Continuous Infusion of Vecuronium in Children

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The average dose of vecuronium required in children during continuous infusion to attain a steady state block of 90% was determined. The electromyographic (EMG) response and mechanical response to supramaximal stimulation of the ulnar nerve recorded simultaneously, were significantly correlated in four children.

The steady-state infusion rate requirement of vecuronium was 1.4 ± 0.03 μg/kg/min during 2% enflurane anesthesia and 3.1 ± 0.03 μg/kg/min during 1% halothane anesthesia. The spontaneous recovery time to 25% of the control by EMG during halothane and enflurane anesthesia was 12.6 ± 1.1 and 10.3 ± 1.5 min, respectively, after termination of the infusion. There was no cumultative effect after prolonged vecuronium infusion. (Key words: neuromuscular relaxant, vecuronium anesthesia, pediatric)

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Vecuronium (ORG NC45), a monoquaternary derivative of pancuronium, has noncumulative effects, a short duration of action, lack of cardiovascular effects and no histamine releasing action. Because of its short duration of action and noncumulative effects, vecuronium may be a suitable muscle relaxant for continuous infusion during prolonged surgery[1,2].

In children, there have been no reports on the vecuronium infusion rates necessary for steady-state neuromuscular blockade with different anesthetic techniques. We examined the vecuronium infusion doses required to provide surgical relaxation in children during anesthesia.

Patients and Methods

Thirty-two children undergoing elective otolaryngologic surgery, ranging in age from one to nine years, were studied. Informed consent was obtained from a parent preoperatively. None had a history of disordered neuromuscular function, hepatic or renal disease. The electrocardiogram, arterial blood pressure and rectal temperatures were monitored. End-tidal carbon dioxide was monitored continuously to maintain normocarbia (measured by a NORMOCAP CO_2 Analyzer, CD-102, Datex, Helsinki, Finland).

1) Correlation between the electromyogram and electromechanogram

In four children (1–8 years old), the electromyographic response and mechanical response of the adductor pollicis using a force-displacement transducer (S-6174-A, Nihon Koden Corp., Tokyo, Japan) were recorded simultaneously. The body weight was 15.1 ± 4.9 kg (Mean ± SE). The patients received intramuscular atropine (0.02 mg/kg) 30 min before induction of anesthesia. Anesthesia was induced with nitrous oxide and halothane by face mask. After the patients became unconscious,

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an intravenous cannula was inserted and ECG electrodes were placed. The bipolar stimulating electrode was placed on the ulnar nerve. Supramaximal stimulation of train-of-four, 2Hz, 0.01 msec duration, was given every 20 sec. In this study, the first response was used for assessment of the single twitch. The bipolar electromyographic (EMG) electrodes were placed over the hypothenar eminence to record the evoked compound action potential, using an AB-100 system (Datex Instruments, Helsinki, Finland). The another electrode was placed on the wrist which was grounded. The degree of neuromuscular block was expressed as a percent of the control response.

2) Cumulative effects with repeated doses

The effects of repeated doses were studied in ten patients, age 2–10 years. Their body weight was 14.5 ± 4.3 kg (Mean ± SE). Following the insertion of an intravenous cannula into a peripheral vein of the forearm and the measurement of a control twitch, succinylcholine (1 mg/kg) was administered intravenously and endotracheal intubation was performed. When the EMG twitch height recovered to 90% of the control, 0.04 mg/kg of vecuronium was given. Repeated doses (0.02 mg/kg) were then given when the peak amplitude of EMG response recovered to 25% of the control. The time from the administration of a dose of vecuronium to 25% recovery of the control was measured.

3) Continuous infusin rate requirements

Eighteen patients, 5–9 years old, were studied to measure the infusion rate of vecuronium required to produce a blockade of more than 90%. Their body weight was 20.1 ± 2.2 kg (Mean ± SE).

They were randomly divided into two groups. Anesthesia was maintained with 70% nitrous oxide in oxygen, which was supplemented with halothane, 1% in the end-tidal phase, in 9 patients and enflurane, 2% in the end-tidal phase, in the remaining 9 patients. After an initial bolus dose of vecuronium (0.08 mg/kg), the trachea was intubated. A continuous infusion was started with a continuously variable infusion pump at an infusion rate of 1 μg/kg/min. The rate of infusion was titrated to induce more than 90% depression of the EMG, which was maintained for at least 15 minutes. When recovery was noted during this period, the infusion rate was increased by a step of 0.5 μg/kg/min. The infusion was discontinued just before the completion of surgery and the time of recovery to 25% of the control twitch height was recorded in the two groups.

