Neuromuscular blockade for rapid tracheal intubation in children: comparison of succinylcholine and pancuronium

Mary Cunliffe MB BS FFARCS,
V. Maxim Lucero MD,
M. Elizabeth McLeod MD FRCPC,
Frederick A. Burrows MD FRCPC,
Jerrold Lerman MD FRCPC

To compare the effectiveness of succinylcholine and pancuronium for rapid intubation in children, 49 healthy children ages two to eight years were studied. After induction of anaesthesia with thiopentone and atropine, and administration of droperidol, fentanyl, nitrous oxide, and oxygen, each child received one of the following muscle relaxants: succinylcholine 1.5 mg·kg^{-1} (n = 12), succinylcholine 1.0 mg·kg^{-1} (n = 13), pancuronium 0.15 mg·kg^{-1} (n = 11), or pancuronium 0.10 mg·kg^{-1} (n = 13). The force of thumb adduction was measured by stimulating the ulnar nerve with repetitive supramaximal single twitches (0.15 Hz). The time to 95 per cent twitch depression (mean ± S.D.) was most rapid with succinylcholine 1.5 mg·kg^{-1} (40.8 ± 3.0 seconds) and succinylcholine 1.0 mg·kg^{-1} (51.8 ± 14.0 seconds), slowest with pancuronium 0.10 mg·kg^{-1} (150.9 ± 38.0 seconds), and intermediate with pancuronium 0.15 mg·kg^{-1} (80.3 ± 21.8 seconds) ($p < 0.005$). The intubating conditions were excellent in 100% of the children who received succinylcholine 1.5 and 1.0 mg·kg^{-1}, and pancuronium 0.15 mg·kg^{-1}, but were excellent in only 69 per cent of those who received pancuronium 0.10 mg·kg^{-1}. We conclude that succinylcholine 1.5 mg·kg^{-1} produces the most rapid onset of excellent intubating conditions in children. In children in whom succinylcholine is contraindicated, pancuronium 0.15 mg·kg^{-1} provides excellent intubating conditions within 80 seconds.

Key words
ANAESTHESIA: paediatric; MEASUREMENT TECHNIQUES: neuromuscular blockade; NEUROMUSCULAR RELAXANTS: pancuronium, succinylcholine.

From the Department of Anaesthesia and the Research Institute, The Hospital for Sick Children, Toronto, Ontario.

Address correspondence to: Dr. Jerrold Lerman, Department of Anaesthesia, The Hospital for Sick Children, 555 University Avenue, Toronto, Ontario M5G 1X8.

Rapid tracheal intubation is recommended for children with full stomachs who require general anaesthesia. In order to secure the airway rapidly and atraumatically during rapid tracheal intubation, the muscle relaxant administered should satisfy two conditions: (1) have a rapid onset of action and (2) provide excellent intubating conditions. In adults, succinylcholine 2.0 mg·kg^{-1} with precurarization (pretreatment with d-tubocurare 3 mg), succinylcholine 1.5 mg·kg^{-1} without precurarization, and pancuronium 0.15 mg·kg^{-1} have been shown to satisfy these conditions.[1,2] In children, although pancuronium 0.15 mg·kg^{-1} is commonly used to facilitate rapid tracheal intubation when succinylcholine is contraindicated, neither the time to 95 per cent twitch depression nor the intubating conditions for succinylcholine 1.5 mg·kg^{-1} and pancuronium 0.15 mg·kg^{-1} have been compared. Therefore, we measured the time to 95 per cent twitch depression and evaluated the intubating conditions in 49 healthy children undergoing elective surgery.

Methods

With approval from our committee on human research, 49 children ages two to eight years were studied. The children were ASA physical status I and II, fasting and unpremedicated. Children were excluded if there was a history of neuromuscular or

renal diseases, or if a difficult intubation was anticipated.

