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Original Article

Five-year audit of adherence to an anaesthesia pre-induction checklist

A. Fuchs,[1] **S. Frick,**[2] **M. Huber,**[3] **T. Riva,**[4,5] **L. Theiler,**[6] **M. Kleine-Brueggeney,**[7] **T. H. Pedersen,**[8] **J. Berger-Estilita**[4,9] and **R. Greif**[10,11]

1 Attending Anaesthetist, 2 Resident Anaesthetist, 3 Statistician, 4 Consultant, 10 Professor, Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, Bern, Switzerland
5 Consultant, Unit for Research and Innovation in Anaesthesia, Department of Paediatric Anaesthesia, Istituto Giannina Gaslini, Genoa, Italy
6 Professor, Department of Anaesthesia, Cantonal Hospital Aarau, Aarau, Switzerland
7 Consultant, Department of Anaesthesia, University Children's Hospital Zurich - Eleonore Foundation, Zurich, Switzerland
8 Resident Anaesthetist, Department of Anaesthesiology, Nordsjællands Hospital, University of Copenhagen, Hillerød, Denmark
9 Consultant, Centre for Health Technology and Services Research, Faculty of Medicine, Porto, Portugal
11 Professor, School of Medicine, Sigmund Freud Private University Vienna, Vienna, Austria

Summary

Although patient safety related to airway management has improved substantially over the last few decades, life-threatening events still occur. Technical skills, clinical expertise and human factors contribute to successful airway management. Checklists aim to improve safety by providing a structured approach to equipment, personnel and decision-making. This audit investigates adherence to our institution's airway checklist from 1 June 2016 to 31 May 2021. Inclusion criteria were procedures requiring airway management and we excluded all procedures performed solely under regional anaesthesia, sedation without airway management or paediatric and cardiovascular surgery. The primary outcome was the proportion of wholly performed pre-induction checklists. Secondary outcomes were the pattern of adherence over the 5 years well as details of airway management, including: airway management difficulties; time and location of induction; anaesthesia teams in operating theatres (including teams for different surgical specialities); non-operating theatre and emergency procedures; type of anaesthesia (general or combined); and urgency of the procedure. In total, 95,946 procedures were included. In 57.3%, anaesthesia pre-induction checklists were completed. Over the 5 years after implementation, adherence improved from 48.3% to 66.7% ($p < 0.001$). Anticipated and unanticipated airway management difficulties (e.g. facemask ventilation, supraglottic airway device or intubation) defined by the handling anaesthetist were encountered in 4.2% of all procedures. Completion of the checklist differed depending on the time of day (61.3% during the day vs. 35.0% during the night, $p < 0.001$). Completion also differed depending on location (66.8% in operating theatres vs. 41.0% for non-operating theatre anaesthesia, $p < 0.001$) and urgency of procedure (65.4% in non-emergencies vs. 35.4% in emergencies, $p < 0.001$). A mixed-effect model indicated that urgency of procedure is a strong predictor for adherence, with emergency cases having lower adherence (OR 0.58, 95%CI 0.49–0.68, $p < 0.001$). In conclusion, over 5 years, a significant increase in adherence to an anaesthesia pre-induction checklist was found, and areas for further improvement (e.g. emergencies, non-operating room procedures, night-time procedures) were identified.

Correspondence to: A. Fuchs
Email: alexander.fuchs@insel.ch
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Twitter: @alexffuchs; @joanaberger3

Introduction

Despite many advances in anaesthesia, current airway management still poses risks for patients [1, 2]. These latest findings align with the Fourth UK National Audit project of 2011 (NAP4) that demonstrated lifelong impairment or death in about 10% of major airway management-related complications [3]. Since the 1990s, airway-related major complications have informed the development of airway management guidelines [4–6]. Some of these guidelines focus on vulnerable patients in the intensive care unit and the physiologically difficult airway [7–9]. The Difficult Airway Society first introduced the importance of human factors in airway-related incidents in its 2015 guidelines [4]. Human factors include: personal aspects (e.g. fatigue and poor communication in teams); organisational issues (e.g. high work-load and multitasking); structural factors (e.g. high-turnover teams); and unusual or unfamiliar work environments [10–12].

Potential human errors have been shown to decrease with the use of checklists [13, 14], which are cognitive aids that provide a straightforward step-by-step approach to solving a problem or carrying out a procedure [15]. Checklists can contribute to improved patient survival [16]. Additionally, using a pre-induction checklist [7, 9] before an anaesthesia crisis may reduce the cognitive load and thereby assist in avoiding fixation errors that result in airway-related complications [17].

Despite several published guidelines recommending the use of checklists [4–7], there is a paucity in reporting team adherence to checklist use. This 5-year audit aimed to report the adherence of anaesthesia providers to an anaesthesia pre-induction checklist.

Methods

In response to a study on the incidence of major and minor airway management events [18], according to the incidence of airway management-related incidents at study baseline, a bundle of interventions was implemented to decrease the incidence of major and minor airway-related incident complications. One of these interventions was an anaesthesia pre-induction checklist, which comprised four main themes: equipment, patient, communication and feasibility (Fig. 1; Table 1). The pre-induction checklist was introduced into the departmental computer-based clinical information system in May 2016, in addition to the pre-existing WHO surgical safety checklist [19]. The department strongly recommended completing the checklist before the induction of general anaesthesia (e.g. during pre-oxygenation), after completion of the sign-in of the WHO surgical checklist but before the time-out [19]. The completion of the checklist was recorded automatically (including a time and date stamp) in the clinical information system. In exceptional circumstances (e.g. anticipated difficult airway), the briefing might involve a surgeon as a backup for an emergency front of neck access.

