

INTRACRANIAL PRESSURE VARIATIONS DURING ENDOSCOPIC LUMBAR SPINE SURGERY

VARIAÇÕES DA PRESSÃO INTRACRANIANA DURANTE CIRURGIAS ENDOSCÓPICAS DA COLUNA LOMBAR

VARIACIONES DE LA PRESIÓN INTRACRANEAL DURANTE CIRUGÍAS ENDOSCÓPICAS DE LA COLUMNA LUMBAR

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ABSTRACT

Minimally invasive spine surgery has achieved remarkable advances in recent years. Despite the numerous benefits associated with this approach, some complications may still occur. Among them, the use of continuous irrigation in the epidural space stands out, as it can cause changes in intracranial pressure (ICP). The present study aims to conduct a systematic review of the literature on ICP variations during endoscopic lumbar spine surgery. To this end, a search was carried out in the PubMed, Embase, Scielo, Lilacs, and Google Scholar databases, selecting studies that evaluated ICP intraoperatively during endoscopic spine procedures. Five comparative studies were included: three measured epidural pressure as an indirect surrogate of intracranial pressure (ICP), whereas two performed direct ICP measurements. Three of these studies identified significant changes in ICP during the procedure, whereas two did not observe relevant fluctuations. The analysis of the literature therefore confirms the possibility of ICP variations occurring intraoperatively in endoscopic lumbar spine surgeries. **Level of Evidence III; Systematic Review.**

Keywords: Intracranial Pressure; Minimally Invasive Surgical Procedures; Systematic Review.

RESUMO

A cirurgia minimamente invasiva da coluna vertebral tem alcançado avanços notáveis nos últimos anos. Apesar dos inúmeros benefícios associados a essa abordagem, algumas complicações ainda podem ocorrer. Entre elas, destaca-se o uso de irrigação contínua no espaço epidural, capaz de provocar alterações na pressão intracraniana (PIC). O presente estudo tem como objetivo realizar uma revisão sistemática da literatura sobre as variações da PIC durante procedimentos de cirurgia endoscópica da coluna lombar. Para tanto, foi conduzida uma busca nas bases de dados PubMed, Embase, Scielo, Lilacs e Google Scholar, selecionando estudos que avaliaram a PIC no intraoperatório de cirurgias endoscópicas da coluna. Foram incluídos cinco estudos comparativos: três mensuraram a pressão no espaço epidural como parâmetro indireto da PIC, enquanto dois realizaram a aferição direta. Três desses trabalhos identificaram alterações significativas da PIC durante o procedimento, ao passo que dois não observaram oscilações relevantes. A análise da literatura confirma, portanto, a possibilidade de variações da PIC no intraoperatório de cirurgias endoscópicas da coluna lombar. **Nível de Evidência III; Revisão Sistemática.**

Descritores: Pressão Intracraniana; Procedimentos Cirúrgicos Minimamente Invasivos; Revisão Sistemática.

RESUMEN

La cirugía mínimamente invasiva de la columna vertebral ha alcanzado avances notables en los últimos años. A pesar de los numerosos beneficios asociados con este enfoque, aún pueden presentarse algunas complicaciones. Entre ellas, se destaca el uso de irrigación continua en el espacio epidural, capaz de provocar alteraciones en la presión intracraneal (PIC). El presente estudio tiene como objetivo realizar una revisión sistemática de la literatura sobre las variaciones de la PIC durante procedimientos de cirugía endoscópica de la columna lumbar. Para ello, se llevó a cabo una búsqueda en las bases de datos PubMed, Embase, Scielo, Lilacs y Google Scholar, seleccionando estudios que evaluaron la PIC en el intraoperatorio de cirugías endoscópicas de la columna. Se incluyeron cinco estudios comparativos: tres midieron la presión en el espacio epidural como parámetro indirecto de la PIC, mientras que dos realizaron la medición directa. Tres de estos trabajos identificaron alteraciones significativas de la PIC durante el procedimiento, mientras que dos no observaron fluctuaciones relevantes. El análisis de la literatura confirma, por lo tanto, la posibilidad de variaciones de la PIC en el intraoperatorio de cirugías endoscópicas de la columna lumbar. **Nivel de Evidencia III; Revisión Sistemática.**

Descriptores: Presión Intracraneal; Procedimientos Quirúrgicos Mínimamente Invasivos; Revisión Sistemática.

