An observational study of airway management at a university hospital in Belgium, with reference to airway equipment and intubation

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Abstract

Background: **In recent years, an increasing range of equipment and techniques has become available for airway management.**
Objectives: **To define and compare current departmental airway management in adult (age ≥ 16 years) and Paediatric (age < 16 years) populations and to relate our findings to published international data.**
Design and setting: **A prospective observational study of airway management was conducted during a 3 month period in a single university hospital in Belgium.**
Methods: **Ethics committee approval was granted and informed consent was waived. Patients registered for anaesthesia care were screened. Details of airway management during maintenance general anaesthesia were recorded in an electronic database.**
Main outcome measures: **Data collection included: airway device (with size), intubation technique and use of adjunct techniques (e.g. high flow nasal oxygen).**
Results: **4038 patients were included (663 in the paediatric subgroup). General anaesthesia was used in 3747 procedures (660 in the paediatric subgroup). The airway devices used were: tracheal tube, 65.9%, (95%CI, 64.3%-67.4%, n = 2469), supraglottic airway device 28.0%, (95%CI, 26.6%-29.5%, n = 1050) and facemask 3.0%, (95%CI, 2.5%-3.6%, n = 113). The remainder were managed with a tracheostoma, jet ventilation catheter, rigid bronchoscope or high flow nasal oxygen (3.1%, 95%CI 2.5%-3.6%, n = 114). Macintosh laryngoscopy occurred in 89.4% (95%CI 88.1% – 90.6%, n = 2118) of patients. Videolaryngoscopy used mainly a hyperangulated blade (10.7% and 2.5% of adult and paediatric intubations respectively). Flexible bronchoscopy occurred in 25 patients: 21 intubations during general anaesthesia, of whom 4 patients were intubated via an i-gel. There were 4 awake intubations (0.2% of all intubations).**
Conclusions: **These data are of value for budgetary planning as well as in the elaboration of quality control, teaching and research protocols.**

Keywords: **Airway management, Intubation, Laryngoscopy, Laryngeal masks.**

Introduction

Maintaining a patent airway is a fundamental skill in anaesthetic practice and is necessary to ensure pulmonary oxygenation and ventilation. To achieve this end, an ever increasing variety of equipment has become commercially available. Selection of devices, however, is limited by financial constraints, specific departmental airway management protocols, surgical practices and the personal experience and preferences of individual anaesthesiologists. Challenging airways require specific, less commonly used equipment, but this is often costly and requires expertise if it is to be deployed safely and effectively.

Furthermore, recommendations for airway management are constantly evolving, as evidenced by the regular updates to national airway algorithms[1,2,3,4].

In our teaching hospital, a wide range of equipment is available for managing both routine and challenging airways, but it is unclear how

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 20/10/1013). Informed patient consent was not required by the ethics committee. Patients were included from 1st June 2020 until 31st August 2020.

often the various devices are used. In addition, we have no information on how often specific airway techniques are applied. We therefore conducted a cross-sectional observational study to define current departmental airway management in adult (age ≥ 16 years) and paediatric (age < 16 years) populations.

Our primary aim was to determine which airway devices are used during maintenance anaesthesia and, where appropriate, the intubation technique applied. We also aimed to compare our findings with internationally published data.

Methods

Our hospital ethics committee granted approval for this cross-sectional observational study on the 30th March 2020 (chairman: Professor Pieter Michielsen, protocol reference number EC UZA 20/10/113). Data are reported according to the STROBE guidelines for the presentation of observational studies. All patients undergoing surgical, diagnostic or interventional radiology procedures with an anaesthesia team were included in the study, which took place from the 1st June until 31 August 2020. Due to its non-interventional nature, the need for informed consent was waived. Patient anonymity was assured using unique operating department identifying numbers. A standard paper data sheet was completed by the anaesthesiologist (trainee or staff member) and used to collect information concerning demographics, the type of anaesthesia, the primary maintenance airway device, the intubation technique (if applied) and the use of accessory equipment, such as high flow nasal oxygen (HFNO). Daily listings of registered procedures were checked to ensure a paper form had been completed for each eligible patient. Each form was checked within 24-72 hours and queries resolved retrospectively as quickly as possible, either by reviewing the anaesthesia case record or contacting the anaesthesiologist involved. Queries directed at specific anaesthesiologists were handled confidentially. Data was entered into an electronic database (OpenClinica Community Edition, v 3.13, OpenClinica LLC, Waltham, MA, USA) and stored on a secure hospital server. Entries were double-checked manually.

Inclusion criteria

All elective and emergency cases requiring the presence of an anaesthesiology team for surgical, diagnostic or interventional radiology procedures were screened. This included patients treated outside the central operating department (maternity unit, fertility unit, gastro-intestinal endoscopy unit, radiology suite, NMR suite and the angiography and catheterisation laboratories.)

