

Muscle Relaxation for Induction in Patients with a Full Stomach

BY FRANÇOIS DONATI, MD

When a patient is suspected of having a full stomach, specific considerations must be included when planning the induction of anesthesia. Vomiting and regurgitation, sometimes leading to pulmonary aspiration, may occur when a patient has depressed reflexes and an unprotected airway. Therefore, the most critical time period is between induction of anesthesia (when protective reflexes are blunted or abolished) and tracheal intubation (when it can be assumed that the airway is protected from aspiration of stomach contents). The concept of "rapid sequence induction" was developed to shorten, as much as possible, the time interval when the respiratory system is not protected.

Aspiration of gastric contents is a rare event, but it occurs more frequently during emergency surgical procedures. In a retrospective study involving 172,334 patients conducted at the Mayo Clinic, the incidence of pulmonary aspiration was found to be 1:895 emergency surgical cases, 4 times as often as in elective cases (1:3,886).¹ In one-third of these cases, aspiration occurred at induction of anesthesia and, in 64% of these cases, there was inadequate paralysis at the time of intubation.

If a full stomach is suspected, pre-oxygenation is performed to avoid hypoxemia, should ventilation be impossible for several minutes. Then, one proceeds with rapid intravenous induction that includes a neuromuscular blocking agent to limit the interval between anesthesia induction and tracheal intubation to approximately 1 minute (Table 1). The goal is to reduce the time period during which aspiration of gastric contents is possible. However, this sequence of events is associated with 2 major disadvantages: first, the need to inject rapidly does not allow titration of anesthetic agents and, second, the technique carries the risk of failure of both intubation and ventilation (a "can't intubate, can't ventilate" scenario).

To minimize the risk of aspiration, intubating conditions must be optimal. To achieve this, it is not realistic to depend on large doses of opioid and hypnotic drugs because of the risk of hypotension. In patients presenting for emergency surgery, optimal intubating conditions cannot be obtained unless adequate doses of neuromuscular blocking agents are given. In this issue of *Anesthesiology Rounds*, discussion is restricted to a case concerning an adult patient with a pre-operative airway exam that suggests no anticipated problems with tracheal intubation. The indications for rapid sequence induction are not discussed, but it is assumed that the anesthesiologist has determined that a rapid sequence induction with tracheal intubation is indicated. Specific cases, such as emergency surgery in children, in pregnant women, and in individuals with elevated intracranial pressure, open eye injuries, or cervical spine trauma, are not covered.

HISTORY

The relationship between anesthesia and aspiration pneumonia became clear in 1946, when Mendelson, an obstetrician, published a case series of pregnant patients, most of whom had been administered an anesthetic via face mask. This led to the widespread acceptance of pre-operative fasting rules, but this solution did not solve the problem of the patient with slow gastric emptying or when the surgical procedure cannot be delayed. The introduction of succinylcholine in 1951 was a major advance. However, in a British survey on peri-operative mortality in the early 1950s, vomiting and regurgitation accounted for as much as 19% of the deaths attributable to anesthesia.² The authors of the study suggested positioning the patients "head-up" before induction or to empty the stomach with a gastric tube before proceeding with the anesthetic. In 1961, Sellick came up with a more elegant solution, which consisted of the application of manual pressure on the cricoid cartilage after induction of anesthesia to reduce the risk of regurgitation. However, there have been no

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TABLE 1: Suggested steps for rapid sequence induction

Time	Action
-3 min to 0	Pre-oxygenation
-3 min (optional)	Pre-curarization (rocuronium, 0.03 mg/kg, or equivalent)
From -2 to -1 min (optional)	Opioid drug
0 min	Hypnotic drug
At loss of consciousness	Cricoid pressure If there was no pre-curarization: – succinylcholine, 1 mg/kg If there was pre-curarization: – succinylcholine, 2 mg/kg If contraindication to succinylcholine: – rocuronium, 1 mg/kg No bag and mask ventilation Turn on nerve stimulator
+ 1 to 1.5 min (after loss of twitch response)	Laryngoscopy and intubation
After intubation	Release cricoid pressure

randomized controlled studies on the effectiveness of this maneuver.

