

Pronation technique in ARDS patients

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Abstract

In severe acute respiratory distress syndrome (ARDS), characterized by the ratio of arterial partial pressure of oxygen over fraction of inspired oxygen (P/F) less than 150 mm Hg, pronation cycles are the only intervention that showed improved survival, in combination with protective ventilation. The physiological advantages of performing pronation cycles, such as the improvement of oxygenation, better tidal volume distribution with increased involvement of dorsal regions, and easier drainage of secretions, overcome the possible complications, that is, endotracheal tube occlusion or misplacement, pressure ulcers, and brachial plexus injury. However, the incidence of complications is dramatically lower in intensive care units with expertise, adopting prone positioning in daily practice.

In this video we are proposing step by step an easy and ergonomic technique to perform pronation maneuvers in patients with severe ARDS. Recent literature suggests that a high percentage of these patients are treated without undergoing pronation cycles.

The main purpose of this video is to help increase the number of intensive care units worldwide commonly performing pronation cycles in patients that have indications to be pronated, in order to decrease healthcare burden and costs directly caused by ARDS.

Proper intensive care unit staff training is fundamental in minimizing the risks associated with the maneuver for both patients and operators; and diffusion of a safe technique encouraging the operators is the second main purpose of this video.

Keywords: ARDS, ICU, Mechanical ventilation, Pronation



Overview

This video provides a technical guide on performing a pronation maneuver in patients affected by severe acute respiratory distress syndrome (ARDS) in whom cycles of ventilation in the prone position are indicated. Our approach is focused on patient safety and ergonomics and the aim of this brief video is to encourage prone position ventilation among intensive care units worldwide.

Prone positioning allows a reduction in the occurrence of ventilator-induced lung injury, which is one of the main complications in patients with ARDS and is due to the condition known as “baby lung.” In the context of an altered lung architecture, nonprotective ventilation causes stress and strain on lung fibers, generating volutrauma and barotrauma when they reach their rupture point.

The association between protective ventilation combined with prone positioning and mortality benefits in selected patients with severe ARDS has been clearly shown (1).

The physiological advantages of performing pronation cycles include improvement of oxygenation, decrease of physiological dead space with increased functional residual capacity, better tidal volume distribution with increased involvement of dorsal regions, better ventilation-to-perfusion ratio, and easier drainage and aspiration of secretions.

However, according to recent studies, no more than 15% of patients with severe ARDS undergo pronation cycles (2,3).

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As mentioned, improvement in overall survival has been observed only in selected groups of patients: pronation cycles should be reserved only in cases of severe ARDS, they should be started early during the disease course, cycles should last at least 16 hours, and their discontinuation should not be time based but rather follow physiological criteria (e.g., observing reduction of ventilator requirements or prone positioning efficacy, evaluating changes in dead space, and improvement of oxygenation). Neuromuscular blockade is indicated. Major complications, such as loss of vascular access, airway obstruction, unintended extubation, and increased vasopressor requirements, occur more frequently in the prone compared to the supine position. However, frequent use of pronation cycles when indicated is encouraged, given that the incidence of these complications is dramatically lower in intensive care units that adopt prone positioning in their daily practice (4).

Indications

Pronation cycles are indicated in patients affected by ARDS with a ratio of arterial partial pressure of oxygen over fraction of inspired oxygen ($\text{PaO}_2/\text{FiO}_2$) of less than 150 mm Hg. Patients should undergo the first cycle of ventilation in the prone position within 48 hours of diagnosis (4).

Contraindications

Pronation cycles are not indicated in patients with elevated intracranial pressure, in those with massive hemoptysis, and in case of cardiovascular instability with a high risk of cardiac arrest. Recent sternotomy, large ventral burns, severe facial or neck trauma, and spine instability are other contraindications (5). Nonexperienced ICU staff should not be engaged in pronation maneuvers without proper training.

Equipment

A slide sheet is necessary to perform the mechanical part of a pronation maneuver effectively and safely. The minimum number of operators required is three, but this may vary based on the type of patient. If extracorporeal membrane circulation is ongoing, at least two more operators should secure the movement of cannulae (at least one person per cannula). Ventilation should be set to deliver no more than 6 mL of tidal volume per kilogram of ideal body weight and neuromuscular blockade is indicated (1). Close attention to all central lines is mandatory, together with repeated zeroing of transducers after the maneuver. Suction of endotracheal tube, nasogastric tube, and the oral cavity before the maneuver is necessary. Once the patient has been prone, the placement of anti-decubitus devices is advised in order to increase protection of pressure points. Frequent reassessment of pressure points is recommended, especially of the shoulders, face, and anterior pelvis (5).

