Rapid sequence induction for appendectomies: a retrospective case-review analysis

Induction en séquence rapide pour appendicectomie: une étude de cas rétrospective

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Abstract

Purpose Rapid sequence induction (RSI) with cricoid pressure is suggested to decrease the risk of aspiration of gastric contents. However, the effectiveness of RSI has been questioned, and the technique may lead to airway and hemodynamic complications. The purpose of this study was to determine the frequency of RSI use in patients with acute appendicitis, the types of drugs administered, and the occurrence of any complications.

Methods After approval by the Ethics Committee, the charts of patients undergoing appendectomy in a one-year period were examined retrospectively. Information was retrieved on Mallampati airway evaluation, airway device used, preoxygenation, RSI, and drugs at induction. Reported complications were noted, including airway difficulties, hypotension (systolic blood pressure < 80 mmHg) and hypertension (>160 mmHg) in the 20-min period after induction.

Results General anesthesia with tracheal intubation was used in 248 of 250 cases reviewed. The Mallampati airway evaluation, preoxygenation, and RSI were recorded as performed in 95, 94, and 81% of cases, respectively. Opioids, propofol, and neuromuscular blocking agents were given in 98, 98, and 99% of patients, respectively. Succinylcholine use was common (80%), with 96% of these patients receiving rocuronium precurarization. Difficult

intubation with successful alternate technique was encountered in three patients (1.2%). Hypotension and hypertension occurred in 27% and 8% of patients, respectively. There were no documented cases of aspiration. Oxygen desaturation was mentioned in one case at induction and in three cases at emergence.

Conclusion An RSI with opioid, induction agent, and succinylcholine is the technique of choice for appendectomies at our institution. The frequency of airway complications is too low to recommend a change in practice.

Résumé

Objectif L'induction en séquence rapide (ISR) avec pression cricoïdienne est la technique suggérée afin de réduire le risque d'inhalation du contenu gastrique. Cependant, l'efficacité de l'ISR a été remise en question car il se pourrait que cette technique cause des complications au niveau de l'hémodynamie et des voies aériennes. L'objectif de cette étude était de déterminer la fréquence d'utilisation de l'ISR chez les patients souffrant d'appendicite aiguë, le type de médicaments administrés et la survenue de complications.

Méthode Après avoir reçu l'accord du comité d'éthique, les dossiers des patients subissant une appendicectomie au cours d'une période d'un an ont été passés en revue rétrospectivement. Les renseignements tirés des dossiers portaient sur l'évaluation des voies aériennes selon la classe de Mallampati, le dispositif utilisé pour sécuriser les voies aériennes, la préoxygénation, l'ISR et les médicaments utilisés à l'induction. Les complications rapportées ont été notées, y compris les difficultés au niveau des voies aériennes, l'hypotension (tension systolique < 80 mmHg) et l'hypertension (>160 mmHg) durant la période de 20 min suivant l'induction.

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Résultats Dans 248 des 250 cas passés en revue, une anesthésie générale avec intubation trachéale a été utilisée. L'évaluation des voies aériennes selon la classe de Mallampati, la préoxygénation et l'ISR ont été notées comme réalisées dans 95, 94 et 81 % des cas, respectivement. Des opioïdes, du propofol et des curares ont été administrés à 98, 98 et 99 % des patients, respectivement. L'usage de succinylcholine était courant (80 %), et 96 % de ces patients ont reçu une précurarisation au rocuronium. Une intubation difficile suivie d'une technique alternative réussie a été observée chez trois patients (1,2 %). Il y a eu des cas d'hypotension et d'hypertension chez 27 % et 8 % des patients, respectivement. Aucun cas d'inhalation n'a été documenté. Un cas fait mention de désaturation d'oxygène à l'induction, et trois au réveil.

Conclusion Dans notre institution, la technique de choix pour les appendicectomies consiste en une ISR accompagnée d'un opioïde, d'un agent d'induction et de succinylcholine. La fréquence des complications au niveau des voies aériennes est trop basse pour justifier un changement de notre pratique.