By the end of the 1960s, rapid sequence induction, including cricoid pressure, was not universally applied. In a review article, Salem³ discussed 4 possible approaches for induction of anesthesia in a patient with a full stomach. Intravenous induction, including a neuromuscular blocking agent, was 1 possibility. The other 3 methods were inhalation induction with muscle paralysis, inhalation induction with hyperventilation, and awake intubation. Since then, very few studies have included patients scheduled for a surgical procedure on an emergency basis. In this setting, a thiopental or ketamine induction was suggested, followed by succinylcholine, 50-100 mg, with or without pre-curarization using d-tubocurarine. In 1982, in a randomized study comparing different induction agents in patients anesthetized for emergency surgery, the neuromuscular blocking drug was succinylcholine, 1.5 mg/kg, preceded by d-tubocurarine, 3 mg.⁴ Since then, many studies have involved simulation of a rapid sequence induction in elective patients, but only 2 recent articles, published in 2005,^{5,6} reported results in patients undergoing emergency surgery.

NEW QUESTIONS, NEW CHALLENGES

In spite of limited evidence-based data during the past quarter century from patients actually undergoing emergency surgical procedures, other advances have modified our approach. New nondepolarizing neuromuscular blocking agents have emerged, with a faster onset and shorter duration of action than the older, pre-1980, drugs. Some have suggested using the newer neuromuscular blocking drugs instead of succinylcholine. New hypnotic drugs (eg, propofol and etomidate) and new opioids (eg, alfentanil and remifentanil) have become available. It has been claimed that adequate

dosage of these drugs makes muscle relaxation unnecessary for tracheal intubation.

It has been thought for a long time that the duration of action of succinylcholine was so short that a properly pre-oxygenated patient would be expected to start breathing before onset of hypoxia. Thus, succinylcholine would offer some kind of protection against the dreaded “can’t intubate, can’t ventilate” scenario. Several recent studies have examined this question. In addition, because obesity has become more prevalent, this has become the topic of recent articles. Last year, a meta-analysis was published on the topic of pre-curarization.⁷ Finally, other medical practitioners have adopted the induction technique developed by anesthesiologists for full stomachs. Emergency physicians prefer to call it “rapid sequence intubation,” and their experience outside the operating room can be useful to us.⁸

PHYSIOLOGY AND PHARMACOLOGY

The first drug to administer when proceeding with induction of anesthesia is oxygen. After 3-5 minutes of pre-oxygenation, an average-sized adult with a normal weight can sustain a period of apnea of approximately 8 minutes with no change in oxygen saturation. If the subject breathes air, desaturation occurs after about 1 minute of apnea. The duration of this apnea period without desaturation varies from one patient to the next but, for each individual, the duration is longer with oxygen, than without.

Patients who present for emergency surgery may be hypovolemic, dehydrated and/or have a diminished cardiac output. This situation alters the pharmacokinetics of drugs, especially in the first few minutes after intravenous bolus injection. If cardiac output is decreased, the time interval between injection into a vein and the first appearance of the drug in arterial blood is prolonged. However, the plasma concentration of the drug will reach a higher peak because of dilution into a smaller volume, and the peak will last longer. Thus, onset of the drug effect is expected to be longer if cardiac output is depressed, but the magnitude of the effect will be greater. This phenomenon is taken into consideration by a new branch of pharmacokinetics, termed “front-end pharmacokinetics.”⁹

To get the full picture, front-end pharmacokinetics must incorporate organ blood flow. For induction agents, it is predicted that high concentrations of a drug will be delivered to the target organ – the brain – in large quantities because blood flow to vital organs is relatively preserved in the face of a diminished cardiac output. This explains why, in patients with hypovolemia and decreased cardiac output, only small doses of hypnotic agent are required, but the effect takes longer to be apparent. For neuromuscular blocking agents, arterial plasma concentrations are increased if cardiac output decreases, but this effect is compensated for by a much reduced muscle blood flow. As a result, the recommended doses of blocking agents remain approximately the same, whether cardiac output is low or normal, but onset time is increased if cardiac output is low. For example, it has been shown that onset of paralysis is slower with esmolol and faster if ephedrine is administered before the neuromuscular blocking agent.

WHY NEUROMUSCULAR BLOCKING AGENTS?

