J Anesth (1994) 8:143–145

Journal of
Anesthesia

Differential effects of vecuronium on the thumb and the big toe muscles evaluated by acceleration measurement

Toshimitsu Kitajima, Keiichi Ishii, Toshiya Kobayashi, and Hiromaru Ogata

First Department of Anesthesiology, Dokkyo University School of Medicine, Mibu, Shimotsugagun, Tochigi, 321-02 Japan

Abstract: To clarify the differential effects of vecuronium on the thumb and on the big toe, train-of-four (TOF) stimuli were applied to the ulnar nerve at the wrist and the tibial nerve at the ankle in anesthetized patients using two acceleration transducers. Ten adult patients, aged 21–55 years, were studied. Anesthesia was induced by an intravenous injection of thiopental, and vecuronium 0.1 mg·kg^{-1} was used for paralysis. Anesthesia was maintained with nitrous oxide (66%)-oxygen-sevoflurane (1 MAC). The duration of time to the maximal twitch depression on the thumb and the big toe was 136.5 ± 32.5 s and 183.0 ± 40.1 s ($P < 0.05$), respectively. The time to 25% recovery of the twitch height on the thumb and the big toe was 48.1 ± 17.3 min and 39.1 ± 11.6 min, respectively; the time to 50% recovery of twitch height on the thumb and the big toe was 54.1 ± 16.1 min and 40.0 ± 9.2 min ($P < 0.05$), respectively. When paralysis was reversed at 25% of TOF ratio on the thumb, the value of the TOF ratio on the big toe was 58.5 ± 18.2% ($P < 0.01$).

Key words: Accelograph, Flexor hallucis brevis, Adductor hallucis, Adductor pollicis, Vecuronium

Introduction

The mechanical response of the thumb to electrical stimulation of the ulnar nerve is the most widely used method to detect the degree of neuromuscular blockade after the administration of a non-depolarizing muscle relaxant. Instead of the arm, however, the leg is sometimes used for monitoring of neuromuscular blockade when a patient is to undergo an operation of the head, face, or arm, because the anesthesiologist must move to the side of the operating table with the anesthetic machine. Therefore, monitoring of the big toe is used for maintenance dosing during surgery and for assessment of the presence or absence of a reversible block. We have observed the degree of neuromuscular blockade on the big toe visually or tactually using an electrical nerve stimulator.

Recently an Accelograph (Biometer, Copenhagen, Denmark) has been developed as a new neuromuscular transmission monitor [1]. It measures the single twitch response and train-of-four (TOF) ratio using an acceleration transducer attached to the big toe. During simultaneous TOF stimulation of the ulnar nerve and the tibial nerve, acceleromyographic responses were measured from the thumb and the big toe, respectively. The purpose of this study was to clarify the differential effects of neuromuscular blockade on the thumb and on the big toe after the administration of vecuronium.

Materials and methods

Ten adult patients, 21–55 years old, ASA physical status I or II, who were scheduled to undergo elective ear-nose-throat surgery were studied after informed consent (Table 1). They were within 15%, of ideal body weight. Patients with hepatic, renal, or neuromuscular disease were excluded from the study.

All patients were premedicated with intramuscular hydroxyzine 50 mg and atropine sulfate 0.5 mg 1 hour before surgery. The cutaneous electrodes of the Accelograph were simultaneously applied to the left wrist and ankle opposite a blood pressure cuff and an intravenous line to stimulate the ulnar nerve and the tibial nerve at a frequency of 2 Hz for TOF stimulation every 15 s, with the positive electrode over the proximal and the negative electrode over the distal parts. The acceleration transducers were fastened to the left thumb and the big toe with adhesive tape.

Anesthesia was induced with thiopental 5 mg·kg^{-1} intravenously. The patients were ventilated manually with 50% nitrous oxide in oxygen with sevoflurane

Address correspondence to: T. Kitajima
Received for publication on March 3, 1993; accepted on June 26, 1993

Table 1. Patient demographics

Sex	Males 7 Females 3
Age (years)	37.8 ± 10.6 (range 21–55)
Body weight (kg)	68.1 ± 13.4 (range 42.4–87)
Operation	ENT Surgery 10

Values expressed as mean ± SD.
ENT, Ear-nose-throat.

