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ACUTE RESPIRATORY FAILURE: INTEGRATED APPROACH TO DIAGNOSIS, TREATMENT AND ALTERNATIVES TO INVASIVE MECHANICAL VENTILATION

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Abstract: Acute respiratory failure (ARF) occurs when the respiratory system cannot maintain adequate oxygenation and ventilation, compromising oxygen delivery and carbon dioxide removal, resulting in hypoxia and hypercapnia. Traditional treatment includes invasive mechanical ventilation, but non-invasive alternatives, such as positive pressure ventilation and high-flow oxygen support, have shown benefits in certain cases. The bibliographic review covers recent and relevant articles in Portuguese and English that detail the characteristics, diagnoses and treatment methods of IRpA collected through searches on platforms such as PubMed and Scopus. Its objective is a comprehensive understanding of the topic. Management of IRpA includes airway clearance, oxygen therapy and, when necessary, invasive ventilation. The study concludes that treatment must be adapted to the patient's specific conditions, with an emphasis on identifying and correcting the underlying cause of respiratory failure.
Keywords: accute breathing insufficiency.

INTRODUCTION

Maintaining adequate levels of oxygen (O2) in arterial blood is crucial for proper cellular functioning, as O2 is essential for oxidative phosphorylation and the production of energy in the form of ATP (LITTLE & EDWARDS, 1993). For this to happen, the correct and coordinated functioning of several systems is necessary: the neurological, pulmonary, cardiovascular, musculoskeletal and hematological systems. Any failure in this chain will result in a decrease in the delivery of O2 to tissues, impairing their functioning and leading to Acute Respiratory Failure (ARF) (HILL & SCHIMDT, 2010; DEL SORBO et al., 2010). This same system, responsible for maintaining oxygenation, also plays a role in regulating appropriate levels of carbon dioxide

(CO_2) and, consequently, in regulating blood pH, which is essential for the body's homeostasis (BEREND et al., 2014).

Acute respiratory failure is characterized by the inability of the respiratory system to maintain oxygenation and/or ventilation, resulting in ineffectiveness in meeting the body's metabolic needs. Furthermore, it is a common cause for admission to intensive care units. Invasive mechanical ventilation, especially positive pressure ventilation, has been the main approach in the treatment of severe forms of acute respiratory failure since the 1950s (BERTHELSEN & CRONQVIST, 2003). However, despite considerable advances in intensive care, complications and mortality associated with intubation and positive pressure ventilation are not negligible (RANIERI et al., 2012). Therefore, considerable efforts have been devoted to exploring alternatives to invasive mechanical ventilation through the use of non-invasive devices. In some situations, such as pulmonary edema of cardiac origin and exacerbations of chronic obstructive pulmonary disease (COPD), non-invasive respiratory support has been shown to be highly beneficial.

However, in cases of respiratory failure hypoxemia with concomitant conditions such as sepsis and shock, the use of non-invasive respiratory support can be risky, with benefits more difficult to define clearly (ROCHWERG et al., 2017; BELLANI et al. 2017). There are three main methods of non-invasive support widely used in the intensive care setting: delivering high-flow gas through a large-caliber, non-occlusive nasal cannula (known as a high-flow nasal cannula), applying continuous positive airway pressure (CPAP) and the use of non-invasive ventilation methods, such as with pressure support and positive end-expiratory pressure (PEEP).

METHODOLOGY

The methodology carried out was a bibliographical review of scientific sources, and selected articles in Portuguese and English, prioritizing recent and relevant articles on the diagnosis and treatment of Acute Respiratory Failure, using the descriptors "respiratory", "failure" and "acute" based on data from PubMed and Scopus. 19 articles related to the topic, published between 1993 and 2022, were analyzed.

GOALS

This article aimed to provide a comprehensive understanding of Acute Respiratory Failure, addressing its concept, causes, diagnosis and treatment.

DISCUSSION

Acute respiratory failure is a condition in which the respiratory system is unable to perform its main function, that is, to carry out gas exchange, supplying oxygen and eliminating carbon dioxide from the tissues. In terms of gases, we have to: when carrying out the transport of these gases through the blood, their concentrations generate pressures that form concentration gradients for their respective diffusion (in this process, gases go from the environment with the greatest gradient to the one with the smallest), either to enter the fabrics, or to come out of them (HALL, 2017).