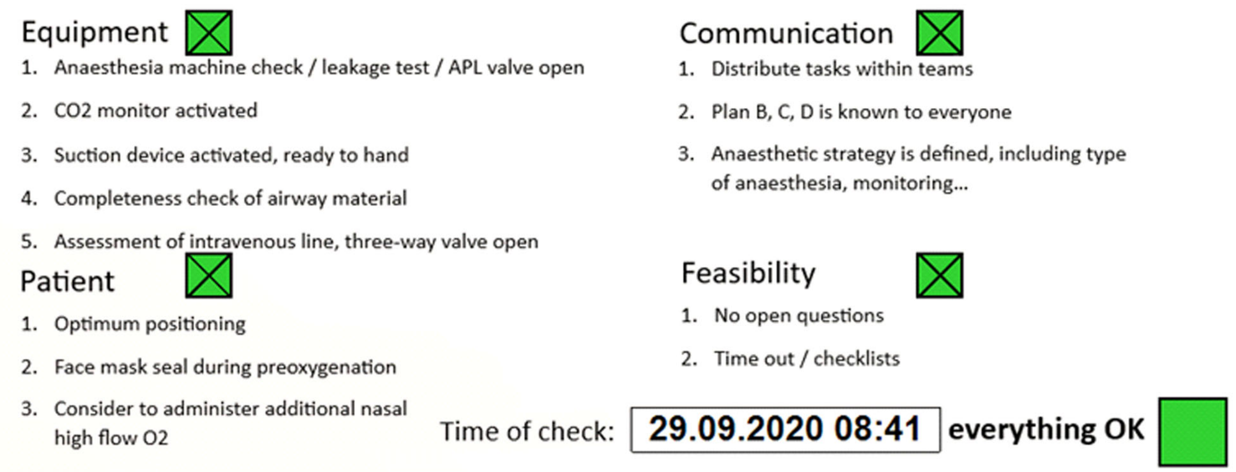

Figure 1 Screenshot of the digital pre-induction checklist.

Table 1 The Bern pre-induction checklist with its themes, sub-items and examples.

Theme	Sub-item	Example
Equipment	Anaesthesia machine check; leak test; adjustable pressure-limiting valve open	Correct machine check in the morning; leak test after last use; make sure that the adjustable pressure-limiting valve is open before starting anaesthesia
	CO_2 monitor activated	Capnography is displayed on the monitor and shows a curve
	Suction device activated and ready to hand	Suction is working correctly, is activated and positioned directly next to the patient's head; for specific cases, a large-bore suction device is at hand
	Completeness check of airway material	Videolaryngoscope is working; direct laryngoscope is working as an alternative; a tracheal tube is prepared in the appropriate size; stylet is ready; intubation introducer as a guide (Frova) is available
	Assessment of intravenous line; the three-way valve is open	The intravenous line has been tested; in case of total intravenous anaesthesia, all three-way valves are open to the patient
Patient	Optimal positioning	Children in sniffing position; obese patient correctly ramped
	Correct sealing of facemask during pre-oxygenation	Confirmed by correct capnography readings during pre-oxygenation, with measurement of end-tidal oxygen
	Supplemental oxygen via low-flow or high-flow device	Supplemental oxygen continuous during airway management; apnoeic oxygenation during all airway procedures (laryngoscopy, supraglottic airway device placement)
Communication	Distribution of all possible tasks	The airway team leader has allocated roles: who will establish patent airway; who is in charge to check patient's monitoring during induction; who will administer drugs; who is the backup personnel – immediate availability and how to call
	Concise airway plan in advance and triggering events	If airway Plan A fails, triggering event for the next step (e.g. 'you tell me you cannot intubate after two attempts') and a failed intubation is declared, 'xy' will 'call for help!', and this person is consultant 'yz', who is available immediately and can be here promptly, can be contacted with this specific phone number
		In the meantime, we continue with Plan B, such as inserting a supraglottic airway device; the appropriate size for the specific patient is number 4 and is in the yellow drawer and has been checked.
		Where supraglottic airway device attempts fail, 'xy' gets in the eFONA set. The backup consultant tries a last attempt to establish a patent airway. If it fails, Plan C: mask ventilation attempt by me, eFONA set opened; and Plan D: eFONA performed by the backup consultant. During all this – continuous apnoeic oxygenation
	Further anaesthetic strategy	After intubation, general anaesthesia is maintained by a volatile anaesthetic agent; the aim is xy% concentration.
		Settings of the anaesthetic machine defined: ventilation pressure and tidal volume set; ventilation frequency and positive end-expiratory pressure
		Tasks after induction assigned: 'Team member A' will place a central venous catheter, while 'Team member B' will place an arterial line
Feasibility	No open questions	Are there any open questions? Is the allocation of roles clear? Are the airway plans A, B, C, D clear to everyone?
	Time out; checklists	Is the surgical WHO checklist filled in? Are there any open points on the checklist? Do all finally agree to the plan?

The Bern Cantonal Ethics Committee waived the need for ethical approval for this retrospective data analysis. This audit extracted all the anaesthesia procedures for adults conducted in the Department of Anaesthesia and Pain Medicine at Bern University Hospital between 1 June 2016 and 31 May 2021, as stored in the computer-based clinical information system. Inclusion criteria were any procedure performed under general anaesthesia or combined with regional anaesthesia in adults. Exclusion criteria were as follows: procedures that included only regional anaesthesia; procedural sedation without airway management; procedures conducted in the children's hospital (children aged < 16 y); and cardiovascular anaesthesia.

