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Review Article

Scandinavian clinical practice guidelines on general anaesthesia for emergency situations

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Emergency patients need special considerations and the number and severity of complications from general anaesthesia can be higher than during scheduled procedures. Guidelines are therefore needed. The Clinical Practice Committee of the Scandinavian Society of Anaesthesiology and Intensive Care Medicine appointed a working group to develop guidelines based on literature searches to assess evidence, and a consensus meeting was held. Consensus opinion was used in the many topics where high-grade evidence was unavailable. The recommendations include the following: anaesthesia for emergency patients should be given by, or under very close supervision by, experienced anaesthesiologists. Problems with the airway and the circulation must be anticipated. The risk of aspiration must be judged for each patient. Pre-operative gastric emptying is rarely indicated. For pre-oxygenation, either tidal volume breathing for 3 min or eight deep breaths over 60 s and oxygen flow 10 l/min should be used. Pre-oxygenation in the obese patients should be performed in the head-up position. The use of cricoid pressure is not considered mandatory, but can be used on individual judgement. The hypnotic drug has a minor influence on intubation conditions, and should be chosen on other grounds. Ketamine should be considered in haemodynamically compromised patients. Opioids may be used to reduce the stress response following intubation. For optimal intubation conditions, succinylcholine 1–1.5 mg/kg is preferred. Outside the operation room, rapid sequence intubation is also considered the safest method. For all patients, precautions to avoid aspiration and other complications must also be considered at the end of anaesthesia.

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These guidelines are on the topic of general anaesthesia for emergency situations. Emergency patients are a major challenge for an anaesthesiologist. They need special considerations and the number of complications and adverse events, including human errors, from general anaesthesia may be higher than during scheduled procedures. Among the complications and events are haemodynamic alterations and airway-related consequences. Guidelines can be used to reduce these complications and events and to make treatment and handling uniform and evidence based.

The work on these guidelines was initiated, and the working group was appointed by the Clinical Practice Committee (CPC) of the Scandinavian Society of Anaesthesiology and Intensive Care Medicine (SSAI). The aim was to find the evidence and latest scientific information for our way of handling these patients, and thereby to provide anaesthesiologists in the Nordic countries with a mutual understanding and a common way to anaesthetize these patients. Hopefully, these guidelines may assist anaesthesiologists in the care for patients, so that patients can be treated with similar standards and equal high quality in our different countries and hospitals.

The working group defines anaesthesia for emergency situations as anaesthesia that is not planned or not for elective patients. Regional anaesthesia may be a good solution in many emergency patients, but finding evidence to assist the anaesthesiologist in choosing between regional and general anaesthesia and describing regional anaesthesia has not been the topic for this working group. However, we all must remember to evaluate the airway before the decision is made to administer

general anaesthesia. The working group has focused on the anaesthesia technique when it has been decided, that the patient should be given general anaesthesia. This implies that the group has not discussed pre-operative optimization, or indications and contraindications for the individual patient. Emergency patients are presented to anaesthesiologists both outside and inside the operation rooms (OR), and therefore care of patients outside OR has also been considered in the guidelines. The guidelines cover only the management of general anaesthesia in adult emergency patients. A short version of the guidelines is presented in Table 1.

A grading system for recommendations and level of evidence was recommended by the CPC. Hence, decisions on the level of evidence and grading of recommendations have been made according to Bell et al.[1] Decisions about both level of evidence and grading of recommendations can be found in the individual chapters. In the text, Grading of evidence from I to V is added in brackets, [ ], and Grading of recommendations from A to E can be found in tables and text.

Methods

Literature references were found after a search in Pub Med, inclusive of Mesh, and the Cochrane Library. Further, cross references from relevant studies have been used. The Search words are specified in Appendix 1. The time frame for the search has been from August 1961 to May 2009. Grading of evidence and grading of recommendations were performed according to a system first used by Bell et al.[1] Table 2. According to this system, evidence is graded from A to E, where recommendation grade A indicates a recommendation based on the best evidence. An immense problem throughout this work has been the lack of evidence grades I and II in many areas. Accordingly, the working group has graded few recommendations as A. As the scientific evidence is weak in many areas, we have consented to grade many recommendations as D or E.

The individual chapters were written in drafts, and after initial discussions via mail, a consensus meeting was held. Evidence was assessed and grading of recommendations was decided. Consensus opinion was used in the many topics where high-grade evidence was unavailable. The specific grading of evidence and grading of recommendation can be found in the individual chapters, where

Table 1

Summary of recommendations.

Pre-operatively
Anaesthesia for emergency patients should be given by, or under very close supervision by, an experienced anaesthesiologist. Haemodynamic and airway-related complications should be anticipated. Alternative plans and adequate equipment for dealing with these complications must be ready. In patients with an increased risk of aspiration of stomach contents to the lungs, precautions to avoid regurgitation must be taken. Unless the patient has an increased risk of aspiration, patients scheduled for emergency surgery can be considered fasting and can be treated according to standards for scheduled patients, if more than 2 h have elapsed since the last intake of clear fluids and more than 6 h have elapsed since the last intake of a meal. In patients at a high risk of regurgitation, either an H_2-blocker or a proton pump inhibitor can be used to reduce the acidity and volume in the ventricle or sodium citrate can be used to reduce acidity. Pre-operative gastric emptying with an orogastric or a nasogastric tube is rarely indicated.

Pre-oxygenation and cricoid pressure
Pre-oxygenation is initiated by explaining the procedure to the patient. Avoid a leak between the patient's face and the oxygen mask. Either tidal volume breathing for 3 min or eight deep breaths over 60 s with an oxygen flow of at least 10 l/min should be used. Non-invasive positive pressure ventilation or the application of positive end-expiratory pressure can be considered in morbidly obese or critically ill hypoxic patients. Pre-oxygenation in obese patients should be performed in the head-up position; otherwise, there is no advantage of one placement over the other. The use of cricoid pressure is not considered mandatory, but can be used on individual judgement. If used, the cricoid pressure must be used correctly, and the pressure should be released if ventilation or laryngoscopy and intubation are difficult. Cricoid pressure should also be released before inserting the Laryngeal Mask Airway should initial attempts at tracheal intubation prove unsuccessful.

Drugs
The hypnotic drug has a minor influence on intubation conditions, and should be chosen on other grounds. Thiopentone seems to be a better choice than propofol to avoid hypotension following induction. On the other hand, propofol is a better choice than thiopentone to avoid a cardiovascular stress response in patients with ischaemic cardiac disease. Ketamine should be considered for hypovolaemic patients (hypovolaemic shock or pre-shock) or for cardiovascular unstable patients when there is no time or possibility of pre-operative optimization. An opioid can be used to reduce the stress response following intubation. A neuromuscular blocking agent is used to optimize intubation conditions. For optimal intubation conditions, succinylcholine 1–1.5 mg/kg is preferred over other neuromuscular blocking drugs. Where contraindications to succinylcholine exist, rocuronium 0.9–1.2 mg/kg is an adequate alternative.

Anaesthesia outside the operation room
Rapid sequence intubation is considered the safest method. Awake intubation can be performed in selected cases. For induction of anaesthesia, all available induction agents can be used.

End of anaesthesia
Take precautions also at the end of anaesthesia to avoid haemodynamic and airway-related complications as well as regurgitation.

Table 2

Grading of recommendations and evidence.

Grading of recommendations	
A	Supported by at least two level I investigations
B	Supported by one level I investigation
C	Supported by level II investigations only
D	Supported by at least one level III investigation
E	Supported by level IV or V evidence
Grading of evidence	
I	Large, randomized trials with clear-cut results; low risk of a false-positive (alpha) error or a false-negative (beta) error
II	Small, randomized trials with uncertain results; moderate-to-high risk of false-positive (alpha) and/or a false-negative (beta) error
III	Nonrandomized, contemporaneous controls
IV	Nonrandomized, historic controls and expert opinion
V	Case series, uncontrolled studies and expert opinion

The table has been adapted from Bell et al.[1]

grading of evidence from I to V is added in the text part in brackets, [ ], and grading of recommendation is presented in tabular form.

A draft with recommendations was presented at the 30th Congress of SSAI, June 2009. Comments from this presentation were incorporated into the next draft, and this draft was presented for comments and critique on the SSAI website* from August until November 2009. Each member of the SSAI was sent an email to notify them of the possibility of reading and commenting on the draft. Comments from SSAI members have been incorporated and the present manuscript and the guidelines have been approved by CPC in February 2010.

Initial considerations

Recommendation

Anaesthesia for emergency patients should be administered by, or under close supervision by, experienced anaesthesiologists. An alternative plan should always be ready for use if failed intubation or haemodynamic complications should occur. The ASA difficult airway algorithm should be known and followed, and the alternative plan should include the option to awaken the patient and be ready to continue with awake intubation or regional anaesthesia. Even though the technique is known as rapid sequence induction or rapid sequence intubation (RSI), the muscle relaxant can be administered after the effect of the hypnotic drug has been observed.

**http://www.ssai.info*

Background

The main aims of general anaesthesia in emergency patients are to put the patient to sleep as safely and quickly as possible, and to secure the airway against the risk of aspiration of gastric contents. The anaesthesia technique for inducing sleep and relaxation is known as RSI. The technique is sometimes referred to as Crash Induction, first named as such by Woodbridge.[2] With this technique, a hypnotic should be able to induce loss of consciousness within a very short time, the administered opioid should be able to prevent or treat the haemodynamic and other autonomic responses to tracheal intubation and a muscle relaxant is administered simultaneously with the hypnotic to reduce the time between sleep and intubation. General anaesthesia in emergency patients can be fraught with complications related to haemodynamic complications such as alterations in heart rate and blood pressure, new-onset cardiac dysrhythmias[3] and, in the worst-case scenario, cardiac arrest.[4] Further, complications can be anticipated related to airway management, complications such as hypoxaemia, failed intubation, multiple intubation attempts, and aspiration of gastric contents.[5,6] Alternative plans must be ready in order to handle the patient if haemodynamic or airway-related complications should occur. These alternative methods include awakening the patient with reestablishment of spontaneous ventilation. When the patient is awake and the situation is stabilized, regional anaesthesia or awake fibreoptic-assisted tracheal intubation should be considered. These guidelines will not further discuss intubation problems and difficult airway algorithms as guidelines on these topics can be found elsewhere.[7,8] Graded recommendations for initial considerations are summarized in Table 3.