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INTRODUCTION

Minimally invasive spinal surgery has been expanding continuously, driven by population aging and the growing demand for less aggressive procedures that provide faster recovery and better quality of life. This evolution reflects not only technological advances but also a paradigm shift in the therapeutic management of spinal disorders^{1,2}.

Among the minimally invasive techniques, the endoscopic surgeries of the spine stand out, which offer multiple clinical and functional advantages: reduced cutaneous incisions, absence of muscle retraction, minimal manipulation of neural tissue and possibility of conducting under local anesthesia. In addition, these procedures are associated with reduced blood loss, reduced surgical time and accelerated recovery, favouring early return to daily activities and significantly contributing to the improvement of the quality of life of patients³⁻⁶.

Despite the significant advances and widely recognized benefits of these interventions, some complications can still occur. Among them is the need for continuous irrigation with saline solution in the epidural space, a procedure that can result in increased intracranial pressure (ICP). This increase in blood pressure can trigger transient or persistent clinical manifestations such as headache, cervicalgia, hypoacusia, paresthesia, visual changes, retinal hemorrhages and, in more severe cases, epileptic seizures. The possible correlation between the increase in ICP and the volume or infusion pressure of the peridural saline solution may be related to the concomitant subaracnoid pressure increase due to the hydraulic transmission of the pressure gradient between the meningeal compartments. This mechanism may cause partial blockage of the reabsorption of the cerebrospinal fluid, whose production remains active, contributing to the progressive increase in ICP⁷⁻¹².

The classical hypothesis on the physiology of cerebrospinal fluid (CSF) and the regulation of PIC suggests that during its active formation (secretion), ICP is determined by resistance to the flow of CSF throughout the production, circulation and absorption system, as well as by the effectiveness of its reabsorption by the capillary network of the brain and spinal cord. In this context, the main forces involved in the control of CSF volume are the hydrostatic and osmotic pressures, directly influenced by the extensive microvascular network that participates in the liquid balance in the intracranial and spinal compartments¹³. There is evidence suggesting that both the volume and pressure of the saline solution administered in the epidural space through the endoscope exert a direct influence on the cervical epidural pressure, which in turn presents a linear correlation with ICP^{8,11,14,15}.

This paper aims to conduct a systematic review of the literature on the possible variations of ICP during endoscopic spine surgery procedures.

MATERIAL AND METHODS

Literature Review

A systematic search was performed in the databases PubMed, Embase, SciELO, Google Scholar and LILACS, using the descriptors "endoscopic spine surgery" and "intracranial pressure", combined by the Boolean operator "AND".

Indexed or available articles were included in postgraduate databases at the Universidade de São Paulo, provided they were reviewed by peers. The inclusion criteria included studies whose main intervention was endoscopic surgery of the spine and which proposed to evaluate ICP during the procedure, regardless of the method used for this measurement.

Non-indexed articles (such as publications on personal websites) and studies that did not address the evaluation of ICP in the context of endoscopic spinal surgery were excluded. The primary outcome considered was the ability to measure ICP during the surgical procedure, as well as the observation of its intraoperative variations.

The selection of the studies was carried out independently by the authors, with initial analysis of the titles and summaries.

Subsequently, eligible articles were submitted for full reading. Only the studies that were proposed to measure ICP oscillations were included in the final analysis. Duplicate publications in different databases were identified and deleted.

RESULTS

According to the established protocol, 148 articles were raised. The distribution by database was as follows: PubMed/MEDLINE contributed 23 articles; Google Scholar, with 124 articles; Embase, LILACS and SciELO did not present relevant results for the defined criteria; and the University of São Paulo postgraduate database provided a thesis relevant to the topic (Figure 1).

Of the 5 articles recovered, 3 of them evaluated the pressure from the epidural space in the spine and 2 of them evaluated the intracranial pressure (Table 1).