Table 2 Difficulties with airway management.

Facemask ventilation	Supraglottic airway device	Tracheal intubation
- difficult or impossible facemask ventilation - airway obstruction - cannot-intubate cannot-ventilate	- failure on placement during the induction of anaesthesia (not possible to position the device adequately or failure to ventilate the patient's lungs due to leakage) - cannot-intubate cannot-ventilate	- difficult laryngoscopy (e.g. Cormack-Lehane grade 3 or 4, or percentage of glottic opening 0%) - failure to advance a tracheal tube - unplanned use of special equipment (e.g. introducers, bougies or Magill forceps) - difficult scope intubation - problems with a tracheal cannula - cannot-intubate cannot-ventilate

Potential difficulty (anticipated or unanticipated) defined by the handling anaesthetist in charge of the patient [18]. Situations were not limited to the above mentioned.

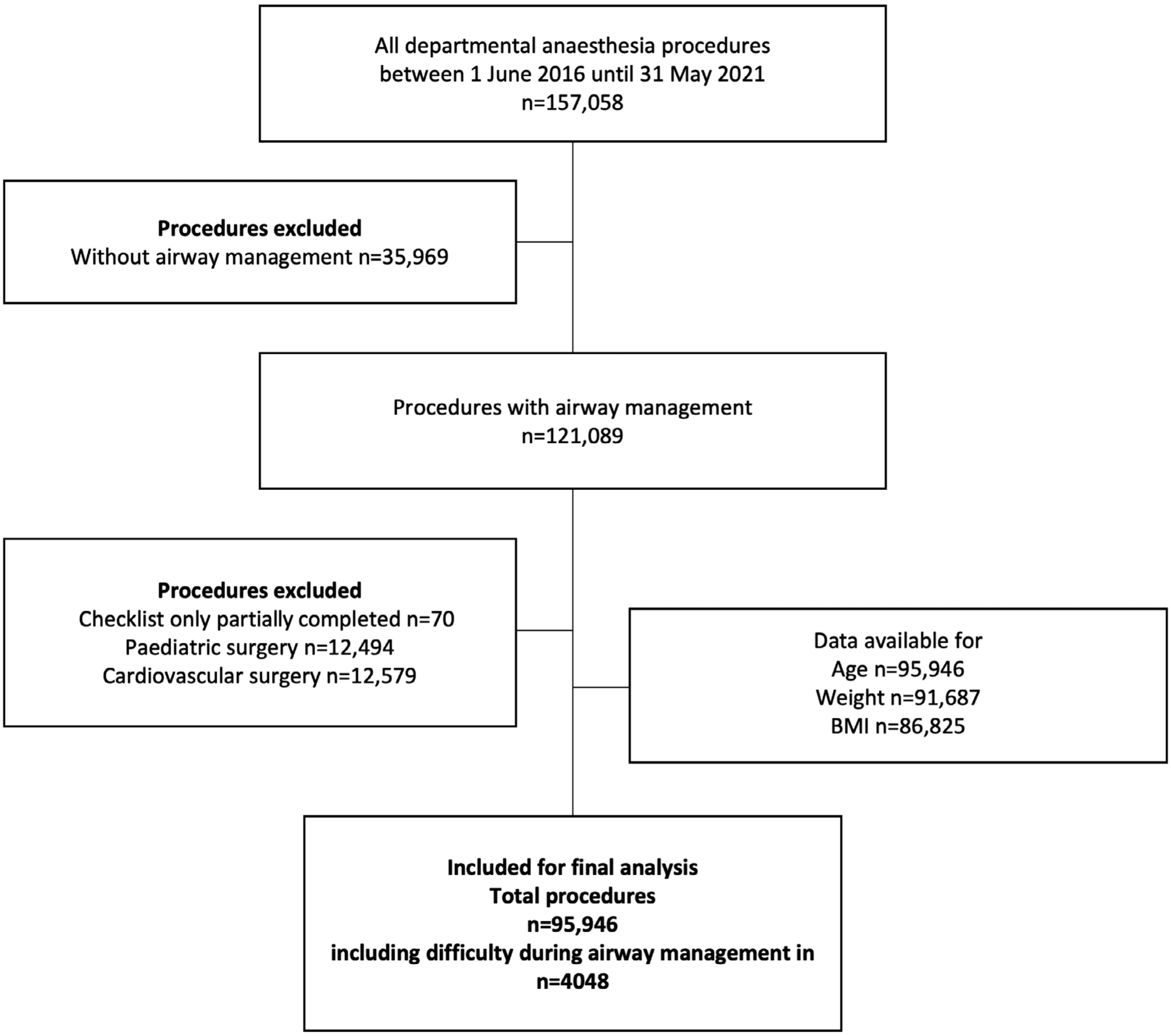

Figure 2 Study flow chart.

Procedures were analysed according to induction time, either during the day (standard working hours, 07.00–16.59) or during the night (reduced personal/out-of-hours, 17.00–06.59). We also differentiated the areas where the anaesthesia induction occurred in terms of 'operating theatre' and 'non-operating theatre'.

There are anaesthesia teams for different surgical specialities that are dedicated to scheduled – and whenever possible non-scheduled – operating theatre and non-operating theatre procedures during daytime hours. The emergency anaesthesia team is primarily in charge of all non-scheduled emergency procedures 24 h/7 days a week and performs both operating theatre and non-operating theatre anaesthesia [20].

