Supportive module 3 "Basics of diagnosis, treatment and prevention of major pulmonary diseases "

Respiratory Failure

LECTURE IN INTERNAL MEDICINE FOR IV COURSE STUDENTS

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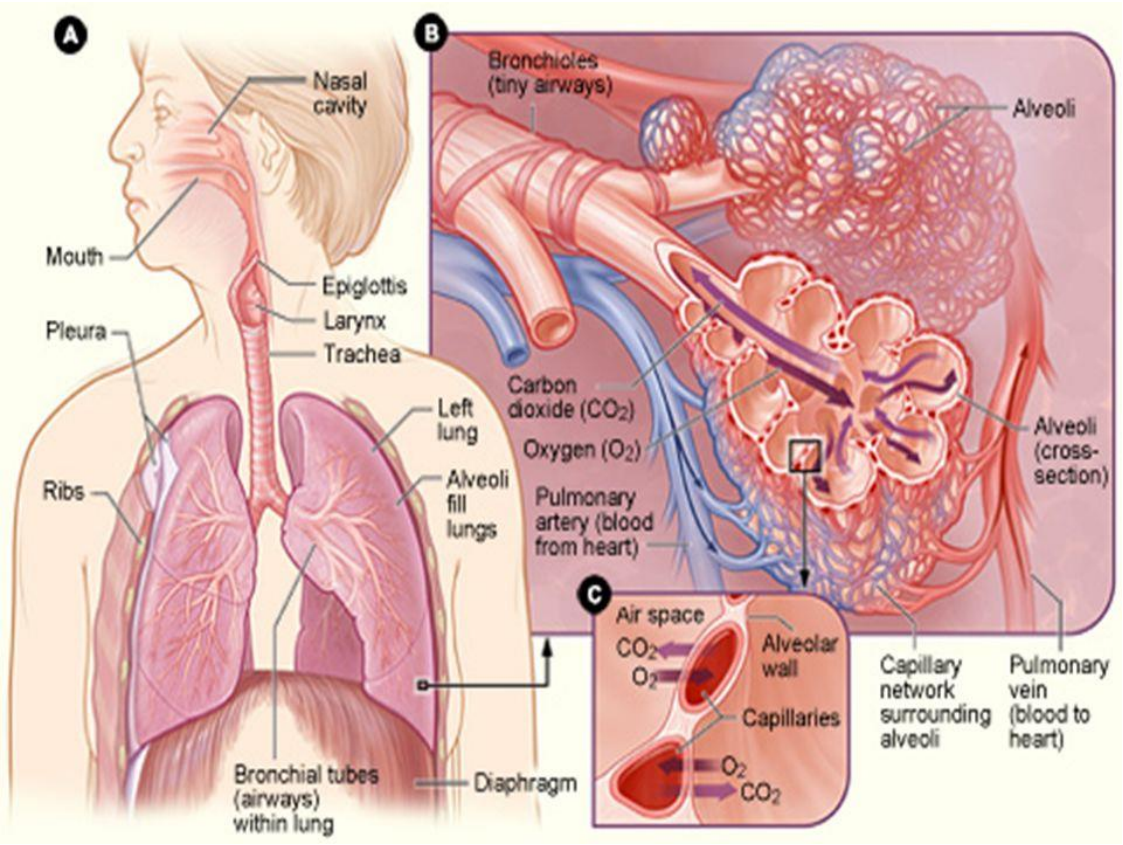
Plan of the Lecture



- Definition
- Epidemiology
- Risk Factors and Etiology
- Mechanisms
- Classification
- Clinical presentation
- Diagnosis
- Treatment
- Prognosis
- Prophylaxis
- Abbreviations
- Diagnostic guidelines

http://images.slideplayer.com/26/8464013/slides/slide_5.jpg

Definition

- Respiratory failure is a clinical syndrome in which the respiratory system fails in oxygenation (hypoxemia) or/and carbon dioxide (hypercapnia) elimination due to dysfunction of one or more essential components (chest wall (including pleura and diaphragm), airways, alveolar, alveolar – capillary units, pulmonary circulation, nerves, central nervous system (CNS) or brain stem) of the respiratory system
- Hypoxemic respiratory failure (type I) is characterized by an arterial oxygen tension (PaO_2) lower than 60 mm Hg with a normal or low arterial carbon dioxide tension ($PaCO_2$)
- Hypercapnic respiratory failure (type II) is characterized by a $PaCO_2$ higher than 50 mm Hg.

