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Sevoflurane affects evoked electromyography monitoring in cerebral palsy

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Abstract: Background: To explore the effect of sevoflurane inhalation anesthesia on evoked electromyography monitoring of spinal nerve root in children associated with cerebral palsy. Methodology: Children with cerebral palsy (n=40) were selected and further divided into 1MAC (minimum alveolar concentration) sevoflurane group and 2MAC sevoflurane group. Following the induction of anesthesia, Nicolet Endeavor-CR16 channel electrophysiological monitor was used to implement three times of successive electrical stimulation with interval of 5 sec at 3.50 mA. Results: Our results suggested a statistical significance of amplitude retention ratio and latency in the sevoflurane inhalation time (P<0.01), with an interaction effect between the sevoflurane inhalation time and concentration for amplitude retention ratio (P<0.01), while there is no interaction effect between the sevoflurane inhalation time and concentration for latency (P>0.05). Compared to 1MAC sevoflurane group, the amplitude retention ratio of 2MAC sevoflurane group decreased remarkably (P<0.01) and the latency of 2MAC sevoflurane group extended at T3 and T4 (P<0.05 or P<0.01). Conclusions: In evoked electromyography monitoring of spinal nerve root in children with cerebral palsy, with the increasing of concentration and duration of sevoflurane inhalation, evoked electromyogram retention ratio reduces gradually, latency extends and the retention ratio has more changes than the latency.

Keywords: Sevoflurane, electromyography, spinal nerve root, cerebral palsy, children

1 Introduction

Cerebral palsy, the syndrome developing from a type of brain lesions due to Hypoxic-ischemia, infection and abnormal labor during perinatal period, mainly manifests as visual loss, dysphagia, salivation, postural dysfunction and dyskinesia [1]. Functional selective spinal posterior rhizotomy is a major surgical therapy to treat cerebral palsy by relieving lower limb spasticity, which further decides the location and proportion to excise the spinal root by evoked electromyography monitoring of spinal nerve. Furthermore, it has been stated that selective posterior rhizotomy is an effective method of alleviating spasticity and provides lasting functional benefits at acceptable complication levels in spastic children with cerebral palsy [2]. Sevoflurane is a proper child anesthesia drug, as it has no airway flash and is hemodynamically stable, with low Blood/gas partition coefficient and rapid recovery, but remains to be further studied about its effect on evoked electromyography monitoring of spinal nerve root in children with cerebral palsy. The studies of sevoflurane have involved many fields in clinical research, which includes anti-inflammatory effects and may attenuate the injury of myocardial ischemia/reperfusion injury [3]. As it is also used as a bronchodilator and sedative drug to treat a severe acute asthma attack [4], and on post-operative pain [5]. This research plan to study on the effect of sevoflurane inhalation anesthesia on evoked electromyography monitoring of spinal nerve root in children with cerebral palsy and provides reference for clinical study.

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2 Material and methods

2.1 General data

40 children associated with cerebral palsy with consent to have the functional selectivity of lumbar posterior rhizotomy were selected. They were selected aged between 3 and 12 without gender limits. The children suffering from epilepsy, neuromuscular disease and congenital heart disease were not included in this research. Patients were divided into 1MAC sevoflurane group and 2MAC sevoflurane group based on the concentration of sevoflurane inhalation with 20 patients in each group. Informed consent has been obtained from the guardians of all the children included in this study. The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee. The guardians of all the children accepting this treatment had been told the method, feature and possible complications in details and also signed the informed consent.

