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Application Value of Sevoflurane Combined with Brachial Plexus Block in Children with Humeral Fracture Surgery and its Effect on Hemodynamics: A Clinical and Anatomical Study

Valor de Aplicación del Sevoflurano Combinado con Bloqueo del Plexo Braquial en Niños con Cirugía de Fractura de Húmero y su Efecto sobre la Hemodinámica: Un Estudio Clínico y Anatómico

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SUMMARY: To observe the effect of sevoflurane combined with brachial plexus block (BPB) in children with humeral fracture surgery and its effect on hemodynamics. 84 children who received surgical treatment of humeral fracture in our hospital from September 2019 to September 2022 were selected. According to different anesthesia methods, the children were divided into control group and study group. The control group only received laryngeal mask sevoflurane; the study group received laryngeal mask sevoflurane combined with BPB. The operation situation, hemodynamic indexes, stress level, pain and adverse reactions of children was observed. The postoperative awakening time in the study group was lower than control group, the postoperative pain onset time in the study group was higher than control group (P<0.05). Intraoperative and postoperative 2 h, mean arterial pressure and heart rate in the study group were lower than control group (P<0.05). Preoperative, intraoperative, and postoperative 2h, there was no significant difference in oxygen saturation between the two groups (P>0.05). Postoperative 2h, the levels of serum cortisol, b-endorpin, norepinephrine and epinephrine in the study group were lower than control group (P<0.05). Postoperative 2 h, 12 h, 24 h, the visual analogue scale scores in the study group were lower than control group (P<0.05). There was no statistical difference in adverse reactions between the two groups (P>0.05). Sevoflurane combined with BPB is helpful to shorten the postoperative awakening time of children with humeral fracture, reduce the degree of postoperative pain, improve hemodynamics, and reduce stress response, and has good safety.

KEY WORDS: Humeral fracture; Sevoflurane; Brachial plexus block; Hemodynamics; Anesthesia.

INTRODUCTION

Violent events including heavy object impact and elbow landing can result in humeral fractures in children. The main symptoms include excruciating pain, swelling, deformity, and loss of upper arm function (Shenoy *et al*., 2020). Children with minor fracture symptoms may receive conservative treatment in a clinic setting. If conservative treatment fails, reduction and fixation of children with fracture through surgery is a common treatment method (Wiktor & Tomaszewski, 2022). However, because of children's immature physical and psychological development, the procedure is invasive, which results in the behavior of sobbing and anxiety in children who have fractures, as well as limited cooperation and low tolerance, which subsequently interferes with the procedure's smooth progression (Wu, 2020). Additionally, children's hemodynamic alterations brought on by the severe traumatic stress caused by surgery frequently have an impact on their postoperative recovery. Therefore, it is essential to use efficient anesthetic techniques to relax and relieve pain in children during humeral fracture surgery, which can effectively increase the safety of the operation.

Sevoflurane is a colorless, transparent, and non-irritating substance, which is mainly used to induce and maintain general anesthesia in surgery. Sevoflurane takes effect quickly, the depth of anesthesia is easy to control, and the circulation interference is small, the solubility is low, the recovery after anesthesia is fast, and the toxicity to the liver is small (Kang *et al*., 2021). Sevoflurane, as an inhalation anesthetic, is widely used through laryngeal mask

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airway in anesthesia of children's surgery because of its small irritation to respiratory tract, quick induction of anesthesia, easy acceptance by children and high safety (Zhong *et al*., 2018). In addition, the brachial plexus is the main nerve innervating the upper limb and scapula, and when it is abnormal, the upper limb movement will be restricted (Yang *et al*., 2020). Local anesthetics are injected all over the brachial plexus trunk (cervival, supraclavicular and axillary approachs) during brachial plexus block, which blocks the innervated tissues (Fig. 1). This technique has gained popularity as a blocking anesthetic technique for upper limb surgery since it is simple to learn and produces effective blocking (Xu *et al*., 2023). At present, there are few studies on the application effect of sevoflurane combined with BPB in children undergoing humeral fracture surgery. The purpose of this study is to observe the effect of this anesthesia on hemodynamics in children.