Scheduled procedures were classified as elective cases. Urgent, non-elective procedures were pre-defined according to the locally used four priority categories: 1, immediate urgency (e.g. cardiopulmonary resuscitation); 2, very urgent (procedure within 6 h); 3, urgent (procedure within 6–12 h); and 4, semi-elective (procedure within 24 h, or integration into the regular operating theatre list). We classified all procedures in categories 1, 2 and 3 as

Table 3 Procedures with general and combined general and regional anaesthesia according to baseline characteristics and anaesthesia conditions. Where data are missing, the numbers of available data are also given. Values are number (proportion) or median (IQR [range]).

	Pre-induction checklist				
	Completed 54,949 (57.3%)	**Not completed 40,997 (42.7%)**	**Total 95,946**	**p**	**Effect size†**
Year				< 0.001	0.10
06/2016–05/2017	8990 (48.3%)	9625 (51.7%)	18,615		
06/2017–05/2018	9964 (51.8%)	9255 (48.2%)	19,219		
06/2018–05/2019	11,485 (58.5%)	8151 (41.5%)	19,636		
06/2019–05/2020	11,458 (60.6%)	7436 (39.4%)	18,894		
06/2020–05/2021	13,052 (66.7%)	6530 (33.3%)	19,582		
Characteristics					
Sex				< 0.001	0.03
Male	28,324 (55.7%)	22,513 (44.3%)	50,837 (53.0%)		
Female	26,625 (59.0%)	18,484 (41.0%)	45,109 (47.0%)		
Age; y	55.0 (38.0–69.0 [0.0–102.0])	56.0 (33.0–70.0 [0.0–120.0])	56.0 (36.0–69.0 [0.0–120.0])	< 0.001	0.02
ASA physical status				< 0.001	0.24
1	6856 (58.4%)	4874 (41.6%)	11,730 (12.2%)		
2	23,323 (64.3%)	12,933 (35.7%)	36,256 (37.8%)		
3	20,263 (60.4%)	13,259 (39.6%)	33,522 (34.9%)		
4	4341 (36.5%)	7549 (63.5%)	11,890 (12.4%)		
5	164 (7.09%)	2148 (92.9%)	2312 (2.4%)		
6	2 (0.9%)	234 (99.2%)	236 (0.3%)		
BMI; kg.m^{-2} (n = 86,825)	25.2 (22.2–29.0 [9.2–79.7])	24.7 (21.6–28.5 [6.2–72.4]	25.0 (22.0–28.8 [6.2–79.7])	< 0.001	0.05
Anaesthesia					
Type				< 0.001	0.10
General	47,165 (55.4%)	37,907 (44.6%)	85,072 (88.7%)		
Combined	7784 (71.6%)	3090 (28.4%)	10,874 (11.3%)		
Time of induction				< 0.001	0.19
07.00–16.59	49,801 (61.3%)	31,448 (38.7%)	81,249 (84.7%)		
17.00–06.59	5148 (35.0%)	9549 (65.0%)	14,697 (15.3%)		
Anaesthesia team				< 0.001	0.30
Emergency anaesthesia team	7329 (33.0%)	14,854 (67.0%)	22,183 (23.1%)		
Non-operating theatre anaesthesia team	2617 (41.0%)	3768 (59.0%)	6385 (6.65%)		
Operating theatre teams	45,003 (66.8%)	22,375 (33.2%)	67,378 (70.2%)		

†Effect sizes are Cramér's V for categorical variables or the Z statistic divided by the square root of the sample size.

emergency cases for the audit. We considered all elective and category 4 procedures as non-emergency cases.

The primary outcome was the overall proportion of completely performed pre-induction checklists. Secondary outcomes were changes to checklist completion adherence over the 5 years with the following explanatory variables captured for analysis: airway management difficulty (defined by the handling clinician [5, 6]) (Table 2); urgency of procedure (emergency vs. non-emergency); time of induction (07.00–16.59 vs. 17.00–06.59); location of induction (operating theatre vs. non-operating theatre); and care by dedicated anaesthesia teams for different surgical specialities vs. care by the emergency anaesthesia team.

Statistical analysis was performed using R (R Project, Vienna, Austria). Effect sizes were calculated with Cramér's V for categorical variables, the Z statistic divided by the square root of the sample size or the difference (95%CI) of the proportion (%) of completed checklists from 50%, thus measuring the degree of difference in adherence in two groups. A generalised linear mixed-effects model with the binary outcome of adherence to the checklist was computed to determine the primary sources of variability for adherence. The generalised linear mixed-effects model included the predictors' time since the introduction of the checklist (months), patient age (y) and BMI ($kg.m^{-2}$) as fixed effects, whereas the fixed effects of the predictor type (general vs. combined anaesthesia), urgency (emergency vs. non-emergency), airway management with difficulty (yes vs. no) and working hours (day vs. night) feature a random slope and intercept for the group factor anaesthesia teams. The goodness of fit was measured by marginal and conditional R^2 [21]. The significance level of probability was defined as <0.05.

Results

In total, 95,946 procedures with airway management were included over the 5 years (Fig. 2 and Table 3). The pre-induction checklist was completed in 57.3% of procedures. Adherence to the checklist increased over the 5 years, from 48.3% in the first year to 66.7% in the last year ($p < 0.001$). Our data defined an annual adherence probability improvement rate for all procedures of 4.5% (95%CI 4.49%–4.53%, $p < 0.001$) (Fig. 3).