http://emedicine.medscape.com/article/167981-overviewen.wikipedia.org/wiki/Respiratory_failure

Epidemiology

- Incidence: about 360,000 cases per year in the United States
- 36% die during hospitalization
- Morbidity and mortality rates increase with age and presence of comorbidities and presence of comorbidities.

https://www.thoracic.org/professionals/dinical-resources/critical-care/clinical-education/mechanical-ventilation/respiratory-failure-mechanical-ventilation.pdf

Risk Factors and Etiology

- Respiratory failure can be grouped according to the primary abnormality and the individual components of the respiratory system (e.g., CNS, peripheral nervous system, respiratory muscles, chest wall, airways, and alveoli).
- A variety of pharmacologic, structural, and metabolic disorders of the CNS are characterized by depression of the neural drive to breathe
- Disorders of the peripheral nervous system, respiratory muscles, and chest wall lead to an inability to maintain a level of minute ventilation appropriate for the rate of carbon dioxide production
- Severe airway obstruction is a common cause of acute and chronic hypercapnia
- Diseases of the alveoli are characterized by diffuse alveolar filling, frequently resulting in hypoxemic respiratory failure, although hypercapnia may complicate the clinical picture.

http://emedicine.medscape.com/article/167981-overview#a5

Risk Factors and Etiology

Type I

- Chronic obstructive pulmonary disease (COPD)
- Pneumonia
- Pulmonary edema
- Pulmonary fibrosis
- Asthma
- Pneumothorax
- Pulmonary embolism
- Pulmonary arterial hypertension
- Pneumoconiosis
- Granulomatous lung diseases
- Cyanotic congenital heart disease
- Bronchiectasis
- Acute respiratory distress syndrome (ARDS)
- Fat embolism syndrome
- Kyphoscoliosis
- Obesity

http://emedicine.medscape.com/article/167981-overview#a5

Risk Factors and Etiology

Type II

- COPD
- Severe asthma
- Drug overdose
- Poisonings
- Myasthenia gravis
- Polyneuropathy
- Poliomyelitis
- Primary muscle disorders
- Porphyria
- Cervical cordotomy
- Head and cervical cord injury
- Primary alveolar hypoventilation
- Obesity-hypoventilation syndrome
- Pulmonary edema
- ARDS
- Myxedema
- Tetanus