We have not been able to find descriptions of current practice in Scandinavia. Studies performed in England[9] and Wales[10] have shown that there is a wide variation in techniques and skills and that there is room for improvement.[9] An accepted practice regarding drug administration during RSI is to administer the pre-determined doses of the different drugs rapidly, without waiting for the effect of the single drug. An alternative method would be to titrate the doses of drugs over a more prolonged time period. The rationale for rapidly administering pre-determined doses is that the majority of hypnotics and opioids reduce both the upper and the lower oesophageal sphincter (LES) tone[11,12] and thus increase the risk of regurgitation.

Table 3

Recommendations for initial considerations.

Recommendation	Grading
Anaesthesia for emergency patients should be given by an experienced anaesthesiologist	D
The inexperienced anaesthesiologist should be assisted and closely supervised by an experienced anaesthesiologist	D
Drugs can be administered in rapid sequence or the neuromuscular drug can be administered after the patient has fallen asleep	E
Be prepared to use an alternative plan for intubation if failed intubation occurs	E
Regional anaesthesia or awake tracheal intubation should be considered in patients with difficult airways. In these cases, the ASA difficult airway algorithm should be used	E

Recommendation grades are based on the grading system used by Bell et al.[1]

The goal of maximal injection of speed is to rapidly achieve a state of anaesthesia, which allows fast tracheal intubation and in this way reduces the time during which patients are at risk of gastric aspiration. If haemodynamic or other complications of rapid bolus injections are severe, this adverse outcome might reduce the potential benefit of the rapid tracheal intubation.

It has not been possible to find data comparing the risk of complications associated with a rapid injection with the risk of aspiration associated with a prolonged interval before tracheal intubation. Further, evidence could not be found supporting the technique of restricting rapid drug administration to patients and circumstances with a high risk of aspiration and a low risk of complications associated with this. It was not possible to find data to support the statement that injection of a hypnotic should be followed by a neuromuscular blocking agent (NMBA) only after the resulting effect of the hypnotic has been seen (the patient has fallen asleep).

The reported incidence of aspiration of gastric contents to the lungs seems to be low. In emergency anaesthesia, the incidence is higher than that in planned anaesthesia.[13–16] In emergency anaesthesia, the incidence is quoted to be one case in every 634 to 809 patients.[13,15] In the planned cases, the incidence is much lower, because the incidence in a mixture of cases is one out of 2131 to 3457 patients.[13,15] The incidence increases in the presence of risk factors or complications such as ileus, obstetric emergencies, light planes of anaesthesia, morbid obesity and difficult intubation.[13,15,16]

The three major factors considered to be able to reduce the incidence of aspiration are experience, assistance by experienced anaesthesiologists and close supervision of inexperienced anaesthesiologists[16] [III]. Studies have shown that residents lack knowledge and practical skills in airway management[17] [III]. Further, supervision of residents by attending anaesthesiologists can reduce the complications of emergency tracheal intubation[18] [III]. It is not possible to define exactly when a trainee is adequately experienced to handle an emergency patient on her/his own. Complications to anaesthesia for elective cases are known to be reduced after 3–6 months of training. Constructing learning curves for residents have shown that a trainee needs 60–80 cases of successfully performed intubations to be able to perform the procedure quickly and safely[19,20] [III]. Hence, these numbers might be used when deciding whether or not a trainee can be trusted with the responsibility of administering anaesthesia to the emergency patient.

Anaesthesia for emergency situations is challenging, and patient safety depends on the skills, vigilance and judgement of individuals working as a team.[21] Studies have shown that anaesthesia care improves with training, and some advocate experience gained in a simulated environment using a human simulator.[21,22] Crew Resource Management with training in the components characterizing effective teams has been attempted, but the scientific evidence for improvement in care for the emergency patient is still scarce. Hopefully, in the future, studies will be performed on emergency patients and teams, determining the effect of effective leadership, mutual performance monitoring, backup behaviour, adaptability and team orientation.[22]

Fasting conditions and identification and treatment of patients at a high risk of aspiration of gastric contents

Recommendations

Emergency and elective surgical procedures are treated in the same way with respect to fasting conditions. Exceptions and risk factors are identical, i.e. gastrointestinal obstruction or delayed gastric emptying.

Patients scheduled for emergency surgery are considered fasting if more than 2 h has elapsed since the last intake of clear fluids and more than 6 h have elapsed since the last meal (inclusive of all

Table 4

Recommendations for the duration of fasting conditions and for the treatment of patients at a high risk of aspiration.

Recommendation	Grading
Use rapid sequence induction if the emergency patient is non fasting or has an increased risk of aspiration or if there is any doubt about this	E
Patients considered to have a high risk of aspiration: ileus, subileus, bowel obstruction, pregnancy, hiatal hernia, reflux, nausea or vomiting pre-operatively	
Patients considered to have a possible risk of aspiration: morbid obesity, diabetes, acute opioid treatment	E
Unless the patient has an increased risk of aspiration, patients scheduled for emergency surgery can be considered fasting and can be anaesthetized as elective patients, if more than 2 h have elapsed since the last intake of clear fluids and more than 6 h have elapsed since the last intake of a meal.	E
Pre-operative gastric emptying with an orogastric or a nasogastric tube is rarely indicated. If necessary, use a large, double-lumen tube	E
Pre-operative gastric emptying with orogastric or nasogastric tube is mandatory during pre-operative treatment of patients with ileus, subileus or bowel obstruction. Treatment should be started at the ward and continued during anaesthesia induction	E
Prokinetic drugs are not recommended to reduce the risk of pulmonary aspiration	E
Antiemetic drugs are not recommended to reduce the risk of pulmonary aspiration	E
Using either a H_2-blocker or a proton pump inhibitor is recommended in high-risk patients, as these drugs reduce gastric acidity and volume	B
Sodium citrate can be used to reduce acidity in the gastric fluids	B

Recommendation grades are based on the grading system used by Bell et al.[1]

types of dairy products), unless the patient suffers from intestinal paralysis/paresis, bowel obstruction or is considered non-fasting after an individual assessment. Patients considered non-fasting, for instance due to pain, critical illness or medical conditions, are given RSI on a liberal basis. Recommendations with grading of recommendations can be found in Table 4.

Background

No randomized studies are available to determine the optimal period of fasting regarding emergency surgery with respect to patient comfort or morbidity/mortality. Studies on elective surgery show an inverse relationship between the duration of fasting and patient satisfaction, and that fasting more than 6 h does not improve gastric emptying when compared with 2–4 h of fasting. The general recommendation for elective surgery is 2 h for clear fluids, and 6 h for all other kinds of nutrition[23–28] [IV–V].

Increased risk of pulmonary aspiration of gastric contents or delayed gastric emptying

Patients with a high risk of pulmonary aspiration:

- patients with subileus, ileus or bowel obstruction are considered non-fasting, irrespective of the time elapsed since the last meal or drink, and insertion of a naso-gastric/-duodenal tube at the ward before anaesthesia is necessary;
- pregnant women of more than 20 weeks of gestation, including the first 24 h post partum;
- patients with hiatal hernia or gastro-oesophageal reflux;
- patients with pre-operative nausea/vomiting, e.g. in connection with newly started opioid pain treatment.

Patients with a possible increased risk:

- morbidly obese patients (BMI $>$ 35);
- diabetic patients (considering the risk of polyneuropathy and gastro paresis);
- patients who have received opioids to alleviate acute pain without developing nausea or vomiting.

These patients should be individually assessed, considering the type and duration of surgery, severity and duration, degree of obesity and their general health condition, including airway assessment. Assessment including specific questioning about heartburn, nausea, vomiting and reflux should be documented in the patient file.

Gastric emptying by an orogastric or a nasogastric tube

Recommendation

Pre-operative gastric emptying by an orogastric tube is not recommended for routine use before emergency surgery and it is contraindicated in conditions with a risk of organ rupture, fractures of the cervical spine and increased intracranial or intraocular pressure. If indicated, a large-bore double-lumen tube should be preferred.

A nasogastric tube should be left in place during induction of anaesthesia, and suction should be

applied to the tube to remove as much gastric content as possible before induction. A correctly applied cricoid pressure can be used to possibly reduce the risk of aspiration of gastric contents.

Background

Gastric emptying by an orogastric tube is rarely indicated[15] [IV], and does not ensure gastric emptiness[29] [III]. A large-bore double lumen with side holes is more efficient than a small-bore single-lumen tube[29] [III] for emptying of gastric fluids. There is no evidence to support that solid matters can be removed by an orogastric tube. Pulmonary aspiration of gastric contents may occur despite the use of an orogastric tube for emptying [16] [V].

In healthy volunteers, gastric reflux is not increased by short time placement of a thick gastric tube up to 12 F[29–31] [III, II and V]. Patients undergoing abdominal surgery with a perioperatively placed nasogastric tube have significant reflux of gastric contents[32][II], with an increased incidence of fever, atelectases and pneumonia postoperatively[33][I]; the duration of the insufficiency of the oesophageal sphincter is not known. A nasogastric tube does not diminish the supposed protective effect of cricoid pressure during intubation [34] [V].

Medical pre-treatment to increase gastric emptying by increasing gastro-intestinal motility

Recommendation

The use of pro-kinetic drugs is not recommended to reduce regurgitation and pulmonary aspiration. The drug can be used to reduce gastric contents.

Background

Metoclopramid given 90 min pre-operatively reduces the volume of gastric contents[35] [I]. The effect outbalances the reduction in gastric emptying by morphine[36] [II]. There is no effect on gastric acidity by Metoclopramid. The relation between prokinetic drugs and aspiration has not been studied. Routine use pre-operatively is not recommended by ASA[28][V]. Aspiration of gastric contents during anaesthesia has been described in patients pre-treated with prokinetic drugs.[16]

Medical pre-treatment to reduce acid secretion

Recommendation

Routine use of either a histamine-2-blocking agent (ranitidine 50 mg) or a proton pump inhibitor (omeprazole 40 mg) is recommended for high-risk patients. It should preferably be administered intravenously 6–12 h before surgery and repeated at least 30 min before anaesthesia induction to reduce both the acidity and the volume of gastric contents. A single-dose regimen of ranitidine reduces the acidity but not the volume of gastric contents. Sodium citrate 30 ml 0.3 M by mouth could be added before induction to neutralize acidity.

