

Advances in the Use of Prone Cardiopulmonary Resuscitation During Spinal Surgery in the Prone Position

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Abstract: Spinal surgery is usually performed in the prone position, which is a longer and more difficult procedure and is prone to complications such as circulatory dysfunction and stress injuries. Among them, stress injury is the main complication of prone spine surgery, but the reasons for stress injury in prone spine surgery are not clear, and whether prone cardiopulmonary resuscitation (CPR) can be used needs to be further verified. Supine cardiopulmonary resuscitation is commonly used in posterior spinal surgery, retroperitoneal surgery, and so on, which can effectively improve the patient's hypoxemia. Such surgeries require a high level of anesthetic management, and cardiopulmonary resuscitation is necessary if a patient in a prone position experiences cardiac arrest. In the process of cardiopulmonary resuscitation, supine cardiopulmonary resuscitation is often used, especially for some obese patients, if they are immediately changed to the supine position, it takes up more time, there may be wound infection, and there is a possibility of missing the optimal rescue and resuscitation time. Based on this, this paper reviews the use of prone-position cardiopulmonary resuscitation for spinal surgery in the prone position.

Keywords: Prone position; Spinal surgery; Cardiopulmonary resuscitation; Research progress

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1. Introduction

Spinal surgery is a common procedure for treating lumbar fractures, herniated discs, spinal tuberculosis, and other spinal disorders. According to the different operation methods, spinal surgery can be categorized into minimally invasive type and open type. Minimally invasive surgeries include radiofrequency ablation, vertebroplasty, intervertebral foraminoscopic nucleus pulposus removal, and percutaneous pedicle root nail rod internal fixation. Open-type surgery can be subdivided into incision and repositioning internal fixation, laminectomy incision and decompression internal fixation, and so on. During spinal surgery, patients may suffer from cardiac arrest, especially during procedures that require monitoring of multiple instruments, and it is challenging to shift a patient from the prone position to the supine position. Therefore, the concept of "prone cardioversion" was proposed by Western scholars in 1989^[1]. However, few studies have been conducted on this

concept, and most of the studies have been conducted through case reports. Prone cardiac arrest usually occurs during spinal surgery, and the main causes include venous air embolism, hemorrhagic shock, tracheal tube obstruction, and pericardial tamponade. After cardiac arrest, the common initial rhythm is “pulseless activity” followed by cardiac arrest. Clinically, the success rate of prone cardioversion is high, which suggests that prone cardioversion has some value in clinical practice. This article first describes the stress injuries associated with prone spine surgery, then introduces prone cardioversion and discusses its application in prone spine surgery.

2. Overview of pressure injuries in prone spinal surgery

2.1. Characteristics of posterior spinal surgery

Posterior spinal surgery has a high incidence of stress injuries and the probability of occurrence varies depending on the site. A follow-up observational study found that posterior spinal surgery has the highest incidence of stress injuries of all surgeries and must be taken seriously ^[2]. Another study showed that the incidence of pressure injuries was higher when spinal surgery was performed using the prone position ^[3]. Most posterior spinal surgeries are performed in the prone position, which has more pressure sites compared to other positions, and pressure injuries occur mainly in the facial area, iliac crest, knee, pedicle, and genital organs, and the incidence of pressure injuries varies from site to site. A retrospective study found that the face is more affected, with the groin having the most severe injuries ^[4]. Therefore, in patients undergoing posterior spinal surgery, it is necessary to strengthen complication prevention and optimize nursing measures to reduce the incidence of pressure injuries.

2.2. Reasons for the occurrence of pressure injuries

The main causes of pressure injuries in posterior spinal surgery include operation time, operation position, patient age, skin temperature changes, and spinal cord injury. A prospective study found that spinal surgery in the prone position decreases the patient’s cardiac index, increases thoracic pressure, affects arterial filling, and leads to decreased congestion in the peripheral areas ^[5]. As a result, localized stress injuries may be induced even if the duration of surgery is brief. Another research investigation reported that increased intraoperative temperature increases the incidence of pressure injuries ^[6]. Some scholars monitored the blood oxygen parameters in the pressure injury-prone areas of spinal surgery patients, and the results of the study showed that changes in the values of blood oxygen parameters would have an impact on the incidence of pressure injuries ^[7]. The occurrence of stress injury is mainly due to the decrease in blood oxygen saturation and the presence of ischemia and hypoxia. Relevant studies have found that spinal cord injury is also the main reason affecting the occurrence of stress injuries because spinal cord injury can lead to a significant decrease in vascular tone, making it difficult to transport nutrients to the injury site, thus forming stress injuries ^[8].

