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Complications associated with prone positioning in neurosurgery: a systematic review

Complicações associadas à posição prona na neurocirurgia: uma revisão sistemática

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Abstract

Introduction: *The choice of patient positioning in neurosurgery is a process that is based on the intervention site and prevention of complications, in order to ensure maximum patient safety. The prone position requires patient monitoring to reduce complications. Alternative positions must be considered if there are patient risk factors* ***Method:*** *The terms "pronation", "prone position", "prone", "complications" and variations were used with the boolean operators OR and AND in different strategies.* ***Results:*** *Forty-nine articles were selected that reported transient or permanent hemodynamic, visual, neurological, muscular and venous complications. Complications are associated with surgical aspects, such as movements adopted during the procedure, hypovolemia, hemorrhage, surgical time, and patients' comorbidities, such as obesity, arterial hypertension, and diabetes mellitus.* ***Discussion:*** *The prone position requires patient monitoring to reduce complications. Alternative positions must be considered if there are patient risk factors.* ***Conclusion:*** *No positioning is without risks, and it is necessary to know the complications to better assess the positioning choice.*

Keywords: *Prone position, Neurosurgery, Laminectomy, Postoperative care*

Resumo

Introdução: *A escolha da posição do paciente na neurocirurgia é um processo que se baseia no sítio de intervenção e na prevenção de complicações, considerando-se a máxima segurança para o paciente. O posicionamento em prona está ligado a complicações transitórias e permanentes pouco discutidas.* ***Método:*** *Pesquisou-se os termos "pronação", "decúbito ventral", "prona", complicações", "intercorrências" e variações utilizado os operadores booleanos OR e AND, em diferentes estratégias.* ***Resultados****: Selecionou-se 49 artigos, que relataram complicações hemodinâmicas, visuais, neurológicas, musculares e venosas, de caráter transitório ou permanente. As complicações estão associadas tanto a aspectos da cirurgia, como movimentação adotada durante o procedimento, hipovolemia, hemorragia e tempo cirúrgico, quanto a comorbidades dos pacientes, como obesidade, hipertensão arterial e diabetes mellitus.* ***Discussão****: A posição prona exige observação dos fatores de risco, para escolha de posicionamentos alternativos, e, caso adotada, a monitorização do paciente, a fim de reduzir complicações.* ***Conclusão:*** *Nenhum posicionamento está destituído de riscos, sendo necessário conhecer as complicações a fim de se melhor avaliar a escolha do posicionamento.*

Palavras chave: *Decúbito ventral, Neurocirurgia, Laminectomia, Cuidados pós-operatórios*

Introduction

Position selection in surgical procedures is based on different parameters and factors, such as surgical site, prevention of complications, and impairment of vital functions, surgery duration, surgeon and anesthesiologist skills in such positioning and team ergonomics. A good surgical position offers maximum safety to the patient, with minimal discomfort, and facilitates the performance of the surgical procedure[1-3].

Positioning the neurosurgical patient is a fundamental aspect of preoperative care. The chosen position must be physiologically favorable, safe and comfortable, due to the long duration of most procedures and the need for high precision in the manipulation of nervous tissues. Inadequate planning, as well as incorrect execution, can cause serious and permanent damage to the patient[1-2].

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The prone position (figure 1) is one of the most used *decubiti* in neurosurgery in procedures performed on the spine, however, it is associated with several transient or even permanent complications that are poorly addressed[1-4]. Thus, this article seeks to discuss the complications related to this positioning and the associated risk factors.

Figure 1 - Prone position in neurosurgical procedure. Source: Authors' archives.

Methods

The electronic databases and data repositories Public/Publisher Medline (PubMed), Scientific Electronic Library Online (SciELO), Latin American and Caribbean Literature on Health Sciences (LILACS) were searched using the terms "prone position", "pronation", "prone", "prone", "complications", "intercurrences", employing the Boolean OR and AND operators, in different strategies.

Original articles, literature review and case reports published in Portuguese, English, French and Spanish between 1980 and 2019 were included. Articles that did not mention complications or dealt with other issues, such as the application of the prone position in environments other than neurosurgery were excluded, as well as brief notes, texts written in other languages and articles not available in full. In addition, an analysis of the references of the initially selected articles was carried out.