Rapid sequence induction (RSI) is applied commonly to decrease the risk of regurgitation of gastric contents and aspiration pneumonitis in patients undergoing emergency surgery. The purpose of the technique is to minimize the time interval between loss of protective airway reflexes and the moment the airway is secured. The introduction of succinylcholine in 1951 and the description of cricoid pressure by Sellick¹ in 1961 have been important milestones in anesthesia. Important steps in the RSI technique include preoxygenation, cricoid pressure, a rapid induction with a pre-determined dose of hypnotic agent and neuromuscular blocking agent, omission of manual ventilation, and intubation with a cuffed tracheal tube.² Variants of the technique include withholding cricoid pressure,³ addition of an opioid and slower injection of induction drugs (modified RSI),⁴ and gentle application of manual ventilation.¹

Although RSI is a widely accepted technique, it does have disadvantages and is associated with a few controversies. First, there are no studies demonstrating the effectiveness of RSI, with or without cricoid pressure.^{3,4} Second, cricoid pressure is a difficult technique to master.^{3,5} Third, in cases of failure to intubate, all advantages provided by the technique are likely lost.⁶ Fourth, since the doses of medications are predetermined and cannot be titrated to effect, there is a risk of under- or over-treatment, with adverse hemodynamic consequences and/or inadequate anesthesia. Finally, there is no universal agreement on the indications for RSI. The risk of aspiration is well recognized, even in Cesarean delivery, but surveys indicate

that RSI practice varies widely.⁶⁻⁸ In emergency abdominal surgery, there is evidence of increased risk of regurgitation and vomiting in the presence of bowel obstruction,^{9,10} but only a few cases of aspiration have been reported in the setting of appendectomies.^{9,10} There are no data on stomach contents in patients with acute appendicitis.

Considering the lack of solid scientific evidence for the benefits of RSI, there appeared to be a need to reassess the use of the technique. However, a change in practice would be indicated only if RSI happened to be associated with additional risk over an alternate technique. Therefore, data on the actual use of RSI and its complications would be needed. To accomplish this objective, we chose appendectomy, a single but common surgical procedure wherein "full stomach considerations" might apply. Also, we preferred to complete a retrospective study in a teaching institution rather than a survey, because the former would be more likely to reveal the particulars of each case. Our primary objective was to determine how often RSI was applied in patients presenting with acute appendicitis. Our secondary objectives were to examine: whether a difficult intubation was anticipated, the induction agents and neuromuscular blocking agents used and their respective doses, how the airway was secured, and the incidence of airway and hemodynamic complications.

Methods

The protocol was approved by the Research Ethics Committee of Maisonneuve-Rosemont Hospital. This research project was a retrospective study based on the anesthetic and medical records of patients who underwent appendectomies in a one-year period from September 1, 2004 to August 31, 2005 at the Maisonneuve-Rosemont Hospital, a University of Montreal affiliated teaching hospital. An Excel spreadsheet was prepared based on the results of a one-month pilot study conducted on the appendectomies performed in August 2004. Inclusion criteria were patients from all ages and sexes who were admitted to hospital from the emergency department and whose preoperative and postoperative diagnosis was acute appendicitis. Exclusion criteria were patients already in hospital whose postoperative diagnosis was not acute appendicitis or who underwent other surgical procedures in the same setting.

Information was retrieved from the hand-written anesthetic records during 2006. Standard demographic data were collected. The pre-anesthetic evaluation sheet was screened for the American Society of Anesthesiologists (ASA) physical status, smoking history, and Mallampati airway assessment, as modified by Samssoon and Young.¹¹