Adherence differed significantly between the day-time and night-time procedures (61.3% vs. 35.0%, $p < 0.001$) and for operating theatre compared with non-operating theatre (66.8% vs. 41.0%, $p < 0.001$) (Fig. 4). Adherence was significantly higher in procedures categorised as non-

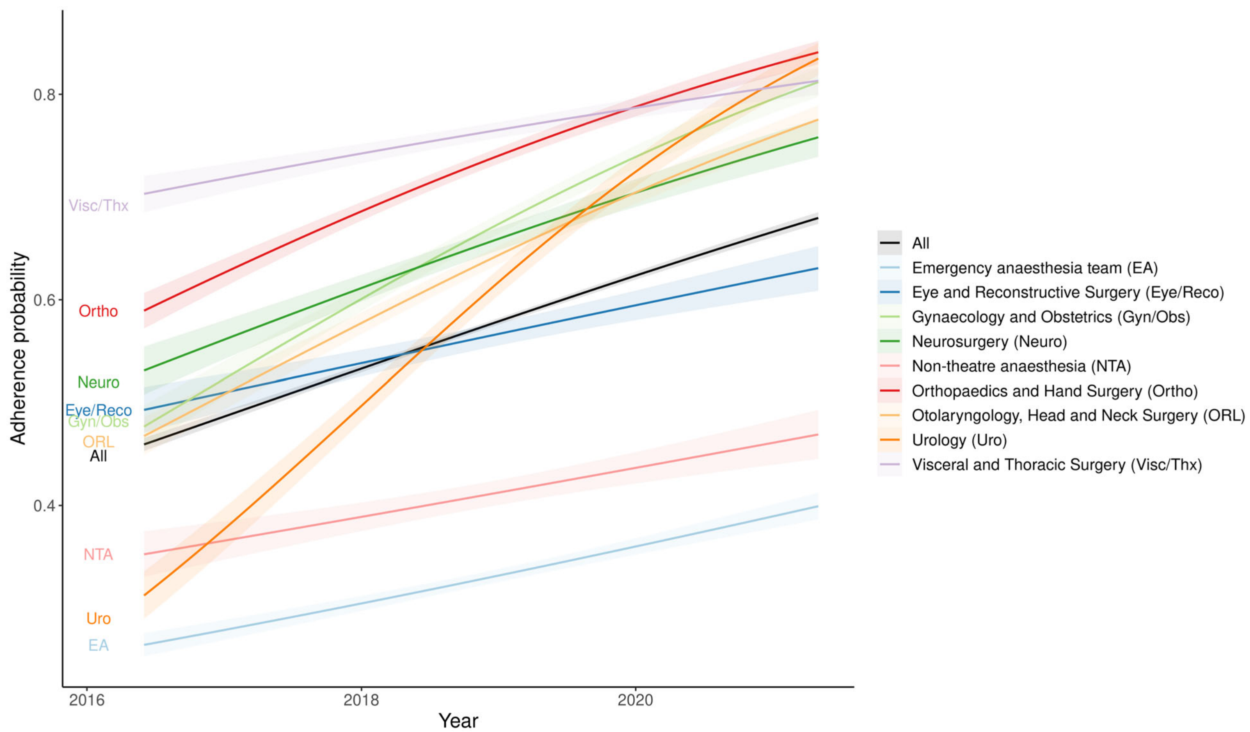

Figure 3 Adherence probability for the entire anaesthesia clinic (All) and stratified by anaesthesia team (as indicated), over time estimated with a binomial logistic regression model. Mean (solid lines) and 95% confidence limits (shaded areas) are shown.