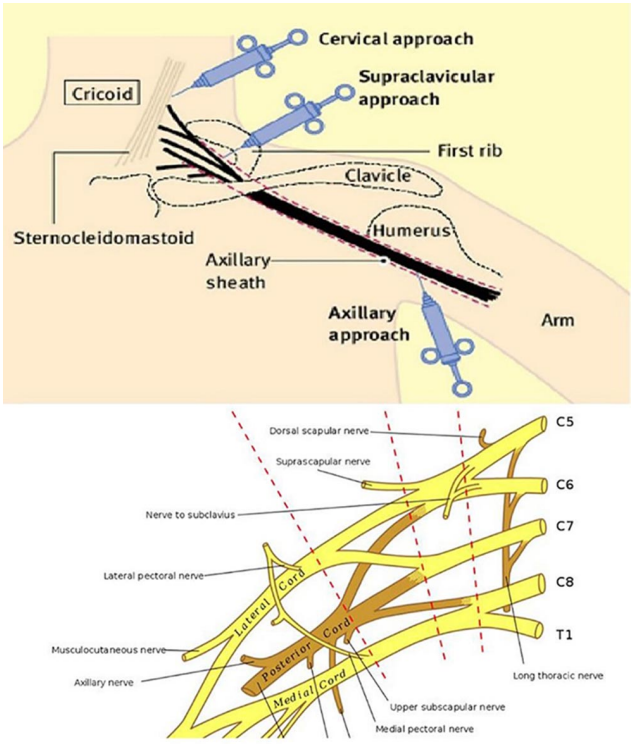

Fig. 1. Schematic representation of the brachial plexus block and its branches.

MATERIAL AND METHOD

Research object. 84 children who received surgical treatment of humeral fracture in our hospital from September 2019 to September 2022 were selected as the research object. Inclusion criteria: The child met the surgical indication of humeral fracture; Age 3-12 years old; The ASA rating was Grade I-II; The family members of the children gave informed consent to the study. Exclusion criteria: Contraindication of anesthesia; Allergy to the study drug; Complicated with serious organic diseases, immune diseases, and congenital diseases; Coagulation dysfunction or active bleeding; Complicated with asthma or upper respiratory tract infection. According to different anesthesia methods, the children were divided into control group and study group, with 42 cases in each group. The general data of the two groups were comparable (P>0.05), As shown in Table I.

Research methods: All children were routinely fasted and forbidden water before operation, and their vital signs were monitored. The control group only received laryngeal mask sevoflurane. Children were given midazolam 0.1 mg/kg+ fentanyl 2mg/kg+ propofol 2.5mg/kg+ cis-atracurium 0.15 mg/kg as anesthesia induction. After the anesthetic takes effect, put a laryngeal mask with appropriate size into the child. After the laryngeal mask is successfully placed, auscultate the breathing sounds in the lungs and observe the

Table I. Comparison of general data between the two groups (n, %, ±s).

Group	Sex		Age (years)	Body mass (kg)	ASA grading		Fracture site		
	Male	Female			Grade I	Grade II	Humeral condyle fracture	Proximal humeral fracture	Humeral shaft fracture
Control group (n=42)	24 (57.14%)	18 (42.86%)	7.81±2.69	24.77±5.69	38 (90.48%)	4 (9.52%)	34 (80.95%)	5 (11.90%)	3 (7.14%)
Study group (n=42)	26 (61.90%)	16 (38.10%)	7.88±2.37	25.22±5.33	37 (88.10%)	5 (11.90%)	31 (73.81%)	7 (16.67%)	4 (9.52%)
X^2/t value	0.198		0.126	0.374	0.124		0.615		
P value	0.657		0.899	0.709	0.724		0.735		

thoracic movement to ensure the correct intubation. During the operation, sevoflurane was inhaled with oxygen flow of 1L/min as anesthesia maintenance. The study group received laryngeal mask sevoflurane combined with BPB. The methods of anesthesia induction and anesthesia maintenance were the same as those of the control group. After the anesthetic took effect, BPB anesthesia was performed under the guidance of ultrasound. A puncture needle was inserted into the affected limb of the child, and the angle of needle insertion was adjusted under the guidance of ultrasound, and ropivacaine hydrochloride injection was given to the child through the puncture needle. The dosage of blocking liquid medicine is matched according to the basic vital signs of children. After the operation, the drug was stopped, and the laryngeal mask was removed after the child resumed spontaneous breathing.