With the routine monitors in place, anaesthesia was induced with intravenous thiopentone 5 $mg \cdot kg^{-1}$ and atropine 0.02 $mg \cdot kg^{-1}$, and maintained with droperidol 0.075 $mg \cdot kg^{-1}$ and fentanyl 0.002 $mg \cdot kg^{-1}$. Ventilation was spontaneous with 70 per cent nitrous oxide and 30 per cent oxygen. Supplemental doses of thiopentone were given as necessary.

Following induction of anaesthesia, two needle electrodes were applied over the ulnar nerve on the volar aspect of the wrist, 2 cm and 7 cm proximal to the wrist. Square wave pulses of supra-maximal voltage were delivered by a Grass S4 nerve stimulator through an SIU5 isolation unit. The pulses were delivered at a frequency of 0.15 Hz and duration of 0.2 msec. The force of thumb adduction was measured using a Grass force displacement transducer FT-03. The twitch response was recorded on a Gould #2200S recorder. After a stable twitch response (control) was obtained, one of four muscle relaxants was administered intravenously: succinylcholine 1.5 $mg \cdot kg^{-1}$ (n = 12), succinylcholine 1.0 $mg \cdot kg^{-1}$ (n = 13), pancuronium 0.15 $mg \cdot kg^{-1}$ (n = 11), or pancuronium 0.10 $mg \cdot kg^{-1}$ (n = 13). Ventilation was controlled after administration of the muscle relaxant. When the twitch response was depressed 95 per cent below control, laryngoscopy and intubation were performed. The intubating conditions were assessed according to criteria adapted from Lund and Stovner (Table I).[3]

Statistical significance ($p < 0.05$) was determined using one-way ANOVA and Student-Newman-Keuls test for comparisons of age, weight, and time to 95 per cent twitch depression among the groups, and the Fisher exact test for comparison of intubating conditions.

Results

The mean ages and weights for the four groups did not differ significantly (Table II). The time to 95 per cent twitch depression (mean ± SD) was most rapid with succinylcholine 1.5 $mg \cdot kg^{-1}$ (40.8 ± 3.0 seconds) and succinylcholine 1.0 $mg \cdot kg^{-1}$ (51.8 ± 14.0 seconds), slowest with pancuronium 0.10 $mg \cdot kg^{-1}$ (150.9 ± 38.0 seconds), and intermediate with pancuronium 0.15 $mg \cdot kg^{-1}$ (80.3 ± 21.8) ($p < 0.005$) (Table III). The intubating conditions were excellent in 100 per cent of the children paralyzed with succinylcholine 1.5 $mg \cdot kg^{-1}$, 1.0 $mg \cdot kg^{-1}$, and pancuronium 0.15 $mg \cdot kg^{-1}$, but were excellent in only 69 per cent of those paralyzed with pancuronium 0.10 $mg \cdot kg^{-1}$ (Table III) (p = NS).

TABLE I Intubating conditions

Excellent	Vocal cords paralyzed
Good	Vocal cords moving
Fair	Coughing, straining, movement of extremities
Poor	Unable to intubate

Adapted from Lund and Stovner.[3]

TABLE II Demographic data

	Succinylcholine		*Pancuronium*	
Dose ($mg \cdot kg^{-1}$):	1.5 (n = 12)	1.0 (n = 13)	0.15 (n = 11)	0.10 (n = 13)
Age (yrs):	4.5 ±2.0	3.9 ±1.8	4.1 ±1.9	4.4 ±1.6
Weight (kg):	18.2 ±6.1	16.4 ±3.7	17.9 ±4.1	17.9 ±3.6

Mean ± SD.
Numbers in parentheses are the number of children in the treatment groups.

