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Master thesis | Original study

An observational study of airway management at a Belgian university hospital: use of neuromuscular blocking agents and a description of current practice during rapid sequence induction of anesthesia with intubation

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Abstract

Background: **Ethical approval for this study was granted by the Ethics Committee of Antwerp University Hospital, Drie Eikenstraat 655, 2650 Edegem on 30th March 2020 (Chairman: Professor Pieter Michielsen, reference EC UZA 20/10/113). Informed patient consent was not required by the ethics committee. Patients were included from 1st June 2020 until 31st August 2020.**
Objectives: **As part of a broad assessment of airway management in both adult (age ≥ 16 years) and pediatric (age < 16 years) practice, this study aimed to determine which neuromuscular blocking agents (NMBA's) and antagonists were being used in our anesthesiology department, with special emphasis on RSII. Moreover, this study seeks to determine how RSII was being performed.**
Design and setting: **A prospective observational study was conducted over a 3-month period in a university hospital in Belgium.**
Methods: **Following ethical committee approval, all emergency and elective cases requiring airway management by anesthesiologists were included. Details were entered into an electronic database stored on a secure hospital server.**
Main outcome measures: **The number of different NMBA exposures, along with antagonists, was recorded. During RSII, positioning for preoxygenation, use of gastric drainage, application of cricoid force and use of pre-intubation bag-mask ventilation were noted.**
Results: **In total, there were 3747 general anesthetics. An NMBA was administered in 60.2%, (rocuronium most common in adults, 57.5%, n=1774). Atracurium was most popular in pediatrics (25.9%, n=171). Succinylcholine was used in 16 patients (4 RSII's). 36.3% of non-depolarising blocks were antagonized (n=812), most commonly with sugammadex (n=437). RSII was used in 187 patients. In the RSII group, preoxygenation occurred head-up in 53.5%, cricoid force was applied in 19.3% and rocuronium used in 97.9%. Nasogastric drainage before induction, and bag-mask ventilation before intubation were used in 25 and 6 cases respectively.**
Conclusions: **Rocuronium and atracurium are the most commonly used NMBA's in the adult and pediatric populations respectively. Approximately one third of non-depolarizing blocks are antagonized, most commonly with sugammadex. Practices during RSII vary greatly.**

Keywords: **Airway management, Rapid Sequence Induction and Intubation, Neuromuscular Blocking Agents.**

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Introduction

Rapid sequence induction of anesthesia with intubation (RSII) is used to rapidly gain control of the airway in patients who are at increased risk of regurgitation, vomiting and broncho-aspiration. Entry of gastric contents into the airway is a feared complication of general anesthesia (GA), especially in non-fasted patients, and the clinical consequences can vary from minor respiratory compromise to severe ARDS with multiple organ failure and death. In 1970, Stept and Safar described a 15-step technique for the rapid induction and intubation of patients with a full stomach1. They combined several key elements that were taught to generations of anesthetists for many years. The original description included: pre-induction gastric decompression using a large-bore nasogastric tube, pre-oxygenation in a 30° head-up position with a tightly fitting face-mask for at least 2 minutes, rapid induction of anesthesia with a barbiturate, fast onset of neuromuscular blockade with succinylcholine, application of cricoid force and swift intubation with a cuffed tracheal tube, before manual ventilation of the lungs. The scientific evidence for much of this has, however, been the subject of intense debate and the technique has been greatly modified. In addition, the development of modern pharmacological agents has opened up new possibilities in this hazardous area of anesthetic management.

During a 3-month period, a prospective observational study of airway practices was conducted in our department. As part of a wide-ranging analysis, the objective was to define which neuromuscular blocking agents (NMBA's) and antagonists were currently being used. Furthermore, there was specific interest in how RSII was being conducted and taught to trainees, with particular emphasis on the use of cricoid force, patient positioning during anesthesia induction, the use of bag-mask ventilation before intubation and the use of nasogastric drainage. Finally, potential differences in these practices between adults (age $\geq$ 16 years) and pediatric patients (age < 16 years) were examined. This article has been prepared in accordance with the STROBE recommendations for the presentation of observational studies.

