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Propofol effects over intracranial pressure waveform and cerebral hemodynamics: A case report

Efeitos do propofol sobre a morfologia do pulso da pressão intracraniana e a hemodinâmica cerebral: Um relato de caso

Efectos del propofol sobre la morfología del pulso de presión intracraneal y la hemodinámica cerebral: Reporte de un caso

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Abstract
Introduction: Few reports have been dedicated on assessing cerebral hemodynamics (CH) and intracranial compliance (ICC) in non-primary neurological patients. Objective: The present study aims to observe the anesthetic influence of propofol on CH and ICC using noninvasive monitoring techniques in the immediate postoperative period. Methodology: This is a case report in which CH and ICC were assessed noninvasively using transcranial Doppler (TCD) and a skull deformation sensor (B4C) respectively, in the immediate postoperative period of a patient just after cardiac revascularization. After exclusion of volemic depletion, TCD and B4C parameters indicated reduction in cerebral blood flow what would be attributed to propofol infusion during surgery. After endovenous additional volume administration and arterial pressure elevation, TCD and B4C parameters improved. Final Considerations: It was possible observing cerebrovascular influences of propofol in the immediate postoperative period, by means of neurological ancillary techniques. Noninvasive neuromonitoring is a way to assess changes in brain physiology that may occur subtly and influence in non-primary neurological patients outcomes.
Keywords: Cerebrovascular circulation; Intracranial pressure; Propofol; Anesthesia; Postoperative care.

Resumo
Introdução: Poucos relatos se dedicaram à avaliação da hemodinâmica cerebral (HC) e da complacência intracraniana (CIC) em pacientes neurológicos não primários. Objetivo: O presente estudo tem como objetivo observar a influência anestésica do propofol no HC e no CIC por meio de técnicas de monitorização não invasivas no pós-operatório imediato. Metodologia: Trata-se de um relato de caso em que o HC e o CIC foram avaliados de forma não invasiva por meio de Doppler transcraniano (DCT) e sensor de deformação craniana (B4C), respectivamente, no pós-operatório imediato de um paciente logo após revascularização cardíaca. Após exclusão da depleção volêmica, os parâmetros DCT e B4C indicaram redução do fluxo sanguíneo cerebral, o que seria atribuído à infusão de propofol durante a cirurgia. Após administração de volume adicional endovenoso e elevação da pressão arterial, os parâmetros DCT e B4C melhoraram. Considerações Finais: Foi possível observar influências cerebrovasculares do propofol no pós-operatório imediato, por meio de técnicas neurológicas auxiliares. O neuromonitoramento não invasivo é uma

forma de avaliar alterações na fisiologia cerebral que podem ocorrer de forma sutil e influenciar nos resultados não primários dos pacientes neurológicos.
Palavras-chave: Circulação cerebrovascular; Pressão intracraniana; Propofol; Anestesia; Cuidados pós-operatórios.

Resumen
Introducción: Pocos informes se han dedicado a evaluar la hemodinámica cerebral (HC) y la distensibilidad intracraneal (DIC) en pacientes neurológicos no primarios. Objetivo: El presente estudio tiene como objetivo observar la influencia anestésica del propofol sobre el HC y el DIC mediante técnicas de monitorización no invasivas en el postoperatorio inmediato. Metodología: Este es un reporte de caso en el que se evaluaron HC y DIC de forma no invasiva mediante Doppler transcraneal (TCD) y un sensor de deformación del cráneo (B4C), respectivamente, en el postoperatorio inmediato de un paciente inmediatamente después de la revascularización cardíaca. Después de excluir el agotamiento volémico, los parámetros TCD y B4C indicaron una reducción en el flujo sanguíneo cerebral que se atribuiría a la infusión de propofol durante la cirugía. Después de la administración endovenosa de volumen adicional y la elevación de la presión arterial, los parámetros de TCD y B4C mejoraron. Consideraciones finales: Fue posible observar influencias cerebrovasculares del propofol en el postoperatorio inmediato, mediante técnicas auxiliares neurológicas. La neuromonitorización no invasiva es una forma de evaluar los cambios en la fisiología cerebral que pueden ocurrir sutilmente e influir en los resultados de los pacientes neurológicos no primarios.
Palabras clave: Circulación cerebrovascular; Presión intracraneal; Propofol; Anestesia; Cuidados posoperatorios.