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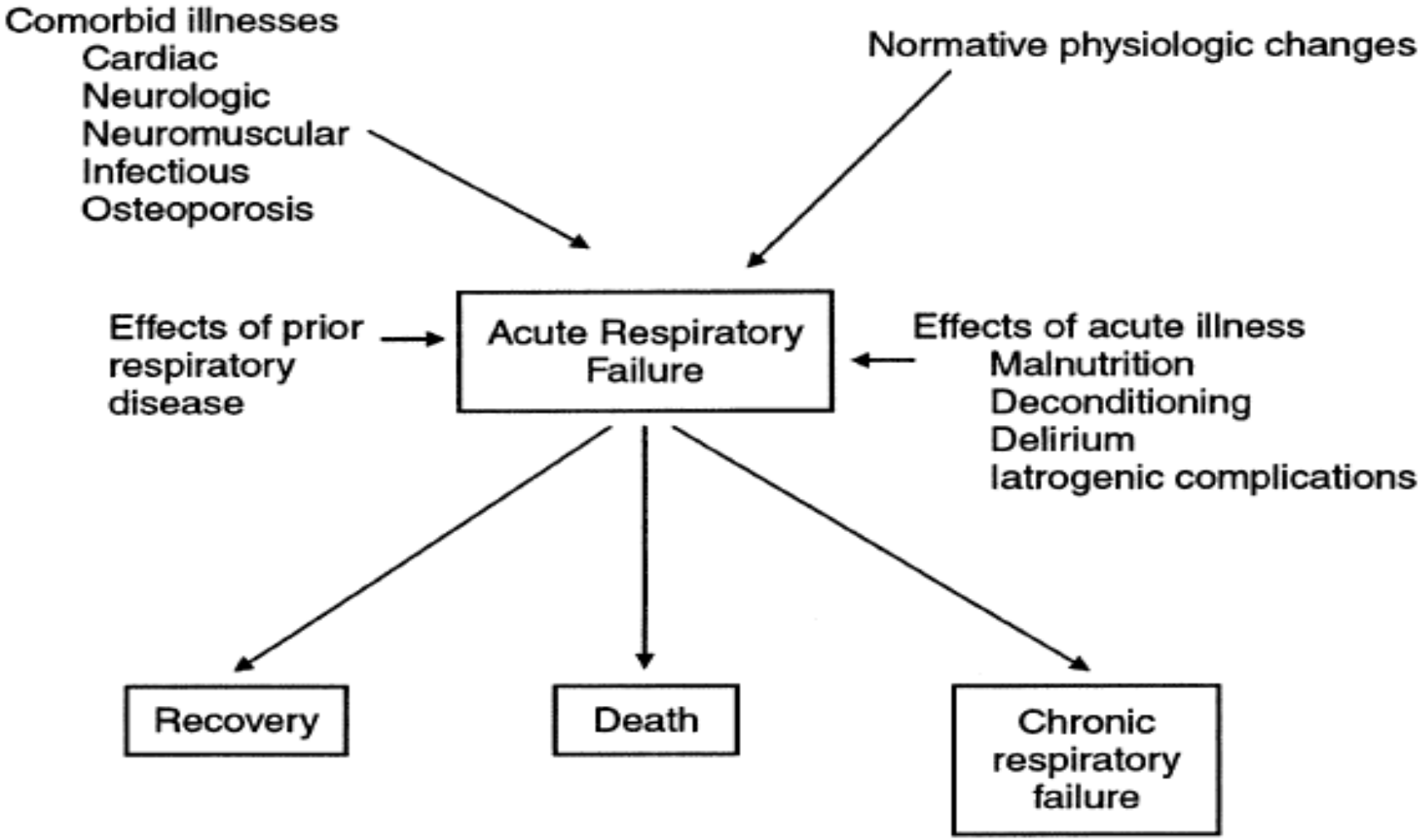
Risk Factors and Etiology



Respiratory failure in elderly patients.

https://www.researchgate.net/publication/10770800_Respiratory_failure_in_elderly_patients

Mechanism

- Respiratory failure may result from either a reduction in ventilatory capacity or an increase in ventilatory demand (or both)
- Ventilatory capacity can be decreased by a disease process involving any of the functional components of the respiratory system and its controller
- Ventilatory demand is augmented by an increase in minute ventilation and/or an increase in the work of breathing.

http://emedicine.medscape.com/article/167981-overview#a4

Mechanism

Hypoxemic (type I) respiratory failure

- The mechanisms are ventilation-to-perfusion ratio (V/Q) mismatch and shunt
- The low-V/Q units contribute to hypoxemia and hypercapnia and may occur either from a decrease in ventilation secondary to airway or interstitial lung disease or from overperfusion in the presence of normal ventilation; hypoxemia increases minute ventilation by chemoreceptor stimulation, but the $PaCO_2$ generally is not affected
- Shunt is defined as the persistence of hypoxemia despite 100% oxygen inhalation; the deoxygenated blood (mixed venous blood) bypasses the ventilated alveoli and mixes with oxygenated blood that has flowed through the ventilated alveoli, consequently leading to a reduction in arterial blood content ; shunt as a cause of hypoxemia is observed primarily in pneumonia, atelectasis, and severe pulmonary edema of either cardiac or noncardiac origin.

