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Effect of rocuronium compared with succinylcholine on intraocular pressure during rapid sequence induction of anaesthesia

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We have compared the effect of rocuronium and succinylcholine on intraocular pressure (IOP) during rapid sequence induction of anaesthesia using propofol and fentanyl, in a randomized, double-blind study. We studied 30 adult patients, allocated to one of two groups. Anaesthesia was induced with fentanyl 2 μg kg^{-1} and propofol until loss of verbal response. This was followed by succinylcholine 1.5 mg kg^{-1} (group S; $n=15$) or rocuronium 0.9 mg kg^{-1} (group R; $n=15$). Laryngoscopy was performed 60 s later. IOP, mean arterial pressure (MAP) and heart rate (HR) were measured before induction, immediately before intubation and every minute after intubation for 5 min. A Keeler Pulsair air impulse tonometer was used to measure IOP and the mean of two readings obtained in the right eye at each measurement time was recorded. Intubating conditions were evaluated according to a simple scoring system. IOP in the succinylcholine group was significantly greater than that in the rocuronium group (mean 21.6 (SEM 1.4) mm Hg *vs* 13.3 (1.4) mm Hg; $P<0.001$). Intubating conditions were equally good in both groups. We conclude that with rapid sequence induction of anaesthesia using propofol and fentanyl, rocuronium did not cause as great an increase in IOP as succinylcholine and may be an alternative in open eye injury cases.

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Succinylcholine remains unsurpassed in providing ideal intubating conditions.[1] However, an increase in intraocular pressure (IOP) after succinylcholine is one of its undesirable effects, especially in patients with an open eye injury. Pretreatment with non-depolarizing neuromuscular blocking agents, diazepam, lidocaine, nifedipine or alfentanil may be protective against increased IOP, although these findings are not universal.[2–5] Pancuronium[6] and vecuronium[7] have also been used instead of succinylcholine for rapid sequence induction of anaesthesia but both of these agents provide less than optimal conditions for rapid intubation.

Rocuronium is a non-depolarizing neuromuscular blocking drug which provides a rapid onset of action with an intermediate duration of action.[8 9] At a dose of 0.9–1.2 mg kg^{-1}, [10] onset time of rocuronium has been shown to be similar to that of succinylcholine. As with other non-depolarizing neuromuscular blocking agents, rocuronium has been shown to cause a decrease in IOP during steady state anaesthesia.[11]

This study was designed to compare the intraocular effect of rocuronium with that of succinylcholine during rapid sequence induction of anaesthesia using propofol and fentanyl.

Methods and results

After obtaining Hospital Ethics Committee approval and informed written consent, we studied 30 ASA I patients, aged 18–50 yr, who required tracheal intubation as part of the anaesthetic technique for elective non-ophthalmic surgery. Patients with Mallampati class 3 or 4 were excluded.

This was a randomized, double-blind, controlled study. Patients were allocated to one of two groups ($n=15$ in each group) to receive succinylcholine (group S) or rocuronium (group R). All patients were premedicated with midazolam 0.15 mg kg^{-1} orally, 2 h before induction of anaesthesia. After preoxygenation for 3 min, anaesthesia was induced with fentanyl 2 μg kg^{-1} and a sleep dose of propofol given at a rate of 200 mg min^{-1} until loss of verbal response.

This was followed immediately by either succinylcholine 1.5 mg kg^{-1} or rocuronium 0.9 mg kg^{-1}, diluted to 10 ml with normal saline. All drugs were administered into a rapidly running i.v. infusion by one anaesthetist (C.Y.W.) who was unaware of the drugs administered. The lungs were not ventilated before tracheal intubation. Laryngoscopy and tracheal intubation were performed 60 s after administration of succinylcholine or rocuronium and in all patients intubation was completed within 30 s. After tracheal intubation, patients' lungs were ventilated with 66% nitrous oxide in oxygen to maintain normocapnia. Throughout induction, all patients were monitored using a pulse oximeter, automated arterial pressure monitor, capnograph and electrocardiograph (Propaq 106EL, Protocol System Inc., USA).