2.3. Improvement measures for posterior spinal surgery

Reducing the pressure generated on the pressure area and increasing the pressure area are the main nursing measures to reduce pressure injury in posterior spinal surgery. Since posterior spinal surgery mainly adopts the prone position, taking into account factors such as anesthesia, the surgeon, nursing staff, and anesthesiologist must discuss and formulate a surgical plan, and it is necessary to adapt to the physiological changes of the human body in the process of position placement. During surgery, nursing staff need to observe the patient’s condition and appropriately move the pressure area to avoid continuous skin pressure. When choosing a support surface, a reactive pressure-reducing mattress can be used to reduce the pressure on the skin. During clinical treatment, most caregivers usually provide care based on their own experience and lack systematic

knowledge of complication prevention; it is very easy to make wrong choices. For example, the Pressure Injury Guidelines 2014 Edition clearly states that biological dressings are not recommended for the treatment of pressure injuries ^[9], but other guidelines indicate that collagen dressings can be used for treatment. Evidence-based nursing is the combination of theoretical and practical research to solve clinical problems through a scientific and rational decision-making approach that allows nursing staff to have some critical thinking. In a study on the implementation of evidence-based nursing ^[10], patients undergoing posterior spinal surgery were used as research subjects, and relevant evidence was sought to support them. The results of the study showed that evidence-based nursing can reduce the incidence of patient complications to a certain extent and promote a good prognosis for patients. In addition, other scholars evaluated based on the principles of evidence-based nursing and supported by evidence to make full use of resources and increase practice and feasibility in clinical work, thereby solving clinical problems ^[11].

3. Prone cardiopulmonary resuscitation

The American Heart Association (AHA) “Guidelines for Cardiac Resuscitation 2010 Edition” clearly points out that cardiac resuscitation should be performed in the supine position under routine circumstances, and if the supine position cannot be used, the relevant staff can carry out cardiac resuscitation in the prone position, especially for some patients who have been inserted with full of organs in the operation, which can play a role in saving time. time-saving effect ^[12]. In addition to this, after cardiac arrest during neurosurgery, guidelines recommend that cardiopulmonary resuscitation can be performed without changing the patient’s position. Prone position CPR is possible with posterior spinal surgery in the prone position. In 2016, two patients who underwent CPR using the prone position were reported ^[13], and immediate initiation of resuscitation was effective in resolving pulse arrest and providing adequate cardiac output. In 2020, it was also reported that a patient with a 2-week history of lower back pain requiring prone position unfolding laminectomy and posterior spinal fusion was resuscitated with prone position cardiopulmonary resuscitation and epinephrine push to restore spontaneous circulation after the patient experienced cardiac arrest. Other scholars have systematically evaluated the application of the prone position in ICU CPR, if supine CPR cannot be performed immediately, prone CPR or even prone defibrillation can be chosen to avoid wasting too much time under the condition of ensuring airway safety.

When compressions are applied to a patient in prone cardiac arrest, the caregiver needs to place his or her hand on the outside of the chest to encourage blood from the left ventricle to flow into the aorta. For example, when the lower part of a patient’s sternum is the optimal site for compressions, for better CPR, compressions need to be provided deep enough to allow blood to flow from the left ventricle into the aorta. Especially in obese patients, switching positions can take a lot of time and require the assistance of multiple rescuers, which may increase the risk to the patient. Compared to supine CPR, prone CPR has the same rate and depth of compression and only requires that the optimal compression position be determined and then compression can be performed. It has been shown that the prone position improves ventilation to some extent and favors the prognosis of patients with respiratory diseases. Interruption of mechanical ventilation may occur during changes in position, increasing the risk of exposure to air.

