

POSSIBILITIES OF CREATING SAFER PATIENT CARE IN THE DOMESTIC AIRWAY MANAGEMENT PRACTICE

PhD thesis

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INTRODUCTION

Airway management can be an integral part of many therapeutic and diagnostic interventions. Ensuring airway patency, airway protection and oxygenation of the body is a routine procedure, but a difficult airway situation can pose a serious challenge to a trained clinician. Improper management of airway difficulties can lead to serious (respiratory and gastrointestinal injuries, surgical airway, cerebral hypoxia) and rarely fatal (brain death, cardiovascular and respiratory arrest) complications. Although the incidence of serious complications is relatively low, we still face significant problems due to the high number of interventions. Creating the conditions for quality patient care is a fundamental and ongoing task. However, despite these aspirations, the gap between opportunities and expectations is still wide. As a practising clinician, experiencing some difficult airway situations, and the consequences of their sometimes inadequate solutions, have prompted me to begin to deal with the subject in more depth. At that time, I was confronted with the fact that the personal, material and most importantly educational and organizational conditions were not optimal for a beginner or experienced anaesthetists to always work properly.

In this dissertation, I summarized the methods I wanted to contribute to creating a safer and better quality patient care environment in the domestic airway management practice.

OBJECTIVES

In order to achieve the conditions of safer and better quality patient care in the domestic airway practice, I set the following goals.

1. Getting to know the current situation (domestic circumstances).
2. Understanding of colleagues' expectations and suggestions about educational methods and opportunities.
3. Further development of training methods.
4. Reducing early complications of airway management through a Quality Improvement Initiative.

METHODS

The following methods were used to achieve my goals.

1. Survey of the current situation of airway management in Hungary.

In May 2009, I made a telephone call to domestic publicly funded hospitals where airway management is a daily practice in operating theatres and intensive care units. The questionnaires were sent electronically to a total of 100 institutions. Introductory questions focused on hospital/ward activity data, the frequency of airway management problems, complications, surgical and intensive care equipment, and physician proficiency in airway management. Further questions included the number of airway management, the rate of endotracheal intubations, and the frequency of difficult airway. We asked about the type and frequency of documentation of airway difficulties and the usual local procedure for informing patients about this. This was followed by a detailed list of the tools, the names of the tools available, and whether the workers had experience with the tool and method. Specific questions were related to the equipment available in the Intensive Care Unit and the availability of people with expertise in airway management. We asked whether the hospital had a fatal airway complication within one or 5 years. The last few questions concerned about training, participation in courses, knowledge of international recommendations, and the existence of local protocols related to airway management. Due to the nature of the questionnaire survey, descriptive statistical analysis was limited to percentages, medians, and quartiles.

2. Questionnaire survey on opportunities and requirements for training in the management of difficult airway among Hungarian anaesthetists

The online survey included a total of 19 closed-ended and open-ended questions that could be answered freely or via predefined options, by single choice or multiple markings. Questions related, among other things, to the type, cost, duration, structure and content of the forms of training. I asked about the shortcomings and expectations of teaching technical and non - technical skills. I have also sought to obtain opinions on vocational training and further training. In order to move forward, I waited for suggestions through the identification of the most important topics and the formulation of long-term goals. The link to the form was emailed to the target audience in the fall of 2017. Incoming answers were entered anonymously. After a 2-month data collection period, the data were summarized and evaluated. Due to the nature of the

questionnaire survey, the percentages were specified in the descriptive statistical analysis.

3. Examination of the suitability of preserved human cadaver during face mask ventilation, direct laryngoscopy and endotracheal intubation

A group-based, observational, two-arm, randomized, prospective, controlled study was conducted. We investigated the success rate of facemask ventilation and tracheal intubation in clusters comprising eight PATEM cadavers (study sample) and eight manikins (control sample).

