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CASE REPORT

Intraoperative awareness as an example of the influence of cardiac output on anesthetic dosing: case report

Despertar intraoperatorio como ejemplo de la influencia del gasto cardíaco en la dosificación anestésica. Reporte de caso

Keywords: Catheter Ablation, Isoproterenol, Adverse effects, Propofol, Intraoperative Awareness

Palabras clave: Ablación por Catéter, Isoproterenol, Efectos adversos, Propofol, Despertar Intraoperatorio

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Abstract

A case of intraoperative awareness during ablation of pulmonary veins—one of the most widely used techniques in interventional cardiology—is discussed. An infusion of isoproterenol was administered following the ablation of ectopic foci. A few seconds after the infusion the patient experienced increased heart rate and intraoperative awareness manifested as an abrupt patient movement and bispectral index elevation. This has been described in similar procedures, following the administration of isoproterenol. In our opinion, the isoproterenol infusion caused the increased heart rate and subsequent abrupt rise in cardiac output. As an inversely proportional relationship between the propofol concentrations and cardiac output has been described, we believe that this rise in cardiac output could have favored the

decline in the concentrations of propofol, leading to an intraoperative awareness episode.

Resumen

Presentamos un caso de despertar intraoperatorio durante la ablación de venas pulmonares, una de las técnicas más empleadas por los cardiólogos intervencionistas. Tras la ablación de focos ectópicos se procede a la infusión de isoproterenol. Segundos después de la infusión se produce un aumento de la frecuencia cardíaca seguido de un despertar intraoperatorio traducido como un movimiento brusco del paciente y un aumento en el índice bi-espectral (BIS). Esto ha sido descrito en procedimientos similares tras la administración de isoproterenol. En nuestra opinión, la infusión de isoproterenol provocó un aumento

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de la frecuencia cardíaca y secundariamente del gasto cardíaco de forma brusca. Dado que se ha descrito una relación inversamente proporcional entre las concentraciones de propofol y el gasto cardíaco, pensamos que este aumento del gasto cardíaco pudo condicionar un descenso de las concentraciones de propofol y esto causar el episodio de despertar intraoperatorio.

Introduction

Catheter ablation of pulmonary veins is one of the most widely used techniques in interventional cardiology.¹ The technique requires patient immobility and the anesthetic approach usually uses intravenous perfusions of propofol and remifentanyl, which have proven to be suitable drugs in this scenario, as they do not significantly interfere with the electrophysiological function of the atrial-ventricular node.^{2,3} To ensure proper depth of anesthesia during the procedure, the bispectral index (BIS) for hypnotic depth is monitored.⁴

It is well known that there is an inversely proportional relationship between cardiac output and plasma concentrations of propofol.^{5,6} This relationship implies that any increase in cardiac output during the maintenance of anesthesia may lower the concentrations of the anesthetic drugs, exposing the patient to a risk of intraoperative awareness. This complication during general anesthesia may result in chronic mental repercussions for the patient,⁷ but may also involve mechanical complications during the procedure when muscle relaxants are not used and the patient moves while a precise technique is being performed.

This paper discusses a case of sudden awareness following isoproterenol infusion, which illustrates how the relationship between cardiac output and drug concentrations may influence the doses required for maintaining the levels of propofol and remifentanyl.

Case description

This is a 50-year-old female patient with 67 kg of body weight who was admitted for radiofrequency ablation of persistent focal atrial tachycardia originating in the left atrium. A right femoral vein approach was used for a transseptal puncture with SLO (vaina Swartz Braided Transseptal St Jude Medical serie SLO 63 cm.) sheath and BRK-1 XS needle to access the left atrium. Through electroanatomical mapping using the Ensite Precision navigation system and a contact force ablation catheter (SJM TactiCath), a left atrial activation map was developed, documenting the origin of the atrial tachycardia in the antrum of the upper left pulmonary vein. Using power and temperature control (40 W–42°), several radiofrequency applications were administered until successful ablation of the atrial tachycardia. The procedure was carried out with the patient anti-coagulated with non-fractionated heparin.

The intervention was conducted under general anesthesia. The patient was pre-medicated with 2 milligrams (mg) of midazolam and the induction was performed with 200 µg of fentanyl, 50 mg of propofol, and 50 mg of rocuronium, for subsequent endotracheal intubation with a Rusch tube. Then, the objective of maintaining the anesthesia was to maintain hypnotic depth BIS values of around 60, which was initially accomplished with low-dose propofol perfusions (1.2 mg/kg/hour) and remifentanyl (0.08 µg/kg/minute), and additional boluses of rocuronium to ensure the patient's immobility during ablation.

The hemodynamic monitoring showed in the electrocardiogram a basal tachyarrhythmia of over 200 bpm, whereas the non-invasive blood pressure monitor was unable to elicit any readings; this issue had been previously reported by the patient. Following the catheterization of the left radial artery, the invasive arterial pressure reading showed quite oscillating values, with maximum readings of 90/50 mm Hg, and a heart rate measured with pulse pressure wave of merely 30–45 bpm.