Each anesthetic record was examined for anesthesia type (regional vs general). If general anesthesia was chosen, we

noted the type of airway device used. Preoxygenation was presumed to have taken place if it was mentioned in the chart. If tracheal intubation was performed, RSI was considered as having been applied if any of the terms “rapid sequence” or “Sellick” or “cricoid pressure” were written. Direct laryngoscopy without any other aid was presumed unless other methods were mentioned (stylet, video-laryngoscope, Trachlight™, etc.). The medications used for induction of anesthesia and their respective doses were noted. The anesthetic record contains a tick box for easy or difficult intubation and an area to indicate the 4-grade Cormack and Lehane¹² view of the glottis. These items were noted for each patient. Any hand-written comment on airway complications was noted, such as number of attempts, failed intubation, use of alternate airway methods, or aspiration and desaturation. Aspiration was presumed likely if there was documentation of regurgitation at laryngoscopy, if “aspiration” was written as a diagnosis on the anesthetic record in the recovery room, or if there was follow up or treatment for aspiration pneumonia in the postoperative period. Hypotension and hypertension were defined as a systolic blood pressure < 80 mmHg and > 160 mmHg, respectively, in the first 20 min following induction of anesthesia. Agents administered to treat these hemodynamic alterations were noted.

The anesthesia record was also screened to ascertain the drugs used to maintain anesthesia and muscle relaxation and the drugs used to reverse neuromuscular blockade. Time of extubation was recorded, whether performed in the operating room or in the recovery room. Also, all airway complications written on the anesthesia or recovery room chart were noted.

Statistics

The primary outcome measurement was the number of times RSI was used. We selected the number of charts to review on the basis that any technique used at a frequency > 1% would have a 95% chance of appearing at least once. The calculated number was 300. Since this result corresponded approximately to the number of appendectomies performed in a one-year period, charts for a one-year period were examined. Continuous data are presented as means and standard deviation (SD). Incidences of a particular event are presented as a number of cases and percentage.

Results

Two hundred sixty-four patients were eligible for the study, but only 250 patients fit our inclusion criteria (Figure 1). General anesthesia with tracheal intubation was performed in 248 cases, and spinal anesthesia was performed in two

Fig. 1 Surgical diagnosis and type of anesthesia. Numbers represent number of patients

cases. The patients’ characteristics are presented in Table 1. There were 72 patients (29%) aged 19 yr and under and 87 patients (35%) aged 20–39 yr. Forty percent of the patients were women, and five of these (5%) were pregnant. Sixty-eight patients (27%) were tobacco smokers, 13 (5%) smoked marijuana, and five (2%) took other recreational drugs.

The Mallampati score was present in 239 patient charts (95%), and the Cormack grade of glottis view was reported in 232 (94%) of the charts. A Mallampati 1 or 2 classification was found in 224 patients (93.3%), and the remaining 15 patients (6.7%) had a grade 3 classification. A nerve stimulator was used in 96.3% of patients.

Agents used for induction and their doses are shown in Table 2. The typical agents administered were an opioid (98% of patients), propofol (98%), and a neuromuscular blocking agent (99.6%). Succinylcholine was administered in 80% of cases, and 96% of these patients received precurarization. Rocuronium was used in the remaining 19% of cases, and only 17% of these patients received a priming dose. Management of muscle relaxation is illustrated in Figure 2. Anticholinesterase agents were given to 218 of the 227 patients who received a non-depolarizing neuromuscular blocking agent.

The anesthetic chart indicated that preoxygenation was applied in most patients (94%). The terms “rapid sequence”, “Sellick”, and/or “cricoid pressure” were mentioned in 81% of patients’ charts (Table 3). A Cormack grade 3 view of the glottis was mentioned in five (2%) of the 232 cases (94%) where a Cormack view was documented, and no grade 4 view was reported. Tracheal intubation was evaluated as “easy” in 245 of 248 patients, including two patients with a Cormack grade 3. Direct laryngoscopy was used in 241 of these cases and a video-laryngoscope was used in 4 cases. A stylet was used with

Table 1 Demographic data ($n = 250$)