The study was conducted in the dissecting room of the Department of Human Morphology and Developmental Biology of Semmelweis University, Budapest, Hungary (simulation in cadavers), in the Department of Anaesthesia and Intensive Therapy of Medical University, Debrecen, Hungary (simulation in manikins) and in the Department of Nursing at the Faculty of Health Sciences, Semmelweis University, Budapest, Hungary (simulation in manikins) between March and July 2015. 80 attempts for facemask ventilations and 80 trials for tracheal intubations were carried out in each sample. Characteristics of the cadavers relative to airway management were evaluated in advance of the trial. Six commercially available manikins provided with eight airway situations. Two body-part manikins and four full-body manikins were used (two of them with and without teeth). Twenty (10-10) anaesthetists performed a total of 320 (160-160) interventions. An anaesthetist who did not participate as an operator, assisted the operators and a different one collected and recorded the results on a pre-prepared worksheet. The mask ventilation was assessed after two min. It was labelled as 'easy' if it was successful at the first attempt and there was no need for any help to obtain perceptible chest movements, the bag pressure did not increase, no augmentation of gas flow was required because of an unsealed mask, and the ventilation was maintained for two min without difficulty. If any other situation occurred, the mask ventilation was considered 'not easy', and the reasons why it was not easy were specified and analysed in the subgroups. Our definition of 'not easy' facemask ventilation included: (1) subject ventilated by mask with oral airway (2) significant gas leak and/or permanent resistance to insufflations and/or if two-handed technique was required to hold the mask, and (3) if there were no perceptible chest movements for two min. Tracheal intubation was carried out immediately after mask ventilation. The larynx was exposed using a Macintosh laryngoscope. Cormack-Lehane grades 1 and 2 were considered as 'easy' while grades 3 and 4 represented 'not easy' laryngoscopy. The criteria for 'not easy' intubation were (1) Cormack-Lehane grades 3 and 4 laryngeal views, (2) the need for

'bougie' or intubation stylet, (3) more than two intubation attempts or (4) more than 90 s required to intubation. Tube insertion more than three min was deemed failed tracheal intubation. Chest movements and respiratory sounds were checked by a separate anaesthetist who confirmed the adequate placement of the tube. The operators were asked to evaluate the procedures using a verbal rating score from 1 to 10, based on several aspects. Binary type outcome measures were defined in advance of the trial.

The primary endpoint was the ease of facemask ventilation (easy/not easy).

The secondary (composite) endpoint was laryngoscopy and tracheal intubation (easy/not easy).

Exploratory endpoints (subgroups) were:

Facemask ventilation:

- a) Oral airway needed (neither easy, nor difficult)
- b) Difficult ventilation (gas leak, increased resistance, two-handed technique)
- c) Impossible ventilation

Laryngoscopy/intubation:

- d) Use of a 'bougie'/stylet (neither easy, nor difficult)
- e) Insertion of the tube >90 s or >2 attempts (difficult)
- f) Failed intubation

Statistics

Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated to compare primary and secondary outcome variables between cadavers and controls. Relative risks (RR), 95% CI and the number needed to treat (NNT) were calculated for comparisons in the subgroups. Verbal rating scores were compared using the non-parametric Mann-Whitney U-test. $P < 0.05$ was considered significant.

4. The impact of a checklist on the short-term complications of airway management in adults

Before and after the quality improvement initiative I performed an observational, prospective, controlled, one-centred examination. I prepared a data collection form and a checklist. In the operating rooms, in the intensive care unit and in the emergency department, all airway interventions were provided for one month without the checklist and then for one month with the checklist.

We did not change the workflows or protocols. The outcome of airway management manoeuvres and the incidence of related complications were evaluated for the period before and after the introduction of the checklist. The study was conducted from April 1, 2018, to May 31, 2018, at the Péterfy KH-RI - National Institute of Traumatology. We also completed a data collection form for each airway management. Patients with the datasheet were followed up the next day (≤ 24 hours).

The early complications related to airway management we studied were: pulmonary aspiration, post-induction hypotension and/or desaturation, circulatory arrest, soft tissue injuries, hoarseness, stridor, difficulty in swallowing / sore throat. Values within 5 minutes after induction of anaesthesia were considered as the most important parameters in the examined parameters. The endpoints have been tabulated for ease of reference (Table 1).

Table 1 List of endpoints AM = face mask; ETI = endotracheal intubation;
LM = laryngeal mask

I. Primary endpoint:
Number of unexpected difficult airway
II. A. Secondary endpoints:
Expected difficult airway and verified
Total number of difficult airway cases
Unexpected difficult airway cases / total number of difficult airway cases
Pulmonary aspiration, cardiac arrest
Other serious complications requiring further treatment
Death
Facemask ventilation: difficult, failed
LM anaesthesia: difficult, failed (switch to endotracheal intubation)
ETI: difficult, failed
ETI: unexpectedly difficult
Unexpectedly difficult ETI/ total number of difficult ETI
ETI: successful at first
ETI: successful (2 / 3 / több, mint 3 kísérlet)
Tooth loss/injury, soft tissue injury/bleeding
II. B. Secondary endpoints (cases are excluded)
Post-induction desaturation, hypotension
III: Additional endpoints (follow-up, cases are excluded)
Hoarseness, stridor, difficulty in swallowing / sore throat

Statistical analysis

Parameters (mean \pm SD) were given to describe the continuous and normal distribution variables. An independent two-sample t-test was used for comparison, and a Pearson chi-square test was used for gender comparison. For categorical variables, absolute and relative frequencies were given. The z-test was used to compare the pre- and post-checklist ratios. For subgroup analysis, relative risk (RR) was calculated for risk measurement supplemented with the chi-square test and the Fischer exact test, and a 95% confidence interval (CI) was calculated. $P < 0.05$ was considered statistically significant.