Table 1 Patient characteristics, baseline readings of mean arterial pressure, intraocular pressure and heart rate, and dose of propofol administered in the two groups (mean (SEM or range) or number)

	Succinylcholine ($n=15$)	**Rocuronium ($n=15$)**
Age (yr)	30.8 (19–47)	33.9 (20–49)
Body weight (kg)	54.7 (1.8)	56.5 (2.5)
Sex (M:F)	6:9	3:12
Intraocular pressure (mm Hg)	14.3 (0.9)	13.9 (1.0)
Mean arterial pressure (mm Hg)	84.3 (2.8)	85.2 (3.0)
Heart rate (beat min^{-1})	70.3 (3.0)	75.4 (3.0)
Propofol (mg kg^{-1})	2.09	2.08

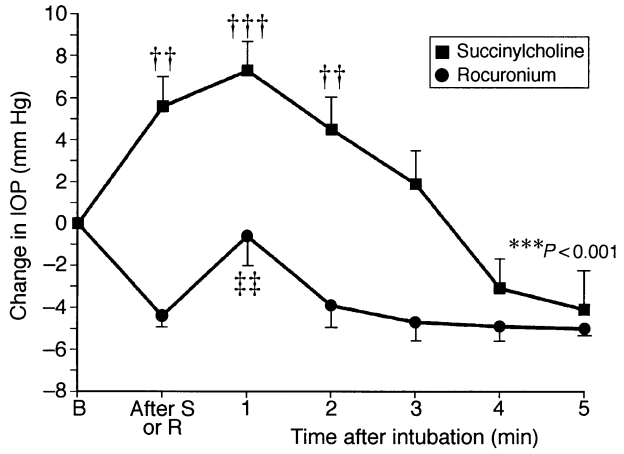

Fig 1 Change in intraocular pressure (IOP) during induction of anaesthesia in the succinylcholine (S) and rocuronium (R) groups (mean (SEM)). Difference between the two groups was statistically significant (***$P<$ 0.001, ANOVA). ††$P<$ 0.01,†††$P<$0.001 *vs* baseline (B); ‡‡$P<$0.01 *vs* post-induction value.

Measurements of IOP, mean arterial pressure (MAP) and heart rate (HR) were made at the following times: before induction (baseline); 1 min after administration of succinylcholine or rocuronium (just before intubation); and every minute after intubation for 5 min.

A Keeler Pulsair air impulse tonometer (Keeler Ltd, Windsor, Berks, UK) was used to measure IOP (accuracy comparable with Goldmann applanation tonometer). Two readings were obtained in the right eye at each measurement time. The mean of the two readings was recorded. At no time did measurement of IOP interfere with the progress of the anaesthetic. A simple scoring system (1–4) was used to grade intubation: 1, *excellent*=jaw relaxed, vocal cords abducted and immobile, no diaphragmatic movement; 2, *good*=jaw relaxed, vocal cords abducted and immobile, some diaphragmatic movement; 3, *poor*=jaw relaxed, vocal cords moving, coughing; and 4, *inadequate*=jaw not relaxed and vocal cords closed. Tracheal intubation was performed by anaesthetists with more than 2 yr experience and all measurements of IOP were performed by one of the authors (C.L.C.). The investigator who measured intraocular pressure and the intubating anaesthetist were not allowed to observe injection of the neuromuscular blocking drug or the presence of any fasciculations, by standing initially with their back to the patient. They were then asked to turn round to face the patient, 45 s after injection of either succinylcholine or rocuronium; by then the fasciculations had subsided in all patients who had received succinylcholine.

Results are expressed as mean (SEM). A paired *t* test and two-way analysis of variance for repeated measurements (ANOVA with treatment group and time as between- and within-group factors) were used to analyse the changes in IOP, MAP and HR using SPSS for Windows computer

Table 2 Multiple comparisons of heart rate (HR), mean arterial pressure (MAP) and intraocular pressure (IOP) at times 1–7 in group S ($n=15$) and group R ($n=15$) (mean (SEM)). Time 1=before induction, 2=after induction, 3–7=every 1 min after intubation for 5 min

	Time						
	1	**2**	**3**	**4**	**5**	**6**	**7**
HR (beat min^{-1})							
Group S	70.3 (3.0)	82.2 (4.4)	82.1 (3.9)	77.7 (4.0)	73.9 (3.8)	69.7 (3.4)	66.3 (3.1)
Group R	75.4 (3.0)	72.2 (3.0)	83.9 (3.2)	84.5 (3.6)	81.6 (2.6)	81.8 (2.9)	79.9 (2.8)
MAP (mm Hg)							
Group S	84.3 (2.8)	84.1 (4.7)	87.2 (4.4)	79.5 (3.3)	73.9 (2.6)	69.7 (1.7)	67.3 (1.8)
Group R	85.2 (3.0)	76.9 (3.4)	88.2 (5.2)	78.9 (4.0)	72.9 (3.0)	71.9 (3.3)	70.1 (3.0)
IOP (mm Hg)							
Group S	14.3 (0.9)	19.9 (1.3)	21.6 (1.4)	18.8 (1.3)	16.2 (0.8)	11.2 (0.4)	10.3 (0.7)
Group R	13.9 (1.1)	9.5 (0.8)	13.3 (1.4)	10.0 (0.7)	9.2 (0.5)	9.0 (0.5)	8.9 (0.4)

software (release 6.0.) After a score of 1–4 was given to the intubating condition, this was analysed using a chi-square test. A two-tailed probability of less than 0.05 was the criterion for statistical significance.