http://emedicine.medscape.com/article/167981-overview#a4

Mechanism

Hypercapnic (type II) respiratory failure

- At a constant rate of carbon dioxide production, $PaCO_2$ is determined by the level of alveolar ventilation
- The relation between $PaCO_2$ and alveolar ventilation is hyperbolic
- As ventilation decreases below 4-6 L/min, $PaCO_2$ rises precipitously
- A reduction in minute ventilation is observed primarily in the setting of neuromuscular disorders and CNS depression
- Hypoventilation is an uncommon cause of respiratory failure and usually occurs from depression of the CNS from drugs or neuromuscular diseases affecting respiratory muscles
  Hypoventilation is characterized by hypercapnia and hypoxemia

http://emedicine.medscape.com/article/167981-overview#a4

Mechanism

Etiologic Categories

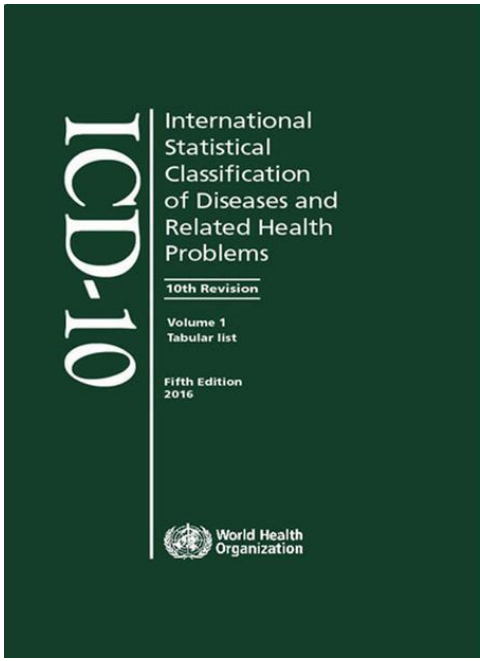
- Type I
  - Alveolar unit failure: collapse , flooding (edema, blood, pus, aspiration), fibrosis
  - Pulmonary vasculature failure): pulmonary embolism, pulmonary hypertension
- Type II
  - Nervous system failure: central hypoventilation, neuropathies
  - Muscle (pump) failure: muscular dystrophies, myopathies
  - Neuromuscular transmission failure: myasthenia gravis m
  - Airway failure: obstruction, dysfunction
  - Chest wall and pleural space failure: kyphoscoliosis, morbid obesity, pneumothorax , hydrothorax, hemothorax.

https://www.thoracic.org/professionals/clinical-resources/critical-care/clinical-education/mechanical-ventilation/respiratory-failure-mechanical-ventilation.pdf

Classification

International Classification of Diseases

- X Diseases of the respiratory system
- J95-J99 Other diseases of the respiratory system
- J96 Respiratory failure, not elsewhere classified
- J96.0 Acute respiratory failure
- J96.1 Chronic respiratory failure
- J96.9 Respiratory failure, unspecified



http://apps.who.int/classifications/icd10/browse/2016/en#/J45

Classification

Types

- Type I or hypoxemic
- Type II or hypercapnic
- Type III or perioperative
- Type IV in patients who are intubated and ventilated in the process of resuscitation for shock

http://www.webmd.com/asthma/tc/classification-of-asthma-topic-overview

Classification

Terms

- Acute
- Chronic
- Acute on chronic (e.g. acute exacerbation of advanced COPD)

http://www.webmd.com/asthma/tc/classification-of-asthma-topic-overview

Symptoms and Signs

Chronic

- Difficulty breathing or shortness of breath, especially when active
- Coughing up mucous
- Wheezing
- Bluish tint to the skin, lips, or fingernails
- Rapid breathing
- Fatigue
- Anxiety
- Confusion