RESULTS

1. Survey of the current situation of airway management in Hungary.

Until the survey was completed (December 31, 2009), data were available from 43 institutions (53 departments) of 26 settlements. Depending on the question, data analysis was done by departments or by respondents' practice and qualifications (Table 2-4). The total number of anaesthesia workstations represented in the responses was between 320-380. In most cases, the route of airway management was endotracheal intubation: 50-75% according to 25 respondents, 76-90% in 13 institutions, and in 10 cases - including 3 cardiac surgeries - almost exclusively with endotracheal tubes. The incidence of intubation difficulties was reported by 45% of respondents as below 1%, and in 23 cases (43%, including head and neck surgery, otolaryngology) between 1% and 5%. The observed intubation difficulty was always reported by 45% of respondents and 8% not always reported in the anaesthetic record. Only 15% also provided specific written documentation to the patient and only 43% reported the problem regularly in the final report. Before the operation, 81% of the doctors informed the patients about the expected difficult airway. 27% (13) of the respondents had no difficult airway equipment at all, 49% (24) had equipment, but not in all operating rooms and only 16% kept assembled equipment in each operating room. (Table 2)

Table 2 Survey anesthetic data ETI = endotracheal intubation; FOBI = fiberoptic bronchoscopic intubation; LM / T = Laryngeal mask / tube; OR = operating room; ILMA = Intubating LM airway

ANAESTHESIA							
Institutional operating beds, department, n	<70 17		71-200 19		201-500 13		> 500 3
Number of anesthesiologists, department, n	<5 10	5-10 22	11-20 13	21-30 4	31-40 2	41-50 0	>50 2
Total number of anesthesiologists, n	522-600						
Number of participants in education <2 years, n	131						
Number of participants in education <6 years, n	161						
Number of airway management (ETI, LM) per month, departm, n	<30 1	31-60 7	61-120 10	121-200 8	201-500 17	> 500 10	
Endotracheal intubation rate (%), department, n	90-100 10		75-90 13	50-75 25	<50 5		
Frequency of airway difficulty (%) department, n	extremely rare 5		<1 24	1-5 23	5-10 1	>10 0	
Documentation of airway difficulty in record, respondent, n	always 24		not always 19		usually not 6		
Documenting airway difficulty for patients, respondent, n	always 8		not always 22		usually not 18		
Documenting airway difficulty in the final report, respondent, n	always 23		not always 12		usually not 14		
Informing patients about the anticipated difficulty, respondent, n	always 43		not always 6		usually not 1		
Difficult airway equipment in OR n (%)	yes, in every operating room 8 (16)		yes, but not in every operating room 24 (49)		yes, but only in the op. block 4 (8)		no 13 (27)
Respondent practice with the following techniques, n	FOBI 39	ILMA 20	retrograde intubation 4	LT 7	cricothyrotomy 22		

Based on the details of the devices, it can be concluded that among the supraglottic devices the laryngeal mask (LM) was available and used everywhere. 25% of the respondents (14 departments) had an intubation LMA and the situation was similar with the laryngeal tubes (LT, LTS available in 10 locations), but in 12 institutions the doctors had no experience with the latter two. Laryngoscope with a bent blade was present in all institutions, but in many cases, the straight blade was missing. Video laryngoscopes were only available in a few hospitals, and because of conceptual confusion, their numbers could not be accurately identified. Rigid fibre-optic device (video-styler) was found in 3 respondent units. Flexible fiberscopes were present in 77% of the departments but were not available when needed and only 35% of the respondents had experience with them. In all hospitals, the rigid tube introducer was standard equipment, but the flexible bougie, although available in many places (70%), was relatively infrequently used in case of difficulties. The kit for puncture of the ligament cricothyroideum was in 26 hospitals (50%) and only 13 of them thought they could

use it if needed, and doctors in 6 institutions did not even attend any training. The handheld jet device was only available in 8 locations (15%), of which 2 respondents were not comfortable using it (Table 3).

Table 3 Data on difficult airway tools and practical skills of respondents.