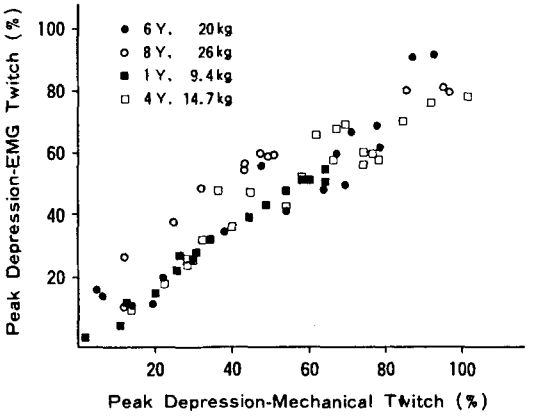

Fig. 1. Depression in EMG amplitude against depression in mechanical twitch in four children. The x-axis shows the peak depressions of the mechanical twitch; the y-axis shows the peak depressions of the EMG twitch height. $Y = 0.812X + 3.64$, $r = 0.92$ ($P < 0.01$).

Standard errors are shown for all mean values. The data were compared using Student's t-test. Statistical differences were considered significant at $P < 0.05$.

Results

Figure 1 compares the peak depression of the EMG twitch height and the mechanical twitch tension of sixty-five simultaneous measurements in four children. The regression line in the four children was $y = 0.812x + 3.64$; the mean correlation coefficient was 0.92. There was a good correlation between the peak depressions by the two methods.

Figure 2 shows the typical example of the record in a child receiving repeated doses of vecuronium. The recovery time to 25% of the control EMG amplitude after the first to fourth dose was 16.1, 13.9, 12.9 and 12.5

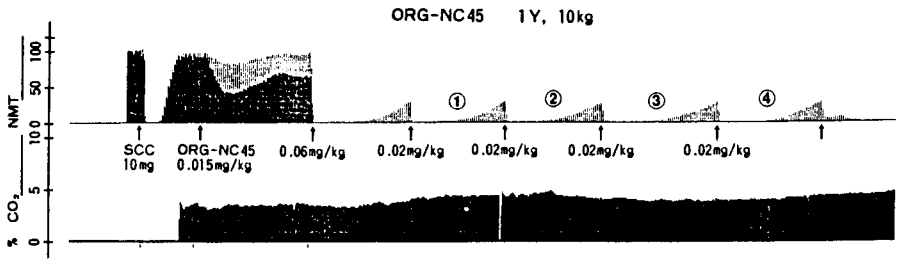

Fig. 2. Individual tracings of the EMG twitch height by repeated injections of vecuronium.

Table 1. Mean vecuronium infusion rate and 25% recovery time

	Enflurane–N_2O (n = 9)	Halothane–N_2O (n = 9)
Infusion time (hr)	3.1 ± 0.52	2.9 ± 0.48
Infusion rate (μg/kg/min)	1.4 ± 0.03	3.1 ± 0.03
25% recovery time (min)	10.3 ± 1.5	12.4 ± 1.2

minutes, respectively. Vecuronium produced no cumultative effects with repeated doses.

The mean rate of infusion of vecuronium required to produce a blockade of 90% or greater during halothane or enflurane anesthesia are summarized in table 1. The infusion rate required to produce a similar degree of blockade during enflurane anesthesia was significantly less than that during halothane anesthesia (P <0.05). However, there were no differences in the recovery time to 25% of twitch height between halothane and enflurane anesthesia.

Discussion

The correlation of electromyographic responses and mechanographic responses in the present study confirmed previous studies[3–5], which indicated that EMG monitoring is a reliable method to monitor the neuromuscular blockade during anesthesia.

The infusion rate required to produce more than 90% depression in children was greater than that reported for adults[6,7]. In the study by Swen[6], the continuous infusion dose of vecuronium was 0.79 μg/kg/min (47.6 μg/kg/hr) during halothane anesthesia whereas our maintenance dose used in this study was 3.1 μg/kg/min. This difference between child and adult may be due to the relatively larger volume of distribution in children than in adults.

It was reported that vecuronium had no cumultative effect with repeated doses[8], as shown in figure 2 or with continuous infusion[7] similar to our study. The recovery time from the end of the infusion of vecuronium to 25% of the control responses averaged 20 min in adults[9]. This recovery time was longer than that in our study; the derived recovery time in our study was 10.3 min in the enflurane anesthesia group and 12.4 min in the halothane anesthesia group.

A greater potentiation of the action of non-depolarizing muscle relaxants by enflurane than halothane are well known[9]. The present study confirmed that the rate of infusion required to produce a similar degree of blockade was greater during halothane anesthesia.

The wide variation in the infusion rate of vecuronium required to produce a certain degree of blockade is a great ploblems in clinical practice[6,10]. Agoston et al.[10] reported a range from 0.18 to 1.5 μg/kg/min during fentanyl–nitrous oxide anesthesia. It ranged from 2.5 to 4.5 mg/kg/min during halothane anesthesia in the present study. It is thus advisable to continuously monitor neuromuscular blockade during anesthesia.

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