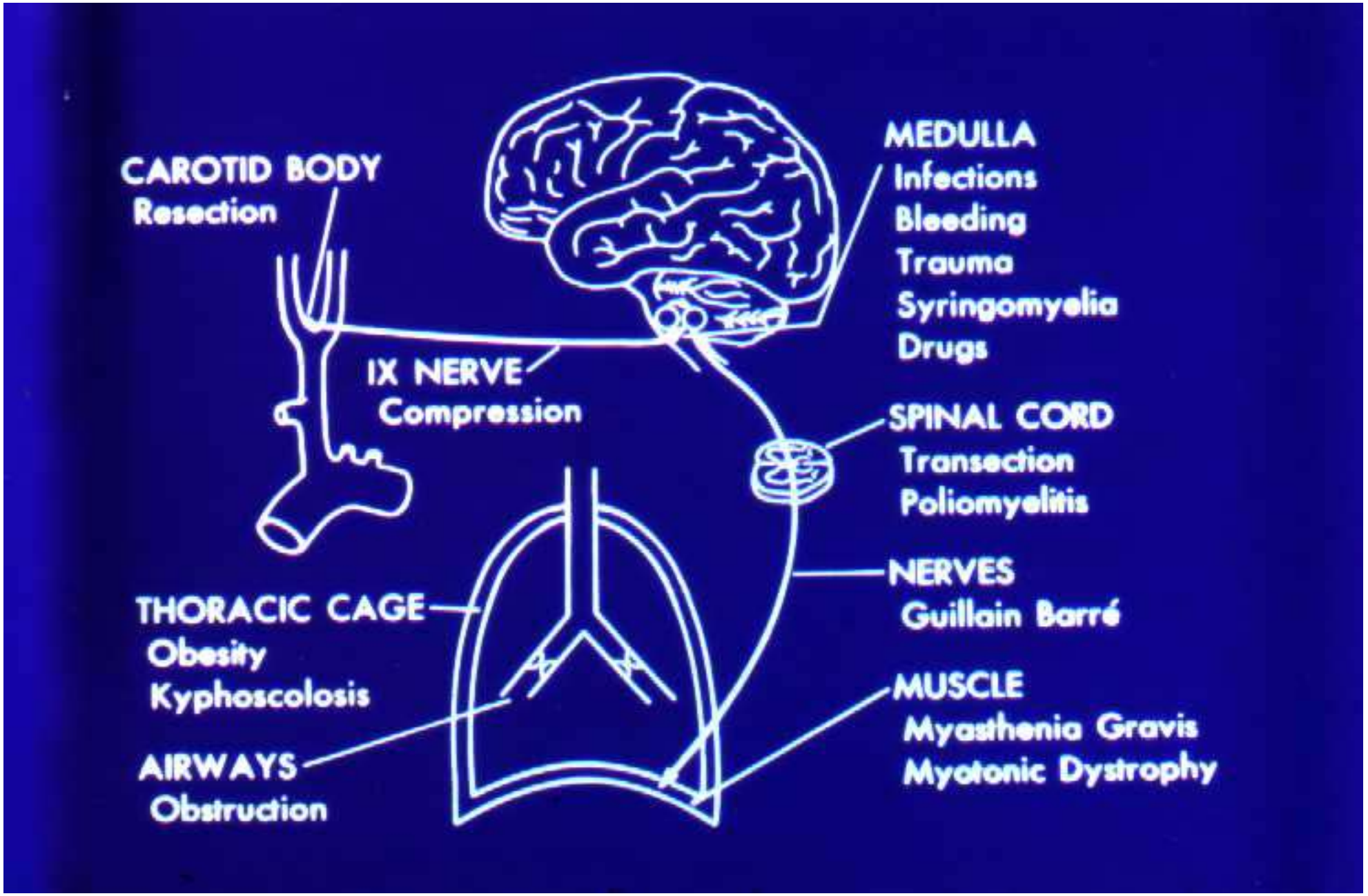
Respiratory failure - intensive care management

Alexandra Lazar

University of Medicine and Pharmacy of Tîrgu Mureș

- Respiratory failure is a syndrome of inadequate gas exchange due to dysfunction of one or more essential components of the respiratory system

- Chest wall (including pleura and diaphragm)
- Airways
- Alveolar– capillary units
- Pulmonary circulation
- Nerves
- CNS or Brain Stem