Difficult airway equipment	do you have?	exercise?
Supraglottic devices		
Nasopharyngeal (Wendl) tube (more sizes)	43	35
Laryngeal mask – classic (more sizes)	50	39
Proseal v. Supreme mask	18	9
Intubating LMA (ILMA/Fastrack)	14	10
Other, special LM	6	5
Combitube, Laryngeal Tube (LT)	10	7
Laryngoscopes		
Conventional curved blade (more sizes)	53	45
With straight blade	26	18
Special laryngoscope (eg with flexible blade or optical prism, etc.)	32	27
Bullard laryngoscope	2	2
Laryngoscope with fibre optic imaging (e.g. McGrath, Glidescope, etc.)	7	2
Stylets, tube introducers		
Rigid stylet	44	38
Flexible, soft plastic coated introducer	53	47
Flexible introducer (Bougie, Eschmann, Cook etc.)	38	31
Magill forceps	51	46
Intubation hook or loop	8	4
Trachlight,	3	2
Fibre optic "tube introducers"		
Rigid device (eg Bonfils, etc.)	3	2
Flexible tracheoscope / laryngoscope	4	2
Fiberoptic bronchoscope	41	19
Other (e.g. Sensascope)	2	0
Tools of invasive airway and ventilation		
Cricothyrotomy set	26	13
Handheld jet ventilation	8	6
Other: e.g. needle catheter	4	4

In 40% of the hospitals (21), the on-call anaesthetist was also responsible for the intensive care unit. On-call physicians are not always experienced in resolving difficult airway situations: 10 responding on-call physicians indicated that they were not sufficiently experienced in dealing with these situations. In 21% of the intensive care units (11), there was only a tube set and a laryngoscope, and there was no special airway device. According to 60% of respondents, the primary cause of tracheostomy was predicted to be prolonged mechanical ventilation, with 38% reporting that it was only

performed in patients who had been ventilated for at least 10 days. The method of making the tracheostomy was more than 46% percutaneous, 28% predominantly surgical, and 22% of hospitals had surgical tracheostomy alone. 63% of the hospitals that returned the questionnaire had no fatal respiratory problems, but 18 did: 2 cases within one year and 18 cases within 5 years. 25% of the doctors represented in the questionnaires have attended a course or training on airway management in the last 6 years. 25% of the departments had a local difficult airway protocol / algorithm and only 18% of the responding units had regular local theoretical and practical training on airway management. Of the 18 hospitals reporting fatal complications, only 4 had regular refresher training on airway management (Table 4).

Table 4. Survey data on intensive care units and more.

INTENSIVE CARE UNIT			
Own on-call doctor, department, n	there is: 27	no: 21	
Own airway equipment, department, n	laryngoscope and tube: 11	there are several tools, including LM: 17	full equipment: 17
24-hour colleague practised in the difficult airway, n	always 34	usually, there is 13	not always 3
OTHER			
Number of cases with fatal outcome, institution, n	no: 27	<1 year: 2	<5 years: 18
Own difficult airway algorithm / protocol, department, n	igen: 13		nem: 37
Own difficult airway training, department, n	regularly: 10	occur: 21	no: 18

2. Questionnaire survey on opportunities and requirements for training in the management of difficult airway among Hungarian anaesthetists

Among the training forms, the priority was the difficult airway course (2 days, even paid), allowing for simulation exercises in crisis situations. The most important parts of the courses are simulation training and the teaching of indirect devices (flexible bronchoscopy, video laryngoscopy). Most people feel incompetent about retrograde intubation. Most of the respondents lack the non-technical skills of leading the team, self-confidence and composure. There is also a need to include current issues of video-laryngoscopy management in the course of advanced and core training.

In order to learn how to properly manage difficult airway situations, each form of education was ranked in the following way (Table 5).

Table 5 Educational forms for solving difficult airway situations.

Difficult Airway Course, Workshop (manikins)	71,9 %
Organized practice on patients as part of vocational training, purposefully	56,3 %
Difficult Airway Course, Workshop (cadavers)	50 %
A full-day educational program by the section at the MAITT annual congress	29,7 %
Practising in your own workplace is enough	14,1 %
Annually / every two years, an independent, domestic difficult airway congress	9,4 %
Other free answers:	
MAITT congresses: only lectures, practice in a separate course	1,6 %
As part of specialist medical training, workshop and simulation training	1,6 %

The majority of respondents agree with the suggestion that the successful completion of a compulsory airway training course is a prerequisite for the final examination. 59.4% would definitely agree to this, and 34.4% would consider introducing it. 81.3% of respondents consider it necessary to include items covering the most important aspects of airway management in the specialist exam. A significant proportion of participants (79.7%) would consider a 2-day course to be optimal. There is a clear need (95.3%) for colleagues to be able to practice unexpected and crisis situations during simulation training. 43.8% believe that it is not enough to practice on phantoms, 39.1% only accept this form of training if there is no better option. Only 12.5% are satisfied with the method. Although it is rare at an international level to provide the opportunity to practice on cadavers as well, according to our survey there would clearly be a need for it in Hungary as well (73.4% certainly, 10.9% would consider it), but every 10th respondent would avoid such a situation. However, the course participants themselves would even be subject to airway manoeuvres (awake intubation). 31.3% would take this opportunity and another 25% would be interested in such a course. I was also expecting an answer from colleagues on how to structure the "ideal" airway course in order of importance (Table 6).