Exclusion criteria

Minor surgical procedures performed under topical or infiltration anaesthesia were excluded. Cases requiring monitored anaesthesia care, where no sedative technique or airway intervention was applied, were also excluded. Airway management techniques used in the intensive care units, emergency department and prehospital setting were outside the scope of this study and were not considered eligible. Patients whose airways had been secured elsewhere were only included when an anaesthetist was required to provide continued care (e.g. operating room, radiology suite).

Statistics

IBM® SPSS® (v 27, IBM, Armonk, NY, USA) was used for statistical analysis. Data are summarised as counts and percentages, and presented with frequency tables and bar charts where appropriate. 95% confidence intervals on proportions (Clopper-Pearson) were calculated using a one-sample binomial test ($\alpha = 0.05$). Comparisons between adult and paediatric subgroups were made on frequency-weighted summary data using the Pearson Chi-Square test of independence. Missing values were treated as 'missing completely at random'. Statistical significance was set at $p < 0.05$.

Results

During the study period (1st June 2020 – 31st August 2020), 5108 procedures were screened for inclusion. Following 1070 exclusions, 4038 procedures remained for analysis. This included 2 patients requiring monitored anaesthesia care during tracheostomy cannula exchange. 3747 procedures were conducted using general anaesthesia (GA) (92.8%, CI 91.9% - 93.5%) of which 3087 were in adults and 660 in paediatrics. The paediatric subgroup (n = 663) was categorized according to the recommended age groups for paediatric trials5: neonates (age < 28 days), infants (28 days < 2 years), children (2 < 10 years) and adolescents (10 < 16 years). Demographic data is summarized in Table I. The distribution of patients registered per clinical service is summarized in Table II. The youngest patient in the cohort was a 3 day old girl (prematurely born at 35 weeks gestation, weighing 2.2kg) whose airway was secured using a non-cuffed nasotracheal tube (3.5mm) and direct Miller blade laryngoscopy. The smallest patient, however, was a premature neonate operated on day 14 (post-menstrual age 25 weeks + 3 days) weighing 0.6kg, already receiving ventilatory support via a 2.0mm nasal tube. The most elderly patient was a 97 year old woman, managed with a supraglottic airway device (i-gel size 4) and

Table I. — Demographic data.

Characteristic	Pediatric group	Adult group
Gender (M/F) (n)	376/284	1484/1603
BMI (kg.m^{-2}, mean ± SD)		26.3 ± 5.4 *(20)
Weight range (kg)	0.6 - 96.0 *(1)	
Age (years)		16 - 97
Neonates (< 28days) (n)	11	
Infants (28days < 2years) (n)	167	
Children (2 < 10years) (n)	317	
Adolescents (10 < 16years) (n)	168	
*(n) Number of missing values		

Table II. — Distribution of general anesthesia cases registered per clinical service.

Clinical service	Pediatric group	Adult group
Abdominal, pediatric and plastic surgery	54 (8.2)	360 (11.7)
Anesthesiology	0	1 (0.03)
Cardiology	1 (0.2)	355 (11.5)
Ear, nose and throat surgery	124 (18.9)	226 (7.3)
Gastroenterology	1 (0.2)	243 (7.9)
Hematology	1 (0.2)	5 (0.2)
Hepatobiliary, endocrine and transplant surgery	7 (1.1)	233 (7.6)
Maxillofacial surgery and stomatology	73 (11.1)	103 (3.3)
Neurosurgery and neurology	65 (9.8)	164 (5.3)
Obstetrics and gynecology	3 (0.5)	374 (12.1)
Ophthalmology	21 (3.2)	137 (4.4)
Orthopedics	67 (10.2)	439 (14.2)
Pediatrics	165 (25.0)	7 (0.2)
Pneumonology	2 (0.3)	5 (0.2)
Thoracic and vascular surgery	15 (2.3)	225 (7.3)
Urology	61 (9.2)	209 (6.8)
Totals	660 (100)	3086 (100)*

n (%) Number of cases with the % per patient group; Pediatric group (< 16 years); Adult group (≥ 16 years); *1 missing value.

assisted ventilation. Overall, the most commonly used airway devices during maintenance anaesthesia were tracheal tubes (orotracheal, nasotracheal and double lumen tubes: n=2469, 65.9%, CI 64.3% - 67.4%). Supraglottic airway devices (SAD's) were used for 1050 procedures (28.0%, CI 26.6% - 29.5%) and facemask anaesthesia, with spontaneous or assisted manual ventilation, was applied in 113 cases (3.0%, CI 2.5%-3.6%). The remaining procedures were conducted using either HFNO or with other devices such as a tracheostomy cannula or tube, a jet ventilation catheter, a rigid bronchoscope or a Tritube (n = 114, 3.1%, 95% CI, 2.5%-3.6%). The use of airway devices in the paediatric and adult age groups is summarized in Table III.