OXYGEN

The transport of oxygen is carried out from the lung to the tissues, to meet tissue needs, therefore, if the PO_2 (partial pressure of oxygen) under normal conditions is usually on average 104 mmHg, the value of the alveolar oxygen pressure must be greater to the point of allowing O_2 to enter the blood during hematosis in the lungs.

alveolar air, forming a concentration gradient, allowing diffusion and subsequently in the tissues, PO2 must allow such passage towards the cells, thus, PO2 must be a value lower than that of the capillary, in this case it is 23 mmhg. However, in cases of respiratory failure, arterial PO2 must be <60 mmhg instead of 104 mmhg, drastically reducing the pressure difference between the blood and the cell, impairing blood oxygenation, leading to hypoxia (low blood O2) (HALL, 2017).

CARBON DIOXIDE

The transport of carbon dioxide is carried out from the tissues to the lungs for excretion during exhalation. In this sense, if the PCO2 (partial pressure of carbon dioxide) in normal values in the blood is around 40 mmHg, then for there to be a diffusion gradient and the CO2 can be eliminated from the cells, the cellular PCO2 must be greater than the arterial, allowing its exit (cellular PCO2 = 46 mmhg), in the lungs, within the alveoli, the PCO2 must be lower than in the capillary for CO2 to be excreted, thus the alveolar PCO2 is close to zero, enabling its exit. However, in cases of respiratory failure, arterial PCO2 increases to >45 mmHg, as the body is unable to eliminate CO2, leading to a situation of CO2 accumulation within cells and in the blood known as hypercapnia (HALL, 2017). CO2 is transported in the blood in the plasma in the form of bicarbonate ion, which is formed from the reaction: CO2 + H2O -> H2CO3 -> HCO3- + H+; such H+ released under normal conditions does not cause changes in blood pH, due to the buffer systems present in the blood that prevent this variation, however in cases of hypercapnia, there is a high release of H+ in the blood due to this reaction for the transport of CO2, it can cause a drop in blood pH, a high-risk factor for the patient (HALL, 2017).

CLASSIFICATION OF ACUTE RESPIRATORY FAILURE

- TYPE 1 - condition in which the patient is hypoxemic but not hypercapnic, that is, PO2 is low but PCO2 is normal (SINGH & KUMAR, 1996).
- TYPE 2 - the patient presents hypoxemia and hypercapnia, that is, low PO2 and high PCO2 (SINGH & KUMAR, 1996).

FACTORS CAUSING HYPOXIA

Numerous factors can lead to respiratory failure, that is, impairing blood oxygenation and the elimination of CO2, thus leading to hypoxia and hypercapnia (HALL, 2017).

- Hypoxia hypoxemia: decrease in arterial PO2, caused by changes in the ventilation-perfusion ratio, changes in diffusion (pneumonia, atelectasis…), presence of intrapulmonary shunt (acute respiratory distress syndrome - ARDS) (HALL, 2017).
- Anemic hypoxia: decreased hemoglobin concentration, impairing O2 transport (HALL, 2017).
- Circulatory hypoxia: hypovolemic shock, there is not enough blood to circulate and meet tissue demands by O2 (HALL, 2017).

ASSOCIATED DISEASES

Severe Acute Respiratory Syndrome (SARS) must be reported and investigated. Some infections are related to the prevalence and severity of this pathology. Among them, it is known that the influenza virus and RSV (respiratory syncytial virus) are the most impactful for the condition, with the influenza virus being the most circulating throughout the world, with the seasonal virus A being the most prevalent in the world. population (ARAUJO et al., 2020). But there are also cases caused by the dengue virus, adenovirus,

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hanta virus and (more recently with high prevalence) coronavirus and bacteria as in the case of pneumococcus (pneumonia). In a cohort study analysis observed between 2013 and 2018 in the city of Goiás, it was observed that immunization against influenza A and B viruses, as well as the early use of antivirals reduced the mortality rate and ICU admission by the syndrome. Concomitantly, a multivariate analysis demonstrated a negative outcome of the disease due to infection with this virus, associated with RSV, which further corroborates the fundamental role of these pathogens in the disease (ARAUJO et al., 2020).

Numerous factors can interfere with the functioning of the respiratory system, leading to IRpA (acute respiratory failure), such as:

- Traumatic injuries that mainly affect the thoracic and central nervous system (RACCA et al., 2019). Patients with neurological trauma, especially bulbar injuries, the development of respiratory disorders such as IRpA can occur as a result of a failure in respiratory control precisely because of the injury, causing CO2 retention and failure in blood oxygenation (hypercapnia and hypoxia). In the thorax, as chest wall and lung compliance may be reduced, as also occurs in neurological injuries, the mechanical load on weakened respiratory muscles (in particular the diaphragm) may be increased. An imbalance between load and capacity leads to muscle fatigue, which in turn causes an increase in respiratory rate and a reduction in tidal volume, causing hypoventilation ("rapid, shallow breathing") and IRpA (RACCA et al., 2019).
- Obstructive airway pathologies such as asthma, COPD, bronchitis and insertion of a foreign body in the airway (HALL,2017).