Observation index

1. The operation situation of children was observed, including the operation time, postoperative awakening time, and postoperative pain onset time.
2. Preoperative, intraoperative, and postoperative 2 h, the hemodynamic indexes such as oxygen saturation (SpO2), mean arterial pressure (MAP) and heart rate (HR) were observed.
3. Preoperative and postoperative 2 h, the stress level of children was observed. 3 mL of peripheral venous blood was collected, and serum was separated after centrifugation. The levels of cortisol (Cor) and β-endorpin (β-EP) were determined by radioimmunoassay. The levels of norepinephrine (NE) and epinephrine (E) were determined by enzyme-linked immunosorbent assay.
4. Postoperative 2 h, 12 h, 24 h, the visual analogue scale (VAS) was used to evaluate the degree of pain of children, with a score of 0-10 points. The higher the score, the stronger the pain (Bodian *et al*., 2001).
5. The incidence of adverse reactions in children during postoperative anesthesia recovery period was counted, including drowsiness, restlessness, nausea, and vomiting.

Statistical analysis. The data were analyzed by SPSS 22.0 software. Measurement data were expressed as mean±standard deviation, and the comparison was analyzed by t test. Counting data were expressed as ratio, and the comparison was analyzed by X^2 test. When P<0.05, the difference was statistically significant.

RESULTS

Comparison of operation situation between two groups. The postoperative awakening time in the study group was lower than control group, the postoperative pain onset time in the study group was higher than control group (P<0.05). There was no significant difference in operation time between the two groups (P>0.05). As shown in Figure 2.

Comparison of hemodynamic indexes between two groups. Compared with preoperative, the MAP increased, and HR decreased intraoperative and postoperative 2h in both groups (P<0.05). Intraoperative and postoperative 2h, MAP and HR in the study group were lower than control group (P<0.05). Preoperative, intraoperative, and postoperative 2h, there was no significant difference in SpO2 between the two groups (P>0.05). As shown in Figure 3.

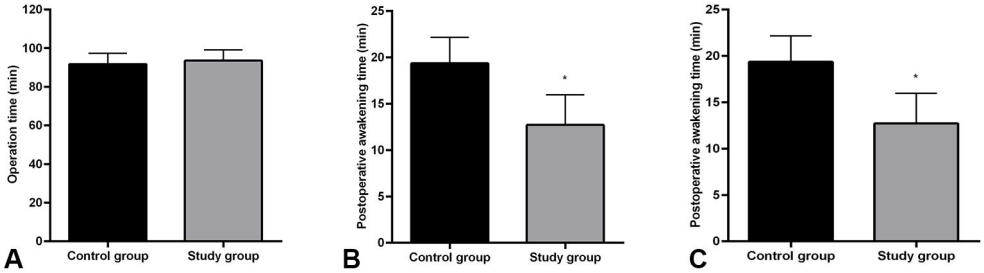

Fig. 2. Comparison of operation situation between two groups (A) Operation time; (B) Postoperative awakening time; (C) Postoperative pain onset time. Compared with the control group, *P<0.05.

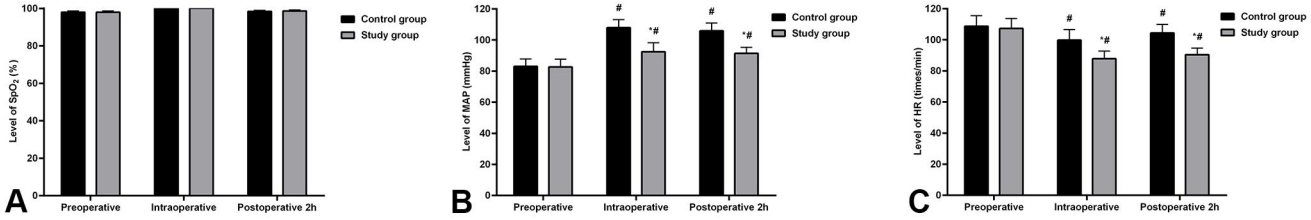

Fig. 3. Comparison of hemodynamic indexes between two groups (A) SpO2 level; (B) MAP level; (C) HR level. Compared with the control group, *P<0.05; Compared with preoperative, #P<0.05.

Comparison of stress indexes between two groups. Compared with preoperative, the levels of serum Cor, b-EP, NE and E in both groups increased postoperative 2h (P<0.05). Postoperative 2h, the levels of serum Cor, b-EP, NE and E in the study group were lower than control group (P<0.05). As shown in Figure 4.