Methods

Ethical approval for data collection was granted by our hospital ethics committee on the 30th March 2020 (chairman: Professor Pieter Michielsen, protocol reference number 20/10/113). Due to the non-interventional nature of the study, the ethics committee waived the need for informed consent. Patients undergoing surgical, diagnostic and interventional radiology procedures with an anesthesia team were screened for inclusion during the study period, which lasted from 1/6/2020 until 31/8/2020. Unique sequential operating department register numbers were used to identify patients. Data concerning the use of NMBA's and their antagonists, along with details of the RSII technique used, were collected on a specifically designed paper form for this study, completed by the anesthesiologist (staff member or trainee). Listings of registered procedures were collected daily and checked to ensure data had been collected from all eligible patients. Queries were resolved and missing data recuperated within 24-72 hours either by consulting the anesthesia record or interrogating the responsible anesthesiologist confidentially. Data were entered into an electronic database and stored on a secure hospital server (OpenClinica Community Edition, v3.13, OpenClinica LLC, Waltham, MA, USA). Entries were later double-checked manually.

Inclusion criteria

All elective and emergency patients, of all ages, managed by anesthesiologists for surgical, diagnostic or interventional radiology procedures were screened for inclusion. If airway management had been previously performed in the prehospital setting, the emergency department or the intensive care unit, patients were only included if they required further care by an anesthesia team in the operating room or radiology suite.

Exclusion criteria

Patients undergoing surgical procedures using infiltration or topical anesthesia applied by the operator were excluded. Vascular access procedures conducted with local anesthesia were also excluded, as were cases requiring monitored anesthesia care, where no sedative technique or airway intervention was applied. A recruitment flow diagram is provided in Figure 1.

Statistics

Statistical analysis was performed using IBM® SPSS® (v27, IBM, Armonk, NY, USA). Data are summarized as numbers and frequencies, and presented with frequency tables and bar charts where appropriate. Clopper-Pearson confidence intervals on proportions were calculated at the 95% level and comparisons of data for adult and pediatric groups were made using frequency-weighted Pearson Chi-Square testing of contingency tables. The Chi-square statistic ($\chi 2$) is quoted with continuity correction for 2x2 tables. Normally distributed continuous data are summarized using the mean with standard deviation.