For the past 10 years, almost all investigators interested in neuromuscular blockade have adopted the same scoring system for intubating conditions. There are 4 possible grades: excellent, good, poor, and impossible, based on the evaluation of 5 components (laryngoscopy, vocal cord position, vocal cord movement, cough, limb movement). The total score is determined by the worst of the components. For example, if one component is judged as "poor," the total score is poor; if at least 1 component is good and none is poor, the intubating conditions are qualified as "good." Intubating conditions are rated "excellent" only if all components are considered excellent. Finally, conditions are considered "impossible" if intubation cannot be performed. Although this scoring system appears to be subjective, the results are remarkably consistent from 1 study to the next. For example, the proportion of excellent intubating conditions after succinylcholine, 1 mg/kg, reported by various studies falls within a relatively narrow range (63%-80%). Similarly, the same studies indicate that 92%-98% are acceptable conditions, defined as either "excellent" or "good."¹⁰

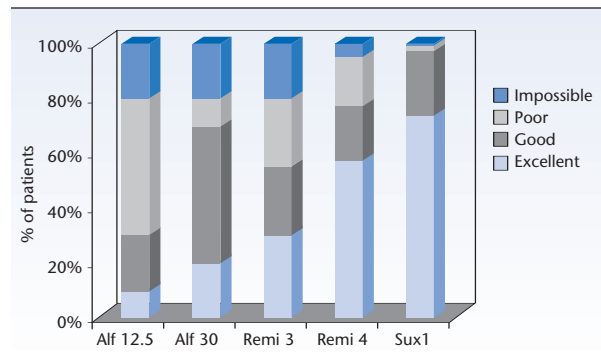
If a low-dose opioid (fentanyl 1-2 µg/kg or equivalent) is part of the induction sequence and, if intubation is attempted without prior injection of a neuromuscular blocking agent, excellent intubating conditions are found in only 30% of cases and intubation is impossible in approximately 20% of instances (Figure 1). High doses of opioid drugs (>30 µg/kg alfentanil or >3 µg/kg remifentanil) are required to decrease the incidence of impossible intubations below the 20% mark. With remifentanil, 4 µg/kg, or alfentanil, 60 µg/kg, intubating conditions are similar to those following succinylcholine, 1 mg/kg, but the incidence of hypotension, even in elective patients, is high.¹¹ One can only imagine the hemodynamic consequences of such high doses of opioids in emergency patients.

Similarly, the emergency medicine literature reports high failure rates when neuromuscular blocking agents are omitted. In a review article on intubations performed in the emergency department, as many as 10%-27% of patients could not be intubated if the procedure was done using sedation only, while the use of a hypnotic and a neuromuscular blocking agent was associated with only a 1%-2% failure rate. In addition to subjecting the patient to the consequences of a failed intubation, omitting a neuromuscular blocking agent is also associated with other complications. For example, in a double-blind study, intubating conditions were found, as expected, to be better with atracurium than without. In addition, the incidence of sore throat and vocal cord lesions (microtrauma and hemorrhage) was less in subjects who had received the neuromuscular blocking agent.¹²

NONDEPOLARIZING NEUROMUSCULAR BLOCKING AGENTS

There is no doubt that, among currently available drugs, rocuronium is the nondepolarizing agent with the fastest onset of action. However, intubating conditions with the usual 0.6 mg/kg dose are not as good as with succinylcholine, 1 mg/kg (Figure 2).¹³ A higher dose of rocuronium (1 mg/kg) must be administered to

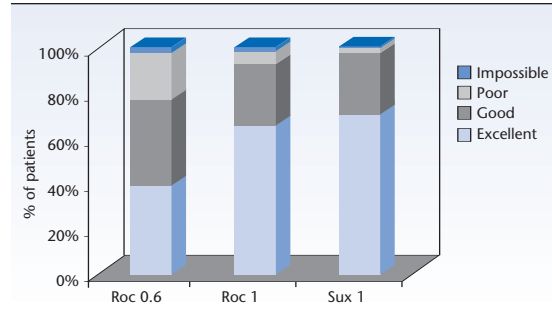
FIGURE 1: Intubating conditions 1 minute after an opioid-propofol or propofol-succinylcholine induction^{10,11}
Opioid doses are in µg/kg, succinylcholine doses are in mg/kg. Alf = alfentanil, Remi = remifentanil, Sux = succinylcholine