Results

The search in the databases resulted in 1948 articles, 1916 of which were eliminated after applying the eligibility criteria. Thirty-two works were analyzed in full. Five full articles were eliminated after applying criteria. Other 22 articles obtained from the works originally evaluated were also included since they fulfilled the eligibility criteria (figure 2).

Cardiorespiratory and hemodynamic complications

The prone position increases intra-abdominal pressure, stasis of blood at extremities, causing reduction of systolic volume and cardiac index, along with increased central venous pressure. These events result in a significant rise in heart rate and peripheral vascular resistance. These factors when combined with significant bleeding, hypothermia, heart disease, thoracic deformities, such as *pectus excavatum* and thoracic lordosis enhance the risk of complications, such as cardiac arrest, a rare complication with adverse management[1,5-11].

Instead of pulmonary complications, transpulmonary pressure is evenly distributed, resulting in more movements of the diaphragm dorsal region and modifications in the conformation of the thoracic cavity, increasing the functional residual and total lung capacities, that implies better perfusion. There is still a decrease in atelectasis[1,5-13].

Regarding cerebral hemodynamics, there are different consequences of the prone position due to different possibilities of positioning the head. The neutral position implies a reduction of jugular venous resistance and increase of jugular venous flow. The positioning below the heart causes an increase of jugular venous strength and elevation of intracranial pressure[2].

Visual complications

The prone position is associated with increased intraocular pressure, as well as closed angle glaucoma, central retinal artery occlusion, visual loss, ischemic optic nerve neuropathy, retinal central artery occlusion, cortical blindness and subconjunctival hemorrhage [4,5-10].

Visual loss

The most related complication of the prone position is visual loss, a rare event, but disastrous. The visual loss occurs unilaterally or bilaterally, with the frequency of 0.0008% to 0.003% in prone position surgeries. Usually, the loss occurs intelligently in the postoperative period, with the lack of light perception, ophthalmoplegia and ptosis [4,5,14-19].

Several elements can cause visual loss, including ischemic optic neuropathy, central retinal artery occlusion, ischemic orbital compartment syndrome and occipital cerebral infarction, which in turn are owed to reduced perfusion pressure, anemia, hemodilution and hemorrhage. Male gender, obesity, diabetes mellitus, coagulopathies, previous neurological disorders and age equal to or greater than 65 are pointed as risk factors. [4-5,14-25].