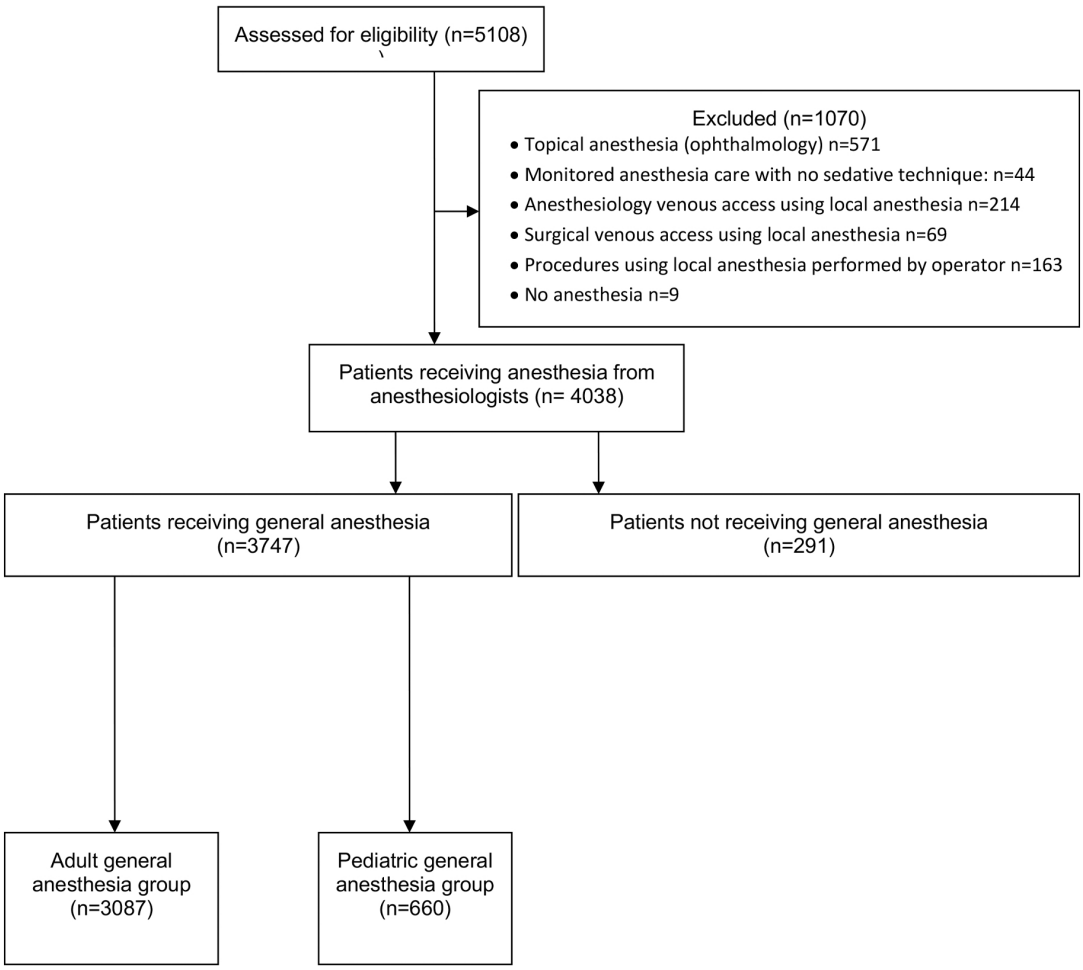

Fig. 1 — Patient recruitment flow diagram.

Missing values were treated as 'missing completely at random'. Statistical significance was set at $p < 0.05$.

Results

During the study, which was conducted from 1st June to 31st August 2020, 5108 patients were screened for inclusion. 1070 patients were excluded. The database consisted of 4038 cases, including 2 patients who received monitored anesthesia care during tracheostomy cannula exchange. A total of 3747 procedures were conducted using general anesthesia (GA, 92.8%, CI 92.0% - 93.6%) of which 3087 were in adults (age ≥ 16 years). The adult male/female ratio was 1483/1603 and their mean body mass index (BMI) was 26.3 ± 5.4 kg m-2 (range 11.0 – 58.8 4 kg m-2, n = 3067). 660 Patients received GA in the pediatric subgroup (n = 663). The pediatric male/female ratio was 376/284 and their weight range was 0.6 kg – 96 kg (n = 659). The patient recruitment flow diagram is illustrated in Figure 1.

Muscle relaxants

The total number of NMBA exposures was 2255 (60.2% of all GA's, CI 58.6% - 61.7%): succinylcholine (n = 16), atracurium (n = 337), cisatracurium (n = 55) and rocuronium (n = 1847). Significantly more adult than pediatric cases received an NMBA (respectively n = 2001, 64.8% of adult GA's versus n = 254, 38.5% of pediatric GA's ,): $\chi 2$ (df = 1, n = 3747) = 156, $p < 0.001$. Rocuronium was the most frequently used NMBA in adults (n = 1774, 57.5% of adult GA's). In pediatric practice, atracurium was most commonly used (n = 171, 25.9% of pediatric GA's). A statistically significant difference in the use of NMBA's was observed between the two age groups. The number of exposures to muscle relaxants is summarized for both pediatric and adult subgroups in Table I. These data include 5 patients who received both rocuronium and cisatracurium (2 were transferred from the intensive care unit already intubated), 1 patient who received both atracurium and cisatracurium, 1 patient who received atracurium and rocuronium and 1 patient who received cisatracurium and succinylcholine. 233 patients were intubated in the absence of neuromuscular blockade (including 5 jet catheters). The number of intubations occurring without an NMBA was: pediatric group (n = 72, 22.8%), adults (n = 161, 7.8%): $\chi 2$ (df = 1, n = 2374) = 67.6, $p < 0.001$. In

Table I. — Number of exposures to neuromuscular blocking agents in the pediatric and adult subgroups.

NMBA	Pediatric group	Adult group	Total	p
Succinylcholine	5 (2.0)	11 (0.5)	16 (0.7)	0.03
Atracurium	171 (67.3)	166 (8.3)	337 (14.9)	< 0.001
Rocuronium	73 (28.7)	1774 (88.7)	1847 (81.9)	< 0.001
Cisatracurium	5 (2.0)	50 (2.5)	55 (2.4)	NS
Total	254 (100)	2001 (100)	2255 (100)	< 0.001

n (% for each age group); p - Pearson Chi-Square test for comparisons between the pediatric and adult age groups; NS: not significant NMBA: neuromuscular blocking agent.

3 cases where muscle relaxation was not planned, difficulties with laryngoscopy required rescue using succinylcholine (2 patients) and rocuronium (1 patient).

In 14 patients, NMBA's were administered to patients managed with a supraglottic airway device (SAD): atracurium (i-gel, n = 1; LM Supreme®, n = 3; 1st generation larynx masks, n = 2) and rocuronium (i-gel, n=7; LM Supreme®, n=1).