Background

No studies are available on the use of acid secretion inhibitors and the risk of pulmonary aspiration of gastric contents during anaesthesia. Cimetidin[37,38][I and III] and ranitidine reduce gastric acidity as well as the volume of contents[39] [II], with the longest duration of effect by ranitidine. Enhanced effect either by a repeated administration of ranitidine or in combination with sodium citrate has been discussed. The use of proton pump inhibitors has been described for emergency caesarean section, and some describe a single dose as being inadequate[40] [II], whereas it is effective if given in combination with sodium citrate and metoclopramid[41] [II]. ASA does not recommend routine use and it is not a safeguard against aspiration during anaesthesia[16] [V].

Medical pre-treatment with antacids

Recommendation

Routine use is recommended only to high-risk patients, including emergency obstetric procedures under general anaesthesia.

Background

No studies are available to demonstrate reduced morbidity or frequency of pulmonary aspiration during anaesthesia after oral intake of antacids. Despite this, antacids have been generally recommended since 1966[42] [V] and since 1993 in Denmark specifically before emergency obstetric surgery[43] [V]. Thirty millilitre sodium citrate 0.3 M increases the pH in the stomach to almost neutral values after a few minutes, but its effect

wears off if given more than 1 h before anaesthesia. A combination of ranitidine and sodium citrate leads to a speedy response[44,45] lasting up to 14 h [III and II]. The intake of sodium citrate increases the gastric volume correspondingly, but without no other known side effects[46] [III]. ASA does not recommend routine use, and it is not a safeguard against aspiration during anaesthesia[16] [V].

Medical pre-treatment with antiemetics

Recommendation

The use of antiemetics is not recommended to reduce the risk of aspiration.

Background

Antiemetics reduce post-operative nausea and vomiting. No studies are available to describe the effect on gastric content acidity or volume, and no studies are available on the risk of post-operative aspiration and the use of antiemetics. It is not recommended by ASA[28] [V].

Medical pre-treatment with anticholinergic agents

Recommendation

The use of anti cholinergic drugs is not recommended to reduce aspiration of gastric contents.

Background

No studies are available on the effect of anti cholinergic agents and the risk of aspiration. Glycopyrrolate reduces tone in the LES and thus increases the theoretical risk of reflux [47] [V]. It might, however, reduce the acidity and volume of gastric contents, but less predictably than cimetidine[48–51] [II and III]. The use of Glycopyrrolate is not recommended by ASA[28] [V].

Pre-oxygenation

Recommendations

Hypoxaemia is a serious complication in emergency patients administered general anaesthesia. Every available method to avoid this complication must be used. If the patient is awake and cooperative, the procedure must be explained before pre-oxygenation is begun. To make pre-oxygenation effective, an oxygen flow of at least 10 l/min for 3 min and without leakage between the oxygen mask and the patient's face must be used. In obese patients, pre-oxygenation is more effective and should be carried out with the patient in the half-sitting or the head-up position. Further, non-invasive positive pressure ventilation can be used in obese patients and in hypoxic or critically ill patients. Graded recommendations for pre-oxygenation can be found in Table 5.

Table 5

Recommendations on pre-oxygenation.

Recommendation	Grading
Explain the procedure to the patient	E
Avoid a leak between the mask and the patient's face	E
Tidal volume breathing for 3 min or eight deep breaths over 60 s, both with an oxygen flow of at least 10 l/min, are equally effective for oxygenation, and one of these techniques should be used	A
Pre-oxygenation in obese patients should be performed in the head-up position	A
Use of non-invasive positive pressure ventilation can be recommended in morbidly obese or in critically ill hypoxic patients	C
Use of positive end-expiratory pressure can be recommended in obese patients	D

Recommendation grades are based on the grading system used by Bell et al.[1]

Background

The primary reasons to maximally pre-oxygenate a patient are to provide the patient with a maximum amount of time to tolerate apnoea and to provide the anaesthesiologist with the maximum amount of time to solve a 'cannot ventilate, cannot intubate' situation. Different end points have been used in studies assessing the effectiveness of various pre-oxygenation techniques. These are as follows: the highest arterial oxygen tension achieved, the highest fraction of end tidal oxygen concentration achieved, the speed of achieving these highest fractions, pulmonary nitrogen washout time and the time to desaturation to a pre-defined value. The latter is also named by some as the safe apnoea time. There is not always a correlation among the results obtained with the different end points and presumably the most meaningful outcome is the safe apnoea time. Hence, articles measuring safe apnoea time have been weighted higher.

Before discussing the different methods of pre-oxygenation, it is necessary to mention that avoiding a leak between the patient's face and the mask may increase oxygenation. Further, it is not

possible to hold the mask close to the patient's face before the method and the rationale for its use has been explained to the patient. These important messages are, however, supported only by numerous citations in text books and by two non-randomized studies in volunteers[52, 53] [III]. Both these studies used end tidal oxygen fraction as the outcome.

Tidal volume breathing

Three randomized-controlled trials have demonstrated that tidal volume breathing for 3 min provides a longer safe apnoea time than 4 deep breaths[54–56] [I]. One study has demonstrated a comparable safe apnoea time using 3 min of tidal volume breathing and 8 deep breaths over a time period of 60 s[57] [I]. Both methods were superior to 4 deep breaths over 30 s.[57] Similar results were found by measuring the end tidal oxygen fraction in pregnant women[58] [I]. Three studies have focused on extension of the pre-oxygenation period. In a non-randomized study using arterial oxygen saturation as an effect parameter, there was no effect of increasing the pre-oxygenation period from 4 to either 6 or 8 min and such an extension was even found to jeopardize oxygenation efforts in some patients[59] [III]. In contrast, studying parturients, it was found that a higher arterial oxygen partial pressure was produced with 5 min of tidal volume breathing, compared with 4, 6 or 8 rapid vital capacity breaths[60] [III]. If the technique with deep breathing is used, it was demonstrated to be necessary to extend the time period to 11/2 or 2 min, and to use an oxygen flow of 10 l/min to achieve a similar end tidal oxygen concentration as that found when using normal breathing for 3–5 min[61] [III].

Effect of position

The effects of position during pre-oxygenation have been studied in two randomized studies[62, 63] [I] and in one non-randomized clinical study[64] [III]. All three studies measured time to desaturation to a predetermined level, i.e. the safe apnoea time. It was concluded that pre-oxygenation using the head-up position in obese patients (25°) prolonged the safe apnoea time in comparison with pre-oxygenation in the supine position.[62, 63] In the non-randomized study from 1992, it was found that pregnant women do not benefit from pre-oxygenation in a 45°degree head-up position.[64] In contrast, it was found that non-pregnant women had a longer safe apnoea time after pre-oxygenation in the head-up position compared with pre-oxygenation in the supine position.[64]

Effect of maximal exhalation

Three studies, two from the same Centre[65,66] [III], have focused on the effect of maximal exhalation before pre-oxygenation. In a small study comprising 10 healthy patients, it was found that the single vital capacity breath technique following forced exhalation could provide adequate pre-oxygenation within 30 s.[65] The effect parameter was an arterial oxygen partial pressure of 295 ± 65 mmHg achieved with the single vital capacity breath technique.[65] In the other study, using healthy volunteers, maximal exhalation before tidal volume breathing produced a significantly faster increase in the end-expiratory oxygen concentration than oxygenation with tidal volume breathing alone.[66] However, the conclusion from the most recent study in 15 healthy volunteers was that pre-oxygenation with maximal exhalation before tidal volume breathing for 5min slightly steepens the initial rise in ETO_2 during the first minute, but confers no real benefit if maximal pre-oxygenation is the goal[67] [III]. In this study, maximal exhalation before deep breathing for 2 min had no added value in enhancing pre-oxygenation.[67]

Pre-oxygenation combined with ventilation or with positive end-expiratory pressure (PEEP)

Pre-oxygenation combined with some kind of ventilation before intubation has been studied in two randomized studies from the same centre. Non-invasive ventilation was followed by a higher oxygen saturation than 3 min of standard pre-oxygenation in critically ill, hypoxic patients [68] [I]. For the control group comprising 26 patients, pre-oxygenation was performed using a non-rebreather bag-valve mask driven by 15 l/min oxygen. For the NIV group with 27 patients, pressure support ventilation was delivered by a ventilator through a face mask with an FiO_2 of 100% and a PEEP of 5 cmH_2O. The pressure was adjusted to obtain an expired tidal volume of 7–10 ml/kg. The positive effect on oxygen saturation was also demonstrable 5 min after intubation, and there were no differ-

ences, either in regurgitations or in new infiltrates on post-procedure chest X-ray.[68] In morbidly obese patients, both a higher and a faster rise in end tidal oxygen saturation were found using non-invasive positive pressure ventilation in comparison with a standard pre-oxygenation technique[69] [II]. The authors used a positive pressure of 14 cmH_2O in the study group (pressure support with 8 cmH_2O and PEEP with 6 cmH_2O), and found no difference in the side effects between the two groups.[69] In a previous study, it was demonstrated that after sleep induction, ventilation with 100% oxygen for 1 min before intubation and pre-oxygenation for 3 min were equally effective in preventing hypoxaemia during induction[70] [III]. PEEP applied during induction of anaesthesia may prevent atelectasis formation in the lungs, in both non-obese and obese patients[71,72] [II]. Application of PEEP has also been shown to increase the duration of non-hypoxic apnoea[73,74] [II]. The technique for application of PEEP used in these studies, however, cannot be used in emergency patients. The authors pre-oxygenated patients using 100% oxygen administered via a CPAP device (6–10 cmH_2O) for 5 min. Following induction of anaesthesia, patients in the study groups were ventilated via a face mask for another 5 min, using PEEP (6–10 cmH_2O), until tracheal intubation.[71–74] Studies could not be found showing the effect of CPAP during pre-oxygenation without face mask ventilation with PEEP before intubation.

During specialist training, anaesthesiologists are generally taught that it is dangerous to ventilate non-fasting patients before intubation. The reason for this is that the facemask ventilation may cause stomach inflation and thereby increase the risk of regurgitation. Two early, non-randomized studies have challenged this concept. Thus, facemask ventilation using pressures below 15 cmH_2O have been demonstrated not to cause insufflation of the stomach [75] [III]. When applying a forceful pressure on the anterior surface of the neck, against the thyroid and cricoid cartilages (a technique later named cricoid pressure), the authors could not force air into the stomach using pressures of up to 50 cmH_2O. Furthermore, in another study, it was demonstrated that in the absence of cricoid pressure, the minimum pressure required to cause gas to enter the stomach of healthy patients was 20 cmH_2O [76][III]. These authors found it impossible to force air to enter the stomach in any of the 20 patients when cricoid pressure was applied, despite insufflation pressures exceeding 60 cmH_2O on occasion.[76] The recommendation reading these two studies is that it may be acceptable to ventilate the acute patient by a facemask using pressures below 20 cmH_2O or, if using cricoid pressure, the insufflation pressure could be higher.