Tracheal tubes

Conventional orotracheal tubes were most frequently used (cuffed and non-cuffed oral tubes, double lumen tubes, n=2304), with cuffed single-lumen tubes predominating (n=2151). Overall, the most commonly used tube size was 7.5mm (n=702, 36.0%). The most commonly used sizes were 7.5mm in women (n = 662, range 6.0mm - 9.0mm) and 8.5mm in men (n = 433, range 6.0mm – 9.0mm). In paediatric practice, single lumen orotracheal intubation was used in 259 cases (39.2%).

Nasotracheal tubes were used in 164 cases (4.4% of all GA's). All nasal tubes in adults were cuffed (n = 102, 3.3%). The most commonly used tube sizes were 6.0mm for women (n = 35, range 5.0mm – 6.5mm) and 6.5mm for men (n = 34, range 5.5mm – 7.5mm). 62 nasal tubes were placed in the paediatric group (9.4% of paediatric GA's).

93 double lumen tubes (DLT, 5 right-sided, 88 left-sided) were placed. Intubation was with Macintosh direct laryngoscopy (DL), (n= 89), but 4 instances of videolaryngoscopy (VL) were

Table III. — Distribution of the airway devices for pediatric and adult subgroups.

	Pediatrics		Adults		
Airway Device	n	% (95% CI)	n	% (95% CI)	Total (n)
Tracheal tube	327	49.5 (45.7-53.4)	2142	69.4 (67.8-71.0)	2469
SAD	241	36.5 (32.8-40.3)	809	26.2 (24.7-27.8)	1050
Facemask	85	12.9 (10.4-15.7)	28	0.9 (0.6-1.3)	113
Miscellaneous	7	1.1 (0.4-2.2)	107	3.5 (2.9-4.2)	114
Totals	660	100.0	3086	100.0	3746

$\chi 2$ (3, n = 3746) = 322, p < 0.001; 95% CI: 95% confidence interval; SAD: supraglottic airway device. Miscellaneous group: tracheostomy canula or tube, jet ventilation catheter, rigid bronchoscope, Tritube and high flow nasal oxygen.

recorded. In one case, an 8.0mm cuffed orotracheal tube (COTT) was placed first and then switched to a left-sided DLT (39F) over an exchange catheter (14F, 100cm soft-tipped exchange catheter, Cook Medical, Bloomington, IN, USA). Five left-sided DLT's were placed in adolescents (one 14-year old boy: 39F; four 15-year old boys: 35F x1, 37F x 2 and 39F x 1). One right-sided DLT was placed in a 14-year old boy (39F). Extubation was almost always performed at the end of surgery, but in 13 cases, the DLT was exchanged for a COTT in order to facilitate postoperative ventilatory support (cardiac surgery n=11, thoracic surgery n=2). In one cardiac surgery case, the DLT was exchanged per-operatively when the patient was repositioned due to bleeding complications and the need for urgent sternotomy. Seven bronchus blockers were placed via a COTT (9.0mm in five men, 8.0mm in 2 women). Six of these tubes were sited with MacIntosh DL. The seventh tube was placed using VL following rapid sequence induction of anaesthesia in an obese man with respiratory failure. Indications for bronchus blockers were: esophagectomy (n=4), robot-assisted cardiac surgery (n=1), thoracic aortic aneurysm repair (n=1) and thoracoscopy (n=1). Positioning of all DLT's and bronchus blockers was checked using a disposable videobronchoscope (Ambu aScope 4 Slim, outer diameter 3.8mm, Ambu b.v., Brussels, Belgium).

Intubation techniques

Intubation techniques are summarized in Table IV. In 104 procedures (2.8% of all GA's) tracheal intubation had already been performed before transfer of care to anaesthetists (adults: n = 94, all cuffed orotracheal tubes; paediatrics: uncuffed nasal tubes, n = 5, uncuffed oral tubes, n = 1, cuffed oral tubes n = 4). There were 4 awake intubations (0.2% of all intubations). In 233 cases, no neuromuscular blocking agent was administered (9.4% of all intubations during GA). DL with a Macintosh blade was the most common intubation method (n=2118, 89.4%, CI 88.1% – 90.6%). One further Macintosh intubation was performed using VL (C-MAC, Karl Storz, Tuttlingen, Germany). A tube stylet was used in 166 DL's (7.0% of all intubations) and a bougie in 12 patients (0.5%). Miller blade DL was recorded for 6 intubations in neonates weighing 3.7±1.6 kg (mean ± SD). VL with a hyperangulated blade (Glidescope, Verathon, Bothell, WA USA or C-MAC D-blade, Karl Storz) was used for 225 intubations (9.5%). Hyperangulated VL was used in 8 paediatric cases (2.5%) and 217 adult patients (10.7%). Combined VL with flexible bronchoscopy was never used. Flexible bronchoscopic intubation alone was recorded in 25 cases (1.1% of all intubations). Twenty-one of these procedures were performed during GA (84.0%) and the indications

Table IV. — Intubation techniques for the placement of conventional tracheal tubes during general anesthesia in the pediatric and adult subgroups.