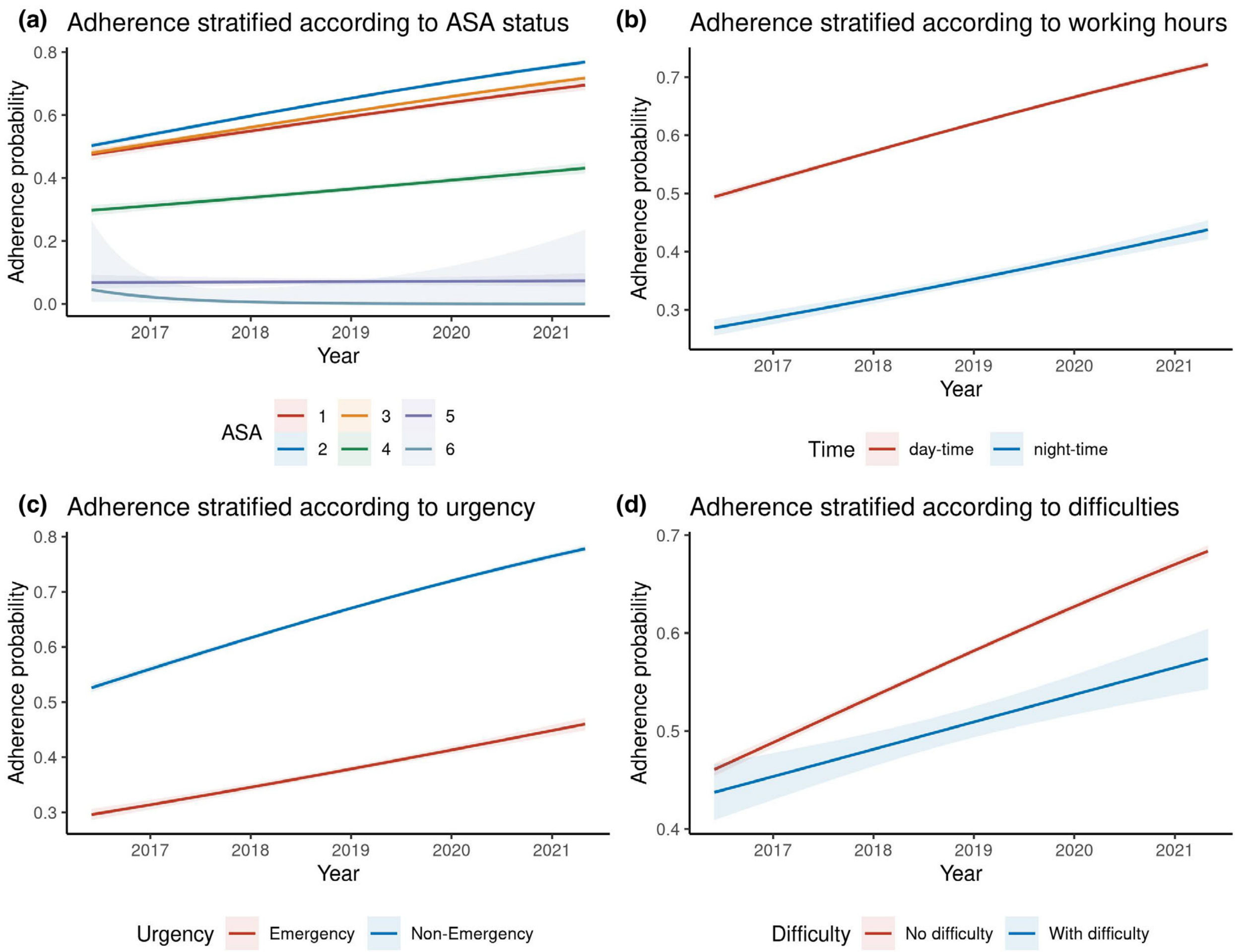

Figure 4 Adherence probability for all procedures over time and stratified by (a) ASA physical status, (b) working hours, (c) urgency and (d) difficulties with airway management, estimated with a binomial logistic regression model. Mean (solid lines) and 95% confidence limits (shaded areas) are shown.

emergency when compared with emergency procedures (65.4% vs. 35.4%, $p < 0.001$), and significantly lower for immediate urgency (category 1) when compared with non-urgent procedures (categories 2–4, elective; 15.0% vs. 49%, $p < 0.001$) (Table 4 and Fig. 4). Procedures including patients with an ASA physical status between 1 and 3 had a higher adherence, compared with procedures including patients with an ASA ≥4 ($p < 0.001$, effect size 0.24) (Fig. 4). Adherence was significantly higher with a pre-obese BMI (completed median (IQR [range]) BMI 25.2 (22.2–29.0 [9.2–79.7]) kg m^{-2} vs. non-completed 24.7 kg m^{-2} (21.6–28.5 [6.2–72.4] kg m^{-2}), $p < 0.001$, effect size 0.05), but that might not be clinically relevant. Adherence was also significantly higher for females (male completed 55.7% vs. female completed 59.0%, < 0.001, effect size 0.03) and younger age (completed 55.0 (38.0–69.0 [0.0–102.0]) y vs. non-completed 56.0 (33.0–70.0 [0.0–120.0]) y, $p < 0.001$, effect size 0.02).

Over the 5-year observation period, 4048 airway management procedures were classified as difficult by the handling clinician (4.2%) (Table 4). Most of these were recorded for interventions conducted by the anaesthesia team for otorhinolaryngology and head and neck surgery (32.7%, n = 1323). In comparison with all procedures, difficulties with airway procedures occurred significantly more frequently during the night than the day (4.3%, n = 637/14,697 vs. 4.2%, n = 3411/81,249, $p < 0.001$); during the induction of procedures categorised as emergency rather than non-emergency procedures (4.5%, n = 1167/25,921 vs. 4.1%, n = 2881/70,025, $p < 0.001$) (Table 5); and for procedures induced by the emergency anaesthesia team compared with the operating or non-operating theatre team (4.4%, n = 974/22,183 vs. 4.2%, n = 2847/67,378 vs. 3.5%, n = 227/6385, $p < 0.001$).

Table 4 Pre-induction checklist for procedures rated as having difficulty during airway management according to baseline characteristics and anaesthesia conditions. Where data are missing, the numbers of available data are also given. Values are number (proportion) or median (IQR [range]).