Cricoid Pressure (Sellick's Manoeuvre)

Recommendations

The use of cricoid pressure to reduce regurgitation is not based on scientific evidence. Therefore, its use cannot be recommended on the basis of scientific evidence. Anaesthesiologists can use the technique on individual judgement, but the anaesthesiologist must be ready to release the pressure if necessary. Cricoid pressure has been shown to limit the glottic view during laryngoscopy, and it should be released if such problems occur. Under these circumstances, backwards-upwards-right pressure on the thyroid cartilage could improve the glottis view. Cricoid pressure should also be released if it becomes necessary to use a laryngeal mask airway (LMA). Finally, if cricoid pressure is used, it must be applied at the correct anatomical location and with the recommended pressure of 30 N. Graded recommendations for the use of cricoid pressure can be found in Table 6.

Table 6

Recommendations on the use of cricoid pressure.

Recommendation	Grading
The use of cricoid pressure cannot be recommended on the basis of scientific evidence	E
The use of cricoid pressure is therefore not considered mandatory but can be used on individual judgement	E
If facemask ventilation becomes necessary, cricoid pressure can be recommended because it may reduce the risk of causing inflation of the stomach	D
Cricoid pressure should be released and backwards-upwards right pressure (BURP) should be applied instead, if cricoid pressure limits the glottic view during laryngoscopy	D
Cricoid pressure should be released before inserting the Laryngeal Mask Airway should initial attempts at tracheal intubation prove unsuccessful	C
Those choosing to use the cricoid pressure in the at-risk patient must take care to apply the cricoid pressure correctly and release the pressure should ventilation or laryngoscopy and intubation prove difficult	D

Recommendation grades are based on the grading system used by Bell et al.[1]

Background

Brian Sellick's article on the use of cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia, published in the *Lancet* in 1961[77][V], has to be considered a landmark reference in anaesthetic practice. Although not cited in Sellick's original 'preliminary communication' in the *Lancet*, the anatomical rationale for cricoid pressure during resuscitation had been but forward in the 1770s by Monro[78] and in 1776 by John Hunter.[79]

Well known to all anaesthesiologists, the method consists of applying external pressure to the cricoid cartilage with the intention of occluding the lumen of the oesophagus between the cricoid cartilage and the cervical vertebral column (C5/C6) with the purpose of preventing aspiration of gastric contents should regurgitation from the stomach occur during induction of anaesthesia.[77] Sellick's original description of the technique suggested that the head and neck should be fully extended and that the head should not be supported by a pillow [V],[77,78] an anatomical position known to have the potential to make tracheal intubation more difficult. No mention is made in Sellick's paper of how much pressure to use, and various pressures have been tested and used [V].[8,77,78,80,81] A pressure of 10 N in the awake and 30 N after induction of anaesthesia has been recommended[82] [V] and seems to have been adopted universally, but pressures as high as 44 N were recommended earlier [78,80,82] [V]. The application of the cricoid pressure has, since its introduction, been an integral part of the RSI of anaesthesia for emergency surgery as well as in emergency airway management for the critically ill patient in the intensive care unit and the emergency room. However, the evidence for its use is practically non-existent, and application of cricoid pressure might have side effects.

Efficacy of the Cricoid Pressure

The efficacy of the cricoid pressure and even the RSI of anaesthesia to control the regurgitation of gastric contents during induction of anaesthesia have been questioned for some time[78,83–85] [V]. In a recent review on the use of cricoid pressure in anaesthetic practice, Priebe[80] highlights the lack of scientific evidence of its effectiveness. He also discusses and reviews the potential of the cricoid pressure, both correctly and incorrectly applied, to interfere with optimal airway management techniques. Gobindram and Clarke,[86] in a recent correspondence in Anaesthesia, also strongly question the efficacy of the cricoid pressure, discussing the potential benefits of another technique, a 40° head-up tilt, for the prevention of aspiration [V]. In Sellick's original work, three out of 26 patients had a 'reflux' of gastric or oesophageal contents into the pharynx upon release of the cricoid pressure.[77] Numerous studies and case reports describing regurgitation and aspiration of gastric and/or oesophageal contents with the cricoid pressure applied have been published[87][V], giving reasons to doubt its effectiveness. The physiological response to applied cricoid pressure deserves some mention. Application of the cricoid pressure has been shown to lower the LES tone and may be a contributing factor facilitating regurgitation and aspiration [78,87,88] [V]. Metoclopramid increases LES pressure but a recent study failed to show a benefit in terms of overcoming the cricoid pressure-induced lowering of the LES tone. The authors concluded that Metoclopramid may have a role in increasing barrier pressure when the cricoid pressure is not applied or has to be released.[88] Studies using advanced imaging techniques such as MRI and CT scanning have shown the oesophagus to be displaced laterally rather than occluded with the cricoid pressure [89,90][III]. Smith et al.,[89] in a recent study of healthy volunteers, using MRI scanning, found the oesophagus to be displaced laterally in over half of the patients without cricoid pressure, increasing to 90.5% when cricoid pressure was applied. In spite of this knowledge and the doubt about the effectiveness of the cricoid pressure, recent textbooks on anaesthesia describe the use of the cricoid pressure, as part of the RSI of anaesthesia, without mention of the technique's eventual lack of efficacy[91–94] [V]. Vanner,[95] in a newly published editorial, concludes that the cricoid pressure probably is effective at preventing regurgitation at induction of anaesthesia [V]. He discusses briefly the impact of better conducted general anaesthesia on lowering mortality from aspiration pneumonitis in obstetrics, making note of the cricoid pressure only being one of many factors, among them pre-oxygenation, antacids and improved fasting routines, making it difficult to judge the value of each single factor. In accordance with this view, many experienced clinicians use the technique in their practice, claiming it to have been highly useful on numerous occasions. Others have taken a stand based on a more evidence-based approach, using the cricoid pressure infrequently or not at all.[80]

Interference of the technique with airway management techniques

Use of the cricoid pressure interferes with airway management in many ways. Even when correctly applied, it can cause partial or complete airway obstruction, interfere with both the insertion of the laryngoscope and the laryngoscopic view and finally external laryngeal manipulation to improve the laryngoscopic view[78,80,81,85,96] [V]. Regarding the laryngoscopic view, a recent large randomized trial did not show an increase in failed intubations with cricoid pressure given by well-trained assistants, the authors concluding that cricoid pressure should not be avoided for fear of increasing the difficulty of tracheal intubation[97] [II]. This study has been criticized for optimizing intubating conditions through patient selection as it excluded patients scheduled for emergency surgery, morbidly obese patients and pregnant women.[80] In another study by Vanner et al.,[98] cricoid pressure was found to improve the laryngoscopic view in the majority of the 50 patients studied, more so if the pressure was applied in a backward and upward direction [III]. The cricoid pressure has also been reported to make insertion of the LMA difficult[78,85] and to interfere with ventilation through the LMA[78,85,99–101] [II]. Asai et al.[99] recommended that cricoid pressure be released during the insertion of the LMA, although it could be associated with an increased risk of aspiration, and reapplied immediately after the placement of the LMA [III]. The difficult airway society's (DAS) guidelines published in 2004 advocate the use of cricoid pressure during RSI of anaesthesia, recommending gradual release should ventilation and maintenance of adequate oxygen saturation prove difficult[8] [V]. The authors discuss the technique's potential to interfere with airway management and recommend that the cricoid pressure be released should insertion of a LMA be deemed necessary.[8] Henderson,[102] in a leading text on anaesthesia, also recommends that the cricoid pressure should be released should there be problems with intubation of the trachea [V]. Maintaining the cricoid pressure when faced with difficulties in managing the airway has a high priority in some textbooks and airway management algorithms[85,92,94] [V], a practice that is not supported by solid evidence[85] [V]. Cricoid pressure has been shown to prevent gastric insufflation during bag mask ventilation, but the lower tidal volumes and longer inflation times now used may obviate this potential benefit of cricoid pressure[87] [V]. The use of cricoid pressure during bag mask ventilation has also been found to result in reduced tidal volumes, increased peak inspiratory pressures and varying degrees of airway occlusion.[87] The use of the cricoid pressure during resuscitation may be impractical, requires an extra hand and may make ventilation and intubation difficult,[78] although it might prevent aspiration of gastric contents, which is not uncommon under these circumstances.

Nasogastric tubes and the Cricoid Pressure

Sellick recommended that nasogastric tubes should be removed after final aspiration before induction of anaesthesia as they might increase the risk of regurgitation and aspiration by tripping the oesophageal sphincters.[77] Experimental evidence has, on the other hand, shown that reflux past the LES is the same with or without a nasogastric tube and the efficacy of the cricoid pressure may even be increased with a nasogastric tube in place, the nasogastric tube occupying the part of the oesophageal lumen not obliterated by the cricoid pressure.[78]

Drugs: hypnotics, opioids

Recommendation

In order to reduce the risk of haemodynamic and airway-related complications during RSI, a combination of a hypnotic and an opioid must be used. It is also recommended to use a NMBA, and the evidence for choosing one above the other is given in another section of this paper. When using succinylcholine, the intubation conditions are good, and the hypnotic drug can be chosen on endpoints other than intubation conditions. An opioid should be used to reduce the haemodynamic complications following RSI. If a non-depolarizing neuromuscular blocking drug is chosen, the hypnotic drug may be important for the intubation condition. Propofol is therefore recommended for these patients, and if haemodynamically indicated, Ketamine can also be used. Further, it is also recommended to use an opioid to reduce the haemodynamic response to tracheal intubation. Grading of evidence from I to V according to Bell et al.[1] can be found in the text, added in brackets. Graded recommendations for the choice of hypnotics and opioids can be found in Table 7.

Table 7

Recommendations on hypnotics and opioids for emergency patients.