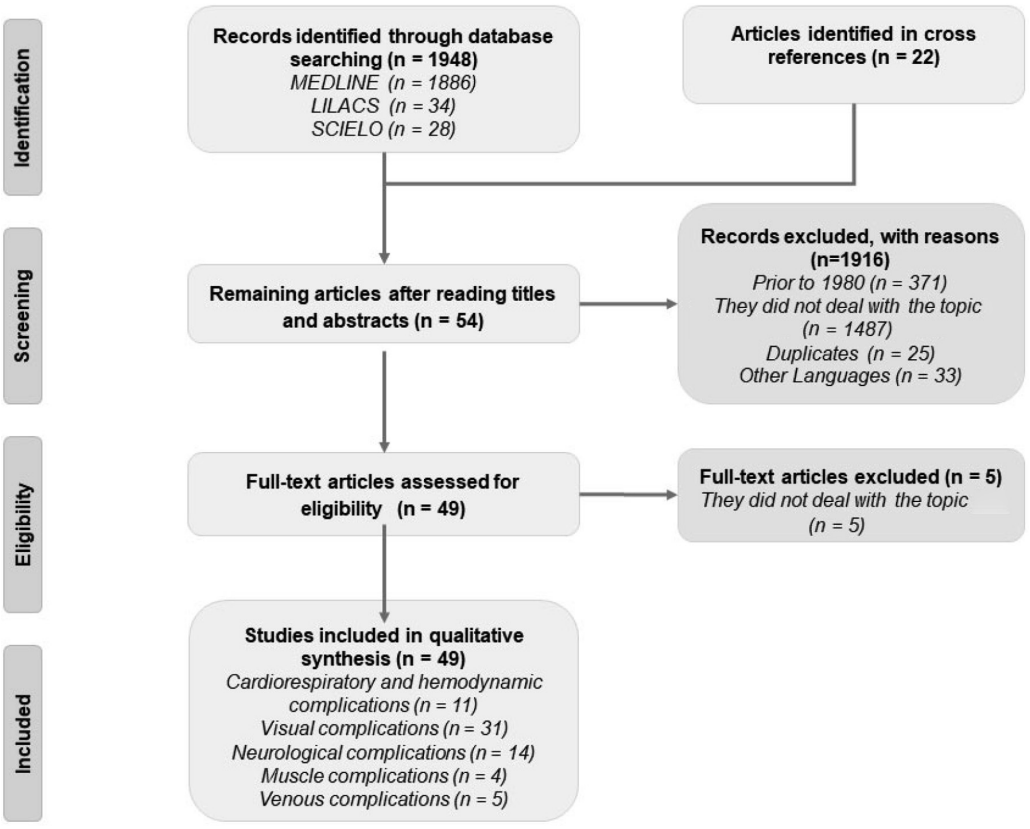

Figure 2 - Selection flowchart of scientific articles. Source: Prepared by the authors.

Increased intraocular pressure

Ocular perfusion pressure is determined by the difference between mean arterial pressure (MAP) and intraocular pressure (IOP). Therefore, both a reduction in mean arterial pressure and an increase in IOP will reduce perfusion and may lead to loss visual [14-25].

Cheng et al[14] measured IOP in patients in the supine and prone position, awake and anesthetized, at different times during the procedure. This study observed an increase in IOP from 19 ± 1 mmHg to 31 ± 2 mmHg ($p<0.005$), with a maximum of 40 ± 2 mmHg, found in the anesthetized prone position at the end of the procedure, with maintenance of normotension. Although the study found reduced ocular perfusion, it did not find visual loss.

Gencer et al[26] found thinning of the lower and nasal quadrant of the retinal nerve fiber layer after surgery in 30 patients aged ± 57 years, , although results were not statistically significant. Regarding IOP, they described an average increase of 4 mmHg after 60 minutes of pronation, with a drop in MAP values from 95 to 82 mmHg ($p < 0.005$).

Angle-closure glaucoma

Extraocular pressure applied to the eyeball can displace the iris diaphragm of the lens anteriorly, causing aqueous humor flow obstruction, increased optic nerve pressure, leading to angle-closure glaucoma. This complication can be traced from the prone position test which is considered positive when IOP increases to 8 mmHg over 60 minutes [2,5-6,27-28].

The angle-closure glaucoma can happen even in fast surgical procedures, but it is more commonly associated with procedures where blood loss is greater than 1000 mL or longer than 6 hours. Also, previous diseases and the patient lifestyle are intimately associated to complications, specially diabetes mellitus, smoking and hypertension. Other risk factors include the axial length of the eyeball, anterior position of the lens, female gender, as well as Eskimos, Asians, and Canadians ethnicities, [3,5,27,28].

In cases of significant risk factors, other surgical positions that reduce intraocular pressure are indicated. However, some measures help reduce the frequency of complications in procedures of limited duration, such as maintaining MAP ≥ 70 mmHg, positioning the head 10 to 15° above and reducing blood pressure fluctuations[3,6,27-28].

Ischemic optic nerve neuropathy

The ischemic optic nerve neuropathy is responsible for 89% cases of visual loss. The incidence is estimated at 0.017%. The neuropathy is a combination of hypotension, hypovolemia and orbital pressure in-

crease. The disorder has as independents risk factors the male gender, duration of anesthetic period and high blood loss [16,25,29-31].

Occlusion of the central retinal artery

The occlusion of the central retinal artery, known as headrest syndrome, is the second most frequent cause of visual loss and results from complications associated with improper positioning. leading to direct or indirect pressure that reduces retinal perfusion. Periorbital ecchymosis and sclera edema are some signals associated with the occlusion. The incidence of the occlusion reported is 0.001%. [7,17,25,31-34].

Cortical blindness

Cortical blindness is the most serious complication associated with improper positioning, caused by visual cortex ischemia due to extreme hypoperfusion. This can lead to bilateral visual loss, bilateral or contralateral homonymous hemianopsia. The condition, however, has a good prognosis and most cases show complete recovery [5,35].

Subconjunctival hemorrhage

The subconjunctival hemorrhage is another rare complication on the post-operative period. It is painless and does not affect IOP or visual acuity. It is a temporary situation that does not require treatment, but it is an alert signal that points to the need for a deep investigation on serious ocular injuries [8,27,36].

Neurological complications

The prone position is associated with several neurological complications, including stroke, increased intracranial pressure, spinal cord dysfunction, plexopathy and herniated discs[37-49].