There was no significant difference between groups in age, sex, weight, propofol dose, baseline IOP, baseline MAP or baseline HR (Table 1).

Changes in IOP in both groups during induction are presented in Figure 1. In the succinylcholine group, IOP increased significantly (from 14.3 to 19.9 mm Hg; $P=0.009$) after induction. Tracheal intubation caused a further increase in IOP compared with baseline (14.3 to 21.6 mm Hg; $P=0.001$). In the rocuronium group, there was initially a decrease in IOP (from 13.9 to 9.5 mm Hg; $P=0.001$) after induction. Although tracheal intubation caused an increase in IOP compared with values after induction (from 9.5 to 13.3 mm Hg; $P=0.009$), it remained below baseline throughout induction. The difference in the changes in IOP between the succinylcholine and rocuronium groups was highly significant ($P<0.001$, ANOVA).

There was no significant difference in changes in MAP during induction between the two groups (Table 2). At 1 min after intubation, there was a slight increase in MAP compared with baseline in both the succinylcholine (84.3 to 87.2 mm Hg; ns) and rocuronium (85.2 to 88.2 mm Hg; ns) groups but this increase was not statistically significant.

Changes in HR during induction (Table 2) were significantly greater ($P<0.001$, ANOVA) compared with baseline in the rocuronium group after intubation (from 75.4 to 83.9 beat min^{-1} at 1 min, 84.5 beat min^{-1} at 2 min, 81.6 beat min^{-1} at 3 min, 81.8 beat min^{-1} at 4 min and 79.9 beat min^{-1} at 5 min). In the succinylcholine group, HR after administration of the drug (70.3 to 82.2 beat min^{-1}; $P=0.03$) and at 1 min after intubation (70.3 to 82.1 beat min^{-1}; $P=0.01$) was significantly greater than baseline. Although rocuronium was associated with a greater increase in HR than succinylcholine, this was not statistically significant.

Intubating conditions were equally good in both groups. Thirteen of 15 patients who received rocuronium 0.9 mg kg^{-1} achieved excellent intubating conditions at 1 min, and two of 15 achieved good intubating conditions. Fourteen of 15 patients in the succinylcholine group achieved excellent intubating conditions and one of 15 achieved good intubating conditions.

Comment

Our study showed that succinylcholine produced a significant increase in IOP compared with rocuronium. In agreement with previous workers,[10] we confirmed that intubating conditions provided by rocuronium 0.9 mg kg^{-1} ($3\times ED_{95}$) were as good as those after succinylcholine 1.5 mg kg^{-1} at 60 s after administration. Although the use of rocuronium was associated with a greater increase in HR, this was not significantly different from that produced by succinylcholine.

In both groups, IOP readings at 1 min after intubation were greater than values before intubation (19.9 to 21.6 mm Hg after succinylcholine; 9.5 to 13.3 mm Hg after rocuronium). This probably indicates that in addition to the drugs used, laryngoscopy and intubation may also increase IOP.

Cricoid pressure is part of the technique of rapid sequence intubation. In this study, cricoid pressure was not applied for technical reasons. IOP needs to be measured rapidly and reliably immediately before intubation and at 60 s after administration of succinylcholine or rocuronium. The Keeler Pulseair air impulse tonometer is quite bulky. Application of cricoid pressure would make it difficult for the investigator to position the tonometer in close proximity to the eye needed to achieve a good focus for an IOP reading. In addition, cricoid pressure may distort the view of the larynx and, if applied incorrectly, may be associated with congestion of the neck veins. A further study is needed to investigate if application of cricoid pressure could produce different changes in IOP.

In summary, the results of this study confirmed that rocuronium did not cause an increase in IOP and provided good to excellent intubating conditions at 60 s after administration. Rocuronium would appear to be the relaxant of choice in patients with penetrating eye injuries requiring emergency tracheal intubation where a longer-acting neuromuscular blocking agent is not contraindicated.

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