TABLE III Results

	Succinylcholine		*Pancuronium*	
Dose ($mg \cdot kg^{-1}$):	1.5	1.0	0.15	0.10
Time to 95% twitch depression (sec):	40.8 ±3.0	51.8 ±14.0	80.3† ±21.8	150.9* ±38.0
Intubating conditions:				
Excellent:	12	13	11	9
Good:	—	—	—	4
Fair:	—	—	—	—
Poor:	—	—	—	—

Mean ± SD.
*$p < 0.001$ compared to the other three groups.
†$p < 0.001$ compared to succinylcholine 1.5 $mg \cdot kg^{-1}$, and $p < 0.005$ compared with succinylcholine 1.0 $mg \cdot kg^{-1}$.
Intubating conditions: p = NS.

Discussion

We found that the time to 95 per cent twitch depression in children is significantly more rapid with succinylcholine 1.5 $mg \cdot kg^{-1}$ than with pancuronium 0.15 $mg \cdot kg^{-1}$ (by 100 per cent). This is

consistent with our clinical impression that succinylcholine has a more rapid onset of action than pancuronium.[4–6] Our results suggest that although succinylcholine 1.5 mg·kg^{-1} remains the preferred muscle relaxant for rapid tracheal intubation, pancuronium 0.15 mg·kg^{-1} will provide excellent intubating conditions within 80 seconds in children in whom succinylcholine is contraindicated.

The difference in the time to 95 per cent twitch depression with succinylcholine 1.5 mg·kg^{-1} and pancuronium 0.15 mg·kg^{-1} is particularly important for children who require a rapid intubation sequence. Because both the ratio of alveolar ventilation to functional residual capacity and the minute oxygen consumption are greater in children than in adults, the period of apnoea which children can tolerate is shorter than for adults. Our results show that the period of apnoea between induction of anaesthesia and maximum muscle relaxation is longer with pancuronium than with succinylcholine. In order to minimize this period, we recommend that pancuronium 0.15 mg·kg^{-1} be administered before thiopentone. This latter drug sequence should provide optimal intubating conditions (maximum depth of anaesthesia coincidental with maximum muscle paralysis) during rapid tracheal intubation when succinylcholine is contraindicated.[7]

The times to 95 per cent twitch depression with pancuronium 0.1 mg·kg^{-1} and pancuronium 0.15 mg·kg^{-1} in this study are consistent with previous published reports,[1,4,8] but are significantly longer than in our previous abstract.[9] This latter difference may be attributed to a variable baseline on a Wanamaker pen recorder. The similarity in the times to 95 per cent twitch depression with succinylcholine and pancuronium in the present study compared with those in other reports indicates that the equipment used in the present study provides accurate measurement of twitch depression.

In order to minimize variability in the data, our technique was standardized. We used only needle electrodes in this study, although other investigators continue to use both surface and needle electrodes for neuromuscular studies in children.[8,10] Previous studies have found no statistically significant difference in the time to 95 per cent twitch depression with these two types of electrodes.[11,12] The optimal position of the electrodes and the optimal sequence of positive and negative electrodes may be important to ensure a maximum twitch response.[13,14] We placed the electrodes over the ulnar nerve proximal to the wrist creases, 5 cm apart. Futhermore, it has been shown that when the frequency of the twitch stimulus is greater than 0.15 Hz, the neuromuscular junction may fatigue.[15] We therefore used a frequency of 0.15 Hz to prevent fatigue.[16,17] Failure to use a supramaximal stimulus may result in an underestimation of the time to maximum twitch depression. We used a supramaximal twitch (30 per cent greater than the maximal response) to stress the neuromuscular junction in each patient.

The criteria for judging the intubating conditions were adapted from those of Lund and Stovner.[3] Because these criteria are objective, we did not use a blinded observer. The intubating conditions were similar for the four muscle relaxants.