Muscle relaxant antagonists

Most patients receiving a non-depolarising NMBA did not receive an antagonist (n = 1424, 63.7%). There were 3 missing responses for antagonists in patients receiving rocuronium. Neuromuscular blockade with cisatracurium was least likely to be antagonized (n = 9, 16.4%,) whereas blocks with rocuronium were most likely to be antagonized (n = 744, 40.3%,). Sugammadex was the most commonly used NMBA antagonist (n = 437, 53.8% of all cases receiving an antagonist). Also, more patients with a rocuronium-induced block were antagonized with sugammadex (n = 437, 23.7%) than with neostigmine/glycopyrrolate (n = 307, 16.6%). NMBA antagonist administration for atracurium, rocuronium and cisatracurium is summarized in Table II.

In the pediatric group, only 14.1% of the 249 non-depolarizing neuromuscular blocks, received an antagonist (neostigmine/glycopyrrolate, n = 20; sugammadex, n = 15). This contrasts with adult data where 39.0% of the 1990 non-depolarizing neuromuscular blocks were antagonised (neostigmine/glycopyrrolate, n = 355; sugammadex, n = 422). These differences in adult and pediatric practice were statistically significant: $\chi 2$ (df = 2, n = 3744) = 127, p < 0.001.

Rapid sequence induction

A total of 187 RSII's were recorded (5.0% of all GA's). Of these cases, 19 occurred in the pediatric group. Demographic data for patients undergoing RSII is summarized in Table III. The youngest and oldest patients in the series were 3 and 86 years-old respectively. The distribution of cases across the surgical disciplines is illustrated in Figure 2. Most cases occurred in abdominal surgery (n = 99, 52.9%). A retrospective analysis showed that most RSII's occurred during normal week-day working hours (n = 102, 54.5%). The timing (day-time hours versus night-time, weekends and holidays) is summarized in Table IV. Fifteen RSII's were performed for Caesarean section.

Pre-oxygenation was usually by face-mask (2 patients received high flow nasal oxygen). Positioning for pre-oxygenation, anesthesia induction and intubation was mainly in the anti-Trendelenburg position (n = 100, 53.5%). Dorsal decubitus was used in 85 patients (45.5%) and Trendelenburg recorded in 2 cases (1.1%). In one of these, head down positioning was chosen for urgent anesthesia in a patient with hypovolemic shock. In 25 cases (13.4%), anesthesia was induced with a nasogastric tube already in situ. In a further 44 patients, a nasogastric tube was placed following intubation. Cricoid pressure was

Table II. — Use of neuromuscular blocking agent antagonists.

	NMBA antagonist			
NMBA	Neostigmine/ glycopyrrolate	Sugammadex	None	Total
Atracurium	59 (29.4)	0	278 (70.6)	337 (100)
Rocuronium	307 (16.6)	437 (23.7)	1100 (59.7)	1844 (100) *3
Cisatracurium	9 (16.4)	0	46 (83.6)	55 (100)
Total	375	437	1424	2236

n (% of total antagonist exposure for each NMBA); *missing values; NMBA – neuromuscular blocking agent.

Table III. — Demographic data for the RSII group – n (%).

Gender F/M	95/92
Age:	
Children (2 < 10 years)	9 (4.8)
Adolescents (10 < 16 years)	10 (5.3)
Adults (≥16 years)	168 (89.8)
ASA score:	
1	45 (24.1)
2	54 (28.9)
3	56 (29.9)
4	23 (12.3)
5	9 (4.8)

applied in 36 cases (19.3%), including 3 patients in the pediatric age group (one 3 year-old, one 6 year-old and one 15 year-old). The choice of muscle relaxant was overwhelmingly in favour of rocuronium (n = 183, 97.9%). Retrospectively, the injected dose of rocuronium was calculated as 1.0 ± 0.2 mg kg-1 actual body weight (mean ± SD, range 0.3 – 1.7 mg kg-1, n = 169). Four patients received succinylcholine (2.1%), none of whom had cricoid force applied. Two patients receiving succinylcholine were children (one 6 year-old and one 8 year-old). In 6 cases, the lungs were manually ventilated using a bag and mask before intubation, but only one of these had cricoid force applied. Regurgitation or vomiting in these patients was not recorded. In one of these cases, ventilation was used to avoid hypercarbia in the context of intracranial trauma. Intubation was performed mainly with direct laryngoscopy (Macintosh blade, n = 159, 85.0%) and assisted by a tube stylet in

Table IV. — Timing of rapid sequence induction of anesthesia.