Table 6. Expected elements of the difficult airway course.

Simulation training (practising unexpected, expected, crisis situations)	87,5 %
Lessons from training	76,6 %
Workshop/practice	75 %
Practical exam: solving specific situations	59,4 %
Discuss special cases	54,7 %
Only theory/lectures dealing with substantive issues	46,9 %
Detailed, comprehensive theoretical training/lectures	40,6 %
Written exam-test questions	15,6 %
Other freely written notes: Pre- printed / e-learning lectures	1,6%

The workshops are expected to teach the following technical skills, in order of importance (Table 7).

Table 7. List of key perceived technical skills.

Fiberoptic Intubation (FI)	92,2 %
Video Laryngoscopy (VL)	67,2 %
Using an Intubation Laryngeal Mask (ILMA)	54,7 %
Application of Bronchial Blockers (BB), Double Lumen (DLT) Tubes	53,1 %
Invasive airway, surgical	51,6 %
Handheld jet ventilation	51,6 %
Ultrasound examination of the airway	50 %
Using High flow O ₂	48,4 %
Special respiratory catheters (for tube replacement, with fiberscope and LMA)	46,9 %
Invasive airway with a catheter, cannula	45,3 %
2nd generation LMAs	35,9 %
Optical stylets (OS)	31,3 %
Laryngeal tubes (LT)	23,4 %

No less important was the question of which practical skills colleagues felt most lacking (Table 8).

Table 8. List of technical skills in relation to lack of competence.

Retrograde intubation	65,6 %
Fiberoptic intubation	60,9 %
Handheld jet ventilation	57,8 %
Invasive airway, surgical	54,7 %
Awake intubation	51,6 %
Invasive airway, catheter/cannula	39,1 %
Video laryngoscopy	37,5 %
Double lumen tubes	31,3 %
Percutaneous dilated tracheostomy (PDT)	21,9 %
Using ILMA	20,3 %
Other freely written notes: Difficult airway situations, LMA	1,6 %

Although first-ranked retrograde intubation is a very rare intervention, most people (65.6%) experience a lack of competence in this practical skill. Many (60.9%) also feel uncertain during flexible bronchoscopic intubation. Handheld jet ventilation also achieved a high percentage. Thorough knowledge and acquisition of non-technical skills is now a basic requirement. Respondents feel the following abilities are lacking (Table 9):

Table 9. Non-technical skills in relation to lack of competence.

Team Leadership	29,7 %
Confidence	28,1 %
Calmness	26,6 %
Communication	26,6 5
Situation awareness	21,9 %
Decision-making ability	20,3 %
Problem-solving skills	20,3 %
Other free answers:	1,6-6,3%
- Managing a troubled team member	
- It depends on fatigue to fulfil them ... you need continuous education!	
- Rather, the tools and the technique practised are lacking	

For a sustainable level of knowledge, 56.3% of respondents clearly expect and 37.5% would find it useful to have at least one 20-40 minute lecture on current issues in airway management at all universities. 92.2% of respondents would attend a foreign airway management congress. If the European Airway Management Society (EAMS) were to hold its due congress in Hungary, 35.9% would definitely come by, 59.4% would consider attending.

3. Examination of the suitability of preserved human cadaver during face mask ventilation, direct laryngoscopy and endotracheal intubation

Primary outcome

The success rate at first attempt at facemask ventilation was 74% (59/80 cases) on cadavers and 41% (33/80 attempts) on manikins (OR: 0.25, 95% CI: 0.12–0.48, $P < 0.0001$). ‘Not easy’ mask ventilation occurred in 21 attempts on cadavers and in 47 manikin trials which were analysed in subgroups (Table 10).

Table 10 End points of the study. n = number of events; N / A = not applicable, OR = odds ratio; RR = relative risk; NS = not statistically significant; OP = oropharyngeal. *

A total of 17 cases occurred. P <0.05: statistically significant difference between cadavers and manikins.