Item	Value	Number (%) of charts where item mentioned
Gender (M/F)	150/100 (60%/40%)	250 (100%)
Age (yr) (mean $\pm$ SD)	29.5 $\pm$ 18.6	250 (100%)
Weight (kg) (mean $\pm$ SD)	66.6 $\pm$ 19.6	220 (88%)
ASA physical status (I-II/III-IV-V)	108/8	116 (46%)
ASA = American Society of Anesthesiologists;		
OR = operating room;		
SD = standard deviation		
Triage to OR time (hr) (mean $\pm$ SD)	12.3 $\pm$ 10.4	245 (98%)
Duration of surgery (min) (mean $\pm$ SD)	70 $\pm$ 27	245 (98%)
Duration of recovery room stay (min) (mean $\pm$ SD)	50 $\pm$ 31	241 (97%)

Table 2 Agents used for induction of anesthesia ($n = 248$)

Agents used at induction	Number of cases (%)	Dose (mg·kg ⁻¹) (μ g·kg ⁻¹ for opioids) Mean $\pm$ SD
<i>Opioids</i>	244 (98%)	
Fentanyl	184 (74%)	2.84 $\pm$ 1.01
Sufentanil	59 (24%)	0.54 $\pm$ 0.76
Alfentanil	17 (11%)	11.40 $\pm$ 4.67
Remifentanyl	23 (9%)	1.63 $\pm$ 1.04
Two or more	37 (15%)	-
<i>Induction agents</i>	248 (100%)	
Propofol	243 (97%)	2.64 $\pm$ 0.81
Thiopental	5 (2%)	4.43 $\pm$ 1.43
Ketamine	1 (0.4%)	-
<i>Neuromuscular blocking agents</i>	247 (99.6%)	
Succinylcholine	199 (80%)	1.97 $\pm$ 0.40
With rocuronium precurarization	192/199 (96%)	0.044 $\pm$ 0.020
Rocuronium	48 (19%)	0.73 $\pm$ 0.19
Priming	8/48 (17%)	0.042 $\pm$ 0.19
<i>Other</i>		
Lidocaine	122 (49%)	1.15 $\pm$ 0.49

SD = standard deviation

direct laryngoscopy in 20 patients and no aid was used in the remaining patients. Tracheal intubation was noted as “difficult” in three patients (1.2%) who had grade 1 or 2 Mallampati scores. The alternatives used for tracheal intubation in these patients included a Trachlight™ and a fibrescope in one case, a stylet in another, and an unspecified technique in the third case.

Oxygen desaturation at intubation was mentioned in only one patient (Table 3). This patient, a 102-kg male smoker, ASA physical status III with a grade 1 Mallampati score, underwent an easy tracheal intubation and experienced a brief episode of desaturation to 85%. Hypotension occurred in 66 patients (27%), 31 of whom (47%) required treatment. Hypertension occurred in 25 patients, only two of whom (8%) required treatment. There were no episodes

Fig. 2 Management of muscle relaxation and reversal of neuromuscular blockade. Numbers represent number of patients**Table 3** Events at intubation and emergence

Event	Number of patients	%
Preoxygenation	234	94%
Rapid Sequence Induction	200	81%
Intubation Technique		
<i>Direct Laryngoscopy</i>	221	89%
<i>Stylet</i>	21	8%
<i>Videolaryngoscope</i>	4	2%
<i>Fibreoptic</i>	1	0.4%
<i>Trachlight™</i>	1	0.4%
<i>Not indicated</i>	1	0.4%
Complications		
<i>Difficult Intubation</i>	3	1.2%
<i>Desaturation at induction</i>	1	0.4%
<i>Aspiration</i>	0	0%
<i>Hypotension (BP < 80)</i>	66	27%
<i>Requiring treatment</i>	31/66	47%
<i>Hypertension (BP > 160)</i>	25	10%
<i>Requiring treatment</i>	2/25	8%
<i>Desaturation at emergence</i>	3	1.2%

BP = systolic blood pressure

of aspiration mentioned in the anesthetic charts nor were there any documented pneumonias by the surgical treating team once the patients were transferred to the ward.