Recommendation	Grade
Without NMBA	
This technique cannot be recommended, undesirable haemodynamic responses may follow	C
If the technique is chosen, propofol is preferred for induction because propofol provides better intubation conditions than thiopentone	C
If the technique is chosen, an opioid must be used. The dose of remifentanil must be 4 μg/kg or higher or the dose of alfentanil must be 30–50 μg/kg to provide optimal intubation conditions	C
With succinylcholine	
Choose a hypnotic based on endpoints other than intubation, the hypnotics have a minor influence on intubation condition	C
An opioid can be used to reduce the risk of hypertension and tachycardia. Alfentanil (15–40 μg/kg) or Remifentanil (1 μg/kg) is optional. Fentanyl < 5 μg/kg cannot blunt this haemodynamic response	C
With a non-depolarizing NMBA	
Propofol is recommended, because propofol provides better intubation conditions than thiopentone	C
An opioid can be used. Alfentanil (20 μg/kg) improves intubation conditions. Fentanyl has minimal effect on intubation conditions	C
Ketamine 1.5 mg/kg can be used	C
Etomidate alone is not recommended. A greater pressor response following intubation is seen after etomidate compared with propofol	B

Recommendation grades are based on the grading system used by Bell et al.[1]
RSI, rapid sequence intubation; NMBA, neuromuscular blocking agent.

Background

An ideal induction drug or a combination of drugs for all RSI situations does not exist. All drugs have undesired side effects associated with their use. Certain agents may be preferable to others under certain circumstances. Further, in the search for references for this chapter, we found a diversity of drug combinations and clinical circumstances. Several study settings have been carried out only once, and the findings from these studies have, to our knowledge, not been reproduced. Therefore, it has been difficult to recommend one drug over others.

An NMBA with a short onset of action is usually administered to obtain good intubation conditions. The choice of an NMBA is covered in another section. However, the choice of a muscle relaxant has an impact on the effects of the hypnotic and the opioid chosen. Hence, this section of the paper will be divided into the following parts:

- Choice of a hypnotic and an opioid for RSI without the use of an NMBA.
- Choice of a hypnotic and an opioid for RSI using succinylcholine.
- Choice of a hypnotic and an opioid for RSI with a non-depolarizing neuromuscular blocker.

Choice of a hypnotic and an opioid for RSI without the use of an NMBA

Propofol 2.5 mg/kg has been used as an agent for intubation after premedication with diazepam and droperidol. With this technique, 19 of 20 patients could be intubated, 12 of them smooth and easy[103] [III]. The technique was, however, followed by undesirable haemodynamic responses. Propofol seems to depress the laryngeal and pharyngeal reflexes more effectively than thiopentone[104] [III]. With propofol 2.5 mg/kg and alfentanil 30 μg/kg, a satisfactory intubation condition was found in 79% of 80 patients and the haemodynamic response to intubation was prevented [105][II]. The authors concluded that the intubation conditions were suboptimal.

If the dose of alfentanil is increased, it is possible to decrease the dose of propofol, but the severity of side effects such as hypotension and bradycardia might increase[106] [II]. It was found that healthy, premedicated patients with a favourable airway anatomy who had received alfentanil 40 μg/kg could be reliably tracheally intubated 90 s after the administration of propofol 2 mg/kg or etomidate 0.3 mg/kg.[106] This was not possible with thiopentone. Intubation was only possible in 55% of patients after alfentanil 40 μg/kg, followed by thiopentone 4 mg/kg.[106] In another study, increasing the dose of alfentanil to 50 μg/kg, followed by propofol 2 mg/kg resulted in acceptable intubation conditions but a 30% decrease in the mean arterial pressure[107] [II]. The combination of propofol 2 mg/kg with alfentanil 50 μg/kg might be an alternative to thiopentone 5 mg/kg plus succinylcholine 1 mg/kg for tracheal intubation[108] [III]. However, the patients receiving propofol and alfentanil showed a decrease in blood pressure and heart rate following induction, whereas patients in the thiopentone succinylcholine group showed an increase in blood pressure and heart rate following induction.[108]

The use of remifentanil for RSI without the use of muscle relaxants has been compared with alfentanil. With the injection of remifentanil 4 μg/kg, followed by propofol 2.5 mg/kg, intubation condi-

tions were better than after alfentanil 30 μg/kg, followed by propofol 2.5 mg/kg[109] [II]. Despite the use of atropine 0.01 mg/kg, the heart rate remained lower after than before induction.[109] Reducing the dose of propofol is possible. Remifentanil 4 μg/kg and propofol 2 mg/kg administered in sequence intravenously provided good or excellent conditions for tracheal intubation in all patients without the use of muscle relaxants[110] [II]. Propofol 2 mg/kg was found to be superior to thiopentone 6 mg/kg and etomidate 0.3 mg/kg for tracheal intubation when combined with remifentanil 3 μg/kg and no muscle relaxant[111] [II]. A recent study, however, has found that administration of remifentanil 4 μg/kg or alfentanil 40 μg/kg before thiopentone 5 mg/kg provided good to excellent conditions for endotracheal intubation with acceptable haemodynamic changes[112] [II]. The conclusion after the above studies is that the dose of remifentanil must be 4 μg/kg, or higher, to achieve acceptable results.

Choice of a hypnotic and an opioid for RSI using succinylcholine

The effects of succinylcholine are apparent within 60 s; hence, the hypnotics and opioids have a smaller influence on intubation conditions. However, they are needed to avoid awareness, eventually to enhance the quality of intubation and to reduce the haemodynamic side effects associated with intubation. Jaw tension after the administration of succinylcholine seems to be influenced by the choice of an induction agent. The increase in masseter muscle tone in patients given succinylcholine 1.5 mg/kg was found to be lower following propofol 2.5 mg/kg than following thiopentone 5 mg/kg[113] [II].

Fentanyl

The haemodynamic response to tracheal intubation was compared in 303 patients in whom anaesthesia was induced with either thiopentone 4 mg/kg, etomidate 0.3 mg/kg or propofol 2.5 mg/kg, with and without fentanyl 2 μg/kg[114] [III]. The use of fentanyl resulted in arterial pressures lower than those after the induction agent alone, and in an attenuation, but not abolition of the responses to laryngoscopy and intubation.[114] The use of fentanyl 3 μg/kg, before RSI with etomidate and succinylcholine, attenuated the response after intubation, without serious haemodynamic effects[115] [II]. The combination of fentanyl 2 μg/kg together with esmolol 2 mg/kg might be an alternative to a higher fentanyl dose for blunting the haemodynamic response to intubation[116] [II]. It has been shown some years ago that it was possible to reduce the dose of thiopentone from 4 to 2 mg/kg by the addition of fentanyl 5 μg/kg during the induction of RSI using succinylcholine[117] [II]. Although the incidence of dysrhythmias was decreased by fentanyl (20% vs. 42%), this incidence was, however, not significantly different, and this combination cannot be recommended.[117]

Alfentanil

The combination of alfentanil 30 μg/kg with thiopentone 4 mg/kg and succinylcholine 1.5 mg/kg provided complete attenuation of the haemodynamic response to intubation[118,119] [II]. Increasing the dose of Alfentanil to 45 or 60 μg/kg resulted in transient but significant decreases in the heart rate and the mean arterial pressure.[119] It has been shown that it is possible to effectively blunt the haemodynamic responses to intubation with an Alfentanil dose of 15 μg/kg given after thiopentone 4 mg/kg and before succinylcholine 1.5 mg/kg[120] [II]. In the same study, lidokaine 2 mg/kg was found to be ineffective in blunting these responses.[120] During RSI with thiopentone 5 mg/kg and succinylcholine 1.5 mg/kg, an intravenous dose of alfentanil 100 mg/kg given 1 min before intubation completely prevented hypertension, tachycardia, decrease in the left ventricular ejection fraction and activation of plasma catecholamines in patients without cardiopulmonary disorders[121] [II]. However, this technique resulted in hypotension[121]. Finally, in a study using succinylcholine 1.5 mg/kg for relaxation, alfentanil 40 μg/kg in combination with propofol 2 mg/kg, in comparison with thiopentone 5 mg/kg, was shown to prevent the increase in intraocular pressure following intubation[122] [II].

Sufentanil

Only two studies could be found investigating the effect of sufentanil for RSI. The combination of sufentanil 5 μg/kg, followed by succinylcholine 1 mg/kg was found to provide more stable haemodynamics and fewer ischaemic myocardial events than etomidate 0.4 mg/kg and succinylcholine 1 mg/kg in patients undergoing revascularization surgery[123] [II]. The effects on intraocular pressure

following RSI with thiopentone 5 mg/kg and succinylcholine 1 mg/kg were studied, comparing sufentanil 0.05 μg/kg with clonidine 2 μg/kg. It was concluded that this subanaesthetic dose of sufentanil, in contrast to clonidine, was effective in blunting the increase in intraocular pressure caused by the intubation[124] [II].

Remifentanil

Two studies indicate that remifentanil 1–1.25 μg/kg intravenously effectively blunts the haemodynamic responses to intubation[125,126] [II]. Given before succinylcholine 1 mg/kg and tracheal intubation, the dose of remifentanil seems to be similar both in combination with propofol 2 mg/kg[125] and in combination with thiopentone 5–7 mg/kg.[126] However, 35% of patients receiving the 1.25 μg/kg dose of remifentanil had hypotensive episodes at some time during the study.[126] In hypertensive patients, using thiopentone 5–7 mg/kg for induction, remifentanil 1 μg/kg was a better adjunct for attenuation of the response to laryngoscopy than lidocaine 1.5 mg/kg[127] [II]. In the same study, it was concluded that the combination of remifentanil 1 μg/kg and succinylcholine 1 mg/kg was more beneficial in terms of haemodynamic stability in comparison with remifentanil 1 μg/kg and rocuronium 1 mg/kg.[127] Finally, Remifentanil 1 μg/kg has been shown to prevent the rise in intraocular pressure following a RSI with thiopentone 5 mg/kg and succinylcholine 2 mg/kg[128] [II].

Choice of a hypnotic and an opioid for RSI with a non-depolarizing neuromuscular blocker

The non-depolarizing muscle relaxant rocuronium has been proposed to replace succinylcholine for RSI. Hence, when looking for references for RSI where a non-depolarizing neuromuscular blocker is used, only papers with rocuronium have been reviewed. As can be seen from the references quoted, the influence of the anaesthetic agents on intubation conditions might be more marked when rocuronium instead of succinylcholine is used for RSI.

