

Intubation Conditions with Low Dose Rocuronium under Sevoflurane Induction for Children

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Background: During short surgical procedures and when there is a need to avoid the use of anticholinesterase at the end of surgery, the use of a smaller intubation dose of neuromuscular blocking drug is preferred. The aim of this study was to evaluate tracheal intubation conditions using smaller doses of rocuronium for children under sevoflurane induction.

Methods: Eighty American Society of Anesthesiologists classification physical status I or II children were enrolled. After mask induction with sevoflurane with nitrous oxide for 3 minutes, 0.3mg/kg of rocuronium was given. Intubation was performed 60 or 90 seconds thereafter. Study group A included children aged 1 to 3 years and 90 seconds between rocuronium injection and intubation. Group B included children aged 1 to 3 years who had 60 seconds between rocuronium injection and intubation. Group C included children aged 4 to 6 years who had 90 seconds between rocuronium injection and intubation. Group D included children aged 4 to 6 years who had 60 seconds between rocuronium injection and intubation. Intubation conditions were judged based on the scoring of ease of jaw opening and laryngoscopy, position of the vocal cords, and degree of straining after tracheal intubation.

Results: All 80 children underwent successful tracheal intubation without laryngospasm or any complications. Intubation conditions were judged as optimal in all children in group A, 95% in group B, 80% in group C, and 65% in group D.

Conclusions: A total of 0.3mg/kg of rocuronium was sufficient for tracheal intubation for children 1 to 6 years old under sevoflurane induction. To guarantee optimal intubation conditions for elder children, allow 90 seconds waiting time after rocuronium administration was recommended.

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Key words: pediatric anesthesia, rocuronium, sevoflurane induction, intubation condition.

Rocuronium is a steroid nondepolarising neuromuscular blocking agent with rapid onset, intermediate duration of action and relatively low potency. During short surgical procedures and when there

is a need to avoid the use of anticholinesterase at the end of surgery, a small intubation dose is preferred. High rocuronium doses did not further improve intubation conditions but only prolonged time of neuro-

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muscular recovery.⁽¹⁾

Sevoflurane is non-irritating to the airway, non-pungent, and provides rapid induction because of its low blood to gas solubility.⁽²⁾ Many researchers have demonstrated the acceptability and rapidity of inhalation induction with sevoflurane in children.⁽³⁾ Some authors have even demonstrated tracheal intubation of children with sevoflurane and no muscle relaxant.⁽⁴⁾ In the study by Politis et al., to achieve 80% successful intubation the induction times needed were 137 s and 187 s for ages 1 to 4 years old and 4 to 8 years old, respectively.⁽⁴⁾ For small children, only 80% successful intubation may be too risky in clinical practice. Sevoflurane induction without muscle relaxant requires high sevoflurane concentrations for longer induction time, which may put the small children at the risk of cardiac depression and hypotension.

Under sevoflurane induction, low doses of rocuronium may be safer to facilitate tracheal intubation for children. A total of 0.3mg/kg of rocuronium is the ED95 at the adductor pollicis muscle (as estimated by supramaximal single twitch stimulation at 0.1 Hz)⁽⁵⁾ and the ED50 at the laryngeal adductor muscles. This is half the recommended intubating dose.⁽⁶⁾ We proposed that 0.3 mg/Kg of rocuronium might meet the needs to facilitate tracheal intubation. The aim of this study was to determine the possibility to achieve optimal intubation conditions using a low dose of rocuronium for different age groups of children under different sevoflurane induction times.

METHODS

After receiving approval by the local ethics committee and informed consent from the children's parents or guardians, we recruited 80 American Society of Anesthesiologists classification physical status I or II children, aged 1 to 6 years (12-84 mo). All children were scheduled to receive an endotracheal tube (ETT) during an elective procedure, and none had the stigmata of a difficult airway. Children with significant cardiac, respiratory, renal, hepatic or central nervous system diseases were excluded. All children fasted for at least 8 hours before surgery and received no pre-medication. Because we hypothesized that intubation conditions would vary by age and induction time, we prospectively separated these 80 children into four groups. Forty children, aged 12

to 48 months, were allocated randomly to group A or group B of 20 each, to receive intubation 90 or 60 seconds after administration of muscle relaxant. The other 40 children, aged 48 to 84 months, were also allocated randomly to group C or group D of 20 each, to receive intubation 90 or 60 seconds after administration of muscle relaxant.