CAROTID BODY
Resection
MEDULLA
Infections
Bleeding
Trauma
Syringomyelia
Drugs
IX NERVE
Compression
SPINAL CORD
Transection
Poliomyelitis
NERVES
Guillain Barré
THORACIC CAGE
Obesity
Kyphoscolosis
MUSCLE
Myasthenia Gravis
Myotonic Dystrophy
AIRWAYS
Obstruction

HYPOXEMIC RESPIRATORY FAILURE(TYPE 1)

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- PaO_2 <60mmHg with normal or low $PaCO_2$ $\rightarrow$ normal or high pH
- Most common form of respiratory failure

- Lung disease is severe to interfere with pulmonary O_2 exchange, but over all ventilation is maintained
- Physiologic causes: V/Q mismatch and shunt

Causes

- Pneumonia
- Cardiogenic pulmonary edema
- Pulmonary edema due to increased hydrostatic pressure
- Non-c ardiogenic pulmonary edema
- Pulmonary edema due to increased permeability
- Acute respiratory distress syndrome (ARDS)
- Pulmonary embolism
- Atelectasis
- Pulmonary fibrosis

Respiratory failure Type II

- Hypercapnic ($PaCO_2$ >45)
- Failure to exchange or remove carbon dioxide
- Decreased alveolar minute ventilation (V_A)
- Often accompanied by hypoxemia that corrects with supplemental oxygen

Causes

- Respiratory centre (medulla) dysfunction
- Drug over dose, CVA, tumor, hypothyroidism,central hypoventilation
- Neuromuscular disease
  Guillain-Barre, Myasthenia Gravis, polio, spinal injuries
- Chest wall/Pleural diseases
  kyphoscoliosis, pneumothorax, massive pleural effusion
- Upper airways obstruction
  tumor, foreign body, laryngeal edema
- Peripheral airway disorder
  asthma, COPD

Type III Respiratory Failure: *Perioperative respiratory failure*

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Increased atelectasis due to low functional residual capacity (FRC) in the setting of abnormal abdominal wall mechanics

- Often results in type I or type II respiratory failure

- Can be ameliorated by anesthetic or operative technique, posture, incentive spirometry, post-o perative analgesia, attempts to lower intra- abdominal pressure

Causes

- Inadequate post- o perative analgesia, upper abdominal incision
- Obesity, ascites
- Pre- operative tobacco smoking
- Excessive airway secretions

Type IV Respiratory Failure: S*hock*

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Type IV describes patients who are intubated and ventilated in the process of resuscitation for shock

- Goal of ventilation is to stabilize gas exchange and to unload the respiratory muscles, lowering their oxygen consumption

Causes

- Cardiogenic shock
- Septic shock
- Hypovolemic shock

Respiratory failure may be

- Acute
- Chronic
- Acute on chronic

E.g.: acute exacerbation of advanced COPD

Clinical and Laboratory Manifestation (non-specific and unreliable)

- **Cyanosis**

  - bluish color of mucous membranes/skin indicate hypoxemia

- **Unoxygenated hemoglobin** 50 mg/L

 - not a sensitive indicator

- **Dyspnea**

 - secondary to hypercapnia and hypoxemia

- **Paradoxical breathing**
- **Confusion, somnolence and coma**
- **Convulsions**

Clinical Manifestation

- Circulatory changes

  - tachycardia, hypertension, hypotension

- Polycythemia

  - chronic hypoxemia - erythropoietin synthesis

- Pulmonary hypertension
- Cor-pulmonale or right ventricular failure

Laboratory Workup

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

ABG

- Quantifies magnitude of gas exchange abnormality
- Identifies type and chronicity of respiratory failure

Complete blood count

- Anemia may cause cardiogenic pulmonary edema
- Polycythemia suggests may chronic hypoxemia
- Leukocytosis, a left shift, or leukopenia suggestive of infection
- Thrombocytopenia may suggest sepsis as a cause

Laboratory Workup

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

Cardiac serologic markers

- Troponin, Creatine kinase- MB fraction (CK- MB)
- B-type natriuretic peptide (BNP)

Microbiology

- Respiratory cultures: sputum/tracheal
- aspirate/broncheoalveolar lavage (BAL)
- Blood, urine and body fluid (e.g. pleural) cultures

Diagnostic Investigations

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

Chest radiography

- Identify chest wall, pleural and lung parenchymal pathology; and distinguish disorders that cause primarily *V/Q mismatch* (clear lungs) vs. *Shunt* (intra- pulmonary shunt; with opacities present)

Diagnostic Investigations

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

Electrocardiogram

- Identify arrhythmias, ischemia, ventricular dysfunction

Echocardiography

- Identify right and/or left ventricular dysfunction

Diagnostic Investigations

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

Pulmonary function tests/bedside spirometry

- Identify obstruction, restriction, gas diffusion abnormalities
- May be difficult to perform if critically ill

