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Lung recruitment in ARDS patients

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Lung recruitment is used to improve oxygenation and decrease the risk of ventilator induced lung injuries. Assessing the potential of recruitability is a pre-requisite for a rational recruitment strategy and setting of PEEP. Using a low flow pressure-volume loop is helpful to assess the potential of recruitability at the bedside. For patients with a high potential of recruitability, recruitment maneuvers are efficient with an appropriate setting of PEEP to maintain the lung recruited. Recruitment maneuvers use pressures from 40 to 60 cmH_2O for a short period of time, either with the sustained inflation or the staircase method. PEEP setting after the maneuver is important; a decreasing PEEP trial is a useful practical method.

Key words: lung recruitment, acute respiratory distress syndrome, mechanical ventilation

INTRODUCTION

Lung recruitment refers to the aeration of previously collapsed or non-aerated lung units. There are many situations where lung recruitment can be applied: post-operative atelectasis, post-intubation, abdominal hypertension… but this review will focus only on lung recruitment in acute respiratory distress syndrome (ARDS) adult patients. In this particular situation, lung recruitment is used to improve oxygenation and to decrease the risk of ventilator induced lung injuries (VILI). This short review will address the rationale and a practical approach presented in three consecutive steps: assessing recruitability, recruiting the lung and setting PEEP.

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MATERIALS AND METHODS

Rationale for lung recruitment

The main reason for recruiting the lung is to improve oxygenation (1). This is particularly useful for the most severe ARDS patients when hypoxemia can be life-threatening. On the other hand, increasing the aerated volume of the lung increases the end-expiratory lung volume and decreases the strain applied to the respiratory system (2). In addition, if we can recruit the lung and keep it recruited, using the appropriate level of PEEP, we may avoid atelectrauma due to repeated opening and closing of distal airways and alveoli (3). Thus, lung recruitment is also used to decrease the risk of VILI.

Some authors have recently described a strategy to fully recruit the lung using high pressure for recruitment maneuver and high PEEP (4). Even if the clinical outcomes seem good (1), the clinician at the bedside should always balance the benefits and risk of such strategy in an individual patient (5). The method we describe in this review is based on an individual approach of the respiratory mechanics and should be applied as soon as possible in the management of ARDS patients.

Assessing recruitability

The potential of recruitability in ARDS patient is highly variable (5, 6) and difficult to predict. Lung recruitability depends mainly on the mechanism (pulmonary versus extrapulmonary injury) (7), the localization (lobar versus nonlobar) and the time from the beginning of the lung disease (early onset if within 48 hours from the beginning or late onset afterward) (8). Thus, assessing recruitability is a pre-requisite for a rational recruitment strategy and setting of PEEP. The gold standard to assess recruitability is to perform a CT-scan at two different levels of pressure and measure the volume of aerated lung (6). It is not practical in the real life as it is time-consuming, needs to transport the patient to the radiologic department and expose the patients to x-ray. A bedside method has been described which is based on a low flow inflation and deflation pressure-volume loop (9). This loop was described a long time ago to try to find the best setting of PEEP. The results were disappointing but a new interpretation gained interest to assess the potential of recruitability. The criteria to predict a high potential of recruitability are a clear low inflexion point on the inflation limb (10), a high linear compliance measured on the inflation limb (11) and a large hysteresis (12). Hysteresis is defined as the surface enclosed between the inflation and deflation limb of the pressure-volume loop. Hysteresis results from stress relaxation and gas consumption and is increased in the ARDS patient because of recruitment occurring along the inflation which does not fully derecruit at the same pressure during deflation (Figure).

This maneuver is usually well tolerated and should be performed early in the management of ARDS patients, as soon as the hemodynamic condition is stabilized and the patient is sedated and passively ventilated. If pressure-volume loop shows no low inflexion point, a decreased linear comp-