Outcome	Cadaver cases n (%)		Manikin cases n (%)		Statistics
	Not easy	Easy	Not easy	Easy	
80 attempts/group					
Facemask ventilation	21(26)	59(74)	47(59)	33(41)	OR:0,25 P<0,0001
Laryngoscopy	14(17,5)	66(82,5)	1(1,25)	79(98,7)	OR:16,75 P=0,007
Intubation	16(20)	64(80)	17(21,3)	63(78,7)	OR:0,92 P=0,84
Not easy subgroups					
Ventilation with oroph.a.	20	N/A	4	N/A	RR:0,06 P=0,004
Gas leak	0	N/A	36*	N/A	RR:0,014 P=0,002
2-handed mask ventil.	1	N/A	24*	N/A	RR:0,04 P=0,0016
Impossible mask vent.	0	N/A	1	N/A	
Intubation: „bougie”	8	N/A	13	N/A	NS
Intubation: „stylet”	6	N/A	4	N/A	NS
Intubation: >2 trials	6	N/A	8	N/A	NS
Intubation: failed	1	N/A	2	N/A	NS

Secondary outcome

The incidence of ‘not easy’ laryngoscopy (Cormack-Lehane grade 3) was 17.5% (14/80 attempts) in cadavers significantly higher than in manikins (1.25%; 1/80 cases) (OR: 16.75, 95% CI: 2.14–131, P=0.007). Cormack-Lehane grade 4 did not occur in either sample. ‘Not easy’ tracheal intubation occurred in 16/80 attempts on cadavers (20%) vs. 17/80 trials on manikins (21.25%) (OR: 0.92, 95% CI: 0.43–1.99, P=0.84) (Table 10) closely associated with the poor laryngoscopic view in cadavers, but not in manikins.

Exploratory outcomes (subgroups)

Insertion of oral airway occurred 21 times in both groups and facilitated ventilation by facemask in 20 attempts on cadavers vs four on manikins (RR: 0.06, 95% CI: 0.01–0.40, P=0.004, NNT: 1.3). Subgroup analysis revealed no gas leak during mask ventilation in cadavers whereas its incidence was 45% (36/80 attempts) in manikins (RR: 0.014; 95% CI: 0.0009–0.22, P=0.002, NNT: 2.25). Furthermore, 30% of manikin trials (24/80 attempts) required two-handed technique for ventilation by mask vs one

cadaver attempt (1.25%) (RR: 0.04; 95% CI: 0.006–0.30; P=0.0016, NNT: 3.5). Impossible facemask ventilation did not occur in cadavers and happened once in manikins (Table 10). The ‘bougie’ and intubation stylet was used eight and six times respectively to facilitate tracheal intubation in cadavers with Cormack-Lehane 3 views. The use of ‘bougie’ occurred 13 times in manikins irrespectively of the grade of laryngoscopy. Two intubation attempts failed in manikins (oesophageal insertions) and one in a cadaver (failed insertion) (Table 10). The median time to intubation was similar in both groups: 30 s (15–190 s) (minimum and maximum) in cadavers and 32 s (15–170 s) in manikins. ‘Not easy’ intubation was associated with ‘not easy’ mask ventilation in six attempts on cadavers and in 13 trials on manikins (not significant [NS]). Mean verbal rating scores (1–10) of mask ventilation were significantly higher for cadavers (9.0, 95% CI: 8.8–9.2) than for manikins (4.2, 95% CI: 3.8–4.5, P<0.0001). Likewise, the mean verbal rating scores of tracheal intubation related to cadavers were higher (8.02, 95% CI: 7.75–8.29) than those related to manikins (5.97, 95% CI: 5.6–6.35) (P=0.0001).

4. The impact of a checklist on the short-term complications of airway management in adults

There were 570 interventions prior to the introduction of the checklist and 619 interventions in the possession of the checklist. In the first month, 502 data sheets were collected, which means that the filling rate (502/570) was 88%. 491 datasheets were rated. After excluding those under the age of 12 (52), 439 datasheets were included to analyze the primary endpoint. In the second month, 500 data sheets were issued, so the willingness to fill (500/619) reached 80%. 484 cases were evaluated, of which 423 were analyzed after excluding those under the age of 12 (61). There was no difference between the two months in terms of patient age (p = 0.4829) and gender (p = 0.5571).

There was no difference (7.28% to 6.14%) in **the primary endpoint** (unexpected difficult airway) between the two months.

The interventions and complications analyzed as part of the **secondary endpoints** (Table 11) also showed no significant difference.

