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Abstract

Background: Using a Macintosh-style videolaryngoscope as a first-intention device for intubating unselected patients in the operating room has not often been studied. We hypothesised that using a Macintosh-style videolaryngoscope as a first-intention device would be associated with an increased proportion of easy tracheal intubation.
Methods: In a quality improvement project for airway management aimed at implementing a Macintosh-style videolaryngoscope as a first-intention device, we included all consecutive intubations in adults from March, 2017 to September, 2020 in two French teaching hospitals. We divided the cohort into three temporal cohorts: the pre-intervention, implementation, and post-intervention periods. The primary outcome was the proportion of easy airway management. The secondary outcomes were the rescue technique, Cormack–Lehane III or IV view, and operator-reported difficulty of intubation. Data from one hospital compliant with the quality improvement project were compared with data from a non-compliant hospital.
Results: A total of 26 692 tracheal intubations were performed. Among 11 938 intubations included in the compliant hospital, 5487 were included in the pre-intervention, 1845 in the implementation, and 4606 in the post-intervention periods. In comparison to the pre-intervention period, the proportions of easy tracehal intubation increased from 94.3% (5177 of 5487) to 98.7% (4547 of 4606)) in the post-intervention period (+4.4% [95% confidence interval 3.7–5.1%], $P<0.001$). In comparison to the pre-intervention period, all secondary outcome proportions were significantly lower in the post-intervention period. No significant changes were noted in the non-compliant hospital between the pre- and post-intervention periods.
Conclusions: Using a Macintosh-style videolaryngoscope as a first-intention device for tracheal intubation in the operating room was associated with a significant increase in the proportion of easy tracheal intubation, compared with use of the standard Macintosh laryngoscope.

Keywords: complications; COVID-19; intubation; operating room; videolaryngoscopy

Editor's key points

- Videolaryngoscopy is potentially useful for tracheal intubation, but its usefulness has not been studied in patients in whom tracheal intubation is indicated.
- Compared with the standard Macintosh laryngoscope, use of a Macintosh-style videolaryngoscope as a first-intention device for tracheal intubation in the operating room was associated with a significant increase in the proportion of easy tracheal intubation.

Standard Macintosh direct laryngoscopy, which requires a direct line of sight to align airway axes, remains the airway management device used first by anaesthesiologists.[1,2] Worldwide recommendations[3,4] have stated that all anaesthesiologists should be trained to use and have immediate access to a videolaryngoscope. After widespread implementation of videolaryngoscopy for difficult tracheal intubation, failed tracheal intubation proportions by skilled providers declined significantly.[5]

Likewise, there is strong evidence that delayed, difficult, or failed tracheal intubation is associated with patient harm and death.[6,7] Despite identification of several predicting factors for difficult tracheal intubation,[5,8,9] >90% of such difficult tracheal intubations are unpredicted.[10] A videolaryngoscope is more often used as a second-intention device or rescue therapy in case of difficult tracheal intubation or in some cases of anticipated difficult intubation. Few centres have adopted universal videolaryngoscopy,[11–13] considering the videolaryngoscope as the first-intention device for all tracheal intubation procedures in unselected patients. In addition, the COVID-19 pandemic has highlighted the potential usefulness of videolaryngoscopy to reduce contamination.[14–16] However, data are lacking regarding the consequences in clinical practice of implementation of videolaryngoscopes as first-intention devices for unselected patients. The recent American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway[4] defined a difficult airway as the clinical situation in which anticipated or unanticipated difficulty or failure is experienced by a physician trained in anaesthesia care.

To our knowledge, no study has compared the proportion of easy airway (absence of difficult airway) for tracheal intubation using the standard Macintosh direct laryngoscope with a Macintosh-style videolaryngoscope in unselected patients. The main objective of this study was to assess whether the implementation of the Macintosh-style videolaryngoscope as a first-intention device through an operating room quality improvement project is associated with an increase in the proportion of easy airway. The secondary objectives were to assess whether the implementation of the Macintosh-style videolaryngoscope as a first-intention devices associated with a decrease of the need to resort to a rescue technique, Cormack and Lehane grades of III or IV, and operator-reported difficulty of tracheal intubation. We hypothesised that implementation of the Macintosh-style videolaryngoscope as a first-intention device would be associated with an increased proportion of easy airway assessed as tracheal intubation, and a decrease of the need for a rescue technique, Cormack and Lehane grades of III or IV, and operator-reported difficulty of tracheal intubation.

Methods

Human subjects protection

We obtained approval from the Montpellier University Hospital ethics committee (Comité Local d'Ethique Recherche, agreement number: 198711). The need for informed consent was waived on the basis that the intervention was an institutional quality improvement project. We used the point-of-care perioperative clinical information system (eXacto, Mexis S.A., Liège, Belgium). These records were merged with a second database derived from the hospital's consultations management system (DxCare, Dedalus S.A., Le Plessis Robinson, France). The final database was de-identified.

The Strengthening The Reporting of OBservational Studies in Epidemiology checklist was used in preparing this report.