All children were from the outpatient department and had no intravenous lines before being transported to the operating room. Routine monitoring, consisting of EKG, pulse oximetry and noninvasive blood pressure measurement were commenced when inhalation induction was started with 8% dialed sevoflurane in 50% N₂O/50% O₂ with a fresh gas flow of 4 L/min for 2 minutes. A dose of 6%-dialed sevoflurane with a fresh gas flow of 2 L/min was applied for the following 1 minute. N₂O was applied only for the first 2 minutes. A total of 0.3mg/kg of rocuronium was administered intravenously 3 minutes after the start of induction and sevoflurane vaporizer was dialed to 4% with a fresh gas flow of 2 L/min thereafter. If intravenous access could not be obtained during the first 3 minutes of inhalation induction, the child was excluded from this study. Airways were managed by attending anesthesiologists or experienced senior anesthesia residents. Because minute ventilation during induction was likely to affect the induction time to achieve good intubation conditions, we sought a means to make ventilation as uniform as possible. To achieve that goal, in each case ventilation was assisted and then controlled as quickly as possible, and instructions were given to hyperventilation without administering airway pressures in excess of 20 cm of H₂O.⁽⁴⁾ Laryngoscope blade and ETT size were at the discretion of the patient's attending anesthesiologist. Laryngoscopy and tracheal intubation were performed 90 seconds after rocuronium was administered in groups A and C, 60 seconds after rocuronium was administered in groups B and D. Tracheal intubation was not attempted if the vocal cords were nearly or fully closed or if there was a possibility of injury to the vocal cords.

The investigators assessed three factors (Table 1) including ease of jaw opening and laryngoscopy (1=easy; 2=fair; 3=difficult), position of the vocal cords and their movement (1=open; 2=moving; 3=closing) and degree of straining (bulking) after tracheal intubation (1=none; 2=with diaphragm;

Table 1. Intubation Scoring Criteria

		Scores		
		1	2	3
Factors	Jaw opening and laryngoscopy	Easy	Fair	Difficult
	Vocal cords	Open	Moving	Closing
	Bulking	None	Diaphragm	Abdominal m.

Tracheal intubation was judged as optimal when all scores were 1 or 2, and judged as suboptimal if any of the score were 3. Failure to intubation was scored as a failure.

3=with abdominal muscles). The intubation conditions, including laryngoscopy and movement of the vocal cords, were assessed by the laryngoscopist. Another investigator assessed the degree of muscle straining at the same time.

The occurrence of any significant complications was recorded. The overall conditions for tracheal intubation were scored in three grades: optimal, suboptimal and failure. Tracheal intubation was judged as optimal when all scores were 1 or 2, and judged as suboptimal if any of the scores were 3. Failure of intubation was scored as a failure.⁽⁷⁾ Opioids were administered only when intubation assessments were completed.

RESULTS

The demographic data of the patients are shown in Table 2. There were no significant differences between the study groups A and B and groups C and D, with respect to age, weight, and ASA status.

Intubation was successful in all children at the first attempt, without the need for other interventions. Intubation conditions were judged as optimal in all children in group A, 95% optimal and 5% suboptimal in group B, 80% optimal and 20% suboptimal in group C, and 65% optimal and 35% suboptimal in group D (Table 3).

Table 2. Patient Data (mean ±SD) or [range]

	Group A	Group B	Group C	Group D
n	20	20	20	20
Age(months)	30.6 [15-45]	26.5 [15-44]	62.15 [48-81]	61.85 [49-78]
Weight (kg)	13.4 (2.39) [1-18]	12.65 (2.0) [9-17]	18.4 (2.7) [13-25]	18.1 (3.34) [13-25]
ASA (I/II)	16/4	14/6	11/9	11/9

Abbreviation: ASA: American Society of Anesthesiologists classification.

Laryngoscopy and movement of the vocal cords were all scored as 1 in all 80 children. The only factor that influenced intubation judgment (optimal or suboptimal) was the degree of straining after intubation (Fig. 1).