Table 11 Secondary endpoint analysis before and after exclusion. n = number of processed, evaluated data sheets; na = not available; DA = difficult airway; NS = not significant, ETI = endotracheal intubation; LM = Larygeal mask;

Airway Maneuvers, Complications:	Frequency of complications in proportion to all evaluable datasheets, before the checklist n=439 (%)	Frequency of complications in proportion to all evaluable datasheets, in possess. of the checklist n=423 (%)	RD% (95% CI), p
II. Secondary endpoints			
Total number of DA	45(32+13) /10,25%	34 (26+8) /8,03%	2,22 (-1,67-6,1), 0,2589
Unexpected DA/ Total number of DA	32/45= (71,11%)	26/34= (76,47%)	5,36 (-14,5-23,6), 0,5957
Pulmonary aspiration	2 (0,45%)	0 (0%)	na
Cardiac arrest	0 (0%)	1 (0,23%)	na
Complication requiring further treatment*	1 (0,22%) ventil. after aspir.	0 (0%)	na
Death	0 (0%)	1 (0,23%)	na
LM: difficult	9/203 (4,43%)	7/191 (3,66%)	0,77 (-3,4-4,9), 0,6990
LM failed (switch to ETI)	7/203 (3,45%)	3/191 (1,57%)	1,88 (-1,55-5,53), 0,2364
Total n. of difficult ETI	29/238 (12,18%)	25/224 (11,16%)	1,02 (-4,9-6,9), 0,7333
ETI: failed	0/238	0/224	na
ETI: unexpectedly difficult	18/238 (7,56%)	16/224 (7,14%)	0,42 (-4,5-5,3), 0,8629
ETI: successful at first	213/238 (89,5%)	199/224 (88,84%)	0,66 (-5,0-6,5), 0,8197
ETI:successful (>1 attempt)	25/238 (10,5%)	25/224 (11,16%)	NS
Tooth injury / loss	0 (0%)	1 (0,23%)	na
<i>Soft tissue injury</i>	<u>20 (4,55%)</u>	<u>9 (2,13%)</u>	<u>2,42% (-0,03-5), 0,0489</u>
II. Secondary endpoints, after cases excluded *			
<i>Number of cases after exclusion:</i>	399* (439-40)	386* (423-37)	
<i>Post-induction desatur.:</i>	9 (2,25%)	8 (2,07%)	0,18 (-2,0-2,4), 0,8624
<i>Number of cases after exclusion:</i>	420* (439-19)	401* (423-22)	
<i>Post-induction hypotens.:</i>	35 (8,33%)	38 (9,48%)	1,15 (-2,7-5,1), 0,5630

In almost 10% of cases (11.62% and 9.22%) physicians expected a difficult airway, but only a quarter of these proved to be difficult. It is instructive that roughly ¼ (71% and 76%, p = 0.5957) of all difficult airway (10.25% and 8.03%) cases occurred unexpectedly. Problems with the use of laryngeal mask were found in 7.88% and 5.23% (p = 0.2901). Here, in half of the cases, the use of the device failed and they switched to intubation. There was no unsuccessful intubation, but it was difficult in 12.18% and

11.16% (p = 0.7333). The proportion of unexpected difficult intubations was also high in both groups, 62% and 64% (p = 0.8805). The rate of successful first intubations was almost 90% (89.5% vs. 88.84%, p = 0.8197). Significant reductions in marginal analysis of minor complications were found for soft tissue injury (4.55% and 2.13%) (2.42%, 95% CI (-0.03%; 5%), p = 0.0489). After exclusion due to unsuccessful optimization, it was possible to analyze hypotensive (8.33% and 9.48%) and hypoxic (2.25% and 2.07%) cases related to airway insurance, but no significant difference was found either. After exclusion of cases, follow-up data could be analyzed for complications classified as secondary endpoints (Table 12) (hoarseness, stridor, sore throat/difficulty to swallow). There was no significant difference either, and the analysis of the subgroups (ET tube - no ET tube) did not come as a surprise either.

Table 12 Additional endpoints based on next day follow-up. FM = face mask; CI = confidence interval; ETI = endotracheal intubation; ETT = endotracheal tube; LM = laryngeal mask; n = number of processed, evaluated data sheets; na = no data; NS = not significant; RD = risk difference; RR = relative risk

