



ORIGINAL ARTICLE

Effect of suxamethonium vs rocuronium on onset of oxygen desaturation during apnoea following rapid sequence induction

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Summary

This study investigates the effect of suxamethonium vs rocuronium on the onset of haemoglobin desaturation during apnoea, following rapid sequence induction of anaesthesia. Sixty patients were randomly allocated to one of three groups. Anaesthesia was induced with lidocaine 1.5 mg.kg⁻¹, fentanyl 2 µg.kg⁻¹ and propofol 2 mg.kg⁻¹, followed by either rocuronium 1 mg.kg⁻¹ (Group R) or suxamethonium 1.5 mg.kg⁻¹ (Group S). The third group received propofol 2 mg.kg⁻¹ and suxamethonium 1.5 mg.kg⁻¹ only (Group SO). The median (IQR [range]) time to reach S_pO₂ of 95% was significantly shorter in Group S (358 (311–373 [215–430]) s) than in Group R (378 (370–393 [366–420]) s; *p* = 0.003), and shorter in Group SO (242 (225–258 [189–370]) s) than in both Group R (*p* < 0.001) and Group S (*p* < 0.001). When suxamethonium is administered for rapid sequence induction of anaesthesia, a faster onset of oxygen desaturation is observed during the subsequent apnoea compared with rocuronium. However, time to desaturation is prolonged whenever lidocaine and fentanyl precede suxamethonium.

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Traditionally, suxamethonium has been the neuromuscular blocking drug of choice for rapid sequence induction of anaesthesia. However, its use may be associated with several side-effects including myalgia, which is caused by muscle fasciculations. These muscle fasciculations produce an increase in whole body oxygen consumption [1, 2]. Increased oxygen consumption following suxamethonium is one of the factors that may have a major effect on the time to oxygen desaturation following apnoea, during induction of anaesthesia [3]. In comparison, studies have shown that non-depolarizing neuromuscular blocking drugs do not alter oxygen consumption in anaesthetised patients [1–4], since the muscular tone is already reduced by general anaesthesia [5]. Rocuronium, a rapidly acting non-depolarising neuromuscular blocking agent, has been suggested as an alternative to suxamethonium for rapid sequence induction of anaesthesia [6, 7]. Therefore, we investigated the effect of using suxamethonium vs rocuronium on the

onset of oxygen desaturation, during rapid sequence induction of anaesthesia.

Methods

The study was ethically approved by the institutional review board and written informed consent was obtained from all patients. Sixty ASA-1 or -2 patients, who were scheduled for elective surgery under general anaesthesia, were recruited into the study.

All patients were assigned to one of three groups, using a computer-generated table of random numbers. Patients were premedicated with 5 mg oral diazepam, 1 h before induction of anaesthesia. An infusion of Hartmann's solution was commenced in the operating room. A standard anaesthetic machine (Datex ADU AS/5 anaesthesia monitor; Helsinki, Finland) with an absorber system and a 2 l reservoir bag was used. Oxygen saturation was measured using a pulse oximeter (Novamatrix pulse

oximeter, Wallingford, CT, USA) throughout the duration of the study, together with non-invasive blood pressure, heart rate and end-expiratory capnography.

Patients were pre-oxygenated with oxygen 8 l.min^{-1} using a tight fitting facemask for 3 min. Anaesthesia was then induced using a rapid sequence induction technique.

Group R received lidocaine 1.5 mg.kg^{-1} , fentanyl $2 \mu\text{g.kg}^{-1}$, propofol 2 mg.kg^{-1} and rocuronium 1 mg.kg^{-1} . Group S received the same regimen, but suxamethonium 1.5 mg.kg^{-1} was administered instead of rocuronium. In Group SO, two saline boluses were infused instead of lidocaine and fentanyl followed by propofol 2 mg.kg^{-1} and suxamethonium 1.5 mg.kg^{-1} . Propofol was administered over 20 s. The intensity of visible muscle fasciculations was scored as follows [8]:

0 = no fasciculations

1 = mild, fine fasciculations of the eyes, neck, face, or fingers without limb movement

2 = moderate fasciculations occurring on more than two sides or obvious limb movement

3 = vigorous or severe, sustained and widespread fasciculations

The duration of muscle fasciculations was also assessed.

Fifty seconds after administration of the neuromuscular blocking agent, the facemask was removed, and laryngoscopy and tracheal intubation were performed by a trained anaesthetist. The tracheal tube was left open to air. The duration of apnoea was measured from the time that the facemask was removed. When oxygen saturation reached 95%, the tracheal tube was connected to the ventilator. The anaesthetist performing pre-oxygenation, also assessed the fasciculation score, the duration of fasciculations and the time for the oxygen saturation to decrease to 95%. This anaesthetist was blinded to the drugs administered and all drugs were administered behind a drape. To avoid awareness during the apnoeic

period, a bolus dose of 10 mg of propofol was administered 2 min after the induction dose, and then every minute until the completion of the study.

End-expiratory oxygen and carbon dioxide were measured after 3 min of pre-oxygenation using a gas monitor (Datex ADU AS/5). End-expiratory carbon dioxide was measured after initiation of ventilation. The time from onset of apnoea to the time that oxygen saturation reached 95% was compared amongst the three groups, as well as the fasciculation score and duration of fasciculations. The mean arterial pressure and heart rate at intubation and 2 min post-intubation were recorded, and compared amongst the three groups.

A power analysis was performed to determine the number of subjects required for the study. From a previous pilot study, we determined that the standard deviation of oxygen saturation is about 7%. For data analysis, we considered that a 5% change in oxygen saturation was clinically significant, assuming type-1 and -2 errors of 5% and 20% respectively (power of 80%). The power analysis indicated that at least 17 patients were required in each group. Analysis of variance was used for statistical analysis of patients' characteristics and clinical data (SPSS 15.0 for Windows Software; SPSS, Chicago, IL, USA). The Bonferroni test was used for post hoc analysis. Significance was considered as a p value of < 0.05 .

Results

Patients' characteristics were similar for all three groups, as were baseline values of haemoglobin concentration, oxygen saturation, end-expiratory oxygen, end-expiratory carbon dioxide, mean arterial pressure and heart rate (Table 1).

The median (IQR [range]) time to reach S_{pO_2} of 95% was significantly shorter in Group S (358 [311–373 [215–430]] s) than in Group R (378 [370–393 [366–420]]

Table 1 Patients' characteristics and baseline clinical data following induction of anaesthesia with lidocaine/fentanyl/propofol/rocuronium (Group R), lidocaine/fentanyl/propofol/suxamethonium (Group S), or propofol/suxamethonium (Group SO). Values are mean (SD) or number.

	Group R (n = 20)	Group S (n = 20)	Group SO (n = 20)
Age; years	34 (10)	35 (11)	35 (9)
Weight; kg	71 (11)	72 (11)	68 (9)
Height; cm	171 (11)	170 (10)	168 (10)
BMI; kg.m^{-2}	24 (2)	25 (3)	24 (2)
Sex M:F	12:8	12:8	13:7
Hb; g.dl^{-1}	14 (1)	14 (1)	13 (2)
S_{pO_2} ; %	99 (1)	99 (1)	99 (1)
F_{E-O_2} ; %	91 (3)	90 (2)	90 (2)
P_{E-CO_2} ; kPa	4 (0.4)	4 (0.4)	4 (0.3)
MAP; mmHg	93 (11)	91 (10)	90 (9)
HR; beats.min^{-1}	80 (11)	77 (9)	78 (9)

Group R: lidocaine, fentanyl, propofol, rocuronium; Group S: lidocaine, fentanyl, propofol, suxamethonium; Group SO: propofol, suxamethonium. BMI, body mass index; Hb, haemoglobin concentration; S_{pO_2} , arterial oxygen saturation; F_{E-O_2} , end-expiratory fractional oxygen; P_{E-CO_2} , end-expiratory partial pressure of carbon dioxide; MAP, mean arterial pressure; HR, heart rate.

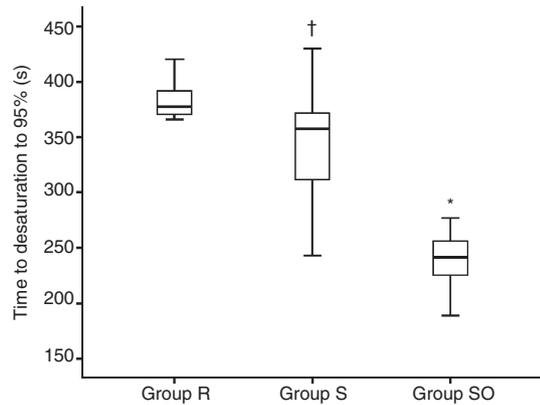


Figure 1 Time to reach S_pO_2 of 95% during apnoea following induction of anaesthesia with lidocaine/fentanyl/propofol/rocuronium (Group R), lidocaine/fentanyl/propofol/suxamethonium (Group S), or propofol/suxamethonium (Group SO). Horizontal line, median; box, IQR; whiskers, range. * $p < 0.001$ compared with Group R and Group S; † $p = 0.003$ compared with Group R.

s; $p = 0.003$), and shorter in Group SO (242 (225–258 [189–370]) s) than in both Group R ($p < 0.001$) and Group S ($p < 0.001$) (Fig. 1).

The fasciculation score, duration of fasciculations, end-expiratory carbon dioxide after the first breath, mean arterial pressure and heart rate at intubation and 2 min post-intubation are shown in Table 2. The fasciculation score and duration of fasciculations were significantly greater in Group SO than in Group R and Group S, and greater in Group S than in Group R. The end-expiratory carbon dioxide achieved by patients in Group SO at the start of ventilation was significantly higher than those achieved by patients in Group R and Group S. No statistically significant differences in mean arterial pressure and heart rate at intubation and 2 min post-intubation were observed between patients in Group R and Group

S. However, mean arterial pressure and heart rate at intubation and 2 min post-intubation were significantly higher in patients in Group SO, compared with their respective values in Group R and Group S.

Discussion

Our study shows that patients who received suxamethonium as the neuromuscular blocking agent, in Group S and Group SO, developed significantly faster oxygen desaturation than those in Group R, who received rocuronium. Moreover, patients in Group SO, who were given propofol and suxamethonium only, exhibited significantly faster onset of oxygen desaturation as compared to Group S, where propofol and suxamethonium were preceded by lidocaine and fentanyl.

This rapid onset of desaturation in Group SO may be attributed to the higher fasciculation score and fasciculation duration in this group. These latter two factors may be responsible for causing an increase in oxygen consumption. Previous reports have shown that, following the administration of suxamethonium to dogs anaesthetised with halothane, an increase in total body oxygen consumption occurs. This may be reflective of a generalised increase in the total body oxygen consumption of skeletal muscles [1, 2].

In addition to the high score and duration of fasciculations in Group SO, the end-expiratory carbon dioxide after initiation of ventilation was significantly increased in comparison with Group R and Group S. This may be attributed to the excessive fasciculations that led to an increase in total body oxygen consumption. This finding confirms the results of a previous investigation where increased carbon dioxide production was reported 1 and 5 min after suxamethonium fasciculations, in patients who received thiopental and suxamethonium, as compared to patients who did not receive suxamethonium [9].

Table 2 Fasciculation score (F-Score), duration of fasciculations (F-Time), mean arterial pressure at intubation and 2 min post-intubation (MAP_{int} , MAP_{2min}), heart rate at intubation and 2 min post-intubation (HR_{int} , HR_{2min}) and end-expiratory carbon dioxide ($P_{E:CO_2}$) after the first breath, following induction of anaesthesia with lidocaine/fentanyl/propofol/rocuronium (Group R), lidocaine/fentanyl/propofol/suxamethonium (Group S), or propofol/suxamethonium (Group SO). Values are number or mean (SD).

	Group R (n = 20)	Group S (n = 20)	Group SO (n = 20)
F-Score	0	1.4 (0.9)*	2.3 (0.7)*†
F-Time; s	0	17 (9)*	21 (2)*§
MAP_{int} ; mmHg	84 (8)	82 (10)	99 (10)*†
MAP_{2min} ; mmHg	77 (7)	75 (9)	95 (9)*†
HR_{int} ; $beats \cdot min^{-1}$	78 (12)	76 (10)	86 (10)‡§
HR_{2min} ; $beats \cdot min^{-1}$	74 (10)	76 (9)	86 (10)*§
$P_{E:CO_2}$; kPa	5.9 (0.5)	5.9 (0.6)	6.4 (0.3)‡§

* $p < 0.001$ when compared with Group R.; † $p < 0.001$ when compared with Group S.; ‡ $p < 0.05$ when compared with Group R.; § $p < 0.05$ when compared with Group S.

Although both Group S and Group SO received suxamethonium, the significant lower fasciculation score and duration in Group S, compared with Group SO, may be secondary to the fact that lidocaine and fentanyl were administered to the former group. The use of lidocaine and fentanyl may not only have attenuated the intensity of muscle fasciculations, but also their duration. Our results are in agreement with previous studies, which showed that when fentanyl was administered to children at a dose of $2 \mu\text{g}\cdot\text{kg}^{-1}$ immediately before suxamethonium, the fentanyl effectively decreased the intensity of fasciculations and their duration [10]. Similarly, alfentanil $50 \mu\text{g}\cdot\text{kg}^{-1}$ given to children and young adults at induction of anaesthesia has been shown to attenuate the intensity of visible fasciculations, but the duration of fasciculations was only reduced in children [11]. The mechanism of inhibitory action of fentanyl and alfentanil on suxamethonium-induced fasciculations is unknown. However, other opioids e.g. morphine, have been shown to inhibit neuromuscular transmission in mammalian preparations, as a result of impaired acetylcholine release [12]. Moreover, lidocaine was found to decrease fasciculations caused by suxamethonium during induction of anaesthesia [13–14]. Lidocaine has also been shown to attenuate the increase in total body oxygen consumption associated with suxamethonium in normal skeletal muscle [15]. The pre-junctional release of acetylcholine associated with suxamethonium administration [16] is reduced by lidocaine leading to decreased fasciculations, and subsequently a reduction in total body oxygen consumption [17].

Mean arterial pressure and heart rate values immediately after intubation and 2 min post-intubation were significantly higher in Group SO, compared with the corresponding values in Group R and Group S, which may indicate sympathetic stimulation. The supplementation of anaesthesia with fentanyl and lidocaine in Group R and Group S may have reduced hypertension and tachycardia, in response to laryngoscopy and tracheal intubation.

In conclusion, when suxamethonium is administered for rapid-sequence induction of anaesthesia, a more rapid onset of oxygen desaturation is observed during the subsequent apnoea as compared to rocuronium. Supplementation of suxamethonium with lidocaine and fentanyl may not only decrease the intensity of fasciculations and also prolong the time to oxygen but also attenuates the haemodynamic response to tracheal intubation.

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