	Pre-induction checklist				
	Completed 2032 (50.2%)	**Not completed 2016 (49.8%)**	**Total 4048**	**p**	**Effect size†**
Year				< 0.001	0.10
06/2016–05/2017	464 (47.2%)	519 (52.8%)	983		
06/2017–05/2018	362 (44.5%)	452 (55.5%)	814		
06/2018–05/2019	393 (50.9%)	379 (49.1%)	772		
06/2019–05/2020	361 (50.1%)	359 (49.9%)	720		
06/2020–05/2021	452 (59.6%)	307 (40.4%)	759		
Characteristics					
Sex				0.056	0.03
Male	1277 (49.1%)	1326 (50.9%)	2603 (64.3%)		
Female	755 (52.2%)	690 (47.8%)	1445 (35.7%)		
Age; y	77.0 (65.0–90.0 [0.0–98.0])	73.0 (62.0–87.0 [0.0–96.0])	75.0 (63.0–90.0 [0.0–96.0]	< 0.001	0.01
ASA physical status				< 0.001	0.16
1	82 (56.2%)	64 (43.8%)	146 (3.61%)		
2	617 (57.2%)	462 (42.8%)	1079 (26.7%)		
3	1056 (51.5%)	996 (48.5%)	2052 (50.7%)		
4	265 (38.4%)	426 (61.6%)	691 (17.1%)		
5	12 (16.2%)	62 (83.8%)	74 (1.8%)		
6	0	6 (100%)	6 (0.2%)		
BMI; kg.m^{-2} (n = 3772)	25.8 (22.5–30.7 [11.1–79.7])	24.7 (21.8–29.1 [10.0–65.1]	25.3 (22.1–29.8 [10.0–79.7]	< 0.001	0.09
Anaesthesia					
Type				< 0.001	0.10
General	1888 (49.0%)	1962 (51.0%)	3850 (95.1%)		
Combined	144 (72.7%)	54 (27.3%)	198 (4.89%)		
Time of induction				< 0.001	0.14
07.00–16.59	1818 (53.3%)	1593 (46.7%)	3411 (84.3%)		
17.00–06.59	214 (33.6%)	423 (66.4%)	637 (15.7%)		
Anaesthesia team				< 0.001	0.22
Emergency anaesthesia team	304 (31.2%)	670 (68.8%)	974 (24.1%)		
Non-operating theatre anaesthesia team	98 (43.2%)	129 (56.8%)	227 (5.61%)		
Operating theatre team	1630 (57.3%)	1217 (42.7%)	2847 (70.3%)		

†Effect sizes are Cramér's V for categorical variables or the Z statistic divided by the square root of the sample size.

The annual improvement rate for adherence to the checklist with airway procedures rated as difficult was 2.70% (95%CI 2.70%–2.71%, p < 0.001).

Regression coefficients and variance components of the generalised linear mixed-effects model with the outcome of checklist adherence can be seen in Table 6. Notably, the odds for checklist adherence are significantly lower for emergency procedures (OR 0.58, 95%CI 0.49–0.68, p < 0.001), higher patient age (OR 1.07, 95%CI 1.06–1.09, p < 0.001) and higher BMI (OR 1.07, 95%CI 1.06–1.09, p < 0.001). The variance components highlight that there are mostly three factors influencing adherence among the different anaesthesia teams: type of anaesthesia (general vs. combined), with higher adherence for combined anaesthesia; the variability between anaesthesia teams for different surgical specialities, also shown in Fig. 3; and

Table 5 Urgency of all cases and cases with airway management difficulty only. Post-hoc comparisons were adjusted for multiple comparisons using the Holm method. Values are number (proportion).

	Pre-induction checklist				
	Completed	Not completed	Total	p	Effect size†
All cases	54,949 (57.3%)	40,997 (42.7%)	95,946		
Urgency				< 0.001	0.27
Emergency	9182 (35.4%)	16,739 (64.6%)	25,921		
Non-emergency	45,767 (65.4%)	24,258 (34.6%)	70,025		
Post-hoc comparisons				< 0.001	0.27
Elective	43,789 (66.0%)	22,554 (34.0%)	66,343	< 0.001	16.0 (19.6–16.4)
Immediate urgency (category 1)	1310 (15.0%)	7446 (85.0%)	8756	< 0.001	−35.0 (−35.8 to −34.3)
Very urgent (category 2)	5039 (44.2%)	6355 (55.8%)	11,394	< 0.001	−5.8 (−6.7 to −4.9)
Urgent (category 3)	2833 (49.1%)	2938 (50.9%)	5771	0.171	−0.9 (−2.2–0.4)
Semi-elective (category 4)	1978 (53.7%)	1704 (46.3%)	3682	< 0.001	3.7 (3.1–5.3)
Airway management difficulty	2081 (47.3%)	2314 (52.7%)	4395		
Urgency				< 0.001	0.21
Emergency	390 (33.4%)	777 (66.6%)	1167		
Non-emergency	1642 (57.0%)	1239 (43.0%)	2881		
Post-hoc comparisons				< 0.001	0.21
Elective	1550 (58.0%)	1124 (42.0%)	2674	< 0.001	8.0 (6.1–9.8)
Immediate urgency (category 1)	61 (16.1%)	318 (83.9%)	379	< 0.001	−33.9 (−37.5 to −29.8)
Very urgent (category 2)	231 (42.5%)	312 (57.5%)	543	0.002	−7.5 (−11.7 to −3.2)
Urgent (category 3)	98 (40.0%)	147 (60.0%)	245	0.004	−10.0 (−16.2 to −3.6)
Semi-elective (category 4)	92 (44.4%)	115 (55.6%)	207	0.126	−5.6 (−12.4–1.5)

†Effect sizes are Cramér's V for categorical variables or the difference (95%CI) of completed checklists' proportion from 50%. This difference compares how different the completion rates are in the different categories of urgency.

particular procedure-related characteristics such as urgency and daytime.

Discussion

This 5-year audit presents the adherence to a pre-induction checklist for 95,946 anaesthesia procedures with airway management, with overall completion in almost 60% of all procedures. We showed a 4.5% increase in the annual adherence rate. Factors influencing adherence included the type of anaesthesia, variability between anaesthesia teams for different surgical specialities and urgent and daytime procedures. The checklist was used more frequently in the operating theatre, for non-emergency procedures and during daytime working hours.