obtain intubating conditions that are close to those provided by succinylcholine, 1 mg/kg. The price to pay is a much longer duration of action. However, the 1-minute interval between injection and intubation is arbitrary and it is not known whether delaying the timing of intubation carries a higher risk of aspiration for the patient. What is known is that intubating conditions after nondepolarizing neuromuscular agents can be made as good as with succinylcholine, provided that appropriate monitoring practices are applied. It is important to realize that blockade at the adductor pollicis occurs late, but it is more intense compared with the diaphragm or the vocal cords. The corrugator supercilii is a small muscle innervated by the facial nerve. It lies under the medial part of the eyebrow and is active during frowning. There has been confusion between the corrugator supercilii and orbicularis oculi in many publications. Irrespective of the name given to that frowning muscle, its timecourse of blockade is similar to that of the diaphragm or the vocal cords. A French study demonstrated that, if the timing of intubation occurred after disappearance of the twitch response at the corrugator supercilii, excellent conditions were found in approximately 80% of cases, whether the neuromuscular blocking agent was succinylcholine, rocuronium, mivacurium, atracurium, or vecuronium.¹⁴ However, the time interval between injection and intubation was longer and more variable with nondepolarizing agents (2-3 minutes), than with succinylcholine (mean: 1 minute).

The only 2 studies conducted in patients scheduled for emergency surgery both compared succinylcholine, 1 mg/kg, with rocuronium, 0.6 mg/kg. A Danish study evaluated intubating conditions at 1 minute after an alfentanil-propofol induction. Excellent intubating conditions were found in 67% of patients who received succinylcholine and 52% of those who received rocuronium, but the difference was not statistically significant.⁶ The other study was conducted in Switzerland and the same doses of neuromuscular blocking agents as in the Danish study were administered following a fentanyl-propofol induction. Laryngoscopy and intubation were attempted, based on the disappearance of the twitch response at the hand. In the succinylcholine group, intubation was performed earlier (40 vs 70 seconds after the neuromuscular blocking drug) and conditions were better.⁵ This last study confirms the findings

FIGURE 2 : Intubating conditions after a neuro-muscular blocking agent preceded by propofol¹³
Doses are in mg/kg. Roc = rocuronium, Sux = succinylcholine



of others in elective patients, in whom intubating conditions were superior with succinylcholine than with rocuronium, 0.6 mg/kg.

SUCCINYLCOLINE: WHICH DOSE?

For many decades, the recommended dose of succinylcholine was 1 mg/kg and this recommendation had not been challenged until recently. The situation changed when it was suspected that, with 1 mg/kg, return of breathing movements after a failed intubation could not be guaranteed before the onset of hypoxia. If pre-oxygenation is adequate, oxygen saturation will normally remain normal during apneic periods ≤ 8 minutes (which is the average time required for return of twitch at the adductor pollicis after administration of succinylcholine, 1 mg/kg). But not all patients are “average” and these data suggest that a significant number are at risk of hypoxia before they recover from the neuromuscular effects of succinylcholine. Several investigators have attempted to verify these predictions. It was found that breathing activity was observed before recovery of hand muscles. On average, the diaphragm took 5 minutes to recover.¹⁵⁻¹⁷ In spite of the short duration of paralysis of respiratory muscles, desaturation was seen in many individuals, the proportion being variable from 1 study to the next (Table 2). The reasons for the discrepancies between studies are not clear; however, it can be concluded that certain individuals are at risk because of a longer-than-average duration of succinylcholine blockade and/or lower-than-normal oxygen stores after pre-oxygenation.

The next step was to verify whether a decrease in the succinylcholine dose could reduce the risk of desaturation, while maintaining the quality of

intubating conditions. In a study on the effect of succinylcholine dose on intubating conditions, acceptable (excellent or good) conditions were found in 98% of subjects after 1 mg/kg. If the incidence of acceptable conditions is set at 95%, it was calculated from the data that only 0.56 mg/kg was required (Figure 3).¹⁸ The apnea time associated with doses of 0.56 and 1 mg/kg were then measured in another study, but no statistically significant difference was found because of the large variability in the response associated with any dose of succinylcholine (Table 2).¹⁷ The lower dose was associated with a 65% incidence of desaturation, instead of 85%, but the difference was not statistically significant. In the same study, patients receiving fentanyl and propofol, but no succinylcholine, had a 45% incidence of desaturation. It can be concluded that there is no ideal dose of succinylcholine. Considering that failure to intubate is a rare event, the priority should be given to the quality of intubating conditions and the 1 mg/kg dose appears to be an adequate compromise. It should be noted that even a 2 mg/kg dose does not provide excellent conditions in all subjects at 1 minute (Figure 3).¹⁹

SUCCINYLCOLINE IN THE OBESE

Intuitively, one would predict that a reduced succinylcholine dose, expressed in mg/kg of actual body weight, would be appropriate in obese patients, because the drug is not distributed to fatty tissue and the apneic period without desaturation is short in obese individuals. However, a recent study contradicts this prediction. It revealed poorer quality intubating conditions if the dose was reduced from 1 mg/kg (87% excellent conditions) to 0.65 mg/kg (47%) to 0.5 mg/kg (27%).²⁰ Duration of action of the same dose, expressed in mg/kg actual body weight, was the same in obese as in lean subjects.