Mechanisms of airway obstruction include the following:

(1) The airway lumen may be partially obstructed by excessive secretions (e.g., chronic bronchitis), edema fluid or aspiration of food or liquids, making air passage difficult and subsequently impairing gas exchange, which may progress to IRpA.

(2) The smooth muscles of the airway wall may be contracted (e.g., asthma) or thickened because of inflammation and edema (e.g., asthma, bronchitis), or the mucus glands may be hypertrophied (e.g., e.g., chronic bronchitis). In this case, the airways become restricted, making the passage of air difficult, impairing gas exchange and potentially developing IRpA.

(3) External airways, the destruction of the lung parenchyma can reduce radial traction, causing the airways to be reduced, with less oxygenated air entering per respiratory cycle, in other words, gas exchange is impaired, which can develop into IRPA. (e.g., emphysema) (HALL, 2017).

- Pathologies that restrict ventilation, such as pneumonia, pulmonary fibrosis, pleural effusion, pleuritis, hemothorax, pneumothorax (HALL, 2017). A common type of pneumonia is bacterial pneumonia, which is most often caused by pneumococci. Infected alveoli become progressively filled with transudate, composed of proteins and cells, which occupies the alveolar space, impairing the arrival of air in the exchange space, which can cause subsequent hypoxia and ARF (HALL, 2017).

• Changes in gas transport can also lead to IRpA, such as cases of hypovolemic shock (HALL, 2017). A considerable number of situations can cause dehydration, such as vomiting, diarrhea, excessive sweating, diabetes mellitus, diabetes insipidus, excessive use of diuretics, destruction of the adrenal cortex with loss of aldosterone and renal loss of fluids with loss of kidney function. If dehydration is severe, shock may occur. When this occurs, there may be hypoxia and tissue hypercapnia, as gas transport is impaired, with less oxygen arriving and less carbon dioxide being excreted, thus leading to IRpA (HALL, 2017).

DIAGNOSIS

The diagnosis of acute respiratory failure (ARF) requires a detailed clinical assessment of the patient, observing the development of respiratory symptoms from a complete history and physical examination. Symptoms vary and may include flu-like symptoms, tachypnea, hypoxemia, hypercapnia and agitation. A history of fever, productive cough, chest pain, aspiration, orthopnea (which suggests cardiogenic edema) and hemoptysis must also be investigated. Furthermore, check the history of other pathologies that may be associated with his condition and prognosis. During the physical examination, the doctor must assess whether there are signs of acute cardiogenic pulmonary edema, such as jugular engorgement, lung expansion, range of thoracovocal thrills, signs of respiratory effort (such as intercostal insufficiency, wishbone retraction, flaring of the nasal flaps), rales, murmurs, stridor and edema in the lower limbs, and pneumonia, such as massive or submassive percussion and pulmonary rales (VELASCO et al., 2020; SIEGEL, 2021). Initially, the x-ray may show no abnormalities. Therefore, the diagnosis is based on the identification of IRpA by its possible causes and prognosis, in addition to a complete history and physical examination, paying attention to respiratory symptoms and the patient's history. According to Barreira et al. 2018, the diagnosis is confirmed by the 2012 Berlin criteria, in the presence of at least one of the following changes:

GSA

The PaO2 < 60 mmHg breathing air (or PaO2/FiO2 ≤ 300) or 2. PaCO2 > 45 mmHg + arterial blood pH < 7.35 (respectively, hypoxemia, hypercapnia and acidosis).

TREATMENT

The IRpA treatment needs to be personalized due to the various etiologies and pathophysiological mechanisms involved. Therefore, treatment depends on identifying and resolving the underlying disease that caused it. However, while the underlying disease is not fully understood and treated, some general principles must be applied in most cases, such as airway management to provide adequate life support and alleviate the symptoms of IRpA (PINHEIRO et al., 2015).