Time period	n (%)
Week-day 08.00-18.00	102 (54.5%)
Week-day 18.00-08.00	54 (28.9)
Week-end/holiday 08.00-18.00	16 (8.6)
Week-end/holiday 18.00-08.00	14 (7.5)
Total	186 (100)

91 patients (48.7%). Videolaryngoscopy (VL) was used for 28 intubations (15.0%). There was a greater proportion of hyperangulated VL's during RSII than in non-RSII patients (15.0% versus 9.5% respectively): $\chi 2$ (df = 1, n = 2374) = 6.5, p = 0.008.

During the entire study period, 2 patients regurgitated/vomited during anesthetic induction. In the first case, no RSII was planned, but cricoid force was quickly applied and the trachea intubated following pharyngeal suctioning. There were no clinical consequences. The second case occurred during RSII for an upper gastro-intestinal tract procedure. Following pre-oxygenation in the anti-Trendelenburg position, regurgitation and bronchoaspiration occurred at the onset of anesthesia, before planned VL. No cricoid force was applied beforehand. The patient developed an aspiration pneumonia requiring antibiotic treatment for 14 days, in spite of oropharyngeal suctioning, prompt intubation and tracheal aspiration. The patient later recovered completely.

Discussion

Our database shows that 60.2% of all patients undergoing a GA receive an NMBA, of whom

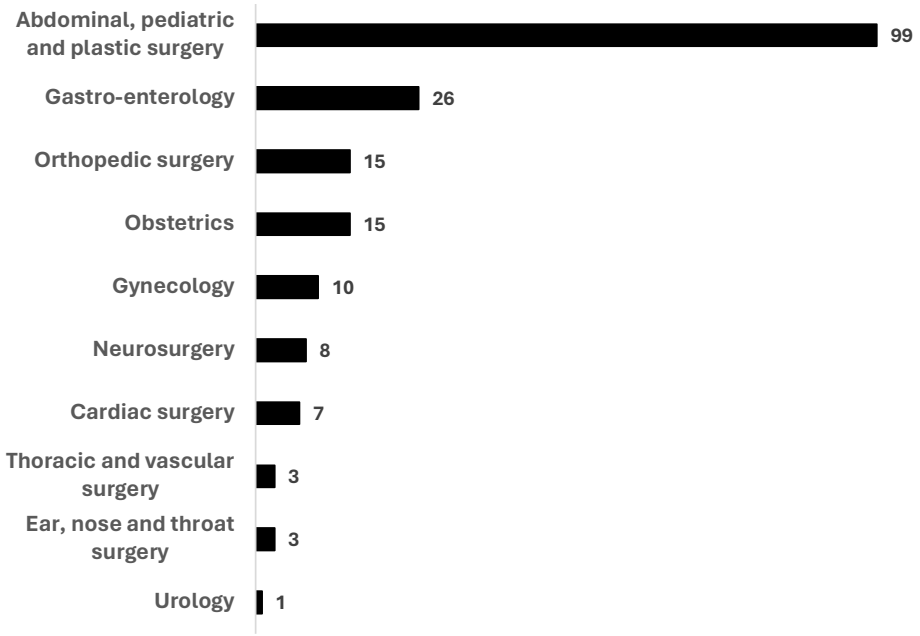

Fig. 2 — Cases receiving rapid sequence induction of anesthesia with intubation distributed across the surgical disciplines.

99.3% receive a non-depolarizing agent. These figures contrast with those from national surveys of anesthetic activity in both the UK and Republic of Ireland. In preliminary studies collecting baseline data for the 5th and 6th National Audit Projects on accidental awareness and perioperative anaphylaxis respectively, NMBAs were recorded in 42% - 47% of GA's[2,3], with non-depolarizing agents being used in 96.2% of exposures[4]. In our study, the most commonly used NMBA was rocuronium (n = 1847, 49.3% of all GA's), accounting for 81.9% of all NMBA administrations. This contrasts with the national UK data, in which atracurium was most used (23.2% of all GA's). These differences could not be fully explained, but a number of factors may be relevant. Our data describe monocentric practices in a tertiary referral centre and may not reflect national practices within Belgium. Decision-making may be influenced by the availability of the different non-depolarizing NMBA's in different countries, by financial constraints and possibly by their known potential for inducing allergic reactions. Of the non-depolarizing NMBA's, rocuronium carries the greatest risk of allergy (~1:17000, versus atracurium, ~1:24000). Also, the ease with which rocuronium-induced neuromuscular blockade can be reversed by sugammadex is a considerable advantage, allowing deep blockade to be maintained until the end of a procedure. Furthermore, the rate of tracheal intubation observed in the UK (38.4% - 44.6%)[3,5] or Ireland (47%) is much lower than that in our own department (65.9%).