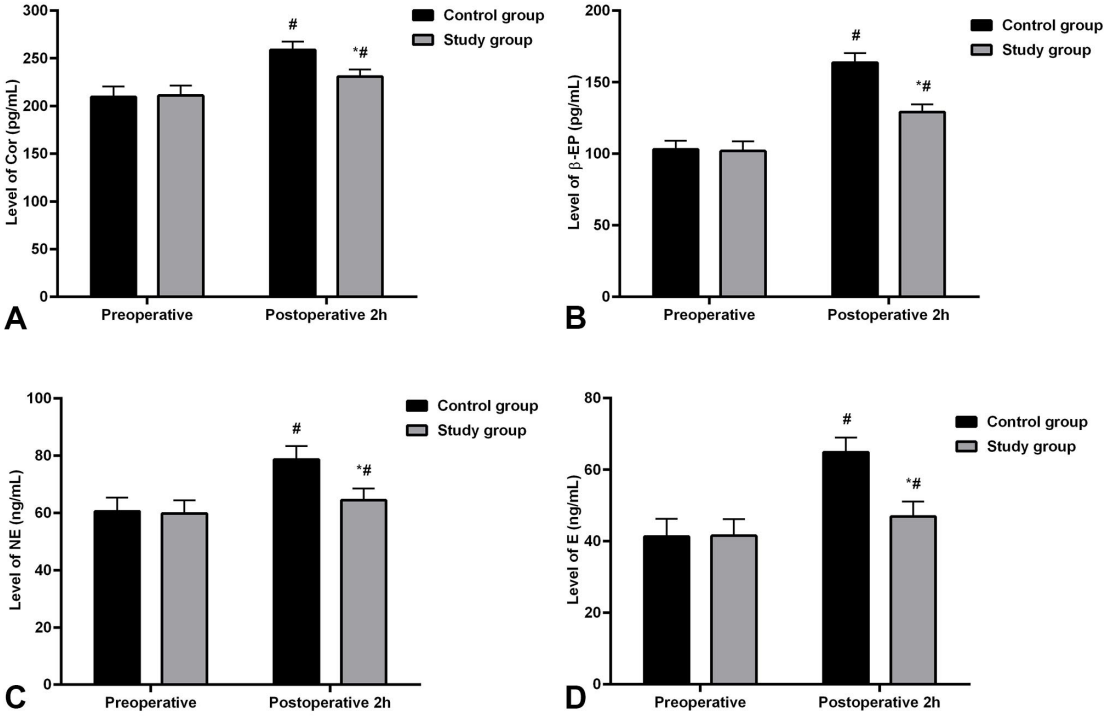

Fig. 4. Comparison of stress indexes between two groups (A) Serum Cor level; (B) Serum b-EP level; (C) Serum NE level; (D) Serum E level. Compared with the control group, *P<0.05; Compared with preoperative, #P<0.05.

Comparison of pain between two groups. Compared with postoperative 2h, the VAS scores in both groups increased postoperative 12h, 24h (P<0.05). Postoperative 2h, 12h, 24h, the VAS scores in the study group were lower than control group (P<0.05). As shown in Figure 5.

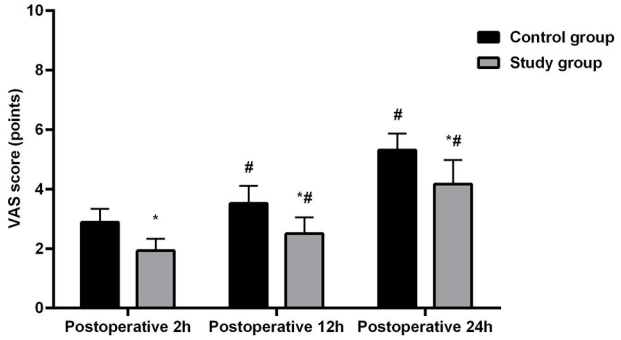

Fig. 5. Comparison of pain between two groups. Compared with the control group, *P<0.05; Compared with postoperative 2h, #P<0.05.

Comparison of adverse reactions between two groups. The total incidence of adverse reactions in the study group was lower than control group, but there was no statistical difference between the two groups (P>0.05). As shown in Table II.

Table II. Comparison of adverse reactions between two groups (n, %).

Group	Drowsiness	Restlessness	Nausea and vomiting	Total incidence rate
Control group (n=42)	2(4.76 %)	3(7.14 %)	4(9.52 %)	9(21.43 %)
Study group (n=42)	1(2.38 %)	1(2.38 %)	2(4.76 %)	4(9.52 %)
X^2 value				2.275
P value				0.131

DISCUSSION

Affected by many factors, the requirement of analgesia and sedation in children's fracture surgery is high, and sufficient intraoperative anesthesia is very important for the successful completion of the operation. In addition, there may be restlessness and hemodynamic instability in children after fracture surgery (Glover *et al*., 2015). Therefore, in order to reduce the pain of children with humerus fracture and stabilize the vital signs of children after surgery, the search for a safe and effective anesthesia program has attracted the attention of clinicians.

