RESEARCH ARTICLE

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The optimal succinylcholine dose for intubating emergency patients: retrospective comparative study

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***Background*:** Succinylcholine remains the drug of choice for satisfactory rapid-sequence tracheal intubation. It is not clear from the literature why the 1 mg/kg dose of succinylcholine has been traditionally used. The effective dose (ED95) of succinylcholine is less than 0.3 mg/kg. The dose of 1 mg/kg represents 3.5 to 4 times the ED_{95}.

***Objectives*:** To compare the effect of the traditionally used 1 mg/kg of succinylcholine with lower doses of 0.6 mg/kg and 0.45 mg/kg on intubation condition regarding the onset time, duration of action, duration of abdominal fasciculation, and the intubation grading.

***Methods*:** This retrospective comparative study was carried into three groups of ASA III & IV (American Society of Anesthesiologist's Physical Status III and IV) non-prepared emergency patients who were intubated at emergency department of Hamad General Hospital, Doha, Qatar during January 1st 2007 to August 31, 2010. The Institutional Research Board (IRB) approval was obtained. This study was limited to 88 patients who received fentanyl 1 μg/kg followed by etomidate 0.3 mg/kg intravenously as induction agents and succinylcholine as a muscle relaxant agent in doses of 0.45 mg/kg, 0.6 mg/kg, or 1 mg/kg.

***Results*:** Increasing the succinylcholine dosage shortened the onset time, prolonged the duration of action, and prolonged the duration of abdominal fasciculation significantly ($P < .001$). Tracheal intubation was 100% successful in the three groups of patients.

***Conclusion*:** Succinylcholine dose of 0.45 mg/kg provides an optimal intubation condition in ASA III & IV emergency non-prepared patients. Duration of action of succinylcholine is dose dependent; reducing the dose allows a more rapid return of spontaneous respiration and airway reflexes.

Keywords: *succinylcholine*; *rapid sequence intubation*; *emergency patients*

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Succinylcholine remains the drug of choice for satisfactory rapid-sequence tracheal intubation. It was first described 50 years ago (1, 2). In early studies, doses averaging less than 0.5 mg/kg were usually administered (total 10–50 mg). Maybe as a consequence, succinylcholine in 1 mg/kg has been established as the usual dose for intubation (3). It is not clear from the literature why 1 mg/kg dose of succinylcholine has been traditionally used for tracheal intubation. Spontaneous recovery from the induced apnea with succinylcholine in 1 mg/kg may not develop fast enough to prevent hemoglobin desaturation in patients with unassisted ventilation (4). That will be clinically significant as a life threatening hemoglobin desaturation in an unanticipated difficult airway. Smaller doses of succinylcholine may shorten this time of vulnerability (5).

The effective dose (ED95) of succinylcholine is less than 0.3 mg/kg (6, 7). A dose of 1 mg/kg represents 3.5 to 4 times the ED_{95}. In succinylcholine, as a depolarizing neuromuscular blocker, doses equivalent to double the ED95 are generally considered to be the appropriate dose for intubation (8). Doses only 1.5 times the ED_{95} can provide satisfactory conditions for tracheal intubations, smaller dose as 0.4 mg/kg might also provide clinical acceptance (7). Naguib et al. strongly supports this hypothesis (8). They found in ASA I & II patients

(American Society of Anesthesiologist's Physical Status I and II) that 0.56 mg/kg succinylcholine was sufficient to provide acceptable (excellent or good) intubating conditions at 60 sec in 95% of patients; where doses as low as 0.3 mg/kg produced the same acceptable intubating conditions in 92% of patients (8).

The possibility of an earlier return of neuromuscular function following low-dose succinylcholine has much to recommend it especially in cases with unanticipated difficult airways or high risk conditions (9–13). All studies with the information about using smaller doses of succinylcholine (less than the conventional dose 1 mg/kg) were dealt with the induction for intubation in elective procedures or simulated rapid sequence induction in well-prepared ASA I & II patients (14). No studies at all were applied to the high risk ASA EIII & EIV non-prepared patients where the letter E indicates an emergency condition.