Adherence to the surgical WHO checklist improves patient outcomes [19]. The benefit of a pre-induction checklist has been described as reducing severe life-threatening events in the intensive care setting [22, 23]. Pre-hospital data have also demonstrated fewer intubation attempts and higher first-pass intubation success using a pre-induction checklist [24], which then led to their widespread use [25]. For anaesthesia, several studies have reported on pre-induction checklists [13, 26, 27], although the evidence for improved patient outcomes is not clear. In a 2020 review, the use of checklists during tracheal intubation was shown to reduce hypoxic events, although this did not impact patient mortality [26]. Such variable results can be explained by the heterogeneity of endpoints – such as the first-attempt success rate – which will depend more on the clinician's skill than on the use of a checklist. In addition, there is a paucity of studies that have reported on long-term adherence to pre-induction checklists. Such quality audits provide data towards a culture of further improvements to patient safety.

Anaesthesia pre-induction checklists trigger a briefing that takes only a few minutes (e.g. during pre-oxygenation). They are designed to reduce human-related errors and thus enhance patient safety [25]. As communication failures can significantly contribute to patient injury and death [2, 28], the focus of an anaesthesia pre-induction checklist lies in correct decision-making and preparation for potential anaesthesia-related problems based on clear communicated action plans (i.e. plans A, B, C, D) [29]. The checklist aims to reduce misunderstandings [29] and

Table 6 Model coefficients for a generalised linear mixed-effects model with outcome adherence to the checklist. Predictors of time, age and BMI are purely fixed effects. Fixed effects of type, urgency, airway management difficulty and working hours feature an additional random slope for the group factor anaesthesia teams for the different surgical specialities. The generalised linear mixed-effects model also features a random intercept for each anaesthesia team. Variance components of the random slope and intercept are given, and the marginal and conditional R^2 measured the goodness of fit.

Outcome: adherence to the checklist	Odds ratio (95%CI)	p
Fixed effects		
Intercepts	1.70 (1.25–2.31)	0.001
Time; months†	1.36 (1.34–1.38)	< 0.001
Age; y†	1.07 (1.06–1.09)	< 0.001
BMI; kg.m^{-2}†	1.07 (1.06–1.09)	< 0.001
Type; combined vs. general	1.03 (0.69–1.54)	0.897
Urgency; emergency vs. non-emergency	0.58 (0.49–0.68)	< 0.001
Airway management difficulty; yes vs. no	0.82 (0.67–1.01)	0.068
Working hours; night vs. day	0.88 (0.69–1.11)	0.282
Random intercepts	Variance	
Intercept	0.25	-
Random slopes		
Type; combined vs. general	0.30	-
Urgency; emergency vs. non-emergency	0.06	-
Airway management difficulty; yes vs. no	0.09	-
Working hours; night vs. day	0.11	-
Goodness of fit		
Marginal R^2	0.052	-

†Centred and scaled variables were used in the generalised linear mixed-effects model.

enhance horizontal communication, helping to establish a 'speak-up' culture. Indeed, recently issued airway guidelines include and emphasise the use of pre-induction checklists [7, 9, 29].

Our analysis shows that adherence to the checklist was relatively low for some anaesthesia teams for different surgical specialities and emergency procedures (the more urgent, the lower the adherence), non-operating theatre anaesthesia and during the night. These are also the procedures where difficulties during airway management were more frequent. Somewhat surprisingly, anaesthesia during the night was related to lower odds of completing the checklist, which raises the possibility of night-time being a confounder. The lower compliance during emergency cases (often associated with ASA ≥4 patients) might be explained by the time pressures that the team experiences, especially for patients suffering hypoxia or cardiac arrest, which are time-critical [20, 30].

We found several patient-related factors for greater adherence to the pre-induction checklist. The most significant effect size was for ASA physical status (higher adherence for ASA 1–3 and lower adherence for ASA ≥4), likely explained by the higher proportion of ASA 1–3 patients in non-emergency cases. The higher adherence for patients with higher BMI, even if clinically not significant, may be due to the anticipated higher airway complication rate in this particular population. Furthermore, we showed that it takes time to improve sustained adherence after implementing a checklist. Consistent unit leadership over the study period and less personal turnover might explain higher adherence in specific anaesthesia teams. Although completing the checklist is highly recommended and is part of the departmental simulation programme, it is not mandatory. This approach aims to stimulate the intrinsic motivation to use such a checklist and avoid negative attitudes towards such a safety tool by a mandate [31].

Known barriers to checklist compliance are personal (negative) attitude towards safety procedures [30] and an overconfidence bias that is the overestimation of one's own abilities and skills [32], leading to not complying with safety checks. Some argued that patients might be unsettled witnessing safety discussions about potential failure during anaesthesia. However, actual data from checklists' use in the induction room have shown that such safety checks are highly appreciated by patients [33].

This audit has some limitations. First, the analysis did not include anaesthesia procedures in paediatrics, under sedation or regional anaesthesia. If the checklist has not been completed, it may add additional stressors in such an emergency. This needs reconsideration because every procedure can unexpectedly and urgently change into the need for general anaesthesia with airway management. Second, the retrospective study design might have led to missing data due to poor data entry (e.g. patients whose tracheas were already intubated or who had a tracheostomy in-situ), which might underestimate the overall compliance. Finally, we could not find any effect of the use of the checklist on patient outcomes.

In summary, we implemented an anaesthesia pre-induction checklist locally designed to improve patient safety during anaesthesia. The checklist focused on correctly preparing the equipment required, communicating the roles and distribution of tasks clarifying the anaesthesia and backup plans. Adherence of use increased from 48% to 67% over 5 years. We identified reduced adherence in non-operating theatres, immediate urgent procedures, some anaesthesia teams for different surgical specialities and during the night. Pre-induction checklists should be used as part of a broader organisational patient safety concept, potentially contributing to reduced anaesthesia-related crises and less fatal patient outcomes.

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