Technique	Pediatrics	Adults	Total
DL (Macintosh)	293 (92.4)	1647 (80.2)	1940
DL (Macintosh) + stylet	7 (2.2)	159 (7.7)	166
DL (Macintosh) + bougie	1 (0.3)	11 (0.5)	12
DL(Miller)	6 (1.9)	0	6
VL (hyperangulated blade)	8 (2.5)	217 (10.6)	225
VL(Macintosh blade)	1 (0.3)	0	1
Flexible videobronchoscope	1 (0.3)	16 (0.8)	17
Flexible videobronchoscope via i-gel	0	4 (0.2)	4
Totals	317 (100)	2054 (100)	2371

n (%) DL: direct laryngoscopy; VL: videolaryngoscopy.

are listed in Table V. The intubation route was oral (n=12), nasal (n=5) and via an i-gel using an Aintree catheter (19F, Cook Medical) in a two-stage exchange procedure (n=4).

Following surgery, the majority of cases were extubated before leaving the operating room. A total of 263 patients remained intubated for transport to intensive care (18 paediatric cases, 245 adults). One patient with an external laryngeal trauma was transferred to the operating room for extubation.

Supraglottic airway devices (SAD's)

The airway was secured with an SAD in 1050 procedures. The i-gel was most commonly used (n = 846, 80.6% of SADs). Fifty-one i-gels were placed in adolescents. First generation larynx masks were used exclusively in the paediatric subgroup (n = 191, 18.2%). The LM Supreme® was placed for 13 ophthalmology cases (size 4, n = 6; size 5, n = 7). In 6 adults, a drainage tube (12F) was passed via the gastric side channel on a size 4 i-gel. An SAD was replaced with a tracheal tube in 16 patients. This occurred with 3 1st generation larynx masks, 1 LM Supreme® and 12 i-gels. Reasons for switching to a tracheal tube were: mal-positioning with gas leak, per-operative larynx spasm and desaturation, per-operative cardiopulmonary resuscitation, vomiting during emergence, gas embolism during a hysteroscopy and drainage of bile-stained fluid via a gastric tube. SAD's were used to rescue 2 difficult laryngoscopies (one i-gel and one LM Supreme®), both in patients with a Cormack-Lehane grade 4 DL. Most SAD's were removed at the end of the procedure but in 20 cases they were removed in the recovery room due to delayed awakening.

Jet ventilation

Jet ventilation was applied in 25 adults (0.7% of all GA's) using the Monsoon Universal Jet Ventilator (Acutronic Medical systems AG, Hirzel, Switzerland). No cases of jet ventilation were recorded in the paediatric subgroup. Subglottic jet ventilation via a catheter was provided for 11 laryngeal procedures. Supraglottic and transglottic jet ventilation were not used. Three rigid bronchoscopies with jet ventilation were described:

Table V. — Flexible bronchoscopic intubations.

Gender	Age	Anesthesia	Tube	Indication
M	57y	GA	OTT+	Failed VL. Tong tumour + previous radiotherapy
F	51y	GA	OTT+	Unstable cervical spine fracture (C3/4)
M	43y	GA	NTT+	Pan-facial trauma
F	66y	GA	OTT+	Failed Macintosh DL, (Cormack-Lehane score 4)
M	11 weeks	GA	NTT-	Pierre-Robin syndrome
F	16y	GA	NTT+	Previous difficult VL – congenital myopathy
M	63y	GA	OTT+	Failed Macintosh DL (Cormack-Lehane score 3)
M	75y	GA	OTT+	Teaching
M	74y	GA	OTT+	Teaching
F	36y	GA	OTT+	Teaching
M	76y	GA	OTT+	Teaching
M	33y	GA	OTT+	Teaching
F	39y	GA	OTT+	Teaching
M	71y	GA	OTT+	Dens fracture
F	63y	GA	OTT+	Previous tracheostomy – sublingual tumour
M	33y	GA	NTT+	Mandibular fracture
M	19y	GA	NTT+	Mandibular fracture
F	68y	GA via i-gel	OTT+	Unstable C6/7 fracture – corpectomy C7
F	23y	GA via i-gel	OTT+	Goldenhar syndrome – radial free flap
F	68y	GA via i-gel	OTT+	Unstable C6/7 fracture – posterior fusion C/T1
F	68y	GA via i-gel	OTT+	Revision of unstable C6/7 fracture
F	71y	Awake	OTT+	Larynx trauma + neck exploration
M	59y	Awake	NTT+	Retracheostomy + hemi-mandibulectomy
M	59y	Awake	OTT+	Laser tube for vallecular carcinoma
M	58y	Awake	OTT+	Failed VL intubation for sleeve gastrectomy

GA: general anesthesia DL: direct laryngoscopy VL: videolaryngoscopy; OTT+: cuffed orotracheal tube; NTT+: cuffed nasotracheal tube NTT-: uncuffed nasotracheal tube.

in one case to facilitate removal of a bronchial foreign body, in a second to remove a bronchial stent, and in a third to debulk a bronchial tumor. Eleven patients receiving microwave ablation of liver tumors were managed with a Wei JET endotracheal tube (a cuffed tracheal tube with combined jet ventilation channel along the posterior wall).