The hemodynamic situation improved gradually, as the elimination of ectopic foci progressed, obtaining progressively higher blood pressure readings. Simultaneously, to maintain the BIS values around 60, it was necessary to increase the propofol and remifentanyl infusion rates (up to 3 mg/kg/hour and up to 0.14 µg/kg/minute, respectively). The hemodynamic situation totally normalized after the ablation (electric and mechanical frequencies were both 61 bpm, the systolic blood pressures stabilized around 100 mm Hg). Over more than 2 hours since the start of the procedure, the BIS was stable at around 60.

To check the efficacy of the ablation, an isoproterenol perfusion was initiated up to 4 µg/minute, resulting in a rapid heart rate increase from 61 to 144 bpm, with a mild drop in the systolic blood pressure to 85 mm Hg which was treated with a 50-µg bolus of phenylephrine. At this moment, the anesthetic infusions were maintained at a stable level. After approximately 3 to 4 minutes of the onset of tachycardia, and with no apparent external stimulus, the patient suddenly stood up from the procedure table with a subsequent abrupt increase in the electrical and muscular BIS values. The immediate administration of boluses of propofol, midazolam, and rocuronium was able to bring the situation under control. Following this episode, the heart rate returned to 61 bpm, but to restabilize the depth of anesthesia at around 60, the perfusion doses of propofol, and remifentanyl had to be raised (4.5 mg/kg/hour and 0.18 µg/kg/minute, respectively). At the end of the study, 1 hour later, the patient emerged swiftly with no memories of the incident.

Discussion

The case herein discussed exemplifies how the isoproterenol infusion may bring about intraoperative awareness. This complication has been previously described in

similar procedures, although in those cases the patients were under sedation when the isoproterenol was infused.⁸⁻¹⁰ However, the infusion of this drug has not been considered an independent risk factor in the various reviews conducted on the causes of intraoperative awareness.⁴ In this case, the decision was made to administer general anesthesia based on the protocol adopted at our institution, and a total intravenous anesthesia was administered, notwithstanding the hemodynamic instability of the patient, because of 2 reasons: one strictly pharmacological (the null effect of remifentanyl² and propofol³ on the electrophysiological function of the atrioventricular node), and the other due to occupational health considerations (the arrhythmia room does not have a system for venting anesthetic gases).

In our opinion, there are 2 probable explanations for this phenomenon of intraoperative awareness. One of the theories that has been postulated is that awareness is the result of the modulation of consciousness at the central level, secondary to isoproterenol-induced stimulation of the adrenergic system.^{8,9} On the other hand, as previously stated, there is an inverse relationship between cardiac output and the concentration of propofol. Some papers have objectively concluded that the concentration of propofol during continuous infusion is inversely proportional to the increase in cardiac output, both in animals^{6,11} and in humans, following the administration of dopamine¹² or atropine.¹³ In fact, it has been established that the exogenous infusion of drugs that cause hyperdynamic circulation, including isoproterenol,^{8,9} adrenaline,^{14,15} or ephedrine,¹⁶ have an awareness effect or a significant increase of BIS in patients undergoing procedures under sedation. In contrast, the infusion of beta blockers has shown to reduce the requirements of intravenous anesthetic agents such as propofol.¹⁷

In our opinion, the second explanation is more consistent with our case, because it could explain both the abrupt episode of intraoperative awareness with isoprenaline due to the sudden drop in the concentrations of propofol, and the continuous increase in the doses of propofol needed to maintain a BIS value of around 60.

In fact, during the maintenance of anesthesia, the doses of propofol required to stabilize the BIS level were lower at basal conditions of disorganized cardiac contraction than the doses needed to maintain that same effect upon eliminating the ectopic foci. We don't have any cardiac output or propofol concentration measurements available, but we assume that the gradual normalization of the cardiac contraction progressively increased the stroke volume and hence the cardiac output, reducing the concentration of propofol, and hence requiring a propofol dose increase. This same reasoning could explain how, upon an abrupt increase in cardiac output with the administration of isoproterenol and phenylephrine, the patient presented with a sudden intraoperative awareness episode. However, the effect of the drugs that increase the

cardiac output has already been measured in animals,^{5,6} so it would be feasible with the necessary resources to undertake similar trials in humans, measuring the propofol concentrations pre and postisoproterenol infusion.

In summary, as a general rule, the recommendation is to adapt the anesthetic requirements to the patient's hemodynamic condition, both in terms of the baseline level, as well as with regards to any alterations that may develop. Our specific recommendation is to evaluate the possibility of administering a bolus of anesthetic agent before the administration of isoproterenol during ablation of pulmonary veins.

Ethical disclosures

Informed Consent. The patient submitted her informed consent to publish this case report.

Protection of persons and animals. The authors declare that no experiments in humans or animals were conducted for this research paper.

Confidentiality of the information. The authors declare that no patient data are disclosed in this article.

Right to privacy and informed consent. The authors declare that no patient data are disclosed in this article.

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Conflicts of interest

The authors have no conflict of interests to disclose.

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