Monitoring orbicularis oculi predicts good intubating conditions after vecuronium in children

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Purpose: The aim of the study was to compare visual estimation of onset of neuromuscular blockade at both the adductor pollicis (AP) and the orbicularis oculi (OO) in children and to determine if monitoring the OO could predict good intubating conditions during vecuronium-induced neuromuscular blockade.

Methods: Thirty ASA I - II children (1.5–9 yr) were studied. Anaesthesia was induced with 6-8 mg·kg $^{-1}$ thiopentone. The ulnar nerve at the wrist and the temporal branch of the facial nerve were stimulated every 10 sec using train-of-four (TOF) stimuli. Vecuronium, 0.15 mg·kg $^{-1}$, was administered as a bolus. The responses at both the OO and the AP were evaluated visually. Patients were randomly divided into two groups. In the AP group (n = 15), the trachea was intubated when the AP was completely blocked. In the OO group (n = 15), intubation was performed when the OO was completely blocked. Intubating conditions were scored on a scale of 1 to 4.

Results: All the patients had complete blockade at both the orbicularis oculi and the adductor pollicis. In the two groups, time from injection of vecuronium to complete neuromuscular blockade was shorter at the orbicularis oculi than at the adductor pollicis, 1.5 ± 0.5 min *vs* 2.3 ± 0.7 min, respectively, ($P < 0.05$; mean ± SD) in the AP group, 1.7 ± 0.3 min *vs* 2.3 ± 0.8 min, respectively, in the OO group ($P < 0.05$). Intubating conditions were excellent in all patients except one, where it was rated as good. They did not differ between groups.

Conclusion: Following administration of 0.15 mg·kg $^{-1}$ vecuronium in children, monitoring of the OO can detect good intubating conditions 0.7 min earlier than with monitoring of the AP.

Objectifs : Le but de cette étude était de comparer chez l'enfant le délai d'installation de la curarisation déterminé visuellement à l'adducteur du pouce (AP) et à l'orbiculaire de l'oeil afin de savoir si le monitorage de la curarisation à l'orbiculaire de l'oeil (OO) permet de prédire de bonnes conditions d'intubation après l'injection de vécuronium.

Méthodes : Trente enfants ASA 1 ou 2 ont été inclus. L'anesthésie était induite par du thiopentone (6–8 mg·kg $^{-1}$). Le nerf cubital était stimulé au niveau du poignet ainsi que la branche temporale du nerf facial toutes les 10 s en utilisant une stimulation par train-de-quatre. Une dose unique de 0,15 mg·kg^{-1} de vécuronium était injectée. Les réponses aux niveaux des deux muscles (AP et OO) étaient estimées visuellement. Les patients étaient répartis au hasard en deux groupes. Dans le groupe AP (n = 15), les trachées étaient intubés quand AP était complètement bloqué. Dans le groupe OO (n = 15), l'intubation était effectuée quand OO était complètement bloqué. Les conditions d'intubation ont été évaluées avec une échelle de 1 (excellentes) à 4 (impossibles).

Résultats : Tous les patients ont présenté un bloc complet au niveau des deux muscles. Dans les deux groupes le délai d'installation du bloc complet après l'injection de vécuronium était plus court au niveau de OO que de AP : 1,5 ± 0,5 min *vs* 2,3 ± 0,7 min respectivement ($P < 0,05$; moyenne ± DS) dans le groupe AP, 1,7 ± 0,3 min *vs* 2,3 ± 0,8 min dans le groupe OO ($P < 0,05$). Les conditions d'intubation étaient excellentes pour tous les patients, excepté un pour lequel elles étaient bonnes et ne différaient pas entre les deux groupes.

Conclusion : Après l'injection de 0,15 mg·kg $^{-1}$ de vécuronium chez l'enfant, l'intubation oro-trachéale peut être effectuée dans de bonnes ou d'excellentes conditions quand un bloc complet est observé au niveau de OO même si AP n'est pas complètement paralysé. Le monitorage de OO permet donc d'aussi bonnes conditions d'intubation mais avec un délai plus court de 0,7 min en moyenne.

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Accepted for publication April 20, 1997.