Extubation was performed in the operating room in 39% of cases and in the recovery room in 60% of the cases. Two patients (1%) were transferred directly to the intensive care unit (ICU) or to the coronary care unit (CCU), respectively. Three patients (1.2%) had oxygen desaturation in the recovery room: one patient desaturated to 90% and was treated with oxygen and an anticholinesterase agent; another patient desaturated to 88%, and no further comments were written; and a third subject, who was obese and had chronic obstructive pulmonary disease, had a “persistent desaturation at 88%”, which necessitated endotracheal suctioning and continuous positive airway pressure for 2.5 hr before extubation. Regurgitation or aspiration was not mentioned in this patient’s chart.

One patient was transferred to the ICU because she was in septic shock, and one patient was transferred to the CCU because of suspicion of acute coronary syndrome, which proved unfounded. The only mortality was that of a 70-yr-old man, ASA physical status III, who died ten days postoperatively after suffering a massive myocardial infarction with failed reperfusion and subsequent stroke. Nothing in particular was indicated in his anesthetic record.

Discussion

In our institution, which is a teaching hospital, general anesthesia with tracheal intubation was the preferred approach for the vast majority of patients scheduled for emergency appendectomy. The charts indicated that pre-oxygenation was applied in 94% of cases, while RSI was chosen in 81%. It is possible that these techniques were used in a larger proportion of patients, as they may have been performed but not charted. Since this study was retrospective and there was no specific entry for “rapid sequence induction”, “cricoid pressure”, or “Sellick” in the chart, it was not possible to determine whether “rapid sequence induction” also included cricoid pressure or vice-versa. However, if one of these terms was entered, it was presumed that consideration was given to the risk of aspiration. Virtually all tracheal intubations were performed under direct laryngoscopy, with a stylet used in some cases. Of note, the laryngeal mask airway (LMA™) was not used in any subject, although we found two LMA cases during the one-month pilot study. The use of LMAs for appendectomies might be a common practice in other parts of the world. A French survey reported that use of tracheal intubation or LMA was used in only 84% of children undergoing appendectomy.¹³

Airway assessment with Mallampati score was present in the anesthetic charts of 95.6% of patients. All three difficult intubations were missed by the Mallampati score, emphasizing its limited sensitivity and specificity¹⁴ and the need for additional screening measures. The incidence of tracheal intubations that were considered difficult was 1.2%, which is less than the 5.8% incidence reported in a recent meta-analysis of 35 trials.¹⁴

The only two descriptions of RSI reported initially were the rapid administration of an induction agent and a neuromuscular blocking drug;¹⁵ however, recent surveys suggest that opioids are given frequently in the RSI setting.^{2,7} In a review of studies done on neuromuscular blocking agents for RSI, induction techniques were divided into “True RSI” and “Modified RSI”, both subdivided into opioid and opioid-free regimens.¹⁶ However, in that review, most of the studies enrolled elective patients in whom RSI was simulated rather than emergency patients suspected of having a full stomach. In the present study, most anesthesiologists (98%) chose to administer opioids. Propofol was the hypnotic agent of choice (97.2%) and was preferred to thiopental, which is the traditional agent recommended for RSI. In 1999, most British anesthesiologists surveyed (96%) reported using thiopental for RSI,⁷ but in two recent studies^{17,18} on RSI in emergency patients, the induction agent was propofol (1.5–3 mg·kg⁻¹), which compares favourably with the mean dose administered here (2.64 mg·kg⁻¹).

The preferred neuromuscular blocking drug for RSI was succinylcholine, which was used in 80% of cases. This is in line with traditional recommendations and with the results of surveys.^{2,7,15} The mean dose was close to 2.0 mg·kg⁻¹, which seems appropriate since precurarization was used in most instances. The dose in this case is probably equivalent to 1.0 mg·kg⁻¹ without precurarization.^{19,20} For induction, precurarization was almost systematic (96%), but priming was present in only 17% of cases. The average dose (0.044 mg·kg⁻¹ ± 0.019) was higher than the recommended 10% of the ED₉₅ (0.03 mg·kg⁻¹).¹⁹

Hypotension occurred in 24% of cases, and only 47% of these required treatment. Hypertension occurred less often (10%) than hypotension, which may indicate a tendency towards an overestimated dose of the hypnotic agent rather than an underestimated dose. It is possible that some of these hemodynamic events were not due directly to RSI per se. Larsen *et al.*,¹⁸ who used alfentanil (10–20 µg·kg⁻¹) and propofol (2–3 mg·kg⁻¹) at induction in the RSI setting, also reported more hypotension than hypertension. Half of their patients had acute appendicitis.