Data source

The point-of-care perioperative clinical information system and the hospital's consultations management system were queried initially and the two databases merged into one de-identified database. In the two databases, the data were prospectively recorded by members of the anaesthetic team, in each participating centre, and data were collected in a standardised manner, using the same definitions. The databases were previously used for research purposes.[1] However, the data published in 2015 were not used in the current work.[1] Pictures of an operating room of the Montpellier University Hospital and screenshots of some of the different items assessed in the data source are provided in Supplementary Figure S1. Several independent chart audits were performed within the hospital certification process and found adequate filling of the database. All French hospitals are certified, by surveyors, who are professionals practising in the hospital, appointed and trained by the Haute Autorité de Santé (HAS), (Art. L. 161–37 of the French Social Security Code and R. 161–74 of the French Social Security Code).[17] During a healthcare facility survey, surveyors assess the level of quality of care. They base their assessment on the certification standard containing 15 objectives broken down into criteria and a system audit is performed. The assessor first examines all components of the process. Then, the assessor meets with the management, the chairperson of the Medical Committee, the persons in charge of a specific unit, and user representatives. The third and last step consists of assessing, with the professionals, the degree of implementation of the process at ground level.[17]

Patients

We included all consecutive tracheal intubations performed in adult patients (≥18 yr old) in the operating room from March, 2017 to September, 2020. Exclusion criteria were tracheal intubations with a bronchoscope.

Quality improvement project

This quality improvement project was the step after a preceding quality improvement project previously reported[1] aiming to select a single Macintosh-style videolaryngoscope for all tracheal intubations performed in the operating room. In this previous study, the McGrath Mac (Medtronic Covidien, Minneapolis, MN, USA) showed superior performance to other Macintosh-style videolaryngoscopes, was associated with less

need to resort to a hyperangulated blade, and showed greater user-friendliness than other devices.[11] Based on this evaluation[11] and review of the literature, the airway committee of the Montpellier University Hospital judged that the McGrath Mac Macintosh-style videolaryngoscopy was the best candidate for the institutional conversion to universal videolaryngoscopy. The main reasons for this choice included the similarity to the standard Macintosh direct laryngoscope, the extra-curved blade for difficult procedures, and the inclusion of a screen separated from the laryngoscope blade.[11] These results led the Montpellier University Hospital to provide all operating rooms with a McGrath Mac.

The quality improvement project presented in the present study aimed to implement the use of videolaryngoscopy as a first-intention technique. The cohort was divided into three temporal cohorts: the pre-intervention period (18 months, from March 17, 2017 to September 17, 2018), implementation period (6 months, from September 18, 2018 to March 21, 2019), and post-intervention period (18 months from March 22, 2019 to September 22, 2020).

In the pre-intervention period, a standard Macintosh direct laryngoscope was available and routinely used as a first-intention device for first-attempt intubation in all operating rooms. A GlideScope® (Verathon, Bothell, WA, USA) videolaryngoscope was available and routinely used as a second-intention device only in case of difficult intubation.

In the implementation period, one videolaryngoscope (McGrath Mac, Medtronic Covidien, Minneapolis, MN, USA) was available in each operating room at both hospitals. The two hospitals were Saint-Eloi University Hospital (abdominal surgery, interventional radiology, digestive endoscopy) and Lapeyronie University Hospital (traumatology, orthopedy, urology). They are both in Montpellier (France), 2km apart, and have separate anaesthesiology staff. The operators had no or little experience with the device, and the videolaryngoscope was presented to all the operators performing intubation. In one hospital, the 'compliant hospital', two anaesthesiologists (YP and ADJ) strongly advised the operators to perform at least half of tracheal intubations with the videolaryngoscope. Briefly,[11] each day the entire team was taught to use the videolaryngoscope, first on manikins during a 2-week period, and then on patients during the implementation period. Two anaesthesiologists (YP, ADJ) were present daily to explain good practices when using a videolaryngoscope: explanation of the correct positioning, of the need to accept less good visualisation of the glottis in order to allow easier placement of the tracheal tube into the trachea, and advice to use a stylet in these unchannelled videolaryngoscopes.[18] A large space open to discussion was left to each operator, some of them raising drawbacks such as loss of expertise using the standard Macintosh direct laryngoscope, loss of student training using the standard Macintosh direct laryngoscope, need to learn a new technique, fear of change, cost of the blades, and battery life. These reluctant operators were reassured, using enablers such as diplomacy, possibility to intubate with a standard Macintosh direct laryngoscope (aim: one intubation out of two with a videolaryngoscope), training, and involvement of the whole team. The advantages of videolaryngoscopy were highlighted: improvement of glottis view, intubation under visual control, reduced haemodynamic consequences, ease in case of cervical trauma, in patients with morbid obesity, and decreased occurrence of oesophageal intubation and of difficult intubation.[19] Meanwhile, in the other hospital, called the 'non-compliant hospital' (Lapeyronie University Hospital, Montpellier, France), no specific teaching or incentive to use the Macintosh-style videolaryngoscope was done, and the choice of intubation device was left at the discretion of the operator.