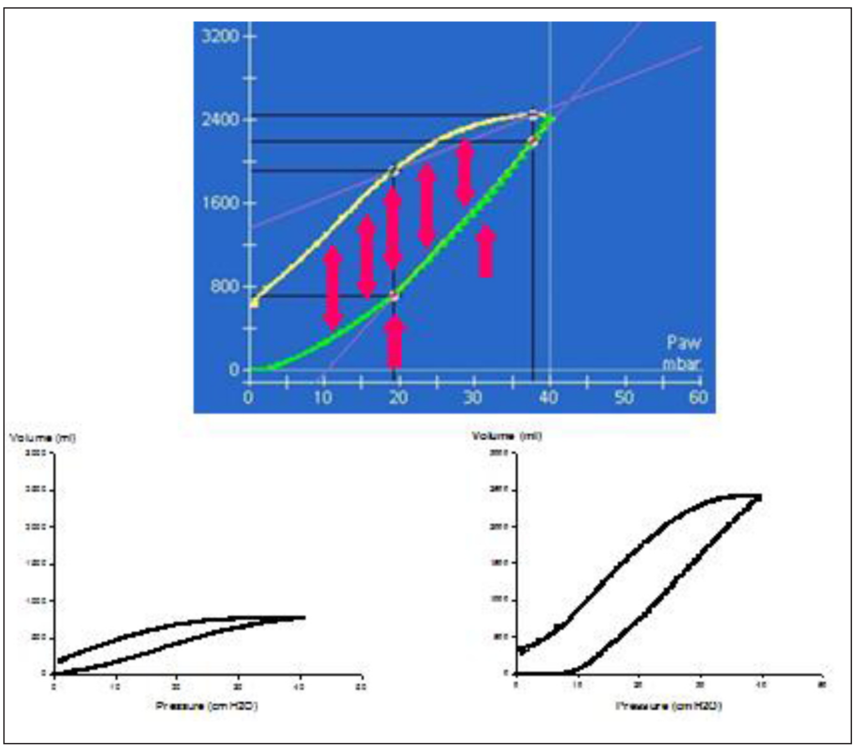

Figure. Assessment of recruitability: A low flow inflation and deflation pressure-volume loop may be used at the bedside to assess the potential of recruitability (upper panel). Interpretation is based on the presence of a low inflexion point, linear compliance and hysteresis to distinguish patient with low (lower panel, left) or high (lower panel, right) potential of recruitability liance and a small hysteresis, probably the patient has a low potential of recruitability. In this case, the recruitment maneuver should not be applied because they are useless and potentially harmful. In addition, a low PEEP is usually set because a high PEEP would result in lung over distension without any recruitment (13). Reversely, if pressure-volume loop shows a clear low inflexion point, a high linear compliance and a large hysteresis, propably the patient has a high potential of recruitability. In this case, the recruitment strategy should associate recruitment maneuver and the adequate setting of PEEP to maintain the lung recruited. A recent study reported that around 80% of early onset ARDS patients present a high potential of recruitability (14).

Recruiting the lung

The conditions to perform recruitment maneuvers are that the patient should be passive (deeply sedated with or without paralysis), in stable hemodynamic condition with the cuff of the endotracheal tube overinflated. The contraindications are hemodynamic compromise, high intracranial pressure (15), pregnancy, lung emphysema, bronchopleural fistula, pneumothorace and right heart failure. Several methods have been described to perform recruitment maneuver: sights (16), sustained inflation (17), staircase method (14), and prone positioning (18). The volume of lung recruited during a recruitment maneuver is a combination of pressure and time. The airway pressure applied is usually 40 cmH_2O (4, 5). Higher pressures, up to 60 cmH_2O, may be required in case of decreased chest wall compliance. The target transpulmonary pressure, estimated by the difference between airway pressure and esophageal pressure, to achieve during the recruitment maneuver is 25 cmH_2O (19). The optimal duration of the recruitment maneuver is short. Whatever method used, it appears that most of the recruitment occurs early during the recruitment maneuver (20, 21).

Thus, the sustained inflation recruitment maneuver should use a pressure from 40 to 60 cmH_2O maintained for 10 seconds. Staircase recruitment maneuvers are usually performed in the pressure control mode with a fixed driving pressure of 15 cmH2O, increasing progressively the PEEP from 20 to 45 cmH_2O by steps of 5 to 10 cmH_2O each 5 minutes (5, 14). Both methods have not been compared. Results are probably the same in terms of efficiency but sustained inflation is less time-consuming and may induce less hemodynamic compromise. In addition, the volume recruited during the recruitment maneuver may be assessed using the sustained inflation method (20).

Setting PEEP

PEEP is an anti-derecruiting force that is used after the recruitment maneuver to maintain the lung recruited. There is no correlation between the pressure needed to recruit the lung and the pressure needed to avoid derecruitment. The adequate level of PEEP is difficult to predict from the pressure-volume curve. A decreasing PEEP trial starting from 25 cmH_2O with steps of 2–3 cmH_2O each 5 min monitoring SpO_2 is a practical approach (5, 14). A more physiological method is based on esophageal pressure monitoring and targets on a transpulmonary pressure (airway pressure minus esophageal pressure) during an end-expiratory pause from 0 to 10 cmH_2O (22).

Limitations

Although this recruitment strategy is based on an individual assessment of respiratory mechanics, there is no evidence to demonstrate that it is associated with better outcomes. Available studies have failed to demonstrate that a high level of PEEP is associated with better outcomes but in these studies patients were not selected according to their potential of recruitability and no assessment was performed to measure if PEEP was associated with lung recruitment (23–25). A small randomized controlled trial demonstrated that an open lung strategy was associated with better oxygenation and decrease in systemic cytokines (26).

CONCLUSIONS

Lung recruitment strategy should be determined early (before 48 hours) in the management of ARDS patients. Recruitability may be assessed by a low flow pressure-volume loop. Recruitment maneuvers should be performed only in patients with a high potential of recruitability. After a recruitment maneuver, PEEP is carefully selected to maintain the lung recruited.

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ŪRDS PACIENTŲ PLAUČIŲ STIPRINIMAS

Santrauka

Stiprinant plaučius siekiama pagerinti oksigenaciją ir sumažinti ventiliacijos sukeltų plaučių pažeidimų riziką. Sustiprinimo potencialo įvertinimas yra racionalios plaučių stiprinimo strategijos ir PEEP nustatymų sąlyga. Vertinant sustiprinimo potencialą panaudojama mažo slėgio ir tūrio srovės kilpa. Esant tinkamiems PEEP nustatymams, stiprinančių manevrų pakanka, kad būtų palaikomas plaučių darbas. Sustiprinimui trumpai naudojamas nuo 40 iki 60 cm H_2O stabilios infliacijos slėgis arba laiptinis metodas. Po manevrų yra svarbūs PEEP nustatymai; mažėjančio PEEP išbandymas taip pat yra naudingas praktinis metodas.

Raktažodžiai: plaučių stiprinimas, ūmus kvėpavimo nepakankamumas, mechaninė ventiliacija