Procedure

The mechanical part of pronation is carried out by a single operator without significant effort. A slide sheet is folded lengthwise into two symmetrical parts and passed under the

patient's body with the help of a second operator so that the folded side is on the side of the first operator. The neck may be gently rotated (and kept rotated throughout the maneuver) toward the intended rotation side, so that patient's head and airway rotate only once, and no further position adjustments of these parts are needed. Arms should not be placed along the patient's chest; conversely hands should be placed on the patient's thighs.

This approach conveys many advantages: the shoulders, and the nervous structures in particular (i.e., the brachial plexus), are stretched less, making pronation less traumatic and reducing the risk of nerve damage. Moreover, operators are more comfortable when performing an in-axis rotation of the patient. The leg opposite to the side of rotation should be crossed over the other (e.g., the left leg if the patient will be rotated to the right). In this way the leg that lays on the side of rotation is kept straight and continues the body axis inferiorly.

In order to pronate the patient, it is advisable to slightly rotate the patient to obtain a smoother passage of the slide sheet. The operator who is holding the folded side of the slide sheet grabs its upper fold and pulls it to rotate the patient to the intended side. Once the position on the side is secured with the help of the second operator, the first operator pulls the slide sheet once again to complete the rotation. Once the patient has reached the desired position, operators can grab the lower fold of the slide sheet and easily take it off. A third operator is mandatory and oversees the ventilator circuit. He must ensure that the circuit will not be placed under tension throughout the maneuver by making it as loose as possible and must also secure the endotracheal tube or tracheostomy to the patient's airway throughout the maneuver. Disconnection may cause loss of alveolar recruitment and decrease the patient's respiratory system compliance.

It is strongly advised to have an anesthesiologist or other airway specialist available on-site in case of loss of airway. If the patient has chest or abdominal drains they must be clamped before performing the maneuver and their lines must be placed to the opposite direction in order to anticipate the rotation and not cross over once the patient is prone.

The same approach should be taken in the presence of extracorporeal membrane circulation cannulae. In this case more operators are needed, and each cannula must be secured to the body throughout the maneuver, so generally two, but in cases such as venous-venous-arterial extracorporeal membrane oxygenation (ECMO), even three more operators are necessary. The head is gently turned and accompanied to anticipate its rotation, while the leg opposite to the desired rotation side must be crossed on the other one as previously stated. The operators make sure that all lines including pulse oximetry, urinary catheter, central venous, and arterial lines are continuously checked and must be loose enough to prevent both line disconnections and development of pressure ulcers caused by devices eventually lying under the patient. Electrocardiography electrodes are usually removed and replaced once pronation is completed.

To rotate the patient, the first operator grabs the upper fold of the slide sheet and pulls it to roll the patient on his side. The second operator holds the patient while the third operator keeps the airway secured.

All operation must be well synchronized between the operators; there should be a team leader designed before the maneuver and setting the pace throughout the procedure. The team must continuously reassess the position of all lines and wires to prevent unintended disconnections and kinking. No device should lie under the patient's body to avoid the development of decubitus ulcers. Once the patient has been put in the desired position, operators can grab the lower fold of the slide sheet and easily take it off. Pressure points are identified and optimized with pads, guards, and pillows where needed. Special attention must be paid to bony surfaces, the face, and the eyes (for which specific glasses are available). Extra rotation of the shoulder must be carefully avoided to reduce the risk of luxation and brachial plexus injury. If the patient has a tracheostomy, we suggest tilting the patient's torso on one side to decrease the pressure on the neck area. To restore the desired horizontal position of the patient, the bed can be slightly tilted to the opposite side.

Complications

Possible complications of ventilation in the prone position include airway-related complications, such as increased oral or endotracheal tube secretions causing endotracheal tube occlusion; endotracheal tube misplacement is another possible danger, especially during the pronation and supination maneuvers, which may be complicated by accidental extubation.

Gattinoni et al. (6) studied the incidence of complications related to prone positioning during a 10-day study period: airway obstruction due to secretions was reported in 39.3% of patients, while tube misplacement leading to accidental extubation occurred in only 0.5% of patients.

Kinking of catheters must be assessed and, where present, corrected. Displacement of thoracic drains is a relatively frequent event (3.9%), especially during position changes (6). Increased gastric residual volume and elevated intra-abdominal pressure are reported complications, consequently vomiting is a possible event in prone position (7.6%) (6).

As shown previously, much effort must be placed in preventing pressure ulcers and facial edema, which represent the most prevalent complications during prone position.

Moreover, brachial plexus injury must be prevented by careful positioning of shoulders and arms (5,7).

The number of complications is directly correlated with the time spent by the patient in the prone position (7).

Summary

Cycles of ventilation in the prone position are life-saving procedures in patients with severe ARDS and should not be avoided or delayed. Careful planning and continuous training are fundamental in limiting the incidence of complications.

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