HFNO

HFNO was used in a total of 103 adult patients (3.3% of all adult GA's). In 70 patients it provided oxygenation during GA in the absence of other airway devices, either with spontaneous breathing or apnoea (THRIVE, trans-nasal humidified respiratory insufflation ventilatory exchange). Eleven patients received HFNO during sedation. HFNO was used to provide preoxygenation and apnoeic oxygenation during intubation in 36 cases, as summarized in Table VI. A number of these were considered to have risk factors for difficult intubation. The technique was used in 3 of the 4 awake intubations.

Tracheostomy

Thirty-five patients were managed with a tracheostomy, 28 of whom presented with a pre-existing tracheostoma in situ. Seven adults underwent per-operative surgical tracheostomy. This was performed in 3 patients at the beginning of reconstructive maxillofacial procedures and in 4 intensive care patients to aid weaning from mechanical ventilatory support. No tracheostomies were conducted in the paediatric population. In this age group 9 cases were managed with pre-existing tracheostomas: six infants and one child with congenital airway malformations, one 9-year old with spinal muscular atrophy and one 14 year-old with neurological injury secondary to Japanese encephalitis.

No cases of emergency tracheostomy or front of neck access for airway obstruction were recorded.

Table VI. — Use of high flow nasal oxygen for preoxygenation and apnoeic oxygenation before intubation during general anesthesia.

Intubation technique	n (%)
DL (Macintosh) with OTT	12 (33.3)
VL with OTT	5 (13.9)
Flexible bronchoscopy with OTT	6 (16.7)
DL (Macintosh) with NTT	5 (13.9)
VL with NTT	1 (2.8)
Flexible bronchoscopy with NTT	4 (11.1)
Rigid bronchoscope	3 (8.3)
Total	36 (100)

DL: direct laryngoscopy VL: videolaryngoscopy; OTT– orotracheal tube NTT – nasotracheal tube.

Tritube and flow-controlled ventilation

Two cases of flow-controlled ventilation with the Evone ventilator (Ventinova, Eindhoven, The Netherlands) were documented during vocal cord surgery. This was provided via the Tritube (Ventinova), one placed orally and a second via the nose.

Discussion

This study documents the first ever census of airway management practices in our department and to our knowledge represents the first such report for a Belgian hospital. It includes both elective and emergency cases managed by anaesthesia teams within the main operating department as well as outlying locations and reflects our contemporary practice. The principal finding was that during general anaesthesia, airway management is provided with a tracheal tube (oral, nasal or double lumen tube) in 65.9% of patients and with an SAD or face mask in 28.0% and 3.0% of cases respectively. Our results contrast with those from the United Kingdom 4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) published in 2011[5]. Of the estimated 2.9 million annual GA's provided within the UK National Health Service, approximately 56.2% were conducted using an SAD, 38.4% with a tracheal tube and 5.3% with a face mask. These data, in which tracheal intubation referred to management with single and double lumen tubes, tracheostomy, surgical bronchoscopy as well as trans-glottic and trans-tracheal jet ventilation catheters, were based on a prospective nationwide 2-week census conducted in September 2008. As no similar analysis has taken place in Belgium, we are unable to compare our data with Belgian national practices. There are, however, a number of reasons why our findings should differ from the NAP4 study.

Firstly, our data relate to a single tertiary referral center, in which the presenting pathology has undoubtedly influenced airway management strategies. In particular, we may see a greater number of difficult airways. Secondly, surgery tends to last longer in teaching hospitals and this may affect the choice of airway devices and techniques. The personal preferences of attending staff anaesthetists, as well as the need to teach airway management has also introduced bias. Furthermore, decision-making is determined by the availability of equipment, as well as technical skills.

Tracheal tubes

The observed range of orotracheal tube sizes was 6.0mm - 9.0mm for both women and men. The most frequently used sizes were 7.5mm and 8.5mm for women and men respectively. Large diameter tubes are associated with a greater risk of intubation trauma and a higher incidence of sore throat and hoarseness. Such complications arise more frequently in women. Smaller tubes can be used safely in anaesthetic practice and allow passage of bougies and stylets, commonly used suction devices and bronchoscopes[6]. Benefits are also derived from the reduced length, diameter and volume of the cuffs. Although they do not increase ventilator-induced lung injury or air trapping, they may not be a good choice in patients with a high secretion load. In the ICU, larger diameter tubes have advantages for patients requiring long-term ventilatory support, as they reduce the work of breathing during weaning[7]. In our study, 108 patients were managed with a size 9.0mm tracheal tube (105 men), of whom 76 received post-operative ventilation on the ICU (74 men, 2 women). A further 3 patients received a 9.0mm tube to facilitate placement of a bronchus blocker. This suggests that size 9.0mm tubes were selected for specific indications, although the reasons for using these tubes in a number of patients deserves further investigation. On the other hand, smaller diameter tubes were chosen mainly for ear, nose and throat (ENT) surgeries. This may have arisen because smaller tubes are indicated for laryngeal procedures, or may reflect heightened awareness of intubation-related laryngo-tracheal injury in this discipline. Currently, we have no data on our post-intubation airway complications and so cannot relate the distribution of tube sizes to airway morbidity.