None of the children had laryngospasm, bronchospasm, oxygen desaturation, bradycardia or other significant complications.

DISCUSSION

Safe and rapid induction with quick recovery is the anesthetic goal for pediatric ambulatory surgery. For children with history of asthma or other conditions, anticholinesterase may be relatively contraindicated as a muscle relaxant reversal. A smaller intubation dose of muscle relaxant is preferred.

Most preschool children are reluctant to have intravenous punctures; mask induction with inhalational anesthetics is a better choice. Sevoflurane has been shown to be an excellent induction agent in pediatric patients because of its low blood-gas solubility and lack of pungency. It also has several advantages compared with halothane including a quicker anesthetic induction^(8,9) and less depression of myocardial contractility.⁽¹⁰⁾ Using a vital capacity technique, the speed of induction with sevoflurane

Table 3. Intubation Conditions

	Group A (n = 20)	Group B (n=20)	Group C (n=20)	Group D (n =20)
Optimal	20 (100%)	19 (95%)	16 (80%)	13 (65%)
Suboptimal	0 (0%)	1 (5%)	4 (20%)	7 (35%)
Failure	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Results given as number of patients (%) in that group

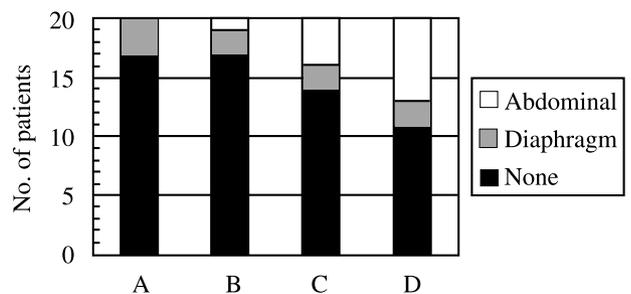


Fig. 1 The only factor influenced intubation judgment (optimal or suboptimal) was degree of straining after intubation.

has been shown to be almost as rapid as that of intravenous propofol.⁽¹¹⁾ This technique is especially practical in our hospital since we do not have intravenous access until the beginning of induction in ambulatory surgery.

Some researchers have demonstrated tracheal intubation of children with sevoflurane without the use of muscle relaxants. Inomata et al. showed that end-tidal sevoflurane concentration of 2.69% appears to be suitable for tracheal intubation without muscle relaxants in pediatric patients.⁽¹²⁾ However, it took more than 15 minutes to maintain this end-tidal concentration.⁽¹²⁾ This long induction time is not clinically practical. Politis et al. reported that the induction times needed to achieve 80% successful intubation were 137 s and 187 s for ages 1 to 4 years and 4 to 8 years, respectively.⁽⁴⁾ However, an 80% successful intubation rate is very risky for small children since mucosal trauma during intubation can cause postoperative edema, stridor, croup, and airway obstruction. Muscle relaxants are favored to facilitate tracheal intubation. Rapid onset, intermittent duration, and no effect on histamine release make rocuronium a good choice for tracheal intubation.

There are situations in anesthesia in which it may be desirable to achieve rapid tracheal intubation under perfect conditions, i.e., no cough or straining. Heier and Caldwell reported using a large dose of up to 2.0 mg/kg of rocuronium that it is possible to achieve perfect conditions for rapid tracheal intubation.⁽¹³⁾ The long duration of the action and expense with large doses of rocuronium may limit the usefulness for short pediatric procedures. Most investigators have suggested that 0.6 mg/kg of rocuronium should be used in order to achieve optimal intubation conditions.⁽¹⁴⁾ Barclay et al. reported that an injection of 0.3 mg/kg of rocuronium with propofol and alfentanil provided a high proportion of optimal intubation conditions.⁽⁷⁾ McCourt et al. showed that 1.0 mg/kg of rocuronium can be used as an alternative to 1.0 mg/kg of suxamethonium as a part of the rapid sequence intubation.⁽¹⁵⁾ Lowry et al. showed that intubating conditions during a rapid-sequence induction using 0.6 mg/kg of rocuronium following induction of anesthesia with sevoflurane or propofol were similar.⁽¹¹⁾ These studies were designed for adult patients. As for children, Fuchs-Buder and Tassonyi found that both 0.6 and 0.9 mg/kg of rocuronium offered good to excellent intubation conditions for rapid

sequence induction at 60 seconds after administration.⁽¹⁶⁾ Succinylcholine with its very rapid onset and offset of action has been popular in both pediatric and adult anesthesia for nearly five decades. However, after several reports of fatal cardiac arrest in children with undiagnosed myopathies, warnings were given on using succinylcholine in pediatric patients.⁽¹⁷⁾