STIMULATION of the ulnar nerve and monitoring of the adductor pollicis is used routinely to assess the onset of neuromuscular blockade (NMB) and to determine when the trachea may be intubated. However, several studies have demonstrated discrepancies between intubating conditions and the onset of NMB at the adductor pollicis.[1] This might be due to differences in both the speed of onset of neuromuscular blockade and sensitivities of the respiratory or upper airway muscles when compared with the adductor pollicis.[2,3] However, monitoring of the muscles which need to be relaxed to achieve good intubating conditions (the laryngeal adductor muscles, the diaphragm), is not feasible in clinical practice. Recent studies have suggested that the orbicularis oculi muscle may be used as a valuable guide to monitor onset of NMB at the diaphragm or the laryngeal adductor muscles because the time course of NMB and sensitivity to nondepolarizing muscle relaxants of the OO and laryngeal adductors are close.[2,4] It was, therefore, suggested that monitoring the OO, which is easy in clinical practice, could be a useful method of predicting intubating conditions.[5] However all these studies were performed in adult patients and no data are available in paediatric patients.

This study was designed to compare the visual estimation of onset of NMB at both the adductor pollicis and the orbicularis oculi muscles in children, and to determine if monitoring the orbicularis oculi could predict good intubating conditions during vecuronium-induced NMB in children.

Methods

The study was approved by the Institution Ethics Committee. Informed consent was obtained from the parents. Thirty children, ASA I or II, 1.5–9 yr, scheduled for peripheral surgical procedures were then included in the study. Exclusion criteria were cardiovascular, respiratory, neuromuscular, hepatic, renal disease, or concurrent administration of any drug known or suspected to interfere with neuromuscular transmission.

All patients were premedicated with 0.3 $mg \cdot kg^{-1}$ diazepam *po* one hour before surgery. In the operating room, ECG, pulse oximetry, arterial blood pressure were monitored non invasively. Surface electrodes were applied over the ulnar nerve at the wrist and the temporal branch of the facial nerve. Anaesthesia was induced with 6–8 $mg \cdot kg^{-1}$ thiopentone. The lungs were ventilated manually with oxygen 30% and nitrous oxide 70%. No halogenated agent was used during the induction of anaesthesia. Supramaximal 2 Hz train-of-four (TOF) stimuli were applied simultaneously at the ulnar nerve and facial nerve every 10 sec with a Curametre (Bioindustry, Boulogne-sur-Mer, France) stimulator. The current intensity for the supramaximal stimuli was 40–50 mA. Stimulation was begun after the loss of consciousness. The number of contractions was visually estimated at both muscles by two separate investigators. Vecuronium 0.15 $mg \cdot kg^{-1}$ was then injected as a bolus. Patients were randomly allocated into two groups. In the adductor pollicis group (AP; n = 15), intubation was performed when all response from the adductor pollicis was abolished. In the orbicularis oculi group (OO; n = 15), intubation was performed when the orbicularis oculi was completely blocked. All intubations were performed by an independent physician unaware of the patient group and the time course of NMB. Direct laryngoscopy was started immediatly after the disapearance of muscular contraction. A MacIntosh blade was used in all the patients.

TABLE I Intubating conditions scale as described by Krieg *et al.*[7]

Vocal cords	*Open*	*Moving*	*Closing*	*Closed*
Coughing	None	With diaphragm	Clear	Severe
Laryngoscopy	Easy	Fair	Difficult	Impossible
Points	1	2	3	4
Points	3–4	5–7	8–10	11–12
	Class I	Class II	Class III	Class IV
Intubating conditions	Excellent	Good	Poor	Bad

Time to complete NMB was defined as the interval between vecuronium administration and complete disappearance of the four responses at the orbicularis oculi or adductor pollicis muscles. Intubating conditions were scored by the anaesthetist on a 1-to-4 scale, as previously described by Krieg *et al.*[6] (Table I).

The results are expressed as mean ± standard deviation (SD). A paired Student's test was used to compare onset time at the adductor pollicis and orbicularis oculi within each group. A CHI square's test with a Yates's correction was used to compare intubating conditions between the two groups. The correlation between onset time at the adductor pollicis and the orbicularis oculi was tested by the significance of the r value determined by a least-squares regression analysis. A P value of 0.05 or less indicate a statistically significant difference.

Results

The two groups did not differ with respect to age, weight, height or sex (Table II).