1. Introduction

Intracranial pressure is an important physiological sign for the management of patients with brain injury in neurocritical care units. Subtle changes in the morphology of intracranial pressure (ICP) (increased intracranial pressure) pulses may reflect cerebral vascular changes (Hu et al., 2010). Pulse pressure is formulated by the transformation of an incidental arterial pressure pulse under the modulating influences of multiple intracranial compartments and can significantly affect cerebral flow and can be monitored by transcranial doppler (Allam et al., 2020).

Pulse morphology is a fundamental part of individualizing patients in relation to monitoring and characterizing ICP dynamics. On the other hand, practice is also limited as it depends on subjective interpretation analyzed on devices that are often of low resolution, making it difficult to recognize the direction of amplitude peaks after neurology interventions (Brasil, 2022). In this context, few reports have been dedicated of assessing cerebral hemodynamics (CH) and intracranial compliance (ICC) in non-primary neurological patients.

Anesthetics are agents that can cause changes in cerebral blood flow (CBF) and cerebral metabolic rate. If used appropriately, they can promote adequate surgical conditions and help protect the brain (Bouzat et al., 2013). One of them is propofol, a short-acting hypnotic agent, which reflects changes in the behavior of ICP and cerebral hemodynamics, in addition to its intrinsic adverse effects (Kotani et al., 2023).

Therefore, the present study aims to observe the anesthetic influence of propofol on cerebral blood flow parameters and intracranial pressure when non-invasive monitoring techniques such as transcranial Doppler and cranial pulsed sensors are used in the postoperative period.

2. Methodology

This is an observational, descriptive and retrospective case report (Pereira et al., 2018) in which the variables were collected from the medical record after the anesthetic procedure where cerebral hemodynamics and intracranial compliance were assessed non-invasively using the brain4care® system through a sensor fixed with an adjustable tape in the patient's parietal region and by transcranial doppler, without carrying out any type of research intervention.

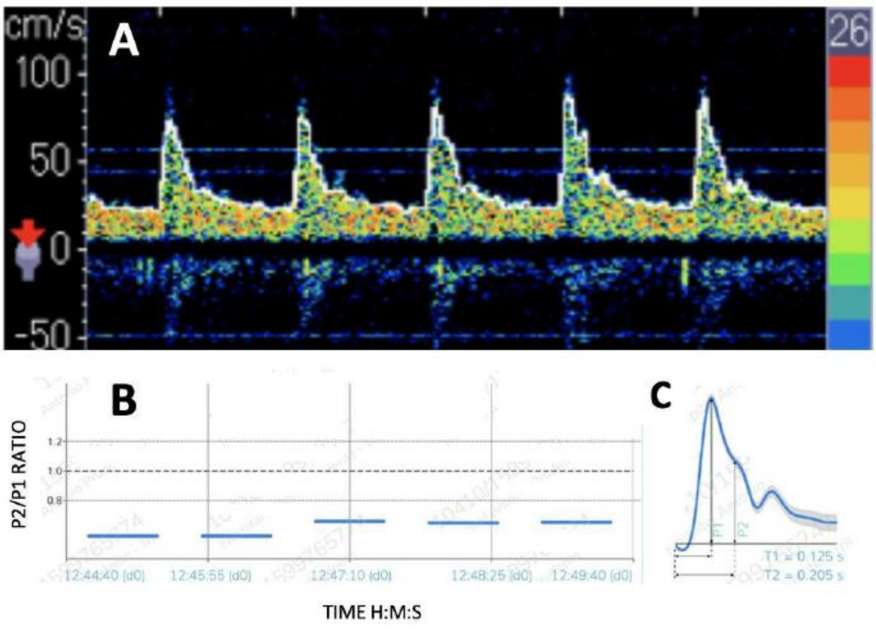
Although it is a study without clinical intervention, to guarantee the ethical and legal support of the study, consent for publication was obtained through the patient's signature in the Free and Informed Consent Form, aiming at the confidentiality and anonymity of their identity, in addition to the report respecting the Declaration of Helsinki, resolution 466/2012 and the principles for case studies involving people, through the letter CONEP/2018.