Airway Maneuvers, Complications:	Frequency of complications in proportion to all evaluable datasheets, before the checklist n=439 (%)	Frequency of complications in proportion to all evaluable datasheets, in possess. of the checklist n=423 (%)	Statistics: RD% (95% CI), p
III. Other endpoints: Follow-up: Next day, <24hrs, after exclusions **			
Post-exclusion cases **	329** (439-110)	296** (423-127)	-
Hoarseness, total	62/329 (18,85%)	53/296 (17,90%)	0,95 (-5,2-7), 0,7598
only ETT	29/168 (17,26%)	24/152 (15,78%)	NS
only LM	33/152 (21,71%)	29/137 (21,17%)	NS
only AM	0/4	0/6	na
ETT / no ETT: RR (95% CI), p	0,81 (0,52-1,28), 0,3745	0,78 (0,47-1,27), 0,3171	
Stridor, total	4/329 (1,21%)	5/296 (1,68%)	0,47 (-1,6-2,8), 0,6218
only ETT	3/168 (1,78%)	4/152 (2,63%)	NS
only LM	1/152 (0,66%)	1/137 (0,73%)	NS
only AM	0/4	0/6	na
ETT / no ETT: RR (95% CI), p	2,82 (0,29-26,81), 0,3671	3,76 (0,42-33,27), 0,2333	
Sore throat/ difficulty swallow.	67/329 (20,36%)	44/296 (14,86%)	5,50 (-0,5-11,4), 0,0726
only ETT	36/168 (21,43%)	22/152 (14,47%)	NS
only LM	31/152 (20,40%)	22/137 (16,06%)	NS
only AM	0/4	0/6	na
ETT / no ETT: RR (95% CI), p	1,08 (0,70-1,65), 0,7298	0,94 (0,54-1,62), 0,8263	

Analysis of subgroups

Interventions that were already analyzed at the endpoints and considered clinically important were also examined according to the experience of the physicians (non-specialist/specialist) and the urgency of the intervention (planned / urgent). There was no clinically significant difference between the two months. Interestingly, in the second month, non-specialists performed significantly worse on successful first intubations (RR: 3.59, 95% CI: 1.49% -8.65%, $p = 0.0044$) than in the month before the checklist. In the case of post-induction hypotension, in April the activities of non-specialists, in May emergency interventions presented a higher, significantly different risk.

CONCLUSIONS

1. I was the first to conduct a nationwide survey of the current state of airway management in Hungary. In this sub-area, I obtained previously unknown domestic data regarding personal, material and organizational conditions, and I gained an insight into the physicians' expertise in airway management and access to training forms.

The results highlighted shortcomings in the domestic situation and provided motivation and an appropriate basis for further work to be done. The most important conclusions and steps:

- Documenting of difficult airway cases, elaboration of a Hungarian professional recommendation, formulation of minimum conditions.
- Encourage the development of local protocols/algorithms.
- Get access to difficult airway equipment anytime, anywhere, within minutes.
- Getting good practice using existing tools.
- Alternative tools are also needed to deal with critical situations.
- The tools of invasive airway management techniques should be made available and the necessary practical skills should be acquired.
- The intensive care units must also have their own full airway equipment.
- The possibility of regular participation in further training should be created.

2. With the help of a questionnaire method, I was the first to assess what Hungarian anesthesiologists think about the possibilities of difficult airway education and what their expectations are. I also got a picture of what organizational and educational methods they would use if possible and which were the most important questions they wanted to be answered. The main conclusions are:

- Successful completion of a compulsory airway management course is a prerequisite for the specialist exam.

- Practising crisis situations is essential during simulation training.
- The topics of advanced courses and compulsory core training for the specialist exam should include current issues in airway management.
- It is recommended to take a course at least once every 5 years to maintain the knowledge gained.
- It would be important to develop a uniform curriculum (theory, practice) with a list of competencies and to define a minimum number of cases.
- Establishing reasonable but uncompromising minimum conditions and settling the financial background is essential.
- Organizing regular local training, developing recommendations / protocols, practising teamwork (non-technical skills) are essential.
- There is a particular need for case discussions, presentation of care strategies in specific areas, clarification of questions related to airway management of critical illness patients, up-to-date algorithms, etc.

3. I was the first to investigate the suitability of PATEM (preserved according to Thiel's embalming method) cadavers during facemask ventilation, direct laryngoscopy, and endotracheal intubation in both domestic and international comparisons. I have found that PATEM cadavers are more suitable for face mask ventilation (the incidence of heavy mask ventilation was similar to that of clinical trials in patients) and provide a more realistic (anatomy, tissue behaviour, colour, etc.) educational environment for practitioners during direct laryngoscopy and endotracheal intubation than the phantoms in the study. I have found that Thiel-fixed cadavers are better suited to practice airway management than formalin-preserved or non-preserved corpses. Experienced operators preferred to use the cadaver model over phantoms. The results of the study can also serve as a reference for assessing the level of training of trainees. A cluster of cadavers with different anatomical features can provide a more diverse environment, more like clinical conditions, as a simulation unit. PATEM cadavers may be more suitable for testing new airway devices before they are clinically introduced. I recommend integrating Thiel-fixed cadavers into the training toolkit.

4. Under domestic circumstances, I was the first to investigate the effects of a checklist on early complications of airway management in adult patients. The study provided a wealth of new and useful data on our institute's airway management practice. However, the introduction of the checklist by itself did not result in a significant change in the incidence of short term complications in airway management at our institute.

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