Our analysis revealed rocuronium as the most popular NMBA in adults (57.5% of adult GA's). Atracurium was more commonly selected in pediatric practice (25.9%). This latter finding concurs with the study by Sury et al. suggesting atracurium was used in 24.7% of all UK pediatric GA's. In our hospital, atracurium is included in many of our pediatric anesthesia protocols, particularly in the neonatal and infant subgroups. The recovery profile of atracurium at these ages makes it an attractive agent[6]. Rocuronium can result in much longer blocks in children under the age of 2 years and as yet, sugammadex has not been approved for this age-group[7].

NMBA's were administered to 1.3% of patients managed with an SAD. This figure is very low when compared to the 9% of cases reported from Ireland. Nevertheless, the reasons for using NMBA's with an SAD technique were not addressed by our study and demands further explanation.

During the study period, a hospital directive (14th August 2020) asked anesthesiologists to preferentially increase the use of atracurium. A pharmacy stock-pile accumulated during the first wave of the Covid-19 pandemic and needed to be liquidated. Therefore, the selection of NMBA's in the final 2 weeks of our study was biased in favor of atracurium. We do not believe, however, that this greatly influences the conclusions of our analysis.

Non-depolarising neuromuscular blockade was antagonized in 36.3% of our cases (n = 812). This figure is very low compared with previously published results. The studies by Sury et al.[3] and Marhino et al.[4] reported antagonism in 68% and 65% of neuromuscular blocks respectively. Therefore, the low rate observed in our study is alarming. All anesthesia work stations in our department are equipped with facilities for monitoring the neuromuscular junction. When surveyed, only 38% of UK anesthetists admitted to routinely using neuromuscular monitoring, which suggests that their higher rate of antagonism (mostly neostigmine with glycopyrrolate) occurs empirically. Our own results merit further investigation.

Interestingly, between 2013 and 2016, there appeared to be a four-fold increase in the use of sugammadex in the UK (1.5% to 5.9%)[4]. This contrasts with our own data which shows sugammadex is administered in 19.5% of neuromuscular blocks. The high rate of rocuronium use in our department may be the main explanation, although it may also relate to the manner in which neuromuscular blocks are managed. Deep blocks may be maintained until the end of some procedures, for example those conducted by laparoscopy.

Succinylcholine was very rarely used during the study period, accounting for only 16 NMBA exposures (0.7% of NMBA's and 0.4% of all GA's). Its use was 4-fold higher in pediatric practice than in adults (2.0% versus 0.5% respectively). The indications included upper gastro-intestinal endoscopies, tracheal tube exchanges (to neuromonitoring tubes) and rescue of difficult laryngoscopy/intubation when a non-depolarizing NMBA had been omitted. Much higher rates of use have been reported in the UK (5.3% - 13% of NMBA's)[4]. Notably, only 4 patients in our database received succinylcholine for RSII (2.1%), implying that it has been practically abandoned for this indication in our department. This is interesting because the highest rates of succinylcholine use have traditionally been described for RSII in different settings. In a multicentre, retrospective analysis of United States trauma patients, succinylcholine was used during 51.4% of RSII's performed in operating rooms compared with 67.3% in emergency departments[8]. Also, in 2017, a postal survey of obstetric anesthesiologists in England showed that 92% of respondents used succinylcholine during RSII for Caesarean section under GA[9]. Even if the

main benefits are the rapid onset of muscle relaxation with a short duration of action, a multitude of adverse effects, some of which are life-threatening, have made succinylcholine increasingly unpopular. The alternative rocuronium/sugammadex combination has gained increasing favor.

Our study addressed a number of airway management practices during RSII. Several national and international surveys have described anesthesiologists' hypothetical airway management strategies during RSII[9,10,11,12], but our data documents actual practice in our department without the availability of a standardized protocol. RSII was used in 5.0% of all GA's (n = 187). Just over half of these (54.5%) were performed during day-time working hours (8am - 6pm), principally for abdominal surgery. Preoxygenation was performed by face-mask (98.9%) and the most commonly used NMBA was rocuronium. Retrospective analysis showed the mean rocuronium dose was 1.0 ± 0.2 mg kg-1 actual body weight. This marks a change from traditional practice in which succinylcholine (1-2 mg kg-1) was considered the gold standard for RSII. A Cochrane Systematic Review found moderate evidence for overall superior intubating conditions with succinylcholine, but no differences when high dose rocuronium was used (≥ 0.9-1.0 mg kg-1)[13]. The onset of neuromuscular blockade is comparably rapid with succinylcholine (1-2 mg kg-1) as with rocuronium (0.6 – 1.2 mg kg-1)[14]. Antagonism of a rocuronium-induced block with sugammadex (16 mg kg-1) occurs more quickly than the spontaneous offset of succinylcholine (1 mg kg-1)[15,16].