Finally, this study seeks to collaborate to encourage a less invasive therapeutic approach seeking to improve diagnosis, evolution and patient safety, as well as improving monitoring and management with additional information about brain dynamics.

3. Case Report

A 62-year-old man was submitted to myocardial revascularization because of circumflex coronary artery sub-occlusion. The procedure lasted for two hours without intercurrences, being the patient sedated with continuous venous propofol infusion and mechanically ventilated. He was extubated just after the procedure and forwarded to the intensive care unit. In the immediate postoperative period with patient cooperative but drowsy, transcranial doppler (TCD, EZ-Dop, DWL, Singen, Germany) and non-invasive intracranial pressure (ICP) waveform monitoring (B4C, Brain4care, São Carlos, Brazil) were performed for the assessment of cerebral hemodynamics and intracranial compliance (ICC) respectively. In this first assessment (Figure 1), cerebral blood velocities were under the standard lower limit for all intracranial arteries assessed (middle cerebral arteries velocities [MCAv] 32 cm/s, pulsatility index 1.38), suggestive of reduced blood flow. Likewise, the non-invasive evaluation was suggestive of impaired ICC by means of low P2/P1 ratio (0.62). Post operative hydric balance was near zero, and 500 ml of saline physiologic solution were then administered intravenously for 30 minutes, elevating mean systemic arterial pressure (MAP) from 70 to 85 mmHg. A reassessment at this moment revealed TCD and B4C parameters within standards (MCAv 40 cm/s, pulsatility index 1.1 and P2/P1 ratio 0.9, Figure 2). 12 hours later, with patient awake, new session of monitoring revealed no changes on TCD and B4C parameters, despite MAP remaining again approximately to 70 mmHg and the absence of significant changes in general clinical features. Patient was discharged next day.

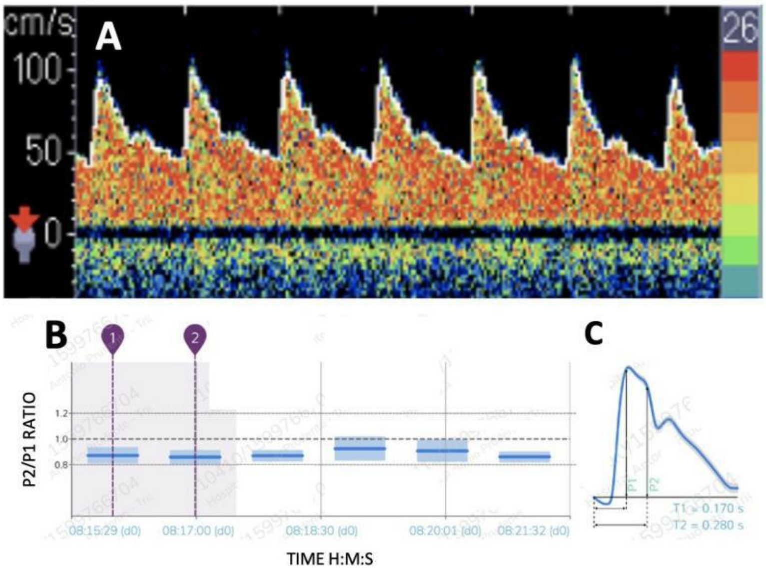
Figure 1 - At baseline with mean arterial pressure ˜70 mmHg, transcranial Doppler (A) registry showing idle cerebral arteries reduced mean blood velocities (~33 cm/s, pulsatility index˜1.38) and brain4care's P2/P1 ratio (˜0.6, B). C shows an impaired mean pulse shape with P2 amplitude much lower than P1.



Source: Authors (2024).

The record presented in Figure 1 shows the result of the multimodal evaluation, making it possible to visualize the same phenomenon with both technologies, where the TCD pulsatility index and the P2/P1 ratio are reduced, with an altered intracranial pressure waveform, presenting P2 below usual, even with a mean arterial pressure of around 70 mmHg.

Figure 2 - After fluid administration and mean arterial pressure ˜85 mmHg, transcranial Doppler (A) registry showing middle cerebral arteries normal mean blood velocities (~60 cm/s, pulsatility index ~1) and brain4care's P2/P1 ratio (˜0.9, B). C shows a standard mean pulse shape with P2 amplitude near P1 amplitude.