Average times to complete NMB in the two groups are summarized in Table III. After 0.15 mg·kg^{-1} vecuronium, complete NMB at the two muscles were achieved in all the patients. The onset time was shorter at the orbicularis oculi than at the adductor pollicis in both groups; 1.5 ± 0.5 min *vs* 2.3 ± 0.7 min for the AP group ($P < 0.05$); 1.7 ± 0.3 min *vs* 2.3 ± 0.8 min for the OO group ($P < 0.05$). Maximum blockade was obtained 0.6 min and 0.8 min earlier at the orbicularis oculi than at the adductor pollicis in the AP and OO groups respectively. The onset time at the orbicularis oculi did not differ between the two groups. Similarly, onset time at the adductor pollicis did not differ between the two groups. A correlation (Figure 1) was found between onset time at the orbicularis oculi and the adductor pollicis ($r = 0.65$; $P < 0.05$).

Intubating conditions were excellent or good in all the patients. No coughing or bucking were observed. Excellent intubating conditions (Class I) were observed in 14 patients in the AP group and in 15 in the OO group. Good intubating conditions (Class II) were observed in one patient in the AP group. Intubating conditions did not differ between the two groups (Table IV).

TABLE II Demographic data for Adductor Pollicis group (AP) and Orbicularis Oculi Group (OO) (Values are mean ± SD).

Group	*Age (yr)*	*Weight (kg)*	*Height (cm)*	*Sex (M/F)*
AP	5.6 ± 1.6	18.4 ± 5.1	108 ± 11	9/6
OO	4.3 ± 1.9	15.5 ± 4.9	100 ± 13	10/5

TABLE III Time to complete neuromuscular blockade at the orbicularis oculi (Onset OO) and the adductor pollicis (Onset AP) muscle following 0.15 mg.kg^{-1} vecuronium. Values are mean ± SD.

	Onset OO (min)	*Onset AP (min)*
Group AP (n=15)	1.5 ± 0.5*	2.3 ± 0.7
Group OO (n=15)	1.7 ± 0.3*	2.3 ± 0.8

*$P < 0.05$ when compared with onset at the AP.

TABLE IV Intubating conditions after 0.15 mg.kg^{-1} vecuronium.

	Excellent (I)	*Good (II)*	*Poor (III)*	*Bad(IV)*
Group AP (n=15)	14	1	0	0
Group OO (n=15)	15	0	0	0

$P = 0.14$, CHI square's test.

Discussion

This study demonstrated that monitoring of the orbicularis oculi may be used in children to detect good intubating conditions. Time to complete NMB was shorter at the orbicularis oculi than at the adductor pollicis muscles in all children, after a bolus of 0.15 mg·kg^{-1} vecuronium. These results are comparable with those previously observed in adults where the orbicularis oculi was paralyzed before the adductor pollicis when twice the ED_{95} at the adductor pollicis was used.[2]

All patients exhibited complete blockade at both muscles and good intubating conditions. Monitoring the onset of NMB at the orbicularis oculi allowed good or excellent intubating conditions, but with a gain of 0.7 min compared with monitoring the adductor pollicis. Good or excellent intubating conditions, observed when the orbicularis oculi is completely blocked, confirm the value of monitoring the orbicularis oculi to predict paralysis of muscles whom relaxation is needed to intubate the trachea, i.e., the diaphragm and the laryngeal adductor muscles. It could appear contradictory to have good intubating conditions (with paralysis of orbicularis oculi) even if the adductor pollicis is still uncompletely blocked. It is likely that these findings can be explained by similar onset times of blockade and sensitivity of the orbicularis oculi, the diaphragm and the laryngeal adductor muscles as previously shown in adults and children.[2,7] The reason for the faster onset of NMB at the orbicularis oculi than at the adductor pollicis muscle might be due to differences in circulation time and muscle blood flow as previously suggested by Donati *et al.*[2,8]

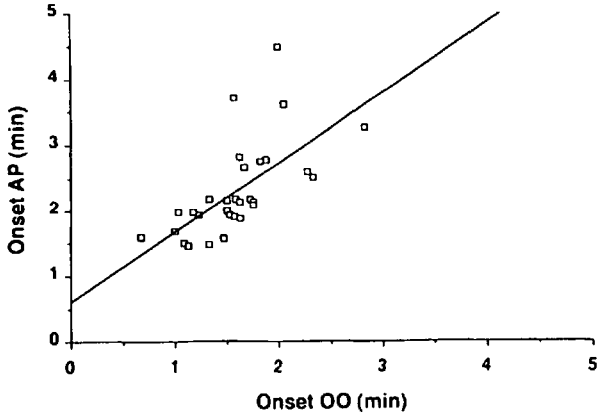

FIGURE 1 Correlation between onset time (min) at the orbicularis oculi (Onset OO) and the adductor pollicis (Onset AP). (n=30; $r = 0.65$; $P < 0.05$).