Stroke

Stroke in neurosurgical procedures arises from the occlusion of the vertebral arteries, resulting from the non-neutral position of the head and improper movements, which are also related to increased intracranial pressure and dissection of the carotid and vertebrobasilar arteries, leading to injury to the intima and thrombus formation[3,6-7].

The risk of stroke is higher in elderly patients having malignant neoplasms, obese patients and those that have a recent history of major surgeries. The risk is reduced by maintaining the head on the body axis[3,6-7].

Central desaturation and delirium

Deiner et al[23] found a greater chance of desaturation in patients in the prone position, but they did not observe a relationship with delirium and postoperative cognitive dysfunction. This retrospective study involved 205 elderly patients submitted to bilateral cerebral oximetry in the supine and prone position.

Spinal cord infarction

According to Maduri et al[43], spinal cord infarction is a rare complication associated with the prone position reported only twice in until 2016, , , which. The complication can lead to complete paraplegia and is possibly owed to hyperflexion of the spine that causes stretching of the segments, resulting in hypoperfusion and intra-abdominal compression. This, in turn, leads to spinal venous congestion or even to the opening of the cisterna magna and rapid loss of cerebrospinal fluid, causing an imbalance of infratentorial and medullary pressure [37-39,43-44].

It is also associated with chest wall deformity and the use of pillows to support the patient, the latter can lead to cardiac compression and reduced perfusion[39,44].

Plexopathy

Plexopathies are lesions resulting from focal tension, increased pressure, local edema and axoplasmic involvement. Diabetes mellitus, hypovolemia, hypothermia, malnutrition, hypertension, alcoholism and previous paresthesia are risk factors [37,45-47].

Brachial plexopathy, which is associated with abduction greater than 90º, is the best-known complication. Others include paralysis of the ulnar nerve, resulting from pressure on the cubital tunnel of the elbow, incorrect positioning of the cuff, flexion greater than 90º and accidental change in position and lateral femoral cutaneous nerve neuropathy associated with the use of pelvic pillows[7,27,47].

Herniated disc

The acute herniated cervical disc is a rare event that probably results from a combination of neck extension in endotracheal intubation, loss of muscular support due to anesthesia, surgical manipulation and the prone position itself [8,27,40]. In turn, a thoracic hernia results from excessive movement of the thoracolumbar spine and marked loss of muscle tone. It may result in paraplegia [8,43,48].

Muscle complications

In the musculoskeletal system, the prone position is a well-known cause of pressure ulcers and compartment syndrome. The diagnosis of compartment syndrome is hard and sometimes misdiagnosed due to similarity with other complications as neuropathy of peripheral nerves. The pressure ulcers themselves are related to surgery time. Ischemia occurs two to six hours after the onset of pressure and necrosis after

six hours. Obesity, advanced age or steroid use are identified as risk factors [3,5,27,38].

Venous complication

Venous air embolism is an event that usually when the surgical site is above the heart or when the venous pressure is very low. Once the risk is identified, it is necessary to use a central venous catheter [2,9,25,37].

Deep vein thrombosis after the neurosurgical procedure in the prone position is an event with variable incidence and data are imprecise. The study by Rokito et al[49] with 309 patients found only one case and concluded that the screening of patients was unjustifiable, as it was within the expected range for surgeries in general.

Discussion

The prone position was described in 1950 by Moore and Edmunds with the aim of performing spinal procedures. To perform it, first, lateral decubitus is adopted and, later, the rotation is performed to the desired position. It is used in parietal, occipital and suboccipital craniotomy, in the cervical, thoracic and lumbar laminectomy[1-2,4].

Like other decubitus, the prone position has its complications, which result from excessive pressure applied to the back and extremities[2]. Surgical time, patient age, hypovolemia, hemodilution, diabetes mellitus, hypertension, obesity and smoking are known risk factors for these complications[1-39].

Complications are rare and little studied. There is also insufficient data on epidemiology, although it is commonly adopted in neurosurgical procedures [1-6]. Therefore, in patients with a risk profile, a study of the position is needed[1-5].

When the prone position is adopted, adequate monitoring and care with the positioning of the limbs are necessary, in order to reduce the risks. Hemodynamic monitoring to identify hypovolemia, a common risk factor, is essential and must be corrected early[1-10].

Conclusion

The prone position is associated with visual, muscular, neurological and hemodynamic complications that can range from transient to severe conditions. When alternative positions are not possible, the identification of comorbidities is imperative.

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