Source: Authors (2024).

In Figure 2 we also observe the agreement of the two technologies, after administration of fluids and elevation of mean arterial pressure from 70 to 85 mmHg, showing the normalization of the pulsatility index, the P2/P1 ratio and the ICP waveform with P2 amplitude close to the P1 amplitude.

4. Discussion

The present case exemplifies the acute effects of propofol over cerebral hemodynamics and ICC. The low P2/P1 ratio reported points to a reduction in the second peak of the ICP waveform, what is known to represent ICP itself, or the spread of blood thru the brain, the tidal wave (Brasil et al., 2021). This phenomenon is probably explained by the effects of propofol in reducing the cerebral blood flow (CBF) (Lagerkranser et al., 1997), and the reduction in brain metabolism (Stewart et al., 1994). For a non-brain injured patient, with preserved cerebral autoregulation, reducing brain metabolism implies an idoneous CBF decrease (Venkat et al., 2016), what was translated in the reduction of P2 and MCAv in the present case. Therefore, although there is evidence that propofol do not have significant influence over ICP (Gu et al., 2014), changing the focus from ICP to ICC brings to light the concept that intracranial volume may suffer changes during the infusion and in a short period after interruption.

The interrelationship between changes in intracranial content volume (especially blood and cerebrospinal fluid) and changes in ICP define the compliance characteristics of the intracranial compartment (Bruce et al., 1981; Aldrich et al., 1992; Levin et al., 1992). Hereby we can say that cerebral compliance is like the adaptive capacity of the cranial vault to allow having the ability to tolerate a large volume dependent on compensation mechanisms, that is, it can be modeled as the change in volume over the change in pressure (dV/dP) (Rodríguez-Boto et al., 2015).

Propofol was the intravenous anesthetic agent used in the present case, as it is widely used in human medicine. It acts as a potent hypnotic that can be used for induction and maintenance of general anesthesia and sedation. It has a rapid start effect and recovery after withdrawal (Mikkelsen et al., 2015). Intravenous anesthetics, such as propofol, can influence the CBF, causing indirect decrease due to blood pressure depression and reduction of the cerebral metabolic rate. The hypotensive effect is caused by a decrease in sympathetic activity and intracellular calcium flow, resulting in vasodilation. The CBF reduction is related to the metabolic depressor effect of this drug due to suppression of neuronal activity, and it also acts as an antioxidant and has neuroprotective properties (Slupe & Kirsch, 2018).

Despite controversial results, it is believed that propofol can influence ICP. Initially, compensatory mechanisms allow volume to increase with minimal rise in ICP. ICP is normally ≤15 mmHg in adults, and pathological intracranial hypertension is present at pressures ≥20 mmHg (Vandesteene et al., 1988). In severe acute brain injury, after a significant increase in ICP, secondary brain injuries may result from reduced CBF (Petersen et al., 2003). Therefore, keeping these patients adequately sedated can reduce brain metabolism, avoid ventilator asynchrony and venous congestion, preventing elevation of thoracic pressure, contributing to the intracranial compartment compliance. In many studies, propofol has shown to reduce ICP and cerebral metabolic rate of oxygen (CMRO2) (Wu et al., 2020). Side effects of propofol are dose-dependent hypotension which can decrease cerebral perfusion pressure even if it induces a decrease in ICP and dose-dependent respiratory depression (Peluso et al., 2019).

5. Final Considerations

In the present case, at the bedside and using non-invasive monitoring techniques as transcranial doppler and a skull pulsatile sensor was possible to observe the reduction of cerebral blood flow produced by propofol, over intracranial compliance. Neurological multimodal monitoring may aid arterial pressure and volemic adjustments in order to warrant a proper cerebral perfusion in critical care. Furthermore, new studies are needed that highlight the positive influence that less invasive techniques have on the parameters of brain dynamics after the use of anesthetics, as well as the implementation of interventions to minimize possible brain damage.

Conflicts of Interest

Sérgio Brasil receives consulting fees from brain4Care Corp and Elaine Peixoto works in the knowledge department at brain4care, although neither they nor the other authors received grants to carry out this study.

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