2.2 Therapeutic methods

The children were put on absolutely no food intake policy for 4 h before the surgery. 10 min before anesthesia, they were intravenously injected 0.1 mg/kg midazolam and 0.01 mg/kg penehyclidine hydrochloride. Heart rate, blood pressure, mean arterial blood pressure, respiration rate, arterial oxygen saturation, end-tidal pressure of carbon dioxide and bispectral index were all under monitoring. After successively injecting 0.3 μg/kg sufentanil, 0.1 mg/kg cisatracurium and 1.5 mg/kg propofol as anesthesia induction, tracheal cannula was performed, the ventilator was connected and in the pressure control ventilation mode, 11 cm H2O inhale positive airway pressure (1 cm H2O=0.098 kPa), 14 times/min ventilating frequency, inspiration and expiration ratio of 1:2, end-tidal pressure of carbon dioxide: 35~45 mm Hg (1 mm Hg =0.133 kPa) and oxygen flow of 1.5 L/min. The patients were intravenously pumped 0.1-0.2 μg.kg-1.min-1 remifentanil, 2-4 mg.kg-1.h-1 propofol to maintain the anesthesia effect and bispectral index to be 45-60. After completing anesthesia induction, the children were made in prone position and inserted needle electrode (2.3mm/160mm, 3005, Friendship Medical, Xian, China) of the electrophysiological monitor into their bilateral psoas major muscle, rectus femoris, musculus gastrocnemius and plantar muscles. The reference electrode was put in any place of both lower extremities. The surgeon incised the arachnoid and placed the children in the position of lower head and high feet, then absorbed cerebrospinal fluid around the nerve root and achieved a good hemostasis.

In this study, we monitored the function of adductor pollicis muscle during anesthesia by stimulating the four strings in ulnar nerve with the muscle relaxation monitor so that eliminating the effect of muscle relaxant on the experiment. When T4: T1≥0.8, a curved stimulation hook was used to induce the nerve root to be excised and implement three times of successive electrical stimulation which lasted 500 ms each time with interval of 5 sec at 3.50 mA. The average amplitude and latency of evoked electromyogram (EEMG) before sevoflurane inhalation (T0) was recorded as the basic value. Then we stopped using propofol. Continuous infusion of remifentanil by intravenous pump and inhaling of sevoflurane were used to maintain anesthesia effect so that achieving and keeping the minimum alveolar concentration (MAC) in need for grouping. At 1 min (Tl), 10 min (T2), 20 min (T3) and 30 min (T4) after achieving the necessary MAC, we implemented three times of successive electrical stimulation with the same interval at same intensity and record average amplitude and latency of EEMG. In case the blood pressure of patients dropped over 20% o f the basic value, the infusion speed of remifentanil was adjusted, or given small dose of ephedrine, and ephedrine in case of sinus bradycardia. Due to great difference in the basic amplitude of EEMG, the change of amplitude was shown by the amplitude retention ratio, namely amplitude retention ratio = EEMG amplitude at different inhaling time point/baseline amplitude. Results from all muscles have been pooled.

2.3 Indicators observed

The relation of amplitude retention ratio and preclinical change with different MAC sevoflurane inhalation and different time points should be observed. The change of heart rate, mean arterial blood pressure, arterial oxygen saturation before and after sevoflurane inhalation and the occurrence of cardiovascular reaction [bradycardia and hypotension (< basic value 20%)] was observed.

2.4 Statistical analysis

This study adopts SPSS 13.0 statistical software for analysis. Measurement data were expressed as mean ± standard deviation ($\bar{x}$ ±s), t test was applied for different group comparison and variance analysis for comparison in the group. $\chi 2$ test was adopted for the comparison of measurement data and P<0.05 was considered statistical significance.

3 Results

3.1 General material comparison between the two group patients

There was no significant difference between the two group patients in age, gender proportion, weight, anesthesia time, operation time and recovery time, then it's of comparability (P>0.05), see Table 1.

3.2 Comparison between the two group patients in the relation of sevoflurane inhalation time with EEMG amplitude retention ratio

According to the multivariate analysis result about the amplitude retention ratio, there was significant difference in the sevoflurane inhalation time (P<0.01). Compared with the time point T0, the amplitude retention ratio of 1MAC and 2AMC sevoflurane groups decreased from T2 and T1, and both reached the lowest at T4, respectively decreasing 7.4% and 14.7%. There was an interaction effect between the sevoflurane inhalation time and concentration (P<0.01). Compared with 1MAC sevoflurane group, the amplitude retention ratio of 2MAC sevoflurane group decreased remarkably (P<0.01) (Table 2; Figure 1).