Materials and methods

According to the succinylcholine injected dose, this retrospective comparative study was carried into three groups of ASA III & IV non-prepared emergency patients who were intubated at the emergency department of Hamad General Hospital, Doha, Qatar in a period from January 1st 2007 to August 31, 2010. The Institutional Research Board (IRB) approval was obtained. Many induction agents in different doses were used in intubation during this period, our study was limited to only 88 patients who received fentanyl 1 μg/kg followed by etomidate 0.3 mg/kg intravenously as induction agents and succinylcholine as a muscle relaxant agent. According to the injected succinylcholine dose, patients were allocated into three groups. Group 1 includes 26 patients who received a dose of 0.45 mg/kg, group 2 includes 27 patients who received a dose of 0.6 mg/kg, and group 3 includes 35 patients who received a dose of 1 mg/kg. Tracheal intubation was carried out by the assigned anesthesiologist in the emergency department.

Records were reviewed for the duration of abdominal fasciculation (time from start of abdominal contractions to total abdominal flaccidity), onset time (time from drug injection to total anterior wall flaccidity), and the duration of action (time from the drug onset of action to resumption of breathing) (11). Intubation condition was graded based on the accepted criteria for good clinical research practice (Table 1) (8, 11, 13).

During the period of this retrospective study, intubation was carried out by different anesthetists with different inductive agents in different doses at the emergency department. The study was limited only to those who received the previously mentioned drugs in its previously described doses, which limits the total number to 88. Applied exclusion criteria included (a) patients with extremity of ages (less than 15 and more than 65 years), (b) patients with body mass indices more than 28 kg/m^2, (c) pregnant women, (d) patients in arrhythmias, and (e) patients with an abnormal airway examination.

Statistical analysis

Descriptive statistics have been performed in the form of mean and standard deviation for continuous variables and frequency with a percentage performed for categorical variables. One way analysis of variance (ANOVA) with post-hoc analysis (Bonferroni Test) has been applied to see significance among groups for continuous variables and the chi-square test was performed for categorical variables. *P*-value less than .05 (two-tailed) has been considered as statistical significance level. SPSS 17.0

Table 1. Criteria for grading tracheal intubation conditions (8, 11, 13)

	Intubating grading			
Variables	excellent	good	poor	failed
Laryngoscopy	Easy	Fair	Difficult	Inapplicable
Vocal cords				
Movements	None	Moving	Closing	Closed
Position	Abducted	Intermediate	Closed	Closed
Reaction to intubation				
Coughing	None	Slight	Vigorous	Persistent
Limbs movements	None	Slight	Sustained (<10 s)	Sustained (>10 s)

Intubation conditions: Excellent: all variables are excellent; Good: all variables are excellent or good; Poor: the presence of one or more variables graded as poor; Failed: inapplicable laryngoscopy graded as failed.
Laryngoscopy: Easy: jaw relaxed, no resistance to blade during laryngoscopy; Fair: jaw not fully relaxed, slight resistance to blade; Difficult: poor jaw relaxation, active resistance by the patient; Failed: no jaw relaxation, extensive resistance by the patient.

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(Statistical Package for the Social Sciences) was used for statistical analysis for the study.

Results

After application of the exclusion criteria, the total number of patients was limited to 60 patients. There were no significant differences among the three groups regarding baseline demographic data, including age, sex, height, weight, and ASA physical status (Table 2).

After doses 0.45mg/kg (group 1), 0.6mg/kg (group 2), and 1 mg/kg (group 3), the onset time was 65 ± 2.5 sec, 55 ± 2.5 sec, and 44.9 ± 2.5 sec, while the duration of action was 5 ± 0.1 min, 6.4 ± 0.8 min, and 12.5 ± 1.3 min, respectively. Increasing the succinylcholine dose shortened the onset time and prolonged the duration of action significantly ($P < .001$) (Table 3).