In the following papers, the dose of rocuronium used was 0.6 mg/kg. The effects on the intubation conditions of thiopentone in comparison with other intravenous hypnotic agents have been tested. Thiopentone 5 mg/kg, in comparison with etomidate 0.3 mg/kg, could not attenuate the reaction to intubation to the same degree as etomidate[129] [I]. Using depth of anaesthesia monitoring (Bispectral Index), it was found that thiopentone 4 mg/kg was more likely to be associated with lighter planes of anaesthesia than propofol 2 mg/kg[130] [II]. The difference could be measured 180 s after injection of the study drug, which corresponded to 120 s after intubation.[130] The effective times to satisfactory intubation conditions (95% CI) were found to be 61 s after propofol 2.5 mg/kg in comparison with 101 s after thiopentone 5 mg/kg[131] [I]. The authors concluded that rocuronium 0.6 mg/kg was suitable for RSI in combination with propofol and not with thiopentone.[131]

Other investigators have found that alfentanil 20 μg/kg constituted an integral part of an induction regimen using RSI containing rocuronium 0.6 mg/kg[132] [II]. This finding was seen both after thiopentone 5 mg/kg and propofol 2.5 mg/kg.[132] The optimal dose of alfentanil in combination with thiopentone was studied recently. It was found that adding 36–40 μg/kg alfentanil to a regimen of thiopentone 4 mg/kg and rocuronium 1 mg/kg during RSI might increase the success rate of optimal intubation conditions[133] [II]. However, significant hypotension requiring vasopressor treatment was described using this technique.[133] In parturients undergoing caesarean section, it was found that tracheal intubation using rocuronium 0.6 mg/kg was difficult in a majority of patients given thiopentone 4 mg/kg, whereas it was easily performed in patients given ketamine 1.5 mg/kg[134] [II].

A greater pressor response following intubation after etomidate 0.3 mg/kg than after propofol 2.5 mg/kg was found in unpremedicated patients. It was concluded that etomidate and rocuronium 0.6 mg/kg alone could not be recommended for RSI [I].[135] The combination of etomidate 0.3 mg/kg and S-ketamine 0.5 mg/kg produced mostly excellent RSI intubation conditions using 0.6 mg/kg rocuronium[136] [I]. This effect could not be demonstrated using etomidate 0.3 mg/kg in combination with fentanyl 1.5 μg/kg.[136]

Haemodynamic influence of hypnotics

Recommendations

To avoid hypotension, thiopentone is the preferred drug over propofol, and hence thiopentone should be used in the emergency patient, where hypoten-

sion is not tolerated. On the other hand, propofol blunts the haemodynamic stress response following intubation better than thiopentone, and propofol should be used in the emergency patient, where hypertension, tachycardia and increased plasma catecholamine levels are not tolerated. Ketamine should be used for cardiovascular unstable patients. Ketamine should, however, be used with caution or not at all in the patient with ischaemic cardiac disease. Midazolam for RSI of emergency patients should only be used after individual judgement.

Table 8

Recommendations for hypnotic drugs considering the haemodynamic system.

Recommendation	Grading
To avoid hypotension, thiopentone is better than propofol	C
To avoid hypertension, increased heart rate and increased plasma adrenaline and nor-adrenaline (i.e. to patients with ischaemic cardiac disease) propofol is a better choice than thiopentone	C
Ketamine should not be used in patients with ischaemic cardiac disease	C
Ketamine should be considered as the drug of choice in cardiovascular unstable patients when there is no time or possibility of pre-operative optimization	C

Recommendation grades are based on the grading system used by Bell et al.[1]

Background

Hypnotics, used to induce and/or maintain anaesthesia, affect the haemodynamic system differently depending on the substance chosen. Hypotension after induction of anaesthesia is a common event. Intubation, on the other hand, may cause hypertension and increased heart rate, leading to an increased cardiac oxygen demand. Depending on the pre-operative status, one hypnotic may be superior to another, according to cardiovascular effects. In this section, comparisons between thiopentone, propofol, ketamine and midazolam for induction of anaesthesia are reviewed. Graded recommendations for the choice of hypnotic considering the haemodynamic influence of the drug can be found in Table 8.

Thiopentone and propofol

When comparing induction doses of thiopentone (2–5 mg/kg) with propofol (1–3 mg/kg), propofol has a more depressing effect on the cardiovascular system; Arterial blood pressure is more reduced with propofol [137–141][II]. Propofol causes a greater reduction in cardiac output[142] [II], cardiac index and systemic vascular resistance[143,144] [II].

After intubation, a more marked increase of arterial blood pressure and heart rate is seen in several studies following thiopentone administration[145–148] [II, III]. Thiopentone leads to increased levels of plasma adrenaline[137] and plasma noradrenaline.[145] However, there are studies where no differences in the heart rate or the cardiac index could be demonstrated[144] [II]. In studies focusing on elderly patients or ASA III–IV patients, the same effects as above are reported[149,150] [II]. However, in a study by Steib et al.[151] [III] using low doses (thiopentone 2 mg/kg and propofol 1 mg/kg), no differences in haemodynamics could be demonstrated.

Thiopentone and ketamine

Very few articles were found comparing thiopentone and ketamine. In a study on caesarean section patients, thiopentone resulted in the most profound decline in arterial blood pressure[152] [II]. Thiopentone has also been shown to cause a reduction of cardiac output in a group of patients ASA class III–IV[153][III]. Cardiac output was unaffected in the group receiving ketamine.[153] The combination of ketamine and fentanyl has been shown to provide stable haemodynamic conditions.[154]

Thiopentone and midazolam

The haemodynamic effects of anaesthesia induction with midazolam (0.2–0.3 mg/kg) compared with thiopentone (3–4.5 mg/kg) differ between different studies. Thiopentone has been demonstrated to increase arterial blood pressure and heart rate after intubation, effects that were not reproducible in a midazolam group[155] [I]. Arterial blood pressure and systemic vascular resistance increased after 3 min following thiopentone administration and decreased following midazolam administration[156] [II]. On the other hand, no differences in arterial blood pressure and heart rate,[157] stroke volume, cardiac output or systemic vascular resistance[158] were demonstrated in these studies [II].

Propofol and ketamine

Ketamine has been compared with propofol for induction and maintenance in a group of elderly patients. Arterial pressure was significantly increased in the ketamine group, together with an increase of 100% in myocardial oxygen demand compared with a decrease of 27% of oxygen demand in the propofol group[159] [II]. Ketamine in combination with propofol has been demonstrated to work well with better preserved circulation compared with propofol alone, in studies of both sedative and anaesthetic procedures in adults[160,161] [III].

Propofol and midazolam

Very few studies could be found comparing propofol with midazolam for induction of anaesthesia. Propofol can cause a greater reduction of blood pressure after induction of anaesthesia[162,163] [II].

Ketamine and midazolam

Only a few articles describing the differences between ketamine and midazolam were found. White compared ketamine, ketamine–midazolam, midazolam and thiopentone for RSI [II].[164] In this study, ketamine was shown to increase arterial blood pressure, whereas blood pressure remained unchanged with midazolam and midazolam–ketamine.[164] Thiopentone decreased arterial blood pressure. Ketamine has also been shown to increase heart rate and arterial blood pressure, parameters that were reduced after midazolam administration[165] [III].

Neuromuscular Blocking Agents (NMBAs)

Introduction

In the context of emergency anaesthesia, a RSI is generally preferred for intubation. This method limits the time that the airway is unprotected during the induction, and is thus thought to limit the risk of aspiration of gastric contents. Also, bag-and-mask ventilation, with its potential of gastric air entry, is intuitively hazardous and therefore avoided. We define RSI as pre-oxygenation, followed by the rapid sequential administration of pre-determined doses of hypnotic and NMBAs, and intubation without prior bag-and mask-ventilation ventilation.

Choice of NMBA

Recommendation

For intubation of emergency cases, the use of NMBAs is recommended for better intubation conditions and for reducing the risk of complications. With regard to superior intubation conditions, succinylcholine is preferred over non-depolarizing NMBAs. Weighing the more favourable side-effect profile of rocuronium against succinylcholine's superiority under intubation conditions, succinylcholine is still recommended as the drug of choice in emergency anaesthesia, where contraindications are not present. In cases where contraindications to succinylcholine are suspected, rocuronium is an adequate alternative. Used for RSI, a dose 0.9–1.2 mg/kg of rocuronium is recommended. Head trauma is not regarded as a contraindication to succinylcholine in the emergency setting.

Background

Even though the beneficial effects of RSI lack firm evidence in clinical trials, this method is widely used.[9,83] A few studies have been conducted to determine whether the administration of NMBAs is beneficial for intubation in emergency cases. A large multicentre trial based on data from residents in emergency medicine concluded that the probability of successful intubation in the emergency room was higher in patients receiving NMBAs (85% vs. 75% for first attempt)[166] [III]. Also, one smaller observational study shows that the complications associated with emergency intubation are reduced when using NMBAs[167] [III]. In the pre-hospital setting, the reported success rates in performing intubation are better in EMS services where NMBAs are used.[168] However, no randomized-controlled trials have been identified that compare the overall benefit of using NMBA in emergency intubation. Graded recommendations for the choice of NMBAs can be found in Table 9.

Traditionally, the depolarizing muscle relaxant succinylcholine has been the drug of choice for RSI. This is mainly due to its uniformly short and predictable onset time, as well as its short duration of action in most, but not all, patients. Succinylcholine, however, has a substantial number of adverse effects, some potentially lethal, as well as a number of contraindications.[169,170] Because of the depolarizing action of succinylcholine, an increase in serum potassium levels should be expected. In

Table 9

Recommendations for choice of a neuromuscular blocking agent.

Recommendation	Grading
For intubation of emergency cases, using neuromuscular blocking agents is recommended for better intubation conditions and for reducing the risk of complications	D
With regard to superior intubation conditions, succinylcholine at a dose of 1.0–1.5 mg/kg is recommended over non-depolarizing NMBAs	A
Weighing the more favourable side-effect profile of rocuronium against succinylcholine's superiority under intubation conditions, succinylcholine is still recommended as the drug of choice in emergency anaesthesia, where contraindications are not present	E
In cases where contraindications to succinylcholine are suspected, rocuronium is recommended as an adequate alternative. Used for RSI, a dose of 0.9–1.2 mg/kg is recommended	C
Succinylcholine can be used in emergency patients with severe traumatic brain injury	C

Recommendation grades are based on the grading system used by Bell et al.[1]

any case, where a proliferation of extrajunctional acetylcholine receptors is present, this response may be severe enough to cause fatal cardiac arrhythmias. Such conditions include burn injuries, massive soft tissue trauma or neuromuscular disorders, particularly muscular dystrophies. Following spinal cord trauma or burn injury, succinylcholine is, however, considered safe within 24 h post-injury. In patients with a history of malignant hyperthermia or anaphylactic reaction to the drug, its use should be avoided.