3.3 Comparison between the two group patients in the relation of sevoflurane inhalation time with EEMG latency

According to the multivariate ANOVA analysis result about the latency, there was statistically significant difference in the sevoflurane inhalation time (P<0.01). Compared with the time point T0, the latency of both groups extended from T2 and T1, and both reached the highest at T4, respectively decreasing 7.4% and 14.7%. There was no interaction effect between the sevoflurane inhalation time and concentration (P>0.05). Compared with 1MAC sevoflurane group, the latency of 2MAC sevoflurane group extended at T3 and T4 (P<0.05 or P<0.01) (Table 3; Figure 2).

3.4 Adverse effect

The change in heart rate, mean arterial blood pressure, arterial oxygen saturation before and after sevoflurane inhalation had no significant differences (P>0.05), and no cardiovascular effect occurred during the observation.

Table 1: Comparison between the two group patients in general situation and operation condition

Group	N	Gender (M/F)	Age (Year old)	Weight (Kg)	Anesthesia time (min)	Operation time (min)	Recovery time (min)
1MAC	20	14/6	6.9±3.2	24.8±8.6	82.3±19.4	87.8±23.6	4.8±3.8
2MAC	20	13/7	6.8±3.4	23.7±8.2	84.6±18.7	92.8±21.4	4.9±4.2

Table 2: Comparison between the two group patients in the relation of sevoflurane inhalation time with EEMG amplitude retention ratio

Time Group	T0	T1	T2	T3	T4
1MAC	100	98.60±1.39	97.15 ± 1.8^{1}a	95.25 ± 1.2^{9}b	92.60 ± 1.9^{0}b
2MAC	100	$96.85\pm1.1^{4*}$b	$93.10\pm2.0^{0*}$b	$89.95\pm2.4^{4*}$b	$85.30\pm2.5^{1*}$b

Footnotes: compared with 1MAC sevoflurane group, *P<0.01; compared with T0, aP<0.05, bP<0.01.

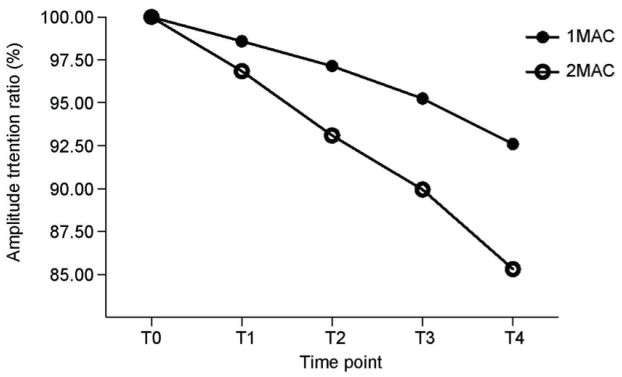

Figure 1: The charge trends of amplitude retention ratio.

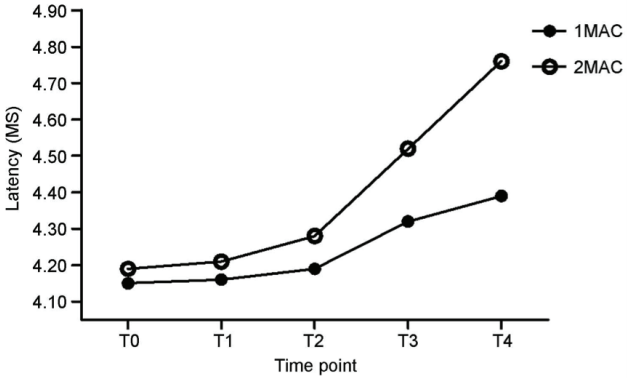

Figure 2: The charge trends of latency.

Table 3: Comparison between the two group patients in the relation of sevoflurane inhalation time with EEMG latency

Time Group	T0	T1	T2	T3	T4
1MAC	4.15±0.25	4.16±0.24	4.19±0.27	4.32±0.1[3]b	4.39±0.2[8]b
2MAC	4.19±0.28	4.21±0.27	4.28±0.2[8]b	4.52±0.3[4*]b	4.76±0.3[1a]b

Footnotes: compared with 1MAC sevoflurane group, *P<0.05, compared with T0, aP<0.05; bP<0.01.