Acute

- An inability to breathe
- Bluish coloration in the skin, fingertips, or lips
- Restlessness
- Anxiety
- Confusion
- Altered consciousness
- Rapid, shallow breathing
- Racing heart
- Profuse sweating

http://www.healthline.com/health/chronic-respiratory-failure#Symptoms2healthline.com/health/acute-respiratory-failure#Symptoms5

History

- The diagnosis of acute or chronic respiratory failure begins with clinical suspicion of its presence
- Confirmation of the diagnosis is based on arterial blood gas analysis
- Evaluation of an underlying cause must be initiated early, frequently in the presence of concurrent treatment for acute respiratory failure
- Cardiogenic pulmonary edema usually develops in the context of a history of left ventricular dysfunction or valvular heart disease
- Noncardiogenic edema (e.g., acute respiratory distress syndrome [ARDS]) occurs in typical clinical contexts, such as sepsis, trauma, aspiration, pneumonia, pancreatitis, drug toxicity, and multiple transfusions).

http://emedicine.medscape.com/article/167981-clinical

Physical Examination 1

- Localized pulmonary findings reflecting the acute cause of hypoxemia (e.g., pneumonia, pulmonary edema, asthma, or COPD), may be readily apparent
- In patients with ARDS, the manifestations may be remote from the thorax, such as abdominal pain or long-bone fracture
- Neurologic manifestations include restlessness, anxiety, confusion, seizures, or coma.
- Asterixis may be observed with severe hypercapnia
- Tachycardia and arrhythmias may result from hypoxemia and acidosis
- Cyanosis, a bluish color of skin and mucous membranes, indicates hypoxemia
- Dyspnea, an uncomfortable sensation of breathing, often accompanies respiratory failure

http://emedicine.medscape.com/article/167981-clinical#b2

Physical Examination 2

- Excessive respiratory effort, vagal receptors, and chemical stimuli (hypoxemia and/or hypercapnia) all may contribute to the sensation of dyspnea
- Both confusion and somnolence may occur in respiratory failure
- Myoclonus and seizures may occur with severe hypoxemia
- Polycythemia is a complication of long-standing hypoxemia
- Pulmonary hypertension is present in chronic respiratory failure
- Alveolar hypoxemia potentiated by hypercapnia causes pulmonary arteriolar constriction; if chronic, this is accompanied by hypertrophy and hyperplasia of the affected smooth muscles and narrowing of the pulmonary arterial bed
- The increased pulmonary vascular resistance increases afterload of the right ventricle, which may induce right ventricular failure (cor pulmonale).

http://emedicine.medscape.com/article/167981-clinical#b2

Complications

- Pulmonary complications include pulmonary embolism, nosocomial pneumonia, barotrauma, pulmonary fibrosis, and complications secondary to the use of mechanical devices
- Cardiovascular complications include hypotension, reduced cardiac output, arrhythmia, endocarditis, and acute myocardial infarction
- Gastrointestinal complications are hemorrhage, gastric distention, stress ulceration, ileus, diarrhea, and pneumoperitoneum
- Nosocomial infections (pneumonia, urinary tract infections, and catheter-related sepsis) occur with the use of mechanical devices
- Renal failure is the result of renal hypoperfusion and the use of nephrotoxic drugs
- Nutritional complications are related to administration of enteral or parenteral nutrition.

http://emedicine.medscape.com/article/167981-clinical#b3

Diagnosis 1

- Arterial blood gas analysis: confirmation of the diagnosis
- Chest X-ray: often identifies the cause of respiratory failure
- Complete blood count (CBC): anaemia can contribute to tissue hypoxia; polycythemia may indicate chronic hypoxemic respiratory failure
- Renal function tests and liver function tests: may provide clues to the etiology or identify complications associated with respiratory failure
- Serum creatine kinase and troponin I: to help exclude recent myocardial infarction
- Thyroid function tests (TFTs): hypothyroidism may cause chronic hypercapnic respiratory failure
- Spirometry: the evaluation of chronic respiratory failure.