Since the introduction of rocuronium, a rapid-onset non-depolarizing amino steroid NMBA, the role of succinylcholine as a standard NMBA in RSI has been questioned. Rocuronium is the only non-depolarizing NMBA that, within the recommended dosage, has a rapid onset comparable to succinylcholine, and is therefore by far the one most studied for RSI.[83]

A number of trials have compared the use of rocuronium vs. succinylcholine for RSI. A meta-analysis by Perry et al.,[171] reviewed 37 trials comparing the two drugs both inside and outside the operating theatre. The primary outcome in this study was *excellent intubation conditions*. An overall statistically significant RR of 0.86 (95% CI 0.80–0.92) favouring succinylcholine was demonstrated [I]. A smaller, but still significant difference was found using the secondary endpoint: *acceptable conditions* (RR 0.96, 95% CI 0.93–0.99). Several subgroups analyses were performed. One compared patients receiving a higher than standard rocuronium dose (0.9–1.0 or 1.2 mg/kg). In these groups, the difference vs. succinylcholine did not reach statistical significance. However, in another subgroup, intubation carried out in emergency settings yielded an RR of 0.79 (0.71–0.88), favouring succinylcholine for excellent conditions. Moreover, a subgroup of patients intubated *within* 60 s, as opposed to *after* 60 s following administration of the NMBA, also showed a favourable outcome for succinylcholine (RR 0.81, 95% CI 0.72–0.91). In a subgroup of studies where opioids were administered before NMBA, this review concluded that succinylcholine was still superior with regard to excellent intubating conditions.

Vecuronium for RSI has, due to its slower onset and prolonged duration of action, been less studied. In one study from Martin et al.,[172] the onset time for vecuronium (0.1 mg/kg) was twice that for succinylcholine (1 mg/kg). The intubation conditions were significantly worse in the vecuronium group. Similar findings have been demonstrated in other studies.[173,174] One study, though, showed that by tripling the dose of vecuronium (to 0.3 mg/kg) intubating conditions were comparable to succinylcholine after 60 s.[175]

To our knowledge, no clinical trial has been conducted in order to determine whether the favourable side-effect profile of rocuronium outweighs succinylcholines superiority under intubation conditions. Such a trial is unlikely ever to be conducted, due to the extremely high number of patients needed for statistical power. In the absence of data on this issue, we find no reason to change the current widely accepted practice, thus recommending succinylcholine as the drug of choice for RSI [V]. In the presence of contraindications against succinylcholine, or in cases where there are reasons to suspect this, rocuronium may be a good alternative, but the high dose needed will lead to a very long duration of action. Further, it is a disadvantage with succinylcholine that a second attempt of intubation may not always be possible because of the short duration of action. Giving a second dose of succinylcholine, on the other hand, may increase the risk of bradycardia, and must be carefully balanced against the possibility to awaken the patient and continue with an alternative plan.

Some concern has been expressed regarding increased intracranial pressure related to succinylcholine.[176] In elective neurosurgical cases, fascicu-

lations following succinylcholine administration are shown to transiently increase intra cranial pressures, particularly in lightly sedated patients. This effect is suppressed when subjects receive a precurarization dose of a non-depolarizing NMBA.[177] For acute traumatic injury, only a few studies have been conducted. One study failed to demonstrate any significant increase in ICP or change in cerebral perfusion following an intubation dose of succinylcholine given to patients with severe head trauma [178] [II]. One systematic review did not find evidence of any benefit from pre-induction doses of non-depolarizing NMBAs before succinylcholine in patients with acute brain injury.[179] The trials in this review, though, were few and of limited quality, and must be interpreted with caution. Considering the well-documented detrimental effects of hypoxia in head trauma patients,[180] optimal intubation conditions are thought to be of superior importance. From the lack of evidence to prove the detrimental effects of succinylcholine, there seems to be no reason to discourage its use for RSI in head trauma patients [III].

Precurarization

Recommendation

Precurarization (or a priming dose of non-depolarizing NMBAs) is not recommended for emergency or RSI (Grade E).

Background

The rationale behind the precurarization principle is multitudinous, and differs depending on the NMBA used after induction. When using depolarizing blocking agents, such as succinylcholine, priming doses of a non-depolarizing NMBA are suggested in order to avoid fasciculations, post-operative myalgia, increased intra cranial, intraocular pressure and intragastric pressures. Typically, a dose 10% of a normal intubation dose is used for this purpose.

Post-anaesthetic myalgia occurs in about 50% of patients treated with intubation doses of succinylcholine. The reduction of fasciculations and post-operative myalgia by precurarization is well documented[181] [I]. Although the condition is uncomfortable to the patient, it is harmless, and the benefits must be weighed against the safety. Precurarization for the suppression of elevated ICP is discussed above.

For non-depolarizing blocking agents, the main reason to administer a priming dose is to shorten the onset times of the NMBAs used for induction, thereby lowering the intubation dose and thus the duration of the block. One study demonstrated a significant reduction in the onset times (74.0 vs. 44.7 s) for normal intubation doses of rocuronium (0.6 mg/kg) when primed with 0.06 mg/kg 3 min in advance.[182] When using a higher dose of rocuronium (1.0 mg/kg), another study showed equal onset times regardless of a priming dose. In the same study, patients with burn injuries also had similar onset times with or without precurarization, when the dose of rocuronium was increased to 1.5 mg/kg.[183]

No studies were identified directly comparing protocols including precurarization vs. protocols with no precurarization with respect to overall complications in patients undergoing RSI. Several of the trials concerning precurarization, however, report adverse effects of the priming dose[183–185] [IV]. The adverse effects are mainly hypoventilation, impaired laryngeal reflexes and muscle weakness. On the basis of an analysis of pharmacological and pharmacodynamic data, Kopman et al. [186] advocate caution with the use of precurarization. The individual variations in sensitivity to NMBAs make it highly difficult to determine a safe and effective dose. Even 10% of a normal induction dose has the potential to cause potentially harmful effects [V].

Reversal with sugammadex

Recommendations

In the unlikely event of a 'cannot intubate, cannot ventilate' situation, high-dose sugammadex (16 mg/kg) should be administered if rocuronium or vecuronium has been used (Grade B).

Background

One reason for the widespread use of succinylcholine is its relatively rapid recovery time compared with any of the non-depolarizing NMBAs used for RSI. The inability to rapidly reverse a deep neuromuscular block by administration of anticholinesterases is well documented.[187] The γ-cyclodextrin derivate known as sugammadex has been introduced recently. Although a number of trials have already been conducted evaluating this drug, the clinical experience is so far limited. One study showed effective reversal (TOF > 0.9) from a deep

rocuronium block after 2 min when maximum dose sugammadex (16 mg/kg) was administered 5 min after high-dose rocuronium.[188] Other trials also support its efficacy.[189,190] Sugammadex also reverses neuromuscular block from vecuronium, although to a lesser extent.[191] In the trials conducted so far, the number and severity of side effect does not exceed that of the control groups. One study in particular aimed to evaluate sugammadex as a rescue drug in a simulated 'cannot intubate, cannot ventilate' situation. The results indicated that a high dose of sugammadex (16 mg/kg) reverses a high-dose rocuronium (1.2 mg/kg) more rapidly than the spontaneous recovery from succinylcholine 1.0 mg/kg[192] [I]. These recent findings have intensified the debate over succinylcholine's role a first-line NMBA.[193] The clinical experience with sugammadex is still limited, and it is, in our opinion, premature to abandon succinylcholine as the drug of choice in emergency cases [V].

Anaphylactic reactions

NMBAs are, according to several studies, the most common cause of anaphylactic reactions related to general anaesthesia.[194] The incidence, however, differs between countries, and their relative frequencies are generally uncertain. Succinylcholine is considered probably the most frequent causative anaesthetic agent worldwide.[194,195] Special considerations apply for Norway, where an unexpectedly high number of anaphylactic reactions have been reported after administration of rocuronium. The frequency of anaphylactic reactions was even thought to exceed that for succinylcholine. Despite the unexpected incidence of anaphylactic reactions, the certainty of a clinical disadvantage of rocuronium compared with other NMBAs has not been established, and its use is still indicated for selected patients in Norway[194] [V]. Interestingly, other Scandinavian countries have not experienced problems of the same magnitude. Differences in sensitization from environmental exposure are hypothesized as a possible cause.

Anaesthesia outside the operating room

Recommendations

Careful preparation and monitoring should be used to reduce the number of complications following anaesthesia to emergency patients outside the OR. Because there is a greater risk of complications, the benefits of emergency anaesthesia outside the OR should always be weighed against the risks. It may be safer for the emergency patient to be transported to the OR, where experienced anaesthesiologists can take the responsibility of care. RSI with sufficient pre-oxygenation is recommended because this is also the safest method outside the OR. As alternatives to RSI, awake intubation or regional anaesthesia can be used. All available induction agents can be used. However, etomidate should only be used under very special circumstances. Graded recommendations can be found in Table 10.

Background

This chapter discusses in-hospital emergency anaesthesia, i.e. airway management and related stabilizing treatment in critically ill patients outside the OR. In the Scandinavian countries, anaesthesiologists play a crucial role in airway management outside the OR, including intensive care units, high-dependency units, coronary care units and also prehospitally.[196–200] However, the pre-hospital environment has been left out of this review because guidelines for pre-hospital airway management have been provided recently by Berlac et al.[168] Indications for emergency intubation and anaesthesia are several outside the OR (Table 11). These indications are based on the clinical need for urgent airway control, reversal of hypoxaemia,

Table 10

Recommendations on anaesthesia outside operation rooms (OR).

Recommendation	Grading
Because of the greater risk of complications, the benefits of emergency anaesthesia outside the OR should always be weighed against the risks. The risk level should be reduced by careful preparations and monitoring whenever possible	E
Rapid sequence intubation with sufficient pre-oxygenation is the safest method outside the OR	D
Alternatives for RSI are awake intubation by topical anaesthesia with light sedation, and ketamine anaesthesia or regional anaesthesia in selected cases and environments	E
For induction of anaesthesia, all available induction agents can be used	D
However, when considering etomidate, the influence of possible etomidate-induced adrenocortical suppression for the patient's outcome must be considered	C

Recommendation grades are based on the grading system used by Bell et al.[1]

Table 11

Indications of emergency anaesthesia outside operation rooms.