Kang et al. (2020)⁸, they used a cervical epidural catheter positioned at C7-T1 level to monitor the fluctuations of the epidural pressure during endoscopic spinal surgery procedures. The results demonstrated a linear correlation between cervical epidural pressure and saline solution infusion pressure. In addition, it was observed that the obstruction of the drainage of irrigation solution can lead to expressive elevations of cervical epidural pressure, reaching peaks up to three times higher than the values recorded at the beginning of surgery.

In a later study, Kang et al. (2020)¹⁵ performed the measurement of cervical epidural pressure during procedures of lumbar endoscopic surgery for treatment of disc hernia, using biportal approach.

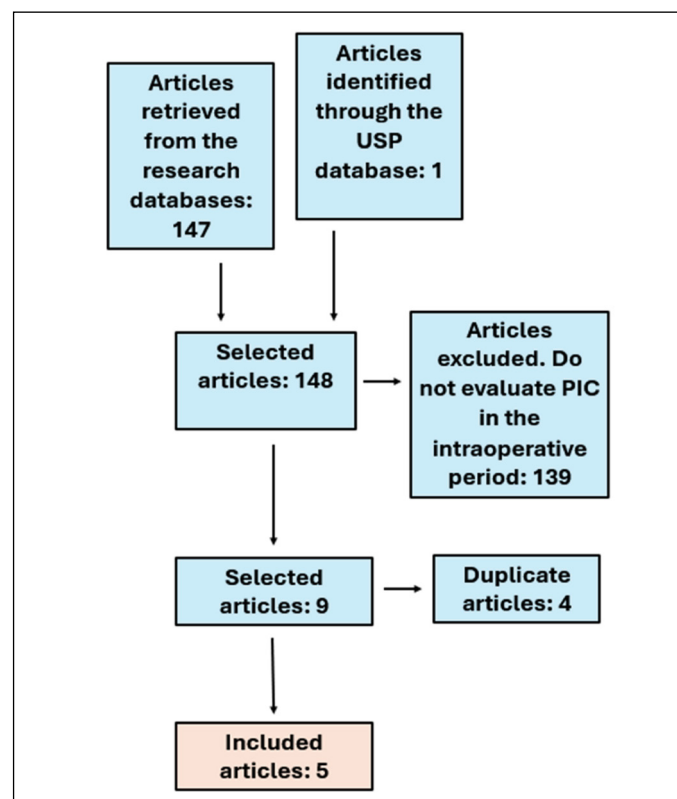


Figure 1. The selection flow of articles, according to the PRISMA Statement.

Table 1. Articles selected according to the protocol of this systematic review.

Author	Year	Access	Type of monitoring	Monitoring location	Population
Kang	2020	Biportal	Peridural catheter	Cervical	Human
Kang	2020	Biportal	Peridural catheter	Cervical	Human
Ribeiro	2021	Uniportal	Extracranial device	Extracraniana	Human
Vargas	2023	Uniportal	Peridural catheter	Lumbar	Human
Amato	2023	Uniportal	Intracranial catheter	Intracranial	Pigs

The results indicated that there were no significant variations in cervical epidural pressure, even in the face of increased salt solution flow speed. This stability was attributed to the constant drainage of irrigation fluid, characteristic of the biportal technique, which seems to minimize pressure accumulation in the epidural space.

Ribeiro, in 2021⁹, used a non-invasive extracranial device to evaluate the oscillation of cerebral complacency through the cranial micropulsation technique, which allows indirect measurement of intracranial pulse waves. In a sample of 31 patients, the author did not identify significant changes in ICP related to the flow or infusion pressure of the saline.

Vargas et al. (2023)¹⁶, they used a lumbar epidural catheter during endoscopic spine surgery procedures to monitor pressure fluctuations in the epidural space. The authors observed that although the values did not reach levels considered extreme, the average recorded pressure was 24,33 mmHg, significantly higher than the usual range of intradural pressure, which ranges from 5 to 15 mmHg. The study also reports that in cases of accidental durotomy, patients presented with neurological complications, evidencing the importance of intraoperative pressure control and dural integrity for the safety of the procedure.