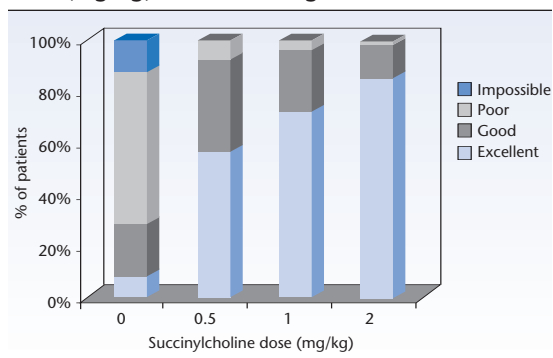
PRE-CURARIZATION

A small dose of nondepolarizing neuromuscular blocking agent, administered approximately 3 minutes before succinylcholine, decreases the incidence and intensity of succinylcholine-induced fasciculations and myalgia. Several meta-analyses have demonstrated the effectiveness of this “pre-curarization,”⁷ but this technique carries the risk of excessive paralysis in the awake patient. When aspiration of gastric contents is a concern, it is important to avoid administering doses associated with breathing or swallowing difficulties.

TABLE 2: Duration of apnea and incidence of desaturation after succinylcholine

Study	Number of subjects	Succinylcholine dose (mg/kg)	Duration of apnea in min (range)	Incidence of desaturation
Heier et al ¹⁵	12	1	5.2 (3.5-9.0)	25%
Hayes et al ¹⁶	100	1	4.7	11%
Naguib et al ¹⁷	20	1	4.7 (2-7)	85%
Naguib et al ¹⁷	20	0.56	4.7 (2-12)	65%
Naguib et al ¹⁷	20	0	2.7 (1-5)	45%

FIGURE 3: Relationship between succinylcholine dose (mg/kg) and intubating conditions at 1 min¹⁹



However, it seems that many safety principles were forgotten when anesthesiologists replaced d-tubocurarine with newer nondepolarizing drugs. Until the 1990s, the most popular pre-curarizing agent was d-tubocurarine and the usual dose was 3 mg, which is one-tenth of the effective dose 95 (ED₉₅) for a 70-kg adult (the ED₉₅ being the dose producing an average 95% block at the adductor pollicis). With the introduction of newer neuromuscular blocking agents, the pre-curarizing doses underwent a sudden inflation. With vecuronium, the commonly administered dose was 1 mg, while 0.3 mg is equipotent with d-tubocurarine 3 mg. As much as 5 mg of atracurium has been given, instead of 1.5 mg. With rocuronium, as much as 6 mg has been recommended, whereas 2 mg would be sufficient. In a study comparing 0.06 mg/kg rocuronium with placebo before induction of anesthesia, symptoms of muscle weakness were reported more frequently in subjects receiving rocuronium.²¹ Obviously, the dose was too high. It should have been reduced to 0.03 mg/kg.

Other advantages of appropriate doses of pre-curarizing agents include decreased oxygen consumption because of a lack of fasciculations, fewer arrhythmias, and blunting of succinylcholine-induced catecholamine release. However, the dose of succinylcholine must be increased if pre-curarization is used because of antagonism between nondepolarizing and depolarizing agents. Onset, intubating conditions, and duration of action after succinylcholine, 2 mg/kg *with* pre-curarization, and succinylcholine, 1 mg/kg *without* pre-curarization, are similar.

HYPNOTIC AND OPIOID DRUGS

Intubating conditions depend on the choice of hypnotic and dose. Usually, propofol provides better conditions than either thiopental or etomidate. For example, etomidate before rocuronium was associated with a 25% incidence of poor conditions compared with only 6% if propofol was the induction agent.²² However, if the neuromuscular blocking agent provides adequate relaxation, the choice of hypnotic agent is less important. For example, no difference was found between propofol, thiopental and etomidate when these drugs were followed by succinylcholine, an effective drug.²³

Among the opioid drugs, only remifentanyl has a short enough duration of action that could theoretically be associated with a return of respiratory function before hypoxia sets in. However, only relatively high doses (4 µg/kg) are associated with intubating conditions that compare well with those following succinylcholine, and these high doses have a major hemodynamic impact.²⁴ In addition, remifentanyl in such high doses with propofol produces 12-14 minutes of apnea. It would seem logical to try propofol-remifentanyl-succinylcholine combinations, but this idea remains untested.