During the post-intervention period, the videolaryngoscope was still available in all operating rooms of each hospital. In the compliant hospital, the videolaryngoscope was again strongly recommended to be used as a first-intention device. At least half of the daily intubation procedures were encouraged to be performed with the videolaryngoscope. Meanwhile, in the non-compliant hospital, use of videolaryngoscope was again left at the discretion of the operator, without any specific incentive to use it. This 'non-compliant' hospital was used as a control group as no specific training was provided despite the device being available.

Setting

As routinely observed in French teaching hospitals,[11] tracheal intubation was performed by an attending anaesthesiologist, a resident anaesthesiologist, or a certified registered nurse anaesthetist. During the study period, there was almost no change in operators who performed intubation.

The anaesthesia technique, including choice of drugs, size of blades, and use of adjuvant airway devices (e.g. stylet, bougie) was at the discretion of the operator.

The compliant hospital case mix was mostly represented by abdominal and transplant surgery and by gastrointestinal endoscopy whereas the non-compliant hospital case mix was mostly represented by orthopaedic, urologic, plastic, and traumatic surgery.[1,20]

Outcomes

'Difficult airway' was recently defined in the American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway.[4] We defined an 'easy airway', the opposite of 'difficult airway', as Cormack and Lehane grades of I or II (absence of difficult laryngoscopy), absence of difficult mask ventilation, and absence of need to resort to a rescue technique for intubation (absence of difficult intubation). The primary outcome measure was easy airway. As the inclusion of absence of difficult laryngoscopy in the primary outcome can be challenged, an alternative primary outcome was defined as the proportion of need to resort to a rescue technique or of operator-reported difficulty of intubation ('easy intubation').

Secondary endpoints were the need to resort to a rescue technique, Cormack and Lehane grades of III or IV (glottis not seen), and operator-reported difficulty of intubation.

Statistical analysis

Statistical analysis was performed using SAS software version 9.4 (SAS Institute, Cary, NC, USA) and R software version 3.0.2 (R Foundation for Statistical Computing, Vienna, Austria). A data analysis and statistical plan was written after the data were accessed.

Expecting a difference of the proportion of easy airway of 2% between pre-intervention and post-intervention periods

(from 94%[21] to 96%[22]), we calculated a sample size as 4262 per period (pre-intervention and post-intervention), using a χ^2 test, with an α level of 0.05 and a power of 0.85. We decided to include 4500 tracheal intubations per period (total of 9000 tracheal intubations) to compensate for dropouts and missing data and calculated that 18 months per period would allow inclusion of at least the required number of tracheal intubations.

Normally distributed quantitative data were described as mean and standard deviation (SD) and compared using Student's *t*-test. If not normally distributed, quantitative data were expressed as median and inter-quartile range and compared using the Mann–Whitney test. Qualitative data were expressed as number (percentage) and compared using the χ^2 square test.

Primary and secondary outcomes were compared in the compliant hospital between pre-intervention and post-intervention periods using the χ^2 square test. The difference of the primary outcome (the proportion of easy airway) between the pre-intervention and the post-intervention periods was computed with 95% confidence interval (CI). A mixed generalised regression model taking into account the proportions of easy airway by trimester was used to compare the easy airway (primary outcome) proportions between pre-intervention and post-intervention periods.[23]

Then, to take into account baseline characteristics differences between the pre-intervention and post-intervention periods, a multivariate logistic regression was performed to provide adjusted results of easy airway proportions (primary outcome), considering *a priori* that predicted difficult intubation, age, sex, body mass index, American Society of Anesthesiologists physical status, Major Adverse Cardiac Events (MACE)[24] risk and use of neuromuscular blocking agents would be confounding factors. These factors were entered into the multivariate model, and a final model including only significant variables was computed, with corresponding odds ratio (OR) and CI.[25]

To limit the risk of reporting outcome results related to natural evolution or chance, we also compared the same endpoints between pre-intervention and post-intervention periods in the non-compliant hospital.[20]

Two *post hoc* sensitivity analyses were performed: one sensitivity analysis assessing the proportions of resort to a rescue technique or of operator-reported difficulty of tracheal intubation as an alternative primary outcome, and one sensitivity analysis removing the COVID-19 period, from March, 2020 to September, 2020.

For the primary outcome, $P<0.05$ was considered significant. For the three secondary outcomes, Bonferroni correction was applied to preserve an overall false-positive proportion of $\alpha=0.05$.[26] $P<0.0125$ was considered significant.[27]

Results

Baseline characteristics

During the study period, a total of 26 692 tracheal intubations were performed among 22 292 patients in the operating rooms of the two hospitals: 11 891 during the pre-intervention period, 4250 during the implementation period, and 10 551 during the post-intervention period (Fig 1).

Demographic characteristics according to hospital and period (pre-intervention, implementation and post-intervention) are summarized in Table 1 and were clinically similar between pre-intervention and post-intervention periods.