RSII is controversial and currently there are no standardized, internationally accepted recommendations as to how it should be performed. Indeed, the term 'RSII' is not clearly defined and many anesthesiologists may adapt the technique according to clinical circumstances. In a survey of European anesthesia societies in 2014, only 3 of the 25 respondents had published their own national guidelines, with Germany providing a specific pediatric RSII protocol[17]. Most countries recommend guidelines from other societies. RSII is not specifically addressed, even in the most recent versions of the American[18] or Canadian[19,20] airway protocols, possibly because the weak evidence base for RSII prohibits sound recommendations. Perhaps the most comprehensive advice is described in the Scandinavian practice guidelines on general anesthesia for emergency situations[21]. In the absence of conclusive recommendations, practitioners follow departmental guidelines, or use their personal judgement according to previous experience. This has resulted in a wide variation in practice, as witnessed by numerous surveys.

Positioning for RSII

Our study shows that approximately half of RSII's (53.5%) were performed with the patient in the head-up (anti-Trendelenburg) position. The reasons for this were not explored. Head-up positioning was originally advocated to reduce the risk of pulmonary aspiration in the case of regurgitation, but it may also improve both the efficacy and efficiency of preoxygenation[22], as well as the grade of laryngoscopy[23,24]. A number of international surveys indicate a wide variation in practice, with the patient population being an important determinant factor. In Germany, anesthesiologists indicated that 84% of patients were managed with upper body elevation, with supine and Trendelenburg positioning being used in 13% and 3% of cases respectively[25]. In the UK, 76% of anesthetists routinely use 20-25° head-up positioning, although lower rates have been observed elsewhere. In the study by Zdravkovic et al, 44% of respondents used head-up positioning, but in the context of intestinal obstruction the figure was significantly higher (70%)[12]. In a further study by the European Society of Anesthesiology, head-up positioning was used in adults by 60.1% of anesthesiologists, whereas for children, the proportion was much lower (44.0%)[11].

Cricoid force

Following the original description by Brian Sellick in his landmark observational study in The Lancet in 1961[26], cricoid force, or Sellick's manoeuver was universally adopted as a standard of care during induction of anesthesia in patients at risk of regurgitation and bronchoaspiration. The scientific basis for its effectiveness, however, does not comply with evidence-based medicine and the technique has perhaps raised more controversy than any other aspect of RSII[27,28]. Some authors have proposed abandoning its use[29]. A Cochrane review on the effectiveness and risks of cricoid force concluded that, in the absence of randomized controlled trials, there was insufficient evidence to confirm its role in the safe conduct of RSII[30]. Some critics of cricoid force cite the lack of conclusive evidence supporting efficacy and safety, as there are reports of fatal bronchoaspiration occurring with its use[31]. It has also been shown to result in reflex relaxation of the lower esophageal sphincter in a force-dependent manner[32], as well as complicating airway management: worsened glottic visualization during laryngoscopy and increased time to intubation[33], reduced success in placing and ventilating via a supraglottic airway device[34] and reduced success of intubation via a larynx mask airway[35]. Notwithstanding these difficulties,

changes in practice are not reflected in national or international airway guidelines. Although the board of the German society of anesthesiology and intensive care medicine no longer recommends routine application of cricoid force, it continues to be used in the United States, possibly due to fear of litigation. The UK Difficult Airway Society (DAS) endorses its use, although they recommend that in case of difficult laryngoscopy and intubation, cricoid force should be released cautiously, with suction at the ready. A similar recommendation applies if a laryngeal mask is to be placed[36]. This advice is also provided by the Canadian Airway Focus Group. The Scandinavian guidelines emphasize the lack of scientific evidence allowing a recommendation and propose that anesthesiologists use the technique based on 'individual judgement'.

Our own data show that cricoid force is used only in 19.3% of cases (n = 36), but details regarding the time point at which it is applied (and by whom), as well as how the cricoid cartilage is identified are unavailable. Further investigation of our practice is merited. In Germany, two thirds of anesthetists surveyed in 2013 claimed to use cricoid force for the usual indications. Also, data from international studies indicate that cricoid force is not applied in 36% and 37.4% of cases, although many anesthesiologists reserve the technique for the management of high-risk situations such as bowel obstruction (71%). Routine use of cricoid force in pediatric practice also seems to be lower (23.5%).