Eikermann et al. found the optimal rocuronium dose (0.29 mg/kg) for intubation during inhalation induction with 8% sevoflurane in 60% nitrous oxide for children.⁽¹⁸⁾ They assessed intubation conditions during steady-state anesthesia after low-dose rocuronium for children aged 2 to 7 years. However, the exact sevoflurane induction times were not recorded. Children of different ages may need different induction times. We divided our patients into four groups according to age and induction time because we hypothesized that intubation conditions would vary according to these two factors.

In our study, the injection of 0.3mg/kg of rocuronium was sufficient for tracheal intubation for children of 1 to 6 years old under sevoflurane induction. Children that were younger with longer intervals between rocuronium injection and intubation had a higher percentage of optimal intubation conditions. The only factor that influenced intubation judgment as optimal or suboptimal was the degree of straining after intubation in groups B, C, and D. Though there were as high as 35% of the children judged as suboptimal in group D, bulking with abdominal muscle after intubation may be clinically acceptable. Laryngoscopy and movement of the vocal cords were all scored as 1 in all four groups of children. When using a low dose of rocuronium and no anticholinesterase, the reversal of muscle relaxant was needed at the end of surgery in all 80 children. Induction with intratracheal intubation was accomplished within 5 minutes.

During sevoflurane induction, younger children required less induction time for successful intubation compared with the older children. Lerman et al. also found that the time from application of the face mask to the loss of eyelash reflex and intubation increased with increasing age.⁽²⁾ Possibilities may include an increased ability to rapid control ventilation and higher alveolar ventilation to FRC ratio contributes to a rapid rise in alveolar anesthetic concentration in the small children.⁽¹⁹⁾

Neuromuscular monitoring was not applied in our study. There is ample evidence that the onset of the block at the adductor pollicis lags considerably behind the neuromuscular effects seen at the muscle that have greater relevance to ease intubation, such as the laryngeal adductors, diaphragm, and masseter.

(20-23)

In conclusion, injection of 0.3mg/kg of rocuronium was sufficient for tracheal intubation for children of 1 to 6 years old under sevoflurane induction. To guarantee optimal intubation conditions for elder-children, allow 90 seconds waiting time after rocuronium administration was recommended.

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兒童在Sevoflurane誘導麻醉下 使用低劑量Rocuronium之插管狀況

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- 背景：**在較短手術或不宜使用抗膽鹼酯酶素之情況下，宜選用較低插管劑量之肌肉鬆弛劑，本試驗目的為評估兒童在sevoflurane誘導麻醉下使用低劑量rocuronium之氣管內插管狀況。
- 方法：**本試驗收入80位麻醉危險分類一或二級的兒童，將之依年齡（1~3歲或4~6歲）和給藥後插管時間（60秒或90秒）分成A-D四組。所有兒童以面罩給予吸入性麻醉藥誘導，三分鐘後從靜脈點滴注射rocuronium 0.3mg/Kg，給藥後60秒或90秒進行氣管內管插管。A組為1到3歲，給藥後至插管時間90秒；B組為1到3歲，給藥後至插管時間60秒；C組為4到6歲，給藥後至插管時間90秒；D組為4到6歲，給藥後至插管時間90秒。以下頷骨打開的難易度、聲帶位置和插管後腹肌動作評估插管狀況為理想、良好及失敗。
- 結果：**所有兒童都接受成功插管，沒有任何併發症。A組兒童全部達到理想插管狀況，B組有95%，C組80%，D組65%。
- 結論：**對於1到6歲的兒童，在sevoflurane麻醉誘導下rocuronium 0.3mg/Kg可提供足夠的插管劑量。對於年齡較大的兒童，建議給藥後等90秒可有較理想插管狀況。
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關鍵字：小兒麻醉，rocuronium，sevoflurane誘導麻醉，插管狀況。

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