AIRWAY MANAGEMENT

To maintain the airways is one of the principles of unblocking and preventing complications, especially aspiration, which are extremely important in patients with Respiratory Failure (RI), especially those who have disturbances in consciousness. Ensuring knowledge of the patient's condition can greatly help with issues of airway treatment and management, as medical management varies according to the patient's condition. In cases of IRpA, it is crucial to position the patient on their side with the head tilted forward and the jaw advanced to avoid airway obstructions caused by the tongue. This maneuver sometimes helps in diagnosing upper airway obstruction due to vomit or foreign body and allows immediate clearance (MATSUNO, 2012). If repositioning the patient is not enough to clear the airway, the cause must be investigated, using the airway management strategy best suited for the condition.

The first option is to offer a high flow of oxygen (oxygen therapy) after using better control measures for the patient's hypoxia, that is, the use of a nasal cannula or nasopharynx. This technique is also used in cases of unilateral nostril obstruction. If the nasal cannula is not effective for the patient to the point of increasing oxygen saturation, it is necessary to analyze the airway parameters for possible intubation, the fact analyzed is the Mallampati classification (classification created to evaluate the degree of visualization of the oropharynx, since the smaller the visualization of the oropharynx, the more difficult it will be to perform intubation) (ATLS, 2018).

The use of an oropharyngeal cannula is appropriate when the patient is expected to quickly regain consciousness, such as, for example, in post-anesthesia recovery situations.

This type of cannula is inserted through the oral cavity (after analyzing the Mallampati classification to see the level of difficulty of the procedure), inserting the device with the curved part facing upwards until it touches the soft palate and at this point the rotation of the cannula must be performed. 180° of the devices, so that the curve of the device faces downwards, fitting into the oral anatomy, allowing the opening of the oral route in the oropharynx (ATLS, 2018).

In cases of a longer period of unconsciousness or the need for mechanical ventilation, endotracheal intubation is recommended. For this type of procedure, it is necessary to ensure that there is no spinal fracture. Endotracheal intubation is the preferred route to protect the airway, indicated mainly in cases of apnea. To perform this procedure, an Eschmann tracheal tube introducer (ITTE), known as an elastic bougie (GEB), is necessary, a tool used to facilitate visualization of the airways. After performing a cervical extension, a laryngoscope is used to see the direction of the patient's airway, after which position the GEB after the epiglottis with its tip inclined so that as soon as it reaches the tracheal rings and when feeling the clicks of the tip of the device in the cartilaginous rings (a fact that confirms that the GEB is in the correct position) pass the lubricated endotracheal tube over the GEB beyond the cords, then remove the GEB and confirm the position of the tube with auscultation. Once this procedure is complete, inflate the cuff that will be connected to the tube and watch the ventilation (ATLS, 2018).

In cases of obstruction above the vocal cords, it may be necessary to perform a cricothyroidotomy or tracheostomy (FONSECA et al., 2013).

For patients with tracheal intubation or tracheostomy, especially when they are sedated or in a coma, as it is a surgical procedure, it is essential to periodically suction the airways to prevent obstructions. When difficulties occur in cycling a mechanical ventilator, characterized by high respiratory rate, low tidal volume and/or excessive inspiratory pressure peaks, the possibility of an obstruction must be considered. (FREEMAN, 2017). This procedure is performed through an incision in the skin that extends to the cricothyroid membrane (between the thyroid and cricoid cartilages). After the incision, curved hemostatic forceps can be used to increase the opening and thus insert a needle. endotracheal tube or a tracheostomy tube (5-7mm) (ATLS, 2018).

Furthermore, regardless of the management used, the fundamental principle is oxygen therapy. or SaO2 less than 90%. In these conditions, oxygen therapy must always be introduced. The specific clinical objectives of oxygen therapy are to correct suspected or proven acute hypoxemia, reduce symptoms associated with chronic hypoxemia, and reduce the workload associated with hypoxemia. imposes on the cardiopulmonary system (NISHIMURA, 2016).

CONCLUSION

Acute respiratory failure is a critical condition that compromises the respiratory system's ability to maintain adequate oxygenation and ventilation. Traditional treatment, which usually involves invasive mechanical ventilation, is still widely used, but non-invasive approaches, such as positive pressure ventilation and high-flow oxygen support, have also been shown to be effective in many cases, depending on patient-specific factors. patient and the nature of the insufficiency. It is essential that management is individualized, taking into consideration, the clinical conditions of each patient and the underlying cause of respiratory failure. Airway clearance and oxygen therapy are essential interventions, and invasive ventilation must be considered when other options are not sufficient. A comprehensive understanding of IRpA treatment is crucial to optimize clinical outcomes and improve patients' quality of life and promote best management practices.

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