Stable conditions during rapid tracheal intubation may be important when choosing the optimal muscle relaxant. Stable conditions are provided by both an adequate depth of anaesthesia and an adequate degree of muscle paralysis. Movement of the head, coughing, and bucking are undesirable during induction of anaesthesia in patients in certain clinical conditions such as penetrating eye injuries. The intubating conditions were excellent in all children given succinylcholine 1.0 and 1.5 mg·kg^{-1} and pancuronium 0.15 mg·kg^{-1}. The intubating conditions were excellent in only 69 per cent of the children given pancuronium 0.10 mg·kg^{-1}. This latter observation may appear confusing since tracheal intubation was attempted only after 95 per cent twitch depression of the ulnar nerve. Although 95 per cent twitch depression was recorded in a peripheral nerve, the extent of twitch depression of the diaphragm may have been less.[18,19] This may explain why in spite of 95 per cent depression of the ulnar nerve twitch response with pancuronium 0.10 mg·kg^{-1}, the diaphragm may move and respiratory effort may still occur. We conclude that excellent conditions for rapid intubation in children may only be assured with succinylcholine 1.5 mg·kg^{-1}, succinylcholine 1.0 mg·kg^{-1} and pancuronium 0.15 mg·kg^{-1}.

In summary, the time to 95 per cent twitch depression in children was significantly more rapid with succinylcholine 1.5 mg·kg^{-1} than with pancuronium 0.15 mg·kg^{-1}. The intubating conditions at

95 per cent twitch depression were excellent in 100 per cent of children given succinylcholine 1.5 $mg \cdot kg^{-1}$ and pancuronium 0.15 $mg \cdot kg^{-1}$. The slower time to 95 per cent twitch depression with pancuronium 0.15 $mg \cdot kg^{-1}$ may be important when choosing the drug sequence to provide optimal intubating conditions for rapid tracheal intubation in children.

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Résumé

Afin de comparer l'efficacité du succinylcholine et du pancuronium pour l'intubation rapide chez les enfants, 49 enfants en bonne santé âgés de deux à huit ans ont été édudiés. Après l'induction de l'anesthésie avec thiopentone et atropine, et l'administration de dropéridol, fentanyl, oxide d'azote, et oxigène, chaque patient a reçu un des relaxants musculaires suivants: succinylcholine 1.5 $mg \cdot kg^{-1}$ ($n = 12$), succinylcholine 1.0 $mg \cdot kg^{-1}$ ($n = 13$), pancuronium 0.15 $mg \cdot kg^{-1}$ ($n = 11$), ou pancuronium 0.10 $mg \cdot kg^{-1}$ ($n = 13$). La force de l'adduction du pouce a été mesurée par la stimulation du nerf cubital avec des twitches uniques répétitives et supramaximales (0.15 Hz). Le temps nécessaire pour avoir une dépression à 95 pour cent du twitch (moyenne ± SD) a été le plus rapide avec la succinylcholine 1.5 $mg \cdot kg^{-1}$ (40.8 ± 3.0 secondes) et la succinylcholine 1.0 $mg \cdot kg^{-1}$ (51.8 ± 14.0 secondes), le plus lent étant avec le pancuronium 0.10 $mg \cdot kg^{-1}$ (150.9 ± 38.0 secondes), et étant intermédiaire avec du pancuronium 0.15 $mg \cdot kg^{-1}$ (80.3 ± 21.8 secondes) ($p < 0.005$). Les conditions d'intubation étaient excellentes chez 100 pour cent des enfants ayant reçu la succinylcholine 1.5 à 1.0 $mg \cdot kg^{-1}$ et du pancuronium 0.15 $mg \cdot kg^{-1}$ mais étaient excellentes chez seulement 69 pour cent de ceux qui ont reçu du pancuronium 0.10 $mg \cdot kg^{-1}$. On conclue que la succinylcholine 1.5 $mg \cdot kg^{-1}$ produit le relâchement musculaire le plus rapide pour des conditions d'intubation excellentes chez les enfants. Pour les enfants où la succinylcholine est contre-indiquée, le pancuronium 0.15 $mg \cdot kg^{-1}$ fournit d'excellentes conditions d'intubation en dedans de 80 secondes.