Bronchoscopy

- Obtain biopsies, brushings and BAL for histology, cytology and microbiology
- Results may not be available quickly enough to avert respiratory failure
- Bronchoscopy may not be safe in the critically ill

Respiratory Failure: Management

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Hypoxemia may cause death in RF
- Primary objective is to reverse and prevent hypoxemia
- Secondary objective is to control $PaCO_2$ and respiratory acidosis
- Treatment of underlying disease
- Patient's CNS and CVS must be monitored and treated

Respiratory Failure: Management

ABC’ s

- Ensure airway is adequate
- Ensure adequate supplemental oxygen and assisted ventilation, if indicated
- Support circulation as needed

Respiratory Failure: Management

Treatment of a specific cause when possible

Infection

- Antimicrobials, source control

Airway obstruction

- Bronchodilators, glucocorticoids

Improve cardiac function

- Positive airway pressure, diuretics, vasodilators,
- morphine, inotropy, revascularization

Oxygen Therapy

- titration based on SaO_2, PaO_2 levels and $PaCO_2$
- Goal is *to prevent tissue hypoxia*
- Tissue hypoxia occurs (normal Hb & C.O.)
  venous $PaO_2 < 20$ mmHg or $SaO_2 < 40\%$
  arterial $PaO_2 < 38$ mmHg or $SaO_2 < 70\%$
- Increase arterial $PaO_2 > 60$ mmHg($SaO_2 > 90\%$) or venous $SaO_2 > 60\%$
- O_2 dose either flow rate (L/min) or FiO_2 (%)

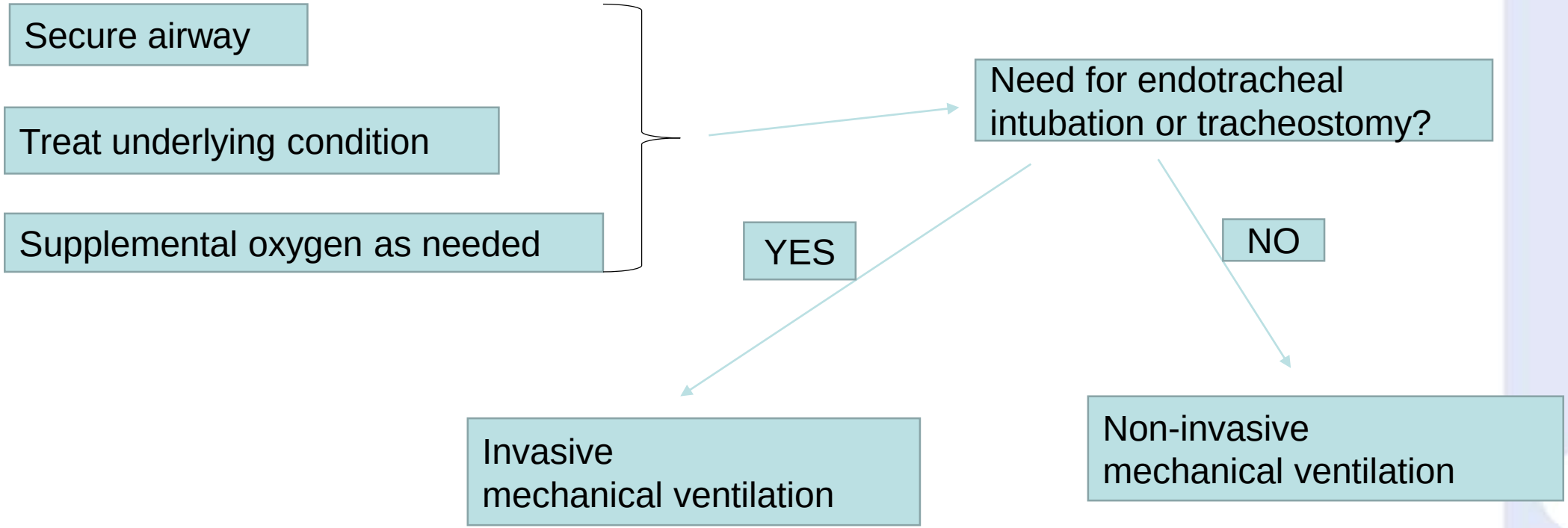
-

Mechanical ventilation

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Non-invasive (if patient can protect airway and is hemodynamically stable)
- Mask: usually orofacial to start
- Invasive
- Endotracheal tube (ETT)
- Tracheostomy – if upper airway is obstructed