4 Discussion

The neurophysiological monitoring technology has been widely applied in the operation of the functional selective spinal posterior rhizotomy for children with cerebral palsy current [6-8], as one of the main methods of this technology, the EEMG monitoring of spinal nerve root will greatly enhance the operation success rate and reduce the risk of iatrogenic nerve injury by monitoring the amplitude ratio and latency of EEMG to detect the excised location and proportion precisely [9], which therefore is of high value to guide the cerebral palsy operation. Sevoflurane is a drug of choice for pediatric anesthesia as it has no airway flash, is hemodynamically stable of low Blood/gas partition coefficient and rapid recovery. Studies have showed that the facial nerve motor-evoked potentials could amplitude from the orbicularis oculi muscle decreased after microvascular decompression in hemi-facial spasm patients whose symptoms were resolved postoperatively, thus suggesting normalization of facial nerve excitability, and facial nerve motor-evoked potentials monitoring during microvascular decompression surgery as well as lateral spread response monitoring could predict postoperative outcome in hemifacial spasm patients [6]. Research has shown that the sevoflurane latency will extend with its inhalation level increasing for facial nerve monitoring [10, 11], but few of them mention the operation for children with cerebral palsy. Therefore, this research studies the effect of sevoflurane inhalation anesthesia on evoked electromyography monitoring of spinal nerve root in children with cerebral palsy based on different MAC. Meanwhile, as there is big difference among the basic EEMG amplitudes of every child, this research adopts the amplitude retention ratio instead of amplitude value for statistical analysis so as to reduce the experimental error [12].

This study selects the sevoflurane concentration from 1 to 2 MAC for anesthesia of cerebral palsy operation based in the feature of sevoflurane pharmacokinetics. It uses a muscle relaxation monitor to measure the function of adductor pollicis muscle and tests at T4: T1≥0.8 so that eliminating the effect of muscle relaxant on the test. According to this research, the EEMG amplitude retention ratio of both groups is decreasing gradually with the extension of sevoflurane inhalation time, and comes to the lowest at T4. At the same time point, the amplitude retention ratio of 2MAC sevoflurane group is lower than 1MAC sevoflurane group and reduced to the lowest within viewing time when inhaling sevoflurane for 30min, which are 92.6% and 85.3%, declined by 7.4% and 14.7% respectively compared with the basic value. The study also indicates that the muscle relaxation is becoming apparent with the increasing of inhalation concentration and duration, which is related to sevoflurane pharmacokinetics that sevoflurane is passed into blood circulation after inhalation and plays anesthesia effect in the central nervous system. Sevoflurane, in contrast to its effect in animal

models, has been showed could promote endothelium-dependent relaxation in human omental arteries and veins via an enhancement of the smooth muscle response to relaxing second messengers [13]. The sevoflurane adsorption and distribution are related to several factor including concentration, alveoli ventilation and partial pressure gradient between alveoli and veins. Compared with 1MAC sevoflurane group, the amplitude retention ratios of 2MAC sevoflurane group decreased more early and greatly, which may be owing to its higher inhalation concentration and partial pressure gradient and then its sevoflurane adsorption and distribution is much quicker. Both groups in this study reached the lowest ratio at 30 min, which may be result by the double effect of sevoflurane on the central nervous system and neuromuscular junction. Suzuki etc [14], has confirmed, amplitude of the group inhaled sevoflurane decreased most evidently 30min later, to be 82.6% of the control value, which accords with the result of this study that amplitude retention ratio of sevoflurane 2MAC reaches 85.3% at 30min time point. Thus this research is of high credibility.

In this study, there are fewer changes in EEMG latency at different time points of sevoflurane inhalation, only evident at the time of 30 min, which indicates that the amplitude retention ratio can be affected by the concentration of sevoflurane more easily than the latency. Therefore, sevoflurane inhalation of 1MAC is appropriate for children needing nerve electrophysiological monitoring.

In conclusion, in evoked electromyography monitoring of spinal nerve root in children with cerebral palsy, with the increasing of concentration and duration of sevoflurane inhalation, EEMG retention ratio will reduce gradually, latency extends and the retention ratio has more changes than the latency.

Abbreviations

EEMG: evoked electromyogram;

MAC: minimum alveolar concentration

Conflict of interest: Authors state no conflict of interest

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