Cricoid force was applied in one in five RSII's in our study, but this very low rate did not result in an excess of broncho-aspirations (one case in 3747 GA's). This finding should be interpreted with caution however, as our numbers are small. It is also impossible to tell from our data how the individual anesthesiologists view the risks and utility of cricoid force, and whether this is influenced by their number of years' experience.

Nasogastric tubes

Gastric drainage was applied in 13.4% of cases before anesthetic induction. A further 23.5% of patients had a gastric tube placed following intubation. In the original description of the technique, gastric drainage was a routine element of RSII. This is no longer the case and seems to be reserved for cases of intestinal obstruction. In the international survey by Zdravkovic et al, only 8% of respondents placed a nasogastric tube before routine RSII, although the figure was much greater in the context of bowel obstruction (59%)[12]. The DAS guidelines advise mechanical drainage in the case of severely delayed gastric emptying or intestinal obstruction[36].

Oxygenation and bag-mask ventilation

Preoxygenation in our patients occurred mostly by face-mask (98.9%). The use of high flow nasal oxygen (HFNO) was recorded in only 2 patients. Studies on the efficacy of HFNO for preoxygenation have yielded conflicting results, and its main benefit may lie in providing apnoeic oxygenation during laryngoscopy, especially if prolonged and difficult.

Manual ventilation of the lungs by bag and face-mask before intubation was performed in 6 patients. This does not form part of the traditional RSII technique, but was described by Sellick who applied cricoid force simultaneously. More recently, gentle bag-mask ventilation to airway pressures < 20 cm H2O has been advocated, to avoid arterial desaturation before intubation, or to check the patency of the airway. In obstetric GA's, where the efficiency of preoxygenation is limited by reduced functional residual capacity and increased oxygen consumption, manual ventilation of the lungs before laryngoscopy is allowed by the UK Obstetric Anaesthetists' Association – DAS guidelines37, as well as by the Canadian Airway Focus Group. In a literature review in 2007, Neilipovitz et al found no evidence to support the avoidance of bag-mask ventilation during the apnoea period of RSII38. Furthermore, maintaining airway pressures below 15-20 cm H2O, was not associated with an increased risk of gas entry into the stomach. In a 2015 survey of DAS members, only 25% of respondents claimed never to use bag-mask ventilation during RSII whereas 3% replied that they always used it[39]. The majority applied it according to clinical circumstances. In obstetric anesthesia, a rate of 49% gentle mask ventilation has been recorded. The ESA international survey showed that bag-mask ventilation was avoided by a significantly greater number of respondents during adult anesthesia (57.2%) as compared to pediatric practice (41.4%). However, it was unclear from these studies whether manual ventilation was used with or without cricoid force.

Laryngoscopy

Macintosh DL was used for 85.0% of our RSII's, and with a tube stylet in 49.2%. Our data collection did not distinguish between intubations using a tube stylet for the primary intubation attempt and those where it was used due to difficulty. In Germany, 86% of surveyed anesthesiologists claimed to routinely mount the tracheal tube on an intubation stylet[25]. Videolaryngoscopy with a hyperangulated blade was used in 15.0% of RSII's, a significantly higher number than in the general surgical population. The

explanation for this finding is unclear and cannot be determined from our data. Primary VL for RSII was used by 17% of English obstetric anesthesiologists for Caesarean section[9]. Also, in their most recent guidelines (2021), the Canadian Airway Focus Group recommends primary VL for intubating the parturient[19]. However, guidelines from the French Society of Anesthesia and Resuscitation explicitly state that they do not provide a recommendation on the use of VL for RSII. If a difficult intubation is not foreseen, they recommend VL only as a second line device, when the Cormack and Lehane grade is III or IV and facemask ventilation is possible[40].

Conclusions and scope for further research

Our database shows that our most commonly used NMBA is rocuronium. Atracurium is preferred in pediatric practice and succinylcholine is now rarely used. Sugammadex is the most commonly used NMBA antagonist, but a high proportion of non-depolarizing blocks are not antagonized. The way in which neuromuscular blockade is managed (deep versus intermediate blocks for example) along with the use of NMBA antagonists should be the subject of further investigation. Rocuronium rather than succinylcholine is preferred for RSII. Also, a wide variability in airway management was observed during RSII. A more detailed description of all aspects of RSII requires further study, recruiting greater numbers of patients. As with our data on airway management techniques, our findings may not be representative of other institutions. A national survey would therefore be of interest to anesthesiologists working in Belgium.

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