Respiratory Failure



Indications for Mechanical Ventilation

- Cardiac or respiratory arrest
- Tachypnea or bradypnea with respiratory fatigue or impending arrest
- Acute respiratory acidosis
- Refractory hypoxemia (when the PaO2 could not be maintained above 60 mm Hg with inspired O 2 fraction (FIO2)>1.0)
- Inability to protect the airway associated with depressed levels of consciousness

- Shock associated with excessive respiratory work
- Inability to clear secretions with impaired gas exchange

or excessive respiratory work

- Newly diagnosed neuromuscular disease with a vital capacity <10-15 mL/kg
- Short term adjunct in management of acutely increased intracranial pressure (ICP)

Invasive vs. Non- invasive Ventilation

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

Consider non- invasive ventilation particularly in the following settings:

- COPD exacerbation
- Cardiogenic pulmonary edema
- Obesity hypoventilation syndrome
- Noninvasive ventilation may be tried in selected patients with asthma or non-cardiogenic hypoxemic respiratory failure

Goals of Mechanical Ventilation

- Improve ventilation by augmenting respiratory rate and tidal volume
- Assistance for neural or muscle dysfunction
- Sedated, comatose or paralyzed patient
- Neuropathy, myopathy or muscular dystrophy
- Intra-operative ventilation
- Correct respiratory acidosis, providing goals of lung protective ventilation are met
- Match metabolic demand
- Rest respiratory muscles

Goals of Mechanical Ventilation

Correct hypoxemia

- High F IO 2
- Positive end expiratory pressure (PEEP)

Improve cardiac function

- Decreases preload
- Decreases afterload
- Decreases metabolic demand

Permissive Hypercapnia

Ventilation strategy that allows PaCO 2 to rise

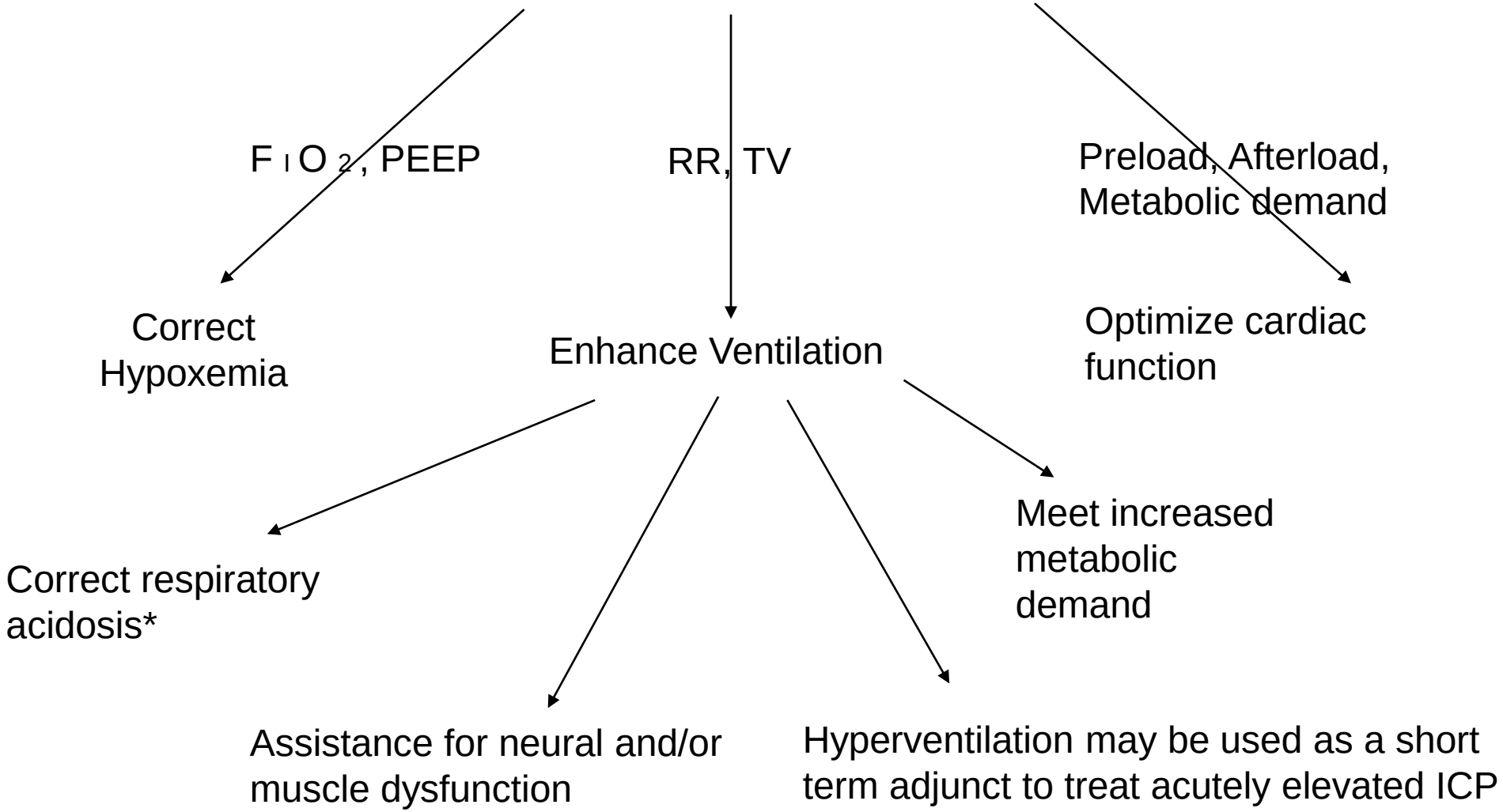
by accepting a lower alveolar minute ventilation to avoid specific risks:

- Dynamic hyperinflation (“auto- peep”) and
- barotrauma in patients with asthma
- Ventilator-associated lung injury, in patients with, or

at risk for ARDS

!!! *Contraindicated in patients with increased intracranial pressure such as head trauma*

Mechanical Ventilation



Other Issues to Consider When Initiating Mechanical Ventilation

Do not wait for frank respiratory acidosis especially with evidence of:

- Inability to protect airway
- Persistent or worsening tachypnea (respiratory rate >35/minute)
- Respiratory muscle fatigue
- Always consider risks and benefits of initiation and continuation of mechanical ventilation

Other Issues to Consider When Initiating Mechanical Ventilation

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- elevate the head of the bed >30º and use ulcer

and DVT prophylaxis, unless contraindicated

- lung protective ventilation strategy for patients with ARDS (TV ~ 6 ml/kg ideal body weight, Plat pressure < 30 cmH2 O)
- Modify ventilator settings primarily to achieve patient ventilator synchrony.
- use the least amount of sedation required to achieve comfort and avoid unnecessary neuromuscular blockade

Other Issues to Consider When Initiating Mechanical Ventilation

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Monitor patient comfort, gas exchange, mechanics, and ventilator waveforms daily, or more frequently if indicated

- When minimal settings are required for oxygenation (FI O2 <55%, PEEP<8) and patient is hemodynamically stable, perform a spontaneous breathing trial daily

Treatment of the underlying causes

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- After correction of hypoxemia, hemodynamic stability
- Antibiotics
  - Pneumonia
  - Infection
- Bronchodilators (COPD, BA)
  - Salbutamol
    - reduce bronchospasm
    - airway resistance

Treatment of the underlying causes

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Anticholinergics (COPD,BA)
  - Ipratropium bromide
    - inhibit vagal tone
    - relax smooth muscles
- Theophylline (COPD, BA)
  - improve diaphragmatic contraction
  - relax smooth muscles
- Diuretics (pulmonary edema)
  - Furosemide

Treatment of the underlying causes

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Methyl prednisone (COPD, BA, acute esinophilic pn)
  - Reverse bronchospasm, inflammation
- Fluids and electrolytes
  - Maintain fluid balance and avoid fluid overload
- IV nutritional support
  - To restore strength, loss of ms mass
  - Fat, carbohydrate, protein

Treatment of the underlying causes

- Physiotherapy
  - Chest percussion to loosen secretion
  - Suction of airways
  - Help to drain secretion
  - Maintain alveolar inflation
  - Prevent atelectasis, help lung expansion

Complications of ARF

UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE TÎRGU MUREȘ

- Pulmonary
  - Pulmonary embolism
  - barotrauma
  - pulmonary fibrosis (ARDS)
  - Nosocomial pneumonia
- Cardiovascular
  - Hypotension, ↓COP
  - Arrhythmia
  - MI, pericarditis
- GIT
  - Stress ulcer, ileus, diarrhea, hemorrhage
- Infections
  - Nosocomial infection
  - Pneumonia, UTI, catheter related sepsis
- Renal
  - ARF (hypoperfusion, nephrotoxic drugs)
  - Poor prognosis
- Nutritional
  - Malnutrition, diarrhea hypoglycemia, electrolyte disturbances