Amato et al. (2023)⁷, conducted an experimental study in pigs, in which the invasive monitoring of ICP was performed using a catheter positioned in the epidural space. The authors observed that during most of the surgical procedure, ICP levels remained within limits considered safe. However, at moments of occlusion of the salt solution drainage, critical pressure peaks were recorded, evidencing the direct impact of irrigation dynamics on intracranial stability.

DISCUSSION

Despite the growing number of publications on endoscopic surgery of the spine, studies aimed at evaluating intracranial pressure (ICP) during these procedures remain limited. Among the available work, there is a lack of standardization in PIC measurement methods, as well as the lack of a validated model that allows precise and reliable measurement of this intraoperative variable. This gap evidences the need for further methodological deepening and the development of specific protocols for monitoring ICP in minimally invasive spinal surgery.

The scarcity of studies on the evaluation of intracranial pressure (ICP) in endoscopic surgery of the lumbar spine becomes even more evident in the absence of scientific reports that present absolute ICP values during these procedures. The most accurate methods available are invasive, especially intraventricular monitoring¹⁷⁻²⁰; however, their application is impossible in elective patients without prior intracranial changes.

At the same time, intraoperative bleeding remains one of the main challenges of endoscopic surgery, representing a significant risk of complications, with postoperative hematoma being the most common occurrence²¹. In this context, we observe the formation of a vicious and potentially dangerous cycle: the increase in bleeding leads to the closure of the irrigation system, which raises

the pressure of the saline solution and, consequently, the ICP and the average blood pressure. These factors, in turn, intensify the bleeding, perpetuating the risk. This mechanism, coupled with the previously discussed methodological gap, reinforces the critical need for reliable monitoring strategies and strict and early control of bleeding during the surgical procedure²².

During the surgical procedure, strategies such as pressure control and irrigation mode, in addition to the appropriate choice of endoscope model, have been shown to be effective in preventing abrupt and excessive increases in intracranial pressure (ICP)¹². The use of endoscopic systems equipped with outflow mechanism, which allow continuous drainage and avoid the complete closure of the irrigation circuit, is fundamental. In addition, it is recommended to keep the system partially open and perform strict control of the patient's average blood pressure, indispensable measures to ensure hemodynamic stability and minimize the risk of intracranial complications^{11,23}.

The inadvertent dural lesion, when not recognized during the surgical act, can progress into serious complications, including increased intracranial pressure (ICP). For this reason, it is essential that the surgeon be attentive to its intraoperative detection and take immediate measures to mitigate its effects. Among the recommended strategies, the opening of drainage channels of the irrigation system is highlighted, a measure that favors the reduction of ICP and contributes to minimizing the risk of clinical deterioration²³.

This set of strategies complements the discussion on the scarcity of standardized and reliable methods for ICP monitoring in lumbar spine endoscopic surgeries, reinforcing the need for specific protocols that integrate both pressure monitoring and intraoperative bleeding management.

CONCLUSION

The measurement of intracranial pressure (ICP) during endoscopic procedures of the spine is a topic of high relevance, especially in the face of the growing spread of this technique and the expressive increase in the number of surgeries performed. Although associated neurological complications are uncommon, their occurrence is documented in the literature and requires attention. The available studies indicate that ICP may undergo intraoperative oscillations, which reinforces the need for more consistent and comprehensive investigations.

It is therefore essential to develop research with a greater number of patients, which employ standardized methodologies for monitoring ICP and describe in detail its variations in the different phases of the procedure. In addition, it is essential to establish the correlation between these oscillations and the emergence of neurological complications, contributing to the understanding of the risks involved and for patient safety.

Thus, the literature shows a promising field of study, with the potential to directly impact clinical practice and promote the improvement of endoscopic techniques of the spine.

CONFLICT OF INTEREST

All authors declare no potential conflict of interest related to this article.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. RRC, CJJ, MBSB: conceptualization, literature review, writing - original draft. JFRL, GOAC: validation and supervision. SEL, JPMB: Formal analysis; Writing - review & editing.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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