Muscles which are closer to the central circulation such as the orbicularis oculi or the diaphragm have a relatively greater perfusion and tend to be paralyzed more rapidly than more peripheral muscles such as the adductor pollicis, even if they are more resistant to muscle relaxants.[2,8] Twice the ED_{95} at the adductor pollicis is considered the usual intubating dose because the laryngeal adductor muscles and the diaphragm are more resistant to nondepolarizing muscle relaxants than the adductor pollicis.[2,3] In children, the ED_{95} of nondepolarizing muscle relaxants is greater than in adults.[9–11] Several studies have reported an ED_{95} for vecuronium at the adductor pollicis of 70–80 $\mu g \cdot kg^{-1}$ in children of the same range of age.[11] A dose of 0.15 $mg \cdot kg^{-1}$, i.e., approximately twice the ED_{95} at the adductor pollicis, was therefore used to obtain complete blockade of the respiratory muscles in the children. With lower doses of vecuronium it is unlikely that the orbicularis oculi would have been fully paralysed in all the children, as previously demonstrated in adults.[2] Onset times at both muscles were shorter than in other studies published in adults. Such findings have already been described with the adductor pollicis. The onset of paralysis at the adductor pollicis occurs sooner in infants (1.5 ± 0.6 min) and in children (2.4 ± 1.4 min) than in adults (2.9 ± 0.2 min).[12] The onset time of neuromuscular blockade may be influenced by several factors such as cardiac output or muscle perfusion. The shorter onset time found in children may be due to the relatively greater cardiac output in children when compared with adults. The correlation of the onset time (Figure 1) desmontrates that children with a shorter onset time at the orbicularis oculi may also have a more rapid onset of paralysis at the adductor pollicis.

In this study, assessment of the neuromuscular response at both muscles was made visually, as is common in clinical practice. Visual assessment was used rather than force or electromyographic (EMG) measurements at the adductor pollicis and orbicularis oculi, because it is more relevant in clinical practice to correlate visual estimation of NMB with intubating conditions. Previous studies have demonstrated a good correlation between visual estimation of onset of blockade and force measurement. A degree of blockade >92–94% is necessary to make TOF undetectable at the adductor pollicis, during visual estimation.[13] No such study has been performed for the orbicularis oculi.

Adequate relaxation of the vocal cords was assessed by measuring intubating conditions on a scale of 1 to 4.[6] The effects of anaesthesia on the intubating conditions might be an additional variable. For example, thiopental dose requirements are greater in childen than in adults.[14,15] We used a dose ranging from 6 to 8 $mg \cdot kg^{-1}$, as recommended for induction of anaesthesia in paediatric patients. It is unlikely that this dose of thiopentone could be responsible the good intubating conditions observed in all the patients because it was administered at least two minutes before intubation was attempted at a time when its effect starts to wear off. No halogenated agent or opioid that might alter the intubating conditions, was used during induction of anaesthesia. Although we have shown that complete paralysis of the orbicularis oculi is associated with good or excellent intubating conditions, we cannot determine from this study whether good intubating conditions may exist before loss of orbicularis oculi response. However there is evidence from previous studies in adults that onset of NMB at the laryngeal adductor muscles parallels paralysis of the orbicularis oculi muscle and monitoring the orbicularis oculi can predict good intubating conditions.[4,5]

In summary, in children after vecuronium administration, time to complete NMB is shorter at the orbicularis oculi than at the adductor pollicis muscles. When monitoring the orbicularis oculi, excellent or good intubating conditions coincide with blockade of the orbicularis oculi, which occurs with a mean time of 0.7 min prior to paralysis of the adductor pollicis.

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