When spinal surgery precludes the use of the supine position for CPR, prone cardioversion can be used. Prone cardiac resuscitation, also known as inverse cardiac resuscitation, is especially valuable in the application of prone cardiac resuscitation in patients in whom an artificial airway has been established. Resuscitation must be prompt, and with the patient in the prone position, compression can be applied to the back of the thoracic

segment of the spine to bring the chest into contact with the surgical wound. Compression causes the spine to sag, thus acting as a cardiac and thoracic pumping mechanism to ensure circulating blood flow. It has been found that prone CPR increases the patient's mean systolic and arterial pressures, whereas conventional supine CPR results in lower pressures, limiting lung expansion and failing to ensure respiratory adaptation. This can be avoided with prone position CPR, which generates higher intrathoracic pressure during compressions and promotes blood circulation. At the same time, the patient's head is tilted to one side, and sufficient oxygen is provided to the patient through mask compression. The patient's tidal volume can be monitored from the anesthetic while compressions are applied to the patient's back. Finally, prone CPR also facilitates keeping the patient's airway open and helps to drain the contents of the mouth. After spinal surgery, poor outcomes may exist due to a narrower spinal canal, which can be effectively improved after a second posterior spinaplasty.

4. Application of prone cardiopulmonary resuscitation in posterior spinal surgery

After cardiac arrest, cardiopulmonary resuscitation is an important step to ensure effective perfusion of the heart and brain, which can effectively improve the success rate of patient resuscitation. Relevant studies have shown that when a patient suffers cardiac arrest and there is severe blood volume insufficiency, compressing the patient's back through prone CPR can control the patient's BP within a controllable range, thus providing effective perfusion to the heart and brain ^[14]. In addition, a study of conventional CPR and prone CPR in six dying patients found that prone CPR was effective in increasing systolic BP even when the patients experienced vasodilatation and severe hypovolemia. It has also been shown that prone CPR was performed on 22 patients undergoing posterior spinal surgery, and 10 patients were successfully resuscitated ^[15]. Prone CPR uniformly elevates the patient's intrathoracic pressure, thereby restoring their body circulation. Generally speaking, a large tension will be generated from the joints of the vertebrae-ribs of the thorax, and the tension of the sternum-ribs itself is insufficient and prone to injury. However, under CPR in the prone position, the pressure in the thoracic cavity is increased and does not damage the patient's thorax. Conventional CPR in the supine position may result in a forward displacement of the abdomen and a significant decrease in intrathoracic pressure. Defibrillation should be performed as soon as possible after effective perfusion. Regarding the position of electrode prevention, due consideration needs to be given to the ability of the current to pass through the heart and achieve depolarization. According to the guidelines for cardiopulmonary resuscitation, in most cases, the right electrode is connected to the patient's right subclavian and the left electrode is connected to the patient's left sublateral part of the chest to ensure that the current passes through the heart and depolarization is achieved. If there is a failure of defibrillation, the right and left electrodes are linked to the left fifth intercostal space and the right scapula as an alternative.

In contrast, for patients undergoing posterior spinal surgery, adequate ventilation is essential. Prone cardiopulmonary resuscitation is more valuable to apply than conventional supine cardiopulmonary resuscitation compared to patients without an established artificial airway. Cardiac arrest is more likely to occur if the patient has a large amount of vomit in the mouth and has developed an airway obstruction. Conventional CPR makes it difficult to remove the vomitus from the patient's mouth, while prone CPR can open the airway by allowing the secretions in the patient's mouth to flow out in time through the effect of gravity. Not only that, the head-backward-forehead-lifting method is a difficult maneuver and is prone to cervical spine fractures. In the absence of an artificial airway, artificial respiration in the supine position can cause gastric dilatation due to incomplete opening of the airway, which is prone to gastric reflux, limiting lung movement and decreasing respiratory compliance at the same time. The prone position can completely open the airway so that the patient

can get a certain amount of tidal volume, quickly restore their circulation, provide good respiratory support, bring a good prognosis for the patient, and improve the success rate of resuscitation.

5. Conclusion

In summary, traditional CPR is performed in the supine position, but patients undergoing spinal surgery are most of the time fully intubated with an airway and other assistive devices and are operated in a prone position. If cardiac arrest occurs during surgery, it is difficult to change positions quickly. Prone CPR not only simplifies the procedure but also reduces the time to avoid missing the best time to resuscitate the patient. Therefore, in the future, when cardiac arrest occurs during spinal surgery, it is not necessary to blindly change the patient's position, but rather, prone CPR can be performed according to the actual situation of the surgery to save time and ensure that the patient has sufficient ventilation with effective cardiac and cerebral perfusion.

Disclosure statement

The author declares no conflict of interest.

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