Traditionally uncuffed tracheal tubes have been recommended for paediatric intubation up to the age of 8-10 years, allowing for gas leak at airway pressures of 20-25 cm H2O[8]. However, advances in technology and tube design, along with improved understanding of paediatric airway anatomy, have meant that even small children can now be intubated safely with high volume low pressure MicroCuff tubes. The recommended cuffed tube size is 0.5mm less than that of an age-related uncuffed tube[9]. In our paediatric practice, 77.2% of orotracheal tubes were cuffed. They were preferred for all sizes down to 3.5mm, which is the smallest size of cuffed tube we have available. In a survey of paediatric anaesthesiologists in the UK and The Netherlands, respondents indicated increased use of cuffed tracheal tubes with increasing age[10]. When surveyed, members of the Society of Paediatric Anaesthesia also responded similarly, with 85% of anaesthesiologists using cuffed tubes in children > 2 years most of the time [9]. Although our results would concur with this pattern, we remain conservative in the use of cuffed tubes in the neonatal age group.

Laryngoscopy

Difficult laryngoscopy and intubation were not specifically addressed in this study. The incidence depends on the definition[11] and has been variously reported as 0.5 - 10.1% in adults[11,12,13,14]. Failed intubation, which is a definite end-point occurs less frequently and has a quoted incidence of 0.1-0.2% in the elective general surgical population[11,15]. These figures relate to the pre-videolaryngoscopy era and more recent data points to a decrease in the incidence of both difficult and failed intubation. Current estimates for failed intubation are as low as 0.06%[16]. Two patients in our series can be considered as intubation failures. The first was an obese male (BMI 38.8kg.m-2) presenting for bariatric surgery in whom hyperangulated VL was unsuccessful. Manual bag-mask ventilation proved difficult, with peripheral arterial desaturation. Intubation attempts were abandoned and the patient awakened. The second was a patient presenting for combined thyroidectomy and parathyroidectomy in whom subglottic stenosis (Cotton-Meyer grade 2, 50-70% narrowing[17]) prevented the passage of a small diameter microlaryngeal tube. Intubation was aborted and the patient awakened. These cases indicate that our failed orotracheal intubation rate is 0.1%.

Six non-channelled videolaryngoscopes, with free-standing monitor screens and reusable hyperangulated blades are available in our department. They appear to be used selectively (10.7% and 2.5% of adult and Paediatric intubations respectively). The reasons for choosing, or avoiding VL, are unclear but the low rate of use implies the technique is reserved for specific indications. Experience with DL remains a fundamental skill taught to all of our trainees. In accordance with difficult airway algorithms, a hyperangulated blade may have been chosen to rescue a failed Macintosh DL. Alternatively, VL may have been selected electively when difficult intubation was anticipated or had been previously documented. Advantages of this technique, quoted in a Cochrane Library Systematic Review are: improved laryngeal view, reduced incidence of laryngeal trauma and hoarseness, and reduced incidence of failed intubation[18]. VL has also been proposed as a new standard of care[19], and in some centers has now replaced DL, with the aim of standardizing and optimizing institutional, team and personal practice[20]. However, the pros and cons of VL versus DL having been widely debated[21,22,23,24]. The French Society of Anaesthesia and Resuscitation proposes VL as a first-line tool for scheduled surgery if mask ventilation is possible and there are at least 2 associated predictors of difficult intubation[25]. A prospective observational study of intubation practices in Singapore revealed first-line management with a Macintosh laryngoscope in 37.2% of 1654 patients[26]. VL was used electively in 60.5% of patients. In a group of 3 Scottish hospitals, the McGrath MAC videolaryngoscope was used in only 7.4 - 32.5% of adult intubations, in spite of its ready availability[27]. The reasons for these low utilisation rates were fear of losing DL skills and lack of a perceived benefit in normal patients. Currently, there are no published data indicating the extent of VL use in Belgium. Furthermore, the availability of the many different VL devices in Belgian operating rooms, intensive care units and emergency departments is unknown.