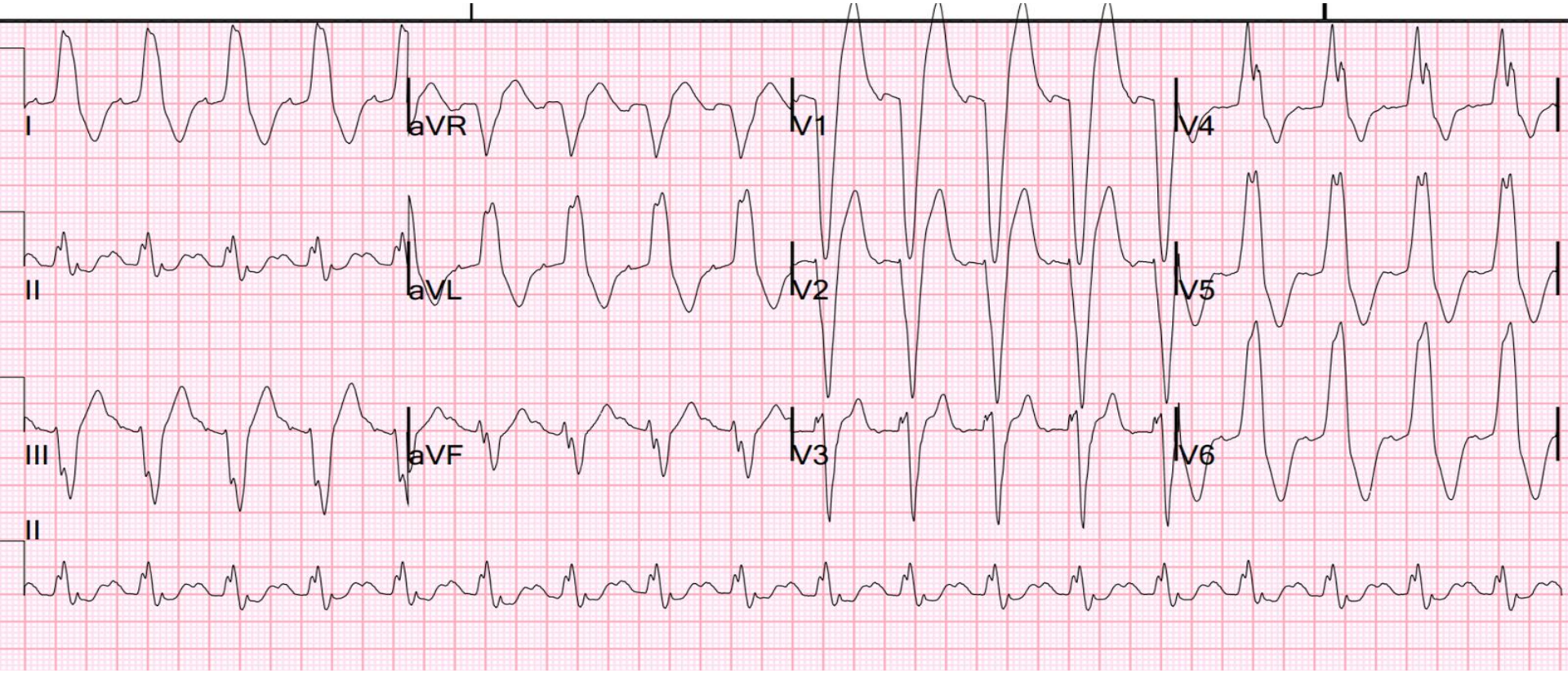
http://patient.info/doctor/respiratory-failure

Diagnosis 2

- Echocardiography: if a cardiac cause of acute respiratory failure is suspected
- Pulmonary function tests: the evaluation of chronic respiratory failure
- Electrocardiography (ECG): to evaluate a cardiovascular cause; it may also detect dysrhythmias resulting from severe hypoxemia or acidosis
- Right heart catheterization: should be considered if there is uncertainty about cardiac function, adequacy of volume replacement and systemic oxygen delivery
- Pulmonary capillary wedge pressure may be helpful in distinguishing cardiogenic from non-cardiogenic edema.