Trauma
Traumatic Brain injury (GCS < 9)
Penetrating neck injury (airway compromise)
Facial injuries (airway compromise)
Major burns (airway compromise)
Thoracic trauma (airway compromise and respiratory insufficiency)
Multiple blunt trauma (shock, altered level of consciousness)
Altered level of consciousness (SAH, ICH, Intoxication, sepsis, CNS infections, metabolic)
Critical respiratory insufficiency (cardiac and non-cardiac)
Cardiogenic shock
High Spinal cord injury
Status epileptics and refractory convulsions
Septic shock (decreased level of consciousness, critical tissue hypoxia, ALI/ARDS)

Adapted from Reid et al.[206]

diminishing work of breathing, optimizing oxygenation and ventilation and securing airway of an unconscious patient when at risk of aspiration of gastric contents or blood. To facilitate the procedure, sedative or anaesthetic agents and peripheral muscle relaxants should be used if the patient is responding. Because of the less controlled environment and underlying critical illness or severe trauma of the patient, emergency anaesthesia induction outside the OR is perhaps even more challenging than inside the OR.

In a recent Cochrane Review, Lecky et al.[201] found only three randomized-controlled studies dealing with emergency intubations outside the OR. None of them clearly studied the anaesthetic techniques and drugs suitable for emergency anaesthesia. Most of the studies are poorly randomized and controlled, and most of them have been carried out in trauma patients in the pre-hospital environment and are not within the scope of this review. The lack of studies and various environmental and patient-related risk factors increase the need for anaesthesiologic experience, clinical skills and knowledge of the physiology of various medical emergencies for successful and safe anaesthesia management.

Environmental considerations, preparedness and patient safety

The usual environmental problems outside the OR include variation in equipment, limited oxygen stores, darkness, less optimal ergonomics, less experienced anaesthesia staff, insufficient monitoring and medications. Also, patients in need of a secure airway are critically ill, and may be haemodynamically unstable, hypovolaemic and, with no exceptions, at risk of aspiration of gastric contents or blood. Often, the information of the predisposing illnesses and medications is unreliable.[202,203] In emergency situations where the anatomy of the patient may be difficult, the position of the patient, facial and neck injuries, gastric contents, saliva and blood and tissue debris in the upper airways may worsen the intubation conditions and make the procedure more difficult or even impossible. Also, predicting an anatomically difficult airway in a patient with a critical condition is more difficult than in a patient having an elective surgical operation[204] [V].

The standard anaesthesia care and patient safety must be levelled as high as possible. Adequately stocked patient cart, anaesthesia machine (ventilator), resuscitation/ACLS equipment and medication, difficult airway preparedness (equipment as well as pathways), monitoring and warming equipment should be available, and the staff should be familiar with the procedure[205] [V]. Equipment for difficult or failed intubation and alternative airway techniques should be available.

Intubation techniques

RSI and intubation is also a cornerstone of emergency intubation outside the operating area. RSI is a suitable and relatively safe method in all emergency intubations, when the use of anaesthetic agents is indicated [206] [V]. However, in their study on RSI, Reid et al. Reid found a 35% complication rate Reid. On the other hand, there were no immediate fatalities. In 50% of the patients, the hypnotic used was propofol. The others were thiopentone, midazolam, ketamine and etomidate. No reports of topical lignocaine were given. All the intubations were successful, a part of them facilitated with a bougie. They did not report any incidence of aspiration or suspected aspiration during the procedure.[206] In urgent intubations, aspiration has been demonstrated in 3.5% of patients[207] [V].

There are no studies discussing differences and influence on outcome between RSI and the alternative awake intubation, and the choice of the method should be based on the clinical condition of the patient, possible airway difficulties and equipment available. There are a few reports of

fibreoptic intubation in the ED, but the more conventional intubation aids and alternative airway equipment are used more commonly. Alternative airway equipments that are useful not only in the pre-hospital area but also in the in-hospital emergency intubations have been discussed elsewhere.[168]

Drugs

All usual induction agents, opioids and muscle relaxants can also be used outside the OR. The drugs and methods have to be chosen according to the general principles applied in the OR for cardiac, CNS-injured and hypovolaemic patients. There are, however, only a few studies outside the OR. RSI is better than etomidate only [208] [IV]. Sedative agents may have synergism with NMBAs during intubation[209] [V]. Propofol may be better than etomidate from this point of view, but may induce more hypotension. If etomidate, midazolam or ketamine is used, the risk of hypotension may be lesser. However, the intubation conditions may be worse and the time needed for intubation may be longer[210] [IV]. Adreno-cortical suppression has raised concern in connection with etomidate use. When comparing a single dose of etomidate with midazolam and fentanyl as induction agents in RSI in adult trauma patients, it was demonstrated that the mean plasma cortisol levels were significantly lower 4–6 h after intubation in the etomidate group [211] [II]. More importantly, intensive care length of stay, ventilator days and hospital length of stay were significantly longer in patients who received etomidate as an induction agent. The same trend was demonstrated in septic shock patients[212] [IV].

Optimizing patient care and complications

Most of the patients who need emergency anaesthesia outside the OR have serious disturbances in respiratory and/or haemodynamic function. Anaesthetic agents may worsen these disturbances. Thus, the underlying conditions should be treated simultaneously with the induction of anaesthesia and intubation. Predicting and treating the complications (hypoxia – pre-oxygenation; hypotension – fluids and vasoactive drugs prepared and given; vomiting and possible aspiration – suction device, RSI; arrhythmias – defibrillator and drugs available, etc.) is an essential part of the treatment[213] [V].

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Appendix 1: Search strategy, words and phrases

Initial considerations

(Rapid sequence induction OR rapid sequence intubation) AND emergency patients OR emergency/acute anaesthesia

Incidence of aspiration AND emergency patients/operations/procedures

Fasting conditions and identification and treatment of patients at high-risk of aspiration of gastric contents

(((((‘General Surgery’[Mesh] OR ‘Surgical Procedures, Operative’[Mesh])) AND ‘Anaesthesia’

[Mesh]) AND ‘Fasting’[Mesh]) AND ‘Preoperative Care’[Mesh]) AND (‘Pneumonia, Aspiration’

[Mesh] OR ‘Respiratory Aspiration’[Mesh])

Fasting, Aspiration pneumonia, Emergency surgery, acute surgery, emergency patients, Anaesthesia,

Gastric emptying by oro-gastric/naso-gastric tube

(oro-gastric tube OR naso-gastric tube) AND (aspiration OR gastric emptying)

Medical pre-treatment to increase gastric emptying by increasing gastro-intestinal motility

(Prokinetic drugs OR Metoclopramid OR Domperidone) AND Gastric emptying AND Aspiration pneumonia.

Medical pre-treatment to reduce acid secretion

(Acid secretion AND gastric emptying AND aspiration pneumonia) AND (cimetidine OR ranitidine OR omeprazole)

Medical pre-treatment with antacids

(Acid secretion AND Gastric emptying AND Aspiration pneumonia) AND (Sodium citrate OR Magnesium trisilicate OR Bicitra)

Medical pre-treatment with antiemetics

Anaesthesia AND (Aspiration pneumonia AND (Metoclopramid OR Ondansetron OR granisetron OR tropisetron)

Medical pre-treatment with anticholinergic drugs

Aspiration pneumonia anaesthesia AND (Atropine OR Glycopyrrolate OR Hyoscine OR Scopolamine)

Preoxygenation

Preoxygenation, OR pre-oxygenation, AND arterial desaturation AND

Tidal volume breathing OR Maximal breathing AND arterial desaturation

RSI OR Rapid Sequence Induction OR Rapid Sequence Intubation

Cricoid pressure

Cricoid pressure (435 references), Sellick's manoeuvre (0), Sellick manoeuvre (7), rapid sequence induction (2492), rapid sequence induction of anaesthesia/anesthesia (363).

Drugs: hypnotics and opioids

A search with the following phrases was performed and the result was.

	Search phrase	Total number of articles	Number of reviews	Number of RCT
#1	RS induction	2450	146	130
#2	RS induction and opioids	64	5	33
#3	RS intubation and opioids	53	3	29
#4	RS induction and hypnotic	140	17	55
#5	RS intubation and hypnotic	147	24	52
#6	Crash induction and hypnotic	8	0	8
#7	Crash intubation and hypnotic	7	0	7
#8	Crash induction and opioid	1	0	1
#9	Crash intubation and opioid	1	0	1
#10	Combining #2 and #3	59	3	29
#11	Combining #4 and #5	113	16	52
#12	Combining #2 and #4	38	2	23

The abstracts of the randomized-controlled trials from search #10, #11 and #12 were reviewed. Papers on anaesthesia in the emergency department and papers dealing solely with the effect of neuromuscular blocking agents are covered in another chapter, and these papers were excluded. Finally, some of the papers were found during all three searches; hence, the total number of RCT's on this subject was 36.

Haemodynamic influence of hypnotics.

Search phrases: haemodynamics and combination of hypnotics as follows:

Substances	Total number of articles	Relevant articles	Number of RCT
Thiopentone/thiopental and Propofol	193	28	18
Thiopentone/thiopental and ketamine	93	3	1
Thiopentone/thiopental and midazolam	49	7	4
Propofol and ketamine	119	6	2
Propofol and midazolam	170	9	5
Ketamine and midazolam	121	3	2

RS, rapid sequence; RCT, randomized-controlled trial

Articles were considered relevant when differences in the haemodynamic parameters between drugs had been studied and described. Abstracts of randomized controls were reviewed. RCT, randomized-controlled trials.

Neuromuscular blocking agents

The primary search was limited to 'Clinical Trial', 'Meta-Analysis', 'Randomized Controlled Trial', 'Review' in English language.

Choice of NMBA.

Search #	Search words	No. of hits
#1	'Rapid Sequence Induction'	163
#2	'Rapid sequence Intubation'	65
#3	#1 OR #2	221
#4	Vecuronium	968
#5	Rocuronium	533
#6	Succinylcholine	926
#7	#3 AND #4	34
#8	#3 AND #5	48
#9	#3 AND #6	101
#10	#3 AND #4 AND #5 AND #6	4
#11	#3 AND (#4 OR #5 OR #6)	129
#12	'emergency intubation'	168
#13	'Neuromuscular blocking agents'	20,466
#14	(#3 OR #12) AND #13	119
#15	'traumatic head injury'	294

#16	'head trauma'	4815
#17	#3 AND #6 AND (#15 OR #16)	2
#18	#6 AND ICP	4

Precurarization

#1	'Rapid Sequence Induction'	163
#2	'Rapid sequence Intubation'	65
#3	#1 OR #2	221
#4	Precurarization	16
#5	Priming	2731
#6	#3 AND (#4 OR #5)	13

Reversal

#1	Sugammadex	91

Anaesthesia outside operating room

Search words: emergency anaesthesia, medical emergency team.