ADJUVANTS

Lidocaine, 1-1.5 mg/kg has minimal effects on intubating conditions and hemodynamic variables. However, ephedrine, by maintaining or increasing cardiac output, improves intubating conditions when rocuronium is injected. For example, the incidence of excellent conditions was found to be 84% after ephedrine administration, compared with 32% without ephedrine.²⁵ However, the hemodynamic effects of ephedrine have to be taken into consideration.

THE FUTURE

Two new advances may change the management of induction of anesthesia in patients with a full stomach. *Gantacurium* is a nondepolarizing neuromuscular blocking agent that is broken down rapidly by a process involving cysteine, an abundant amino acid, probably making the degradation of this compound independent of genetic variations. The duration of action compares well with that of succinylcholine, with onset being slightly longer.²⁶ *Gantacurium* is still in the experimental stage.

Sugammadex is a totally different compound. It does not bind to any receptor, but binds specifically to rocuronium, the end result being reversal of blockade. Reversal may be complete even if blockade is intense.²⁷ One can imagine using rocuronium instead of succinylcholine for intubation, with sugammadex as backup if the procedure fails. This new compound is not yet available for clinical use.

KEY POINTS

- When a rapid sequence induction is indicated in a patient at risk for aspiration of gastric contents, the following sequence is recommended: (1) pre-oxygenation; (2) appropriate intravenous doses of opioid and hypnotic drugs, depending on the patient; (3) injection of a neuromuscular blocking agent; (4) cricoid pressure and no bag and mask ventilation; (5) turn on the nerve stimulator and wait for disappearance of the twitch response; (6) laryngoscopy, intubation, inflation of the cuff, release of cricoid pressure (Table 1).
- Unless there is a contraindication, the neuromuscular blocking drug of choice is succinylcholine, and the dose is 1 mg/kg.
- Lower doses of succinylcholine are associated with poorer intubating conditions without a significant decrease in the risk of hypoxia in case intubation is unsuccessful.

- The same succinylcholine doses, calculated in mg/kg actual body weight, are indicated in obese subjects.
- If succinylcholine is contraindicated, rocuronium, 1 mg/kg, is recommended.
- Pre-curarization with a nondepolarizing agent, 3 minutes before induction, is recommended, provided the dose does not exceed one-tenth the effective dose for 95% block (ED₉₅); (eg, rocuronium, 0.03 mg/kg or atracurium, 0.02 mg/kg).
- When pre-curarization is given, the succinylcholine dose should be doubled, to 2 mg/kg.
- Onset of neuromuscular blocking drugs depends on the hemodynamic condition of the patient. Therefore, it is useful to monitor neuromuscular function and wait until disappearance of the twitch response before attempting laryngoscopy and intubation.

Dr. Donati is a Professor in Anesthesiology at the University of Montreal. He is a recognized authority in the area of curarization and has published numerous articles on the subject.

