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Alveolar recruitment in pulmonary contusion. Case report and literature review

Manobra de recrutamento alveolar na contusão pulmonar. Relato de caso e revisão da literatura

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ABSTRACT

Treatment of pulmonary contusion when adequately established is very simple in most cases. Pathophysiological changes occur as a result of the effects produced by loss of chest wall integrity, accumulation of fluid in the pleural cavity, obstruction of the airways and lung dysfunction. The alveolar recruitment maneuver is the reopening of collapsed lung areas by increasing inspiratory pressure in the airway. The primary objective of this case report was to evaluate the effectiveness of the alveolar recruitment maneuver in a patient with pulmonary contusion. A 33 year old male patient, with a clinical condition of bilateral chest trauma and traumatic brain injury, evolved with reduction of the level of consciousness, acute respiratory failure, hypovolemic shock and hemoptysis. The patient underwent thoracentesis, bilateral thoracic drainage and was also submitted to invasive mechanical ventilation. After 48 hours of invasive mechanical ventilation, in accordance with protective strategy an alveolar recruitment maneuver mode, pressure-controlled ventilation, pressure controlled 10 cmH_2O, respiratory rate 10 rpm, inspiratory time 3.0, positive end-expiratory pressure 30 cmH_2O and $FI0_2$ 100%, for two minutes. After the alveolar recruitment maneuver, the patient presented clinical pulmonary improvement, but there was a variation of 185 to 322 of $Pa0_2/FiO_2$ (arterial partial pressure of oxygen/ fraction of inspired oxygen). He was discharged from the intensive care unit 22 days after admission. The alveolar recruitment maneuver in this patient showed significant results in the treatment of pulmonary contusion, improving blood oxygenation, preventing alveolar collapse and reversing atelectasis.

Keywords: Respiratory failure; Thoracic injuries; Pulmonary ventilation

INTRODUCTION

Trauma is one of the main causes of handicap and death in the world today, especially in the younger population, moreover, chest injury represents a major aggravating factor in the evolution of polytrauma patients.[1] It is directly related to 25% of cases and indirectly with another 25%. About one third of chest trauma cases require hospital admission.

A chest injury represents a major aggravating factor in the evolution of polytrauma patients with multisystemic trauma accounting for 20% of the deaths of traumatic origin. Although incidence of death in thoracic injuries has a prominent place in global statistics, many of the patients with this type of trauma may be managed without major surgical procedures. Thoracotomy is only used in about 10% to 20% of the cases.

Nevertheless, approximately one third of the patients with severe chest injuries die prior to hospital care and another 20% present late death, due to pleuropulmonary complications of an infectious nature that, direct or indirectly are brought about by this type of violence.[2-4]

The primary cause of traumatic lung injuries are automobile accidents[5,6] Trauma may produce injuries in the intrathoracic organs. In the case of pulmonary contusions, the most common of the parenchymal injuries are atelactasis, lacerations and hematomas.

Pulmonary contusion is defined as an injury in which interstitial and alveolar damage occurs, such as the presence of blood and edema, however with no significant rupture of alveolar walls.[6,7]

Pulmonary contusion is the most common traumatic parenchymal injury[7,8] Pathophysiological changes derive from the effects produced by loss of integrity of the thoracic wall, accumulation of fluid in the pleural cavity, obstruction of the airway and pulmonary dysfunction. Normally, contusion appears in four to six hours after trauma and disappears in four to six days, an abrupt onset of parenchymal opacification and its rapid disappearance are characteristics of pulmonary contusion.[9] The most significant factor is blunt trauma. This condition results from pulmonary contusion due to compressive forces acting on the lung, producing capillary ruptures with edema formation and intravascular fluid extravasation, damaging aeration of the affected areas forming of atelectatic zones. Accurate diagnosis and early treatment reduce morbidity and mortality of this complication.[9]

Clinical importance of the extent of pulmonary contusion in the evolution of patients who were victims of trauma was evaluated by Wagner and Jamieson, who established a quantitative method that divides pulmonary lobes according to their volume. They found that patients with pulmonary contusions or lacerations affecting more than 28% of the lung tissue had mechanical ventilation (MV) indicated. On the other hand, patients with less than 18% of lung tissue impairment did not require this procedure. Use of computerized tomography (CT) represents a significant progress in the modern approach to trauma victims. Chest CT in cases of thoracic trauma, defines more precisely the extension and severity of injuries which usually are underestimated by conventional radiographies[10,11] Currently, with the introduction of helicoidal CT, its use has been considered for early diagnosis of thoracic trauma.[12]