http://patient.info/doctor/respiratory-failure

Diagnosis 3



Acute Pulmonary Edema, Respiratory Failure, and LBBB: There is sinus tach with left bundle branch block (LBBB). There is excessively discordant ST elevation in leads V1 and V2. The highest ST/S ratio is in V1, with a ratio of 8/30 = 0.27, highly suggestive of LAD occlusion.

https://www.researchgate.net/publication/10770800_Respiratory_failure_in_elderly_patients

Diagnosis 4

Hypoxic Respiratory Failure Criteria

- Hypoxic respiratory failure is diagnosed in patients without chronic lung disease when there is falling pulse oximetry from 92% saturation or initial pulse oximetry <80% saturation on room air (severe respiratory failure is diagnosed when arterial blood gas shows PaO2 of <60 mmHg on room air)
- Patients with chronic lung disease may have low pulse oximetry readings and baseline PaO2 values of 50 mmHg, making worsening hypoxia difficult to recognise.
- Decreases of 10% from baseline oxygenation can indicate impending respiratory failure in patients with chronic lung disease.

http://bestpractice.bmj.com/best-practice/monograph/853/diagnosis/criteria.html

Diagnosis 5

Hypercapnic Respiratory Failure Criteria

- Hypercapnic respiratory failure is diagnosed in patients without chronic lung disease when there is hypoxia and acute elevation of arterial $PaCO_2$ >45 to 50 mmHg and associated acidosis (pH <7.35)
- Patients with chronic lung disease can usually tolerate $PaCO_2$ levels of up to 80 mmHg with secondary renal compensation
- Increasing acidosis (decreasing pH) in these patients indicates respiratory failure.

http://bestpractice.bmj.com/best-practice/monograph/853/diagnosis/criteria.html

Management 1

- The first objective in the management of respiratory failure is to reverse and/or prevent tissue hypoxia
- Hypercapnia unaccompanied by hypoxemia generally is well tolerated and probably is not a threat to organ function unless accompanied by severe acidosis when the arterial blood pH falls below 7.2
- Appropriate management of the underlying disease obviously is an important component in the management of respiratory failure
- A patient with acute respiratory failure generally should be admitted to a respiratory care unit or intensive care unit (ICU)
- Most patients with chronic respiratory failure can be treated at home with oxygen supplementation and/or ventilatory assist devices along with therapy for their underlying disease

http://emedicine.medscape.com/article/167981-treatment#d9

Management 2

Noninvasive ventilation in immunocompromised patients with acute respiratory failure.

https://www.hamilton-medical.com/de/Products/Mechanical-ventilators/HAMILTON-C3.html

Management 3

- Extracorporeal membrane oxygenation (ECMO) may be more effective than conventional management for patients with severe but potentially reversible respiratory failure
- Assurance of an adequate airway with endotracheal intubation and ventilation are required in cases of severe respiratory failure (PaO_2 less than 50 mmHg); another indication is airway protection in patients with altered mental status
- Once the airway is secured, attention is turned toward correcting the underlying hypoxemia, the most life-threatening facet of acute respiratory failure