VL failed in two of our patients, who demonstrated risk factors for difficult intubation (0.9% of videolaryngoscopies). In one case presenting with a sublingual tumor, intubation succeeded with a flexible bronchoscope. The second case, presenting for bariatric surgery, has already been described. Our low rate of failure compares favourably with published data. When the GlideScope and C-MAC D-blade were compared in a diverse multi-center patient population, with risk factors for difficult DL, the overall failure rate was 1.6% following multiple attempts[28].

The incidence of difficult Paediatric intubation was 1.4% in a retrospective analysis of 11219 Paediatric GA's, at a German university center[29]. In patients under 1 year of age, the incidence increased to 4.7%. The prospective multinational NECTARINE study, which examined difficult tracheal intubation in a cohort of neonates and infants to 60 weeks postmenstrual age, revealed a difficult intubation rate of 5.8%[30]. Our database included only 93 children under the age of 1 year, in whom there was 1 GlideScope intubation and 1 flexible bronchoscopic intubation (an 11 week old infant with Pierre-Robin syndrome). This would imply a difficult intubation rate of at least 2.2% in the under 1 year-olds. It is likely that this figure is an under representation, however, as our study did not collect information regarding the number of intubation attempts and reasons for choosing an intubation stylet or VL. Our database is comparatively small and under-reporting of difficulty may also have occurred. In our hospital, neonates are usually intubated by neonatal intensivists before transfer to the operating room. No case of failed intubation was reported in the Paediatric subgroup.

Data from the Paediatric Difficult Intubation Registry (PeDI-R) indicate that the success rate of GlideScope intubation is lower in children than in adults, but in the difficult airway, carries a greater chance of success, compared to DL[31]. On the other hand, a Cochrane Library Systematic Review observed low grade evidence for prolonged intubation time and increased intubation failure during VL in children[32]. A further review in neonates concluded that VL increased success rate at first-attempt and did not increase either time to intubation or number of attempts[33]. Our data show that hyperangulated VL was used 4 times less frequently in Paediatric practice than in adults, with no failed Paediatric VL's. A more recent analysis from the PeDI-R suggests that if VL is used to visualise the airway of infants < 5 kg, standard blades (Macintosh and Miller) result in significantly higher first-pass success rates when compared with non-standard blades[34]. In our series, the smallest patient intubated with the GlideScope was 20 weeks old and weighed 6.2kg.

Supraglottic airway devices

Supraglottic airway devices were used in a total of 1050 general anaesthetics, with i-gels predominating in adult cases. These second-generation devices outperform the classical first-generation larynx mask in terms of oropharyngeal seal pressure, separation of airway and gastrointestinal tracts with reduced risk of bronchoaspiration, and are associated with a lower incidence of airway trauma and sore throat[35]. A gastric channel not only allows venting of gastric fluid, but allows the passage of a gastric tube. Guidelines for the management of the unanticipated difficult airway recommend the placement of a second-generation device when primary intubation attempts fail[1,2,3,4]. Familiarity with a second-generation device is therefore of benefit if it is required during an airway crisis. For all of these reasons, as well as staff satisfaction, the i-gel has been our first choice in adults for a number of years. A further advantage is the ease of tracheal intubation through the i-gel[36]. Many techniques for intubation via an SAD conduit have been described, but this is most commonly performed using a flexible bronchoscope, either with a tube alone, where the SAD remains in situ, or as a two-stage exchange procedure using an Aintree catheter. These procedures are facilitated by the shape and shorter length of the i-gel as well as by the absence of internal aperture bars. We no longer use blind tracheal intubation via the intubating larynx mask airway.

In 12 cases, an i-gel was replaced with a tracheal tube, but difficulties with i-gel placement during Anaesthesia induction occurred in only 8 of these patients. This corresponds to a failure rate of 0.8% and compares very favourably with a Swiss prospective multi-center study reporting an overall failure rate of 4% in 2049 i-gel placements[37].

In pediatrics, we most commonly use the classic first-generation larynx mask due to familiarity with these devices in young patients. Other SADs have been tested, but to the dissatisfaction of many staff members. Interestingly, our practice concurs with a survey of Paediatric SAD use in the UK which revealed a preference for first generation devices in 88% of Paediatric anaesthesiologists.

Flexible bronchoscopy

Flexible bronchoscopy was used to intubate 25 patients. Six intubations were performed for teaching purposes. Although the ethics of such practice has been debated, live clinical teaching carries benefits over skills lab training and can be safely conducted in a controlled elective setting when difficulty with airway management is not anticipated. One 11 week-old infant with Pierre-Robin syndrome was intubated with a 3.5mm uncuffed nasal tube using a paediatric fibreoptic bronchoscope (2.6 mm, Olympus Corporation, Tokyo, Japan). All other bronchoscopic intubations were performed using single-use devices (3.8mm or 5mm, Ambu). Double lumen tubes and bronchus blocker placements were also checked with 3.8mm bronchoscopes, resulting in 124 disposable devices being used during the study period. This represents a considerable financial burden, but cost effectiveness as well as benefits in terms of cross-contamination and resource utilization have been reported for single-use bronchoscopes[39]. Other advantages are the immediate availability and absent repair costs, which previously in our department were unacceptably high.