(2 MAC) using an anesthesia face mask. When the depth of anesthesia was adequate, both apparatuses were adjusted to supramaximal stimulation and baseline responses from the thumb and the big toe were obtained in each transducer. Then tracheal intubation was facilitated with a single bolus intravenous injection of vecuronium 0.1 mg·kg^{-1} and anesthesia was maintained with 66% nitrous oxide in oxygen supplemented with sevoflurane (1 MAC). Ventilation was controlled and end-tidal carbon dioxide tension was maintained between 32 and 38 mmHg. Paralysis was reversed using intravenous neostigmine 2 mg with atropine 1 mg when the TOF ratio at the thumb returned to 25%.

We measured the time from injection of vecuronium to the maximal (100%) twitch depression on the thumb and the big toe, the time to 25% and 50% recovery of the twitch height on the thumb and the big toe, and the value of TOF ratio on the big toe at 25% of TOF ratio on the thumb. The values of single twitch height were obtained from the first height of TOF.

Analysis of variance (ANOVA) was used for analysis of data. Results are provided as mean ± SD. The threshold for statistical significance was $P < 0.05$.

Results

The mean values (±SD) obtained from both transducers on the thumb and the big toe are shown in Table 2. The time to the maximal twitch depression from the initial dose on the big toe was significantly longer than that on the thumb. Figure 1 shows a typical example of the recording of TOF fade from both transducers. The time of spontaneous recovery to 25% of the control twitch height on the big toe was shorter than that on the thumb. However, no statistically significant difference was observed between them. The time of spontaneous recovery to 50% of the control twitch height on the big toe was significantly shorter than that on the thumb. There was a significant difference between the recovery rates. The value of TOF ratio on the big toe was 58.5 ± 18.2% when the reversal for vecuronium was performed at 25% of TOF ratio recorded from the thumb.

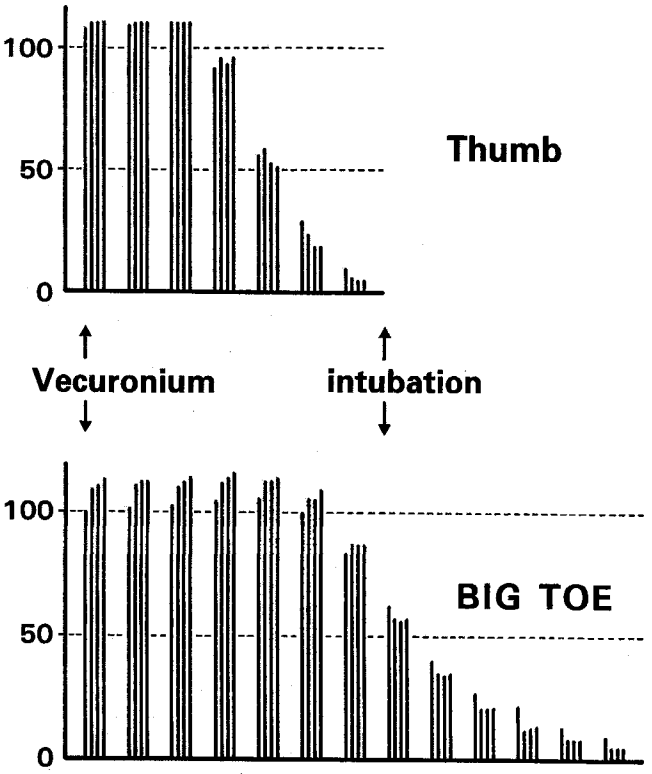

Fig. 1. Recording from the Accelograph showing the disappearance of the train-of-four response on the thumb and the big toe after the injection of vecuronium 0.1 mg·kg^{-1}

Discussion

An electrical nerve stimulator is often applied to the leg to detect the degree of neuromuscular blockade after

Table 2. Variables obtained from both transducers on the thumb and the big toe

	Thumb	Big toe
Time to maximal twitch depression (s)	136.5 ± 32.5	183.0 ± 40.1*
Time of spontaneous recovery to T_{25} (min)	48.1 ± 17.3	39.1 ± 11.6
Time of spontaneous recovery to T_{50} (min)	54.1 ± 16.1	40.0 ± 9.2*
TOF ratio at reversal (%)	25.0	58.5 ± 18.2**

Values expressed as mean ± SD.
TOF, train-of-four.
* $P < 0.05$; ** $P < 0.01$.

the administration of a non-depolarizing muscle relaxant during surgery when a patient is anesthetized to undergo an operation of the head, face, or arm. We have observed the movement of the big toe visually or tactually and conjecture about the degree of neuromuscular blockade.