References

- Warner MA, Warner ME, Weber JG. Clinical significance of pulmonary aspiration during the perioperative period. *Anesthesiology* 1993;78:56-62.
- Edwards G, Morton HJ, Pask EA, Wylie WD. Deaths associated with anaesthesia; a report on 1,000 cases. *Anaesthesia* 1956;11:194-220.
- Salem MR. Anesthetic management of patients with "a full stomach". A critical review. *Anesthesia Analgesia* 1970;49:47-55.
- White PF. Comparative evaluation of intravenous agents for rapid sequence induction—thiopental, ketamine, and midazolam. *Anesthesiology* 1982;57:279-84.
- Sluga M, Ummenhofer W, Studer W, Siegemund M, Marsch SC. Rocuronium versus succinylcholine for rapid sequence induction of anesthesia and endotracheal intubation: a prospective, randomized trial in emergent cases. *Anesthesia Analgesia* 2005;101:1356-61.
- Larsen PB, Hansen EG, Jacobsen LS, et al. Intubation conditions after rocuronium or succinylcholine for rapid sequence induction with alfentanil and propofol in the emergency patient. *Eur J Anaesthesiol* 2005;22:748-53.
- Schreiber JU, Lysakowski C, Fuchs-Buder T, Tramer MR. Prevention of succinylcholine-induced fasciculation and myalgia: a meta-analysis of randomized trials. *Anesthesiology* 2005;103:877-84.
- Kovacs G, Law JA, Ross J, et al. Acute airway management in the emergency department by non-anesthesiologists. *Can J Anaesth* 2004;51:174-80.
- Krejcie TC, Avram MJ. What determines anesthetic induction dose? It's the front-end kinetics, doctor! *Anesthesia Analgesia* 1999;89:541-4.
- Donati F. The right dose of succinylcholine. *Anesthesiology* 2003;99:1037-8.
- Klemola UM, Mennander S, Saarnivaara L. Tracheal intubation without the use of muscle relaxants: remifentanil or alfentanil in combination with propofol. *Acta Anaesthesiol Scand* 2000;44:465-9.
- Mencke T, Echternach M, Kleinschmidt S, et al. Laryngeal morbidity and quality of tracheal intubation: a randomized controlled trial. *Anesthesiology* 2003;98:1049-56.
- Andrews JI, Kumar N, van den Brom RH, Olkkola KT, Roest GJ, Wright PM. A large simple randomized trial of rocuronium versus succinylcholine in rapid-sequence induction of anaesthesia along with propofol. *Acta Anaesthesiol Scand* 1999;43:4-8.
- Le Corre F, Plaud B, Benhamou E, Debaene B. Visual estimation of onset time at the orbicularis oculi after five muscle relaxants: application to clinical monitoring of tracheal intubation. *Anesthesia Analgesia* 1999;89:1305-10.
- Heier T, Feiner JR, Lin J, Brown R, Caldwell JE. Hemoglobin desaturation after succinylcholine-induced apnea: a study of the recovery of spontaneous ventilation in healthy volunteers. *Anesthesiology* 2001;94:754-9.
- Hayes AH, Breslin DS, Mirakhor RK, Reid JE, O'Hare RA. Frequency of haemoglobin desaturation with the use of succinylcholine during rapid sequence induction of anaesthesia. *Acta Anaesthesiol Scand* 2001;45:746-9.
- Naguib M, Samarkandi AH, Abdullah K, Riad W, Alharby SW. Succinylcholine dosage and apnea-induced hemoglobin desaturation in patients. *Anesthesiology* 2005;102:35-40.
- Naguib M, Samarkandi A, Riad W, Alharby SW. Optimal dose of succinylcholine revisited. *Anesthesiology* 2003;99:1045-9.
- Naguib M, Samarkandi AH, El Din ME, Abdullah K, Khaled M, Alharby SW. The dose of succinylcholine required for excellent endotracheal intubating conditions. *Anesthesia Analgesia* 2006;102:151-5.
- Lemmens HJ, Brodsky JB. The dose of succinylcholine in morbid obesity. *Anesthesia Analgesia* 2006;102:438-42.
- Mencke T, Schreiber JU, Becker C, Bolte M, Fuchs-Buder T. Pretreatment before succinylcholine for outpatient anesthesia? *Anesthesia Analgesia* 2002;94:573-6.
- Skinner HJ, Biswas A, Mahajan RP. Evaluation of intubating conditions with rocuronium and either propofol or etomidate for rapid sequence induction. *Anaesthesia* 1998;53:702-6.
- El Orbany MI, Joseph NJ, Salem MR. Tracheal intubating conditions and apnoea time after small-dose succinylcholine are not modified by the choice of induction agent. *Br J Anaesth* 2005;95:710-4.
- McNeil IA, Culbert B, Russell I. Comparison of intubating conditions following propofol and succinylcholine with propofol and remifentanil 2 micrograms kg-1 or 4 micrograms kg-1. *Br J Anaesth* 2000;85:623-5.
- Tan CH, Onisong MK, Chiu WK. The influence of induction technique on intubating conditions 1 min after rocuronium administration: a comparison of a propofol-ephedrine combination and propofol. *Anaesthesia* 2002;57:223-6.
- Belmont MR, Lien CA, Tjan J, et al. Clinical pharmacology of GW280430A in humans. *Anesthesiology* 2004;100:768-73.
- Gijzenbergh F, Ramael S, Houwing N, van Iersel T. First human exposure of Org 25969, a novel agent to reverse the action of rocuronium bromide. *Anesthesiology* 2005;103:695-703.

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