Excluding the 6 teaching intubations, bronchoscopy was required in 15 patients during general anaesthesia (0.6% of all oral and nasal intubations) and in 4 awake patients (0.2%). The technique was used in 17 anticipated difficult airways and to rescue 2 failed Macintosh laryngoscopies.

In a Canadian 12-year retrospective analysis of 146252 GA's, awake endotracheal intubation was performed in 1.1% of cases[40]. Comparatively, our rate of awake intubation is much lower and concurs with the rate of 0.2% quoted from the NAP 4 study[41]. This year-long prospective study examining major airway complications in the UK, suggested that awake intubation is an underutilized technique. Higher rates of awake intubation are observed in high volume head and neck surgery referral centers (1.7%)[42]. In a prospective analysis of 600 awake intubations from London, the principle indications were reduced mouth opening (<3.5cm), previous airway surgery, head and neck radiotherapy and limited neck extension. In experienced hands, the technique has been shown to be safe, with a high success rate (98%)[40]. Limited data from a single center in the UK showed that the introduction of VL was associated with a reduction in the number of asleep bronchoscopic intubations, but had no effect on the number of awake procedures[43]. Our data shows that we perform approximately 4 times as many flexible bronchoscopic intubations under GA than awake. More recently, the use of HFNO and THRIVE has meant that some bronchoscopic intubations can be more safely managed during GA. HFNO is also recommended by the Difficult Airway Society guidelines on awake intubation[44] and was used in 3 of our 4 patients. It was avoided in a patient with laryngeal trauma, in order to prevent subcutaneous emphysema.

The larynx mask can be used as a conduit for guiding a flexible bronchoscope into the lower airway[45]. The Aintree catheter (56cm, 19F, Cook) was developed for this purpose. These plastic catheters can be snuggly loaded onto a slim bronchoscope leaving the flexible tip free. Continued ventilation via the SAD is possible whilst the catheter/bronchoscope assembly is threaded into the trachea. A 7.0mm tube, or greater, can then be introduced over the catheter, following removal of the bronchoscope and larynx mask. In a multi-center retrospective analysis of 1427 failed DL's in adults, 82 patients were managed with an SAD conduit for intubation. Success was reported in 78% of cases (blind intubation, n=43; bronchoscopic intubation, n=39)[46]. During our study, an Aintree catheter exchange procedure was electively performed on 4 occasions, all of them in adults. The selection criteria for the different bronchoscopic intubation techniques were not determined from our analysis.

Tracheostomy

Thirty-five patients were managed with a tracheostoma, but only 7 patients underwent per-operative surgical tracheostomy. Of these, 4 tracheostomies were performed to aid weaning from long-term ventilatory support. Percutaneous tracheostomies are performed in the intensive care unit, but we do not have data indicating the total numbers of cases or which techniques are used. The clinical indications include: managing upper airway obstruction, airway protection, bronchial toilet, weaning from ventilatory support, need for long-term ventilation and surgery in the face/neck region[47]. We did not examine how tracheostomies were managed during surgery (e.g. use of a tracheal cannula, placement of a reinforced tube in the tracheostoma or jet ventilation). Further study is required to provide a more detailed description of our current practice. In particular, the types of tracheostomy performed, along with their indications and complications, need to be determined for both adults and children. Such data is valuable for elaborating protocols addressing the routine management of tracheostomies and their complications.

Limitations and scope for further study

Data collection occurred between the first and second waves of the COVID-19 pandemic. During this time, only patients with a negative SARS CoV-2 PCR test were accepted for elective surgery. Even if this testing biased our study population, airway management at that time was unlikely to have been altered. The surgical activity in our hospital may also have been reduced during the summer period of data collection. Annual figures may not therefore be easily determined by factoring our data 4-fold. Data obtained from the operating department manager show that in comparison with the previous two years, operating activity during the study period in 2020 was representative of the summer months (total number of cases for June, July and August 2018: 5146, 2019: 5363, 2020: 5108).

This study did not focus on complications or difficulties with airway management, as a more detailed case report form would have increased the study complexity and reduced compliance with data collection. Future studies should address these concerns.

A larger database with a greater number of patients may have produced more meaningful results, especially for less frequently performed techniques. However, given our current resources, this study represented a considerable logistical undertaking. Extension of the data collection period would have been impractical.

Finally, our results rely greatly on the accuracy with which the per-operative questionnaires were completed by our colleagues. As with all such studies, the validity of data entry cannot be fully guaranteed.

In conclusion, this analysis provides insight into our current airway management practices. These data can be used for budgetary planning, as well as the elaboration of quality control, teaching and research protocols. Extrapolation of our results to other centers is not reasonable, although further national studies would be of interest to anaesthetists working in Belgium.

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