Use of alveolar recruitment maneuvers (ARM) has been proposed as supplemental therapy in the MV strategies for patients with acute respiratory distress syndrome (ARDS) and acute lung injury (ALI). ARM is a technique using support pressure increase in the airway to recruit collapsed alveolar units, by increasing the pulmonary area available for gas exchange and therefore arterial oxygenation.[13] It is not only used in patients with ARDS, but also in clinical situations with development of collapsed pulmonary areas (atelectasis). ARM aims to stabilize alveolar permeability which, then must be kept at adequate levels of positive end expiratory pressure (PEEP) that is to say, with lower pressure than that needed for recruitment. When successful, benefit of each maneuver tends to disappear over time, unless a sufficient PEEP level is applied to avoid alveolar derecruitment[14,15] when the patient will remain under mechanical ventilation. Mechanical ventilation has greatly contributed to increase survival in various clinical situations, but notwithstanding this major advance, when used inadequately it can contribute to increase morbidity mortality rates.[16] MV may cause or perpetuate pulmonary injury if there is cyclic overdistension and collapse of the alveolar units at each breath. To reduce mortality of patients with ARDS and of ALI, Amato et al, presented positive results by use of ventilation with a lung protective strategy, consisting of use of low tidal volumes (4 to 6mL.kg-1), maximum plateau pressure of 35 cmH_2O and PEEP above the lower inflection point of the pressure-volume curve.[17] The purpose of this report was to present a case of pulmonary contusion, assessing the effectiveness of the alveolar recruitment maneuver and review of literature.

CASE REPORT

A male, 33 year old patient was admitted to the intensive care unit (ICU) of Internal Medicine of Hospital São Paulo with a clinical condition of bilateral chest trauma and brain injury. He evolved with a Glasgow Coma Score (GCS) > 8, acute respiratory failure (ARF) and hypovolemic shock. CT scan showed pulmonary contusion, pleural effusion and bilateral atelectasis (Figure 1). Due to progressive worsening of the ventilation mechanics, an orotracheal intubation and invasive mechanical ventilation (IMV) were needed, the protective ventilation strategy was established early. After 48 hours ARM was started with PEEP titration for a better compliance of the respiratory system. This was repeated every 6 hours, keeping adequate PEEP levels and with a closed suction system, as studies disclosed an excellent correlation between the ratio of partial oxygen

pressure/fraction of inspired oxygen (PaO_2/FiO_2) and ARM. This ratio PaO_2/FiO_2 continues after 6 hours of ARM, because patients were not disconnected from the system. ARM was maintained for 10 days and a comparative assessment was made pre and post ARM with conventional radiography (Figures 2 and 3). The patient presented an initial $PaO_{2/}FiO_2$ value of 178 and static compliance (Cstat) of 24 mL/cmH_2O. After ARM the oxygenation index PaO_2/FiO_2 went to 342 and (Cstat) 71 mL/cmH O. The patient presented an improved clinical condition, hypoxemic (PaO_2/FIO_2 ratio), and improvement at X-ray exam. On the 16th day of stay, a percutaneous tracheostomy was made and after 2 days weaning from mechanical ventilation was begun. The patient was discharged from the ICU after 22 days and from the hospital 32 days after admission.

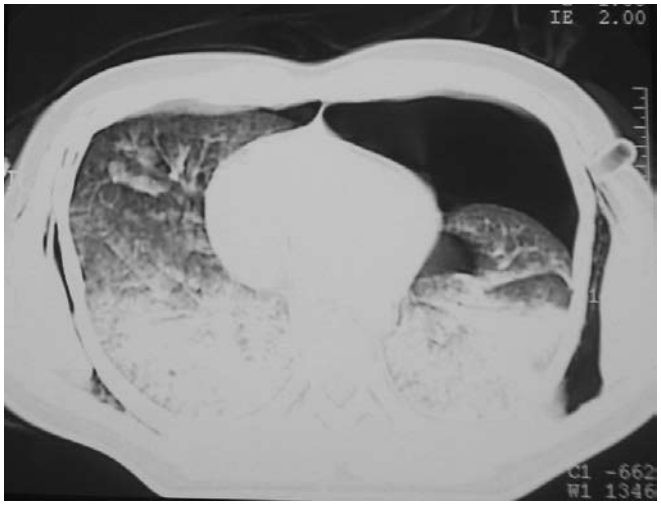

Figure 1 – Thorax computerized tomography at admission

Figure 2 - Thorax x-ray before recruitment maneuver

Figure 3 - Thorax x-ray after recruitment maneuver

DISCUSSION

ARM consists of reopening of collapsed pulmonary areas by an increase of inspiratory pressure in the airway, promoting reduction of pulmonary shunt and better gas exchange.[18] ARM is a technique using the sustained increase of pressure in the airway for the purpose of recruiting collapsed alveolar units increasing the pulmonary area available for gas exchange and, therefore arterial oxygenation. There are different ways to carry out alveolar recruitment maneuvers, but use of the "ideal" PEEP achieved with 2.0 cm of H_2O above the lower point of inflection of the pressure x volume curve maintains the lung only partially open. Current proposal is to carry out the ARM aiming to open the lung and keep it completely open in an efficient way and this can be achieved by means of higher PEEPs and high support pressures, for specified periods. PEEP titration strategy intended to increase alveolar recruitment, although limiting hyperinsuflation does not significantly reduce mortality. However, the pulmonary function is improved, mechanical ventilation time is reduced, also duration of organ failure.[19] Amato et al. with a strategy of pulmonary protection observed a decreased mortality at 28 days in the evolution of patients with ARDS using continuous positive airway pressure (CPAP) of 35-40 cmH_2O for 40 seconds, PEEP above the lower inflection point, tidal volumes lower than 6ml/kg, and a survival rate of 62% was found using this strategy.[17] Fujino in 2002 proved that a recruitment maneuver, repeated four times with two levels of different pressures (CPAP of 40 cmH_2O for 40 seconds and pressure controlled ventilation (PCV) of 20 cmH_2O+PEEP of