Our study has some limitations. First, it is a retrospective study. However, most of the data regarding RSI in the literature have been obtained through surveys,^{2,7} and respondents might answer what they consider as right

rather than what they would do in a given situation. A retrospective study is more likely to reflect what was done, and it is probably better than a prospective survey in this case, because practitioners might change their practice if they know a study is taking place. Considering the wide acceptance of RSI among our anesthesiologists, it would have been difficult to involve them in a prospective randomized controlled study comparing RSI with an alternate technique. Thus, a retrospective study is probably the best design to obtain data on what was actually done.

The second limitation is that all the data used are directly dependent on the anesthetic record. The frequency of the studied events was probably underestimated, since it is likely that some actions were performed and not charted. Thus, if anything, preoxygenation and RSI may have been performed more frequently than the results suggest (94% and 81%, respectively), which indicates widespread acceptance of these techniques. On the other hand, the incidence of difficult intubation and/or desaturation may have been underestimated. However, the airway was managed successfully in all cases. A third limitation is that it is not certain that our conclusions are applicable to surgeries other than appendectomies. Fourth, the study was conducted in one teaching hospital, and it is not clear how RSI is used in other centres.

A randomized controlled study designed to demonstrate the effectiveness of RSI in preventing pulmonary aspiration would require many thousands of patients because the incidence of aspiration is low.⁴ The present study also shows that a trial designed to demonstrate that RSI is associated with more airway complications than other techniques would require thousands of patients, given the low incidence of such complications.

Emergency surgery is considered as a risk factor for aspiration, and surveys indicate that the incidence of pulmonary aspiration is greater in patients presenting for emergency surgery.^{10,21,22} However, the risk may not be the same for all emergency procedures. Before RSI became a widespread practice, abdominal cases comprised 71 of the 110 fatal cases of regurgitation and vomiting in a report of deaths attributed to anesthesia.⁹ However, appendicitis is not cited in that study, although there were ten cases of peritonitis, the origin of which is not specified. In subsequent surveys, Olsson *et al.* mentioned appendicitis in five cases among 83 reports of aspiration.¹⁰ In the series of 24 cases of aspiration in children published by Warner *et al.*, there were no cases of appendicitis.²¹ Similarly, appendicitis is not part of the diagnoses listed by Sakai *et al.*²³ (23 cases) and Neelakanta *et al.*²⁴ (23 cases). Thus, aspiration in patients presenting for appendix surgery is a rare event, and it is not surprising that none were found in our study. However, it is unclear whether the incidence is low because of a low baseline risk or because of the

effectiveness of RSI. In the present study, anesthesiologists mentioned using RSI in 81% of cases. In a recent survey conducted in Wales, 94% of respondents said they would choose an RSI technique for an emergency appendectomy.²⁵ Tracheal intubation appears to protect patients against aspiration. In a recent French retrospective study, 36 cases of aspiration were found. Twenty-five of these did not undergo RSI with tracheal intubation.²² In an Australian study of 133 cases of aspiration occurring during anesthesia, the airway was managed with a tracheal tube in only eight cases, an LMA in 23 cases, and a face mask in most of the remaining cases.²⁶

In conclusion, while the evidence regarding the safety and efficacy of RSI for appendectomies is weak at best, the present study suggests that the incidence of airway complications associated with RSI does not appear to be greater than in the general population. Hemodynamic consequences are more frequent, but minor. Therefore, it seems reasonable to continue to apply RSI for appendectomies and perhaps for other procedures where a “full stomach” might be a consideration. There is no need to recommend a change in practice.

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Conflicts of interest None declared.

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