In recent years, laryngeal mask airway technology is becoming more and more mature, and many clinicians choose laryngeal mask airway instead of tracheal catheter as anesthesia equipment. Laryngeal mask anesthesia operation is simple, ventilation is reliable, and it has the advantages of less damage to throat and airway mucosa, less cardiovascular reaction, and good patient tolerance (Chen *et al*., 2020). Sevoflurane is a gas anesthetic with low blood gas distribution coefficient. It can also achieve sedative effect by short-term inhalation in application, without increasing airway and oral secretions, and has a positive effect on the management of respiratory tract (Kangralkar & Jamale, 2021). Sevoflurane administered through laryngeal mask does not require laryngoscope to expose glottis, which has low position requirements and is suitable for children with younger age or low coordination (Gupta & Datta, 2020). Choosing the intermuscular sulcus as the puncture point for BPB can cause nerve conduction block around the brachial plexus nerve trunk, and quickly take effect to inhibit local pain. Under the guidance of ultrasound, the puncture angle and depth of BPB can be accurately adjusted and controlled, which not only enhances the operability of BPB, but also urges anesthetic drugs to infiltrate nerve bundles to the greatest extent (Altinay *et al*., 2020; Zadrazil *et al*., 2020). However, due to the deep position of the lower trunk of brachial plexus at the level of intermuscular sulcus, application of intermuscular sulcus BPB alone may result in an incomplete block with a range that does not meet surgical requirements (Takeuchi *et al*., 2014). This study found that sevoflurane combined with BPB is beneficial to shorten the postoperative awakening time and prolong the postoperative pain onset time of children with humeral fracture, without increasing the operation time, and significantly reduce the postoperative pain of children. The possible reason is that compared with sevoflurane anesthesia alone, sevoflurane combined with BPB can exert a synergistic effect, which can block the sensory nerve, motor nerve and sympathetic nerve of upper limbs at the same time, give full play to the anesthetic advantages of nerve block. This is conducive to further strengthening the analgesic effect, not only can prolong the analgesic maintenance time, inhibit local pain, but also promote the postoperative awakening of children.

When suffering from physical and mental trauma caused by fracture surgery, the activity of sympathetic-adrenal medullary system will be strengthened, and the activation of hypothalamus-pituitary-adrenal cortex axis will be changed, so that the synthesis and secretion of various endocrine hormones will be changed, and the stress response will be activated (Clemmesen *et al*., 2019). When the body is strongly stimulated, there will be a series of stress reactions, mainly sympathetic nerve excitation and obvious enhancement of endocrine function of adrenal cortex and medulla, which will promote the release of Cor, b-EP, NE and E, promote the contraction of blood vessels and cause hemodynamic fluctuations (Hosseini *et al*., 2023). Ao *et al*. (2022) reported that during surgery for lower limb fractures, ultrasound-guided BPB combined with dexmedetomidine anesthesia can reduce the levels of NE and E, increase the level of MAP, and reduce the HR at T1, and this anesthesia scheme has little impact on patients' hemodynamics. Lin D *et al*.' s research shows that the application of intermuscular sulcus BPB combined with general anesthesia is beneficial to reduce the stress reaction and inflammatory reaction of patients undergoing shoulder arthroscopy, promote patients to have lower blood pressure and stable HR, and also reduce the dosage of opioids (Lin *et al*., 2021). This is roughly consistent with the results of our study. We found that MAP and HR in the study group were lower than control group intraoperative and postoperative 2h, and there was no significant difference between the two groups in SpO2. Postoperative 2h, the serum levels of Cor, b-EP, NE and E in the study group were lower than control group. The results suggest that sevoflurane combined with BPB can stabilize the intraoperative and postoperative vital signs of children with humeral fracture, reduce stress response, improve hemodynamics, and promote postoperative recovery. Sevoflurane acts on various receptors in the central nervous system and has a slight inhibitory effect on myocardium. When anesthesia deepens, blood pressure and HR decrease (Haraldsen *et al*., 2020). In addition, ropivacaine is a long-acting amide local anesthetic, which is mainly metabolized by the liver and has low neurotoxicity. Ropivacaine is not only a potassium channel blocker, but also can inhibit the sodium ion conduction of nerve cells and has an obvious blockade and separation effect of sensory and motor nerves, which is conducive to inhibiting neuronal excitation and preventing the transmission of pain signals (Vadagandla *et al*., 2020). Using ultrasound-guided injection of ropivacaine into BPB can dynamically monitor the distribution and diffusion degree of anesthetic drugs, ensure accurate