40 cmH_2O for 2 minutes). In this study there was a maximum recruitment of the lung in both groups with no histological damage[20] Maintenance of opened airways and alveolar recruitment rest upon various factors such as PEEP level, plateau pressure, expiratory time and time of action of pressure on the airways. The time, which the small airways and alveoli remain open after a recruitment maneuver is a matter of discussion. For Hamilton it is possible that recruitment lasts for up to 20 hours.[21] While Neumann et al. showed experimentally that to avoid cyclic collapse PEEP must be kept equal or higher than 20 cmH_2O or the expiratory time must be reduced to values equal or lower than 0.6 s, high levels of PEEP higher or equal to 20 cmH_2O practically prevent alveolar collapse at expiration.[22]

To monitor the effects of ARM, most authors assessed improvement of arterial oxygenation, a method commonly used in clinical practice, where the PaO_2 values and the ratio PaO_2/FiO_2 are analyzed.[23,24] PaO_2 values higher than 450 mmHg would indicate a recruited lung. Valente Barbas, in a study evaluated results of the maneuver by summing of PaO_2 and of $PaCO_2$, defining the complete recruitment as PaO_2+$PaCO_2$ higher than 400mmHg[25] Another method described to assess efficacy of alveolar recruitment is computerized tomography, capable of quantifying the recruited lung tissue.[26]

In the surveyed articles authors did not describe contraindications for use of ARM but use as exclusion criteria hemodinamically unstable patients, presence of penumothorax, pneumomediastinum and subcutaneous emphysema, lung biopsy and recent resections. Some complications may result from application of high inspiratory pressures, with hemodynamic alterations and risk of barotrauma being most common. Application of support pressure to the airway causes hemodynamic repercussions (decrease of venous return and increase of post-loading of the right ventricle during application) and also exposes the lung to greater risk of barotrauma. Hypotension, with rapid improvement after interrupting the maneuver, it is more frequent in hypovolemic patients.[27]

Although quite widespread for the treatment of ARDSA and ALI, literature shows good results when ARM is used inpatients submitted to general anesthesia, because, during the anesthetic procedure areas of atelectesis developed with impairment of gas exchange, increase of pulmonary shunt and worsening of oxygenation.[28,29]

However, the decision to use mechanical ventilation is usually based upon gas exchange findings, on respiratory rate and presence of shock or associated injuries, such as brain injury.[9] Blostein and Hodgman confirmed the value of this estimate, correlating values of arterial blood oxygen with the percentage of the lung volume impaired by contusions and concluded that the oxygen rate is reduced with the percentage increase of the lung impaired by contusions.[7]

CONCLUSION

For this patient the alveolar recruitment maneuver presented significant results in the treatment of pulmonary contusion, improving arterial oxygenation, preventing alveolar collapse and reversing the condition of alelectasis.

RESUMO

O tratamento da contusão pulmonar quando instituído de forma correta é bastante simples na maioria das vezes. As alterações fisiopatológicas acontecem como decorrência dos efeitos produzidos pela perda da integridade da parede torácica, acúmulo de líquidos na cavidade pleural, obstrução da via aérea e disfunção pulmonar. A manobra de recrutamento alveolar consiste na reabertura de áreas pulmonares colapsadas através do aumento da pressão inspiratória na via aérea. O objetivo deste relato foi apresentar um caso de contusão pulmonar, avaliando a efetividade da manobra de recrutamento alveolar e revisão da literatura. Paciente do sexo masculino, 33 anos, com quadro clínico de trauma de tórax bilateral e trauma crânio-encefálico, evoluiu com rebaixamento do nível de consciência, insuficiência respiratória aguda, choque hipovolêmico, hemoptise. Foi submetido a toracocentese, drenagem torácica bilateral e submetido a ventilação mecânica invasiva. Após 48 horas de ventilação mecânica invasiva, segundo os preceitos da estratégia protetora, iniciou-se manobras de recrutamento alveolar modo, Pressão controlada 10 cmH_2O, freqüência respiratória 10rpm, tempo inspiratório 3.0, pressão positiva no final da expiração 30 cmH_2O, FIO2 100%, durante dois minutos. Após a aplicação da manobra de recrutamento alveolar O paciente apresentou melhora pulmonar significativa da oxigenação, caracterizada por aumento da relação PaO_2/FiO_2, porém houve variação da mesma entre 185 a 322. Obteve alta da unidade na terapia intensiva após 22 dias e hospitalar após 32 dias da admissão. A manobra de recrutamento alveolar neste paciente apresentou resultados significativos no tratamento da contusão pulmonar, melhorando a oxigenação arterial, prevenindo o colapso alveolar e revertendo quadros de atelectasias.

Descritores: Insuficiência respiratória aguda; Traumatismo torácico; Ventilação pulmonar

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