Recently, the Accelograph has been developed for the reliable method of evaluating neuromuscular blockade [2–5]. It is based on a new measuring principle; measurement of force is replaced by measurement of acceleration. The muscle on which the measurement is being made can move without any restriction. Therefore, we can easily measure the degree of neuromuscular blockade using an acceleration transducer which is fastened to the big toe with adhesive tape. The necessary data concerning the neuromuscular transmission is available on a print-out.

In the present study, the electrical stimulation was applied to the ulnar nerve at the wrist and the tibial nerve at the ankle. The innervation of the ulnar nerve ends the adductor pollicis in the thenar region and the motor response is assessed at the thumb. The tibial nerve innervates the flexor hallucis brevis and the adductor hallucis in the plantar region. Since we observed the flexion of the big toe as the main response to the tibial nerve stimulation, the big toe was considered as the optimal placement of the acceleration transducer.

The time required from the administration of vecuronium to the completion of the maximal block on the thumb was shorter than on the big toe. The shorter onset time of the thumb may be due to quicker blood delivery of vecuronium and the different sensitivity to the muscles.

The time of spontaneous recovery to 50% of control twitch height on the thumb was statistically longer than that on the big toe. When paralysis of vecuronium was reversed at 25% of the TOF ratio on the thumb, the value of the TOF ratio on the big toe was 58.5% and significantly higher than that on the thumb. The reason why the recovery of the adductor pollicis, which has a high percentage of fast fibers [6], is slower than the flexor hallucis brevis and the adductor hallucis may be that fast fibers have greater sensitivity to a non-depolarizing muscle relaxant [7,8].

In a previous study, Sopher et al. [9] compared the response of the adductor pollicis with that of the flexor hallucis brevis using surface-electromyogram. Recovery of neuromuscular function of the adductor pollicis correlated to that of the flexor hallucis brevis. The reason why our results were different from theirs may be due to different methods for the assessment of neuromuscular blockade. We usually observe the movement of big toe visually or tactually to detect the degree of neuromuscular blockade. Accordingly, the results from an acceleration transducer may be closer to the clinical observation.

Monitoring at the big toe muscle using an acceleration transducer may result in underestimation of neuromuscular blockade. If so, residual paralysis may exist in the airway muscles when the neuromuscular function is assessed from the movement of the big toe.

References

1. Jensen E, Viby-Mongensen J, Bang U (1988) The Accelograph: A new neuromuscular transmission monitor. Acta Anaesthesiol Scand 32:49–52
2. Itagaki T, Tai K, Katsumata N, et al. (1988) Comparison between a new acceleration transducer and a conventional force transducer in the evaluation of twitch responses. Acta Anaesthesiol Scand 32:347–349
3. Viby-Mogensen J, Jensen E, Werner M, et al. (1988) Measurement of acceleration: A new method of monitoring neuromuscular function. Acta Anaesthesiol Scand 32:45–48
4. May O, Nielsen HK, Werner MU (1988) The acceleration transducer—An assessment of its precision in comparison with a force displacement transducer. Acta Anaesthesiol Scand 32:239–243
5. Werner MU, Nielsen HK, May O, et al. (1988) Assessment of neuromuscular transmission by the evoked acceleration response. Acta Anaesthesiol Scand 32:395–400
6. Johnson MA, Polgar J, Weightman D, et al. (1973) Data on the distribution of fibre types in thirty-six human muscles: An autopsy study. J Neurol Sci 18:111–129
7. Secher NH, Rube N, Secher O (1982) Effects of tubocurarine on human soleus and gastrocnemius muscles. Acta Anaesthesiol Scand 26:231–236
8. Day NS, Blake GJ, Standaert FG, et al. (1983) Characterization of the train-of-four response in fast and slow muscle: Effects of d-tubocurarine, pancuronium, and vecuronium. Anesthesiology 58:414–417
9. Sopher MJ, Sears DH, Walts LF (1988) Neuromuscular function monitoring comparing the flexor hallucis brevis and adductor pollicis muscles. Anesthesiology 69:129–131