injection, effectively block sympathetic nerve, improve the success rate of nerve block, reduce the stress on the body and improve hemodynamics (Gao *et al*., 2022). We believe that after receiving sevoflurane with laryngeal mask and BPB with ropivacaine, children with humeral fracture can reduce the irritation of respiratory tract, prevent respiratory depression and cough, so SpO2 is in a relatively stable state, and MAP and HR are also improved. At the same time, this combined anesthesia scheme can give full play to their respective advantages, reduce the release of stress hormones, and alleviate the stress response of the body. Finally, this study observed that the addition of BPB on the basis of sevoflurane has good safety and does not increase the occurrence of adverse reactions. This may be due to the fact that BPB directly blocks the nerve of the affected limb in children with humerus fracture, and the depth of anesthesia is controllable, which is helpful to reduce the respiratory and circulatory inhibition caused by excessive dosage of anesthetic drugs, and thus does not increase the occurrence of drowsiness, restlessness, nausea and vomiting in children during postoperative anesthesia recovery (Li *et al*., 2023).

CONCLUSION

To sum up, sevoflurane combined with BPB is helpful to shorten the postoperative awakening time of children with humeral fracture, reduce the degree of postoperative pain, improve hemodynamics, and reduce stress response, and has good safety. Considering the various and complicated factors that affect the anesthetic effect of children's surgery, we still need to increase the sample size in the future to further verify the effectiveness and safety of sevoflurane combined with BPB in children with humeral fractures.

GUI, X.; XU, G.; SHU, R.; HE, Y. & LIU, R. Valor de aplicación del sevoflurano combinado con bloqueo del plexo braquial en niños con cirugía de fractura de húmero y su efecto sobre la hemodinámica: un estudio clínico y anatómico. *Int. J. Morphol., 41(6)*:1751-1757, 2023.

RESUMEN: El objetivo fue observar el efecto del sevoflurano combinado con bloqueo del plexo braquial (BPB) en niños con cirugía de fractura de húmero y su efecto sobre la hemodinámica. Se seleccionaron 84 niños que recibieron tratamiento quirúrgico de fractura de húmero en nuestro hospital desde septiembre de 2019 hasta septiembre de 2022. Según diferentes métodos de anestesia, los niños se dividieron en grupo control y grupo de estudio. El grupo control solo recibió sevoflurano en mascarilla laríngea; el grupo de estudio recibió sevoflurano con mascarilla laríngea combinado con BPB. Se observó la situación operatoria, índices hemodinámicos, nivel de estrés, dolor y reacciones adversas de los niños. El tiempo hasta el despertar postoperatorio en el grupo de estudio fue menor que el del grupo control, el tiempo de aparición del dolor postoperatorio en el grupo de estudio fue mayor que el del grupo control (P<0,05). Las 2 horas intraoperatorias y postoperatorias, la presión arterial media y la frecuencia cardíaca en el grupo de estudio fueron más bajas que en el grupo control (P <0,05). Preoperatorio, intraoperatorio y postoperatorio 2 horas, no hubo diferencias significativas en la saturación de oxígeno entre los dos grupos (P>0,05). A las 2 horas postoperatorias, los niveles séricos de cortisol, β-endorfina, norepinefrina y epinefrina en el grupo de estudio fueron más bajos que los del grupo control (P <0,05). Después de 2 h, 12 h, 24 h después de la cirugía , las puntuaciones de la escala analógica visual en el grupo de estudio fueron más bajas que las del grupo control (P <0,05). No hubo diferencias estadísticas en las reacciones adversas entre los dos grupos (P>0,05). El sevoflurano combinado con BPB es útil para acortar el tiempo de despertar del posoperatorio de los niños con fractura de húmero, reduce el grado de dolor postoperatorio, mejora la hemodinámica y reduce la respuesta al estrés, además de tener buena seguridad.

PALABRAS CLAVE: Fractura de húmero; Sevoflurano; Bloqueo del plexo braquial; Hemodinámica; Anestesia.

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