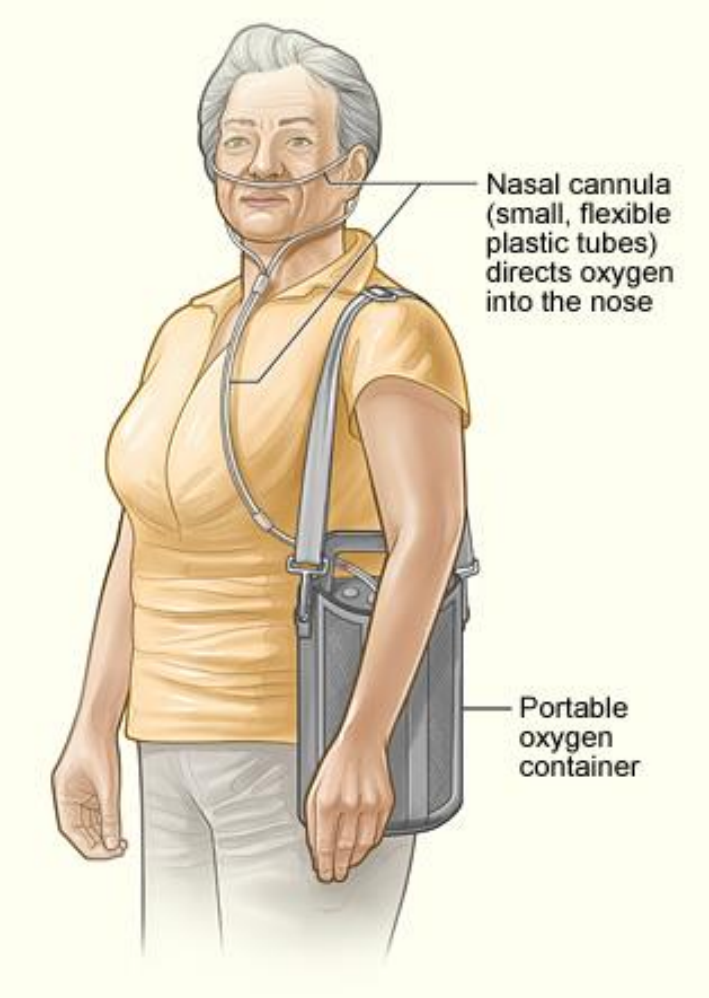
http://emedicine.medscape.com/article/167981-treatment#d9

Management 4

- The goal is to assure adequate oxygen delivery to tissues, generally achieved with an arterial oxygen tension (PaO_2) of 60 mm Hg or an arterial oxygen saturation (SaO_2) greater than 90%
- Respiratory stimulants such as doxapram are rarely used, and if the respiratory failure resulted from an overdose of sedative drugs such as opioids or benzodiazepines, then the appropriate antidote (naloxone or flumazenil, respectively) will be given
- There is tentative evidence that in those with respiratory failure identified before arrival in hospital, continuous positive airway pressure can be useful when started before conveying to hospital.

https://en.wikipedia.org/wiki/Respiratory_failure

Management 5



A nasal cannula and portable oxygen container are attached to a patient.

https://www.hamilton-medical.com/de/Products/Mechanical-ventilators/HAMILTON-C3.html

Prognosis

- The mortality varies according to the etiology
- For ARDS, mortality is up to 45%
- Significant mortality occurs in patients admitted with hypercapnic respiratory failure
- For patients with COPD and acute respiratory failure, the overall mortality is up to 26%.

http://emedicine.medscape.com/article/167981-overview#a7

Prophylaxis

- Prevention is based on risk awareness of relevant medical conditions or trauma, and control or correction of underlying illnesses or injuries
- It is standard practice to administer influenza and pneumococcal vaccinations to patients at risk of respiratory failure with the thought that the vaccines control influenza and pneumococcal pneumonia and can help prevent respiratory failure in vulnerable groups
- Smoking cessation for all patients with lung disease limits the progression of pulmonary dysfunction
- Monitoring and continued medical management of patients with relevant chronic lung disease helps limit acute exacerbations and reduces the risk of respiratory failure.
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https://online.epocrates.com/diseases/85344/Acute-respiratory-failure/Prevention

Abbreviations

ARDS - acute respiratory distress syndrome

CBC - complete blood count

CNS - central nervous system

COPD - chronic obstructive pulmonary disease

ECG - electrocardiography

ECMO - Extracorporeal membrane oxygenation

ICU - intensive care unit

TFTs - thyroid function tests

V/Q - ventilation-to-perfusion ratio

Diagnostic and treatment guidelines

BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults

Respiratory Failure

Respiratory Failure

Respiratory Failure Treatment & Management

Treatment of respiratory failure in COPD