Duration of abdominal fasciculation revealed significant shortening with less than 5 sec in 95% of patients (group 1), 60% (group 2), and only 16% (group 3). Prolonged fasciculation time more than 10 sec was not observed in group 1 but was reported in 15% of group 2, and 47% in group 3. Increasing the succinylcholine dose prolonged the duration of abdominal fasciculation significantly ($P < .001$) (Table 3).

There were dose dependant significant differences among the different doses of succinylcholine. High doses result in fast onset of action ($P < .001$), prolong the duration of action ($P < .001$), and prolonged abdominal fasciculation duration ($P < .001$).

Tracheal intubation was successful (equals to accepted) in all patients (Table 4). The incidence of excellent intubating conditions was increased by increasing the drug dose in the form of 85.7%, 90%, 94.7% for doses 0.45 mg/kg, 0.6 mg/kg, and 1 mg/kg, respectively.

There were no significant differences between the three groups in laryngoscopy, vocal cords (movements or position), and reaction to intubation (coughing or limb movements) ($P = .637$). The incidence of aspiration was none in this study.

Discussion

Although the use of succinylcholine was markedly reduced over the last few years with the use of the new short acting non-depolarizing muscle relaxants, succinylcholine still has the upper hand as the muscle relaxant of choice for endotracheal intubation in emergency patients. The aim of this retrospective study is to investigate if small doses of succinylcholine (less than 1 mg/kg) can produce satisfactory intubation for rapid sequence endotracheal intubation in non-prepared patients and if it is associated with a shorter recovery time that might avoid critical oxygen desaturation especially when not able to intubate ventilated patients?

The nature of patients subjected for intubation in the study in both trauma and medical resuscitative rooms in emergency department includes unknown past and current medical history, unknown anesthesia history, full stomach, and critically ill status (ASA III & IV). All those factors indicate the reduction of fentanyl dose to 1 mcg /kg, the use of etomidate in 0.3 mg/kg body weight to provide a minimum effect in the hemodynamic stability of the patients and avoid any synergistic effect of both agents with the succinylcholine in the intubation conditions (14, 15). The dose 1 mg/kg represents more than triple ED95 of succinylcholine.

Many inductive agents in different doses were used for intubation at the emergency department during the period of the study. The study was limited only to patients who received fentanyl in 1 μg/kg followed by

Table 2. Demographic data (SD based)

	Succinylcholine dose			
Variables	Group 1 0.45 mg/kg	Group 2 0.6 mg/kg	Group 3 1 mg/kg	*P*-value
Age (year)	37.3±7.9	38.6±15.9	36.6±13.4	0.086
Sex				
Men	17 (81%)	19 (95%)	19 (100%)	0.075
Women	4 (19%)	1 (5%)	0 (0%)	
Weight (kg)	69.9±7.5	70.5±14.2	72.4±19.8	0.862
Height (cm)	166.2±6.1	167.3±7.5	172.4±11.8	0.069
Body mass index (kg/m2)	25.1±1.9	24.8±3.4	23.9±3.8	0.452
ASA E				
III	4 (19%)	9 (45%)	8 (42.1%)	
IV	17 (81%)	11 (55%)	11 (57.9%)	0.161

Table 3. Onset time and durations of block and abdominal fasciculation

Variables	Succinylcholine dose			*P*-value
	Group 1 0.45 mg/kg	Group 2 0.6 mg/kg	Group 3 1 mg/kg	
Onset time (second)	65±2.5	55±2.5	44.9±2.5	<0.001
Duration of block (minute)	5±0.6	6.4±0.8	12.5±1.3	<0.001
Duration of abdominal fasciculation:				
<5 sec	20 (95.2%)	12 (60%)	3 (15.8%)	
5:10 sec	1 (4.8%)	5 (25%)	7 (36.8%)	<0.001
>10 sec	0 (0%)	3 (15%)	9 (47.4%)	

etomidate in 0.3 mg/kg intravenously as induction agents followed by the succinylcholine in the subjective doses of the study: 0.45 mg/kg, 0.6 mg/kg, and 1mg/kg. The total number was limited to 88 patients, and after application of other exclusion criteria the number was restricted to 60. Exclusion criteria included (a) patients with extremity of ages (less than 15 and more than 65 years), (b) patients with body mass indices more than 28 kg/m^2, (c) pregnant women, (d) patients in arrhythmias, and (e) patients with an abnormal airway examination.

The assessment of the neuromuscular response of the depolarizing muscle relaxant through the twitches of the adductor policies is not a very useful measure for evaluating the neuromuscular block at the laryngeal, diaphragm, and masseter muscles. The return of the diaphragm muscle activity (re-polarization = end of paralytic effect = resumption of breathing) was 2 min earlier than the hand adductor policies muscle after succinylcholine in many studies (16, 17). For the above mentioned reasons and because these were emergency patients, peripheral nerve stimulation was not used. The onset time, the duration of action, and duration of abdominal fasciculation were obtained from records to anterior abdominal wall inspection during induction and recovery from the drug effect.

There were no significant differences among the three groups regarding baseline demographic distribution including age, gender (men/women), weight, height, and ASA physical status ($P = .161$) (Table 2). After intravenous administration of 0.45 mg/kg, 0.6 mg/kg, and 1 mg/kg succinylcholine (group 1, 2, and 3), the onset time was 65±2.5 sec, 55±2.5 sec, and 44.9±1.3 sec, respectively (Table 3), which was nearly similar to the results obtained by El-Orbany et al., results that were 67.3±1 sec, 55± 11 sec, and 52±5 sec, respectively (11). Increasing the dose of succinylcholine allows a faster onset of action ($P <$ .001) (Table 3). No data is available about the risk of aspiration if the tube is introduced into the trachea at 60–90 sec instead of the usually advocated 60 sec (8). The incidence of aspiration in this study was none. Comparing groups 1, 2, and 3, the mean durations of apnea were 5 min, 6.4 min, and 12.5 min, respectively ($P < .001$) (Table 3). Reducing the dose of succinylcholine allows a more rapid return of spontaneous respiration and airway reflexes, which is very important in critical emergency patients especially if difficult to ventilate or intubate (5, 18).

It was observed that the onset of action and duration of action of succinylcholine were dose dependent (20). Studies revealed or predicted when ventilation is not assisted the possibility of life-threatening, profound dropping of arterial oxygen saturation below 90% is common with the high dose of 1 mg/kg due to prolonged apnea time. It does not occur in low doses like 0.5 mg/kg succinylcholine with short apnea time (19, 20). This is augmenting the support for the small dose and indicates that the recovery time is more important than the onset of action especially in situations in which the health care provider is less than certain of complete control of a patient's airway (21).

The duration of fasciculation of the anterior abdominal wall in the study reflect a significant shorten in duration <5 sec in 95% with a low dose (0.45 mg/kg), compared to prolonged fasciculation duration in the high common dose (1 mg/kg) 5:10 sec in 37% and >10 sec in 47% (prolonged in total of 84% with 1 mg/kg) ($P < .001$) (Table 3). Reduction in fasciculation time gives the advantage for use of low dose to reduced incidence of an increase in intra-abdominal pressure, intra-gastric pressure, and consequently minimizes the risk of vomiting and aspiration in full stomach emergency patients (22).

The outcome of laryngoscopy and intubating conditions with different doses in group 1, 2, and 3 revealed easy intubation in 85.7%, 90%, and 94.7% and fair intubation in 14.3%, 10%, and 5.3%, respectively. Laryngoscopy outcome was 100% successfully accepted in all patients in the three groups (Table 4). Tracheal intubation condition, vocal cords movements/position, and reaction to intubation (coughing and limb movements) revealed excellent intubation in 85.7%, 90%, and 94.7% in group 1, 2, and 3, while good intubation in

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Table 4. Outcome of laryngoscopy and tracheal intubation

Variables	Succinylcholine dose			*P*-value
	Group 1 0.45 mg/kg	Group 2 0.6 mg/kg	Group 3 1 mg/kg	
Laryngoscopy				
Easy	18 (85.7%)	18 (90%)	18 (94.7%)	
Fair	3 (14.3%)	2 (10%)	1 (5.3%)	0.637
Difficult	–	–	–	
Failed	–	–	–	
Vocal cords				
Movements				
None	18 (85.7%)	18 (90%)	18 (94.7%)	0.637
Moving	3 (14.3%)	2 (10%)	1 (5.3%)	
Closed	–	–	–	
Closed	–	–	–	
Position				
Abducted	18 (85.7%)	18 (90%)	18 (94.7%)	0.637
Intermediate	3 (14.3%)	2 (10%)	1 (5.3%)	
Closed	–	–	–	
Closed	–	–	–	
Reaction to intubation:				
Coughing				
None	18 (85.7%)	18 (90%)	18 (94.7%)	0.637
Slight	3 (14.3%)	2 (10%)	1 (5.3%)	
Vigorous	–	–	–	
Persistent	–	–	–	
Limb movements				
None	18 (85.7%)	18 (90%)	18 (94.7%)	
Mild	3 (14.3%)	2 (10%)	1 (5.3%)	0.637
Moderate	–	–	–	
Vigorous	–	–	–	
Intubation outcome				
Excellent	18 (85.7%)	18 (90%)	18 (94.7%)	0.637
Good	3 (14.3%)	2 (10%)	1 (5.3%)	
Poor	–	–	–	
Failed	–	–	–	
Acceptable				
Excellent	18 (85.7%)	18 (90%)	18 (94.7%)	0.637
Good	3 (14.3%)	2 (10%)	1 (5.3%)	
Unacceptable	0%	0%	0%	

14.3%, 10%, and 5.3%, respectively. Tracheal intubation outcome was 100% successfully accepted in all patients in the three groups (Table 4). There was no significant difference in the outcome of laryngoscopy and intubating conditions in the three groups ($P = .637$). Naguib et al. (8) found that in a dose of 1.0 mg/kg succinylcholine, it is associated with an 80% incidence of excellent intubating conditions and they recommended the use of 0.56 to facilitate endotracheal intubation, which achieves acceptable intubating conditions in 95% of well-prepared ASA I & II patients. Therefore, use of 1 mg/kg may be excessive if the goal is to achieve accepted intubation (8).

Other studies (23–25) recorded the range of excellent intubating conditions after the administration of

1.0 mg/kg succinylcholine in a simulated rapid-sequence induction in elective cases of 63% to 74%. It is a lower incidence than those in our current study that dealt with emergency critically ill cases (ASA III & IV). The intubating conditions depend on several factors including: the type and dose of inductive agents, the depth of anesthesia, the interval between drug administration and laryngoscopy, the dose of the neuromuscular blocker given, the anatomy of the airways, and the experience of the intubating person (4, 13).

Reducing the dose of succinylcholine (from 1 mg/kg to 0.45 mg/kg) in emergency patients has numerous clinical advantages. It minimizes the incidence of idiopathic malignant hyperthermia, myalgia, masseter spasm, rhabdomyolysis, and hemodynamic changes (10). It reduces the aggravated hyperkalemia in end-stage renal failure, burn, and potassium sparing diuretics patients (26). It avoids the excessive increase in intracranial pressure in head injuries and minimizes the increase in both intra-abdominal and intra-gastric pressures, decreasing the incidences of vomiting and consequent aspiration (10).

Conclusion

Succinylcholine in a dose of 0.45 mg/kg ($1.5 \times ED_{95}$) compared with doses of 0.6 mg/kg ($2 \times ED_{95}$) and traditionally doses of 1 mg/kg ($>3 \times ED_{95}$) was sufficient to provide acceptable intubating conditions in 100% of the patients. It shortens the duration of neuromuscular block and abdominal fasciculation with non-clinical significant delay in onset of action. Duration of action of succinylcholine is dose dependent, so reducing the dose allows a more rapid return of spontaneous respiration and airway reflexes. Thereby it decreases the window of vulnerability in airway management during induction of anesthesia in addition to reducing the incidence of succinylcholine-induced side effects and complications. A succinylcholine dose of 0.45 mg/kg provides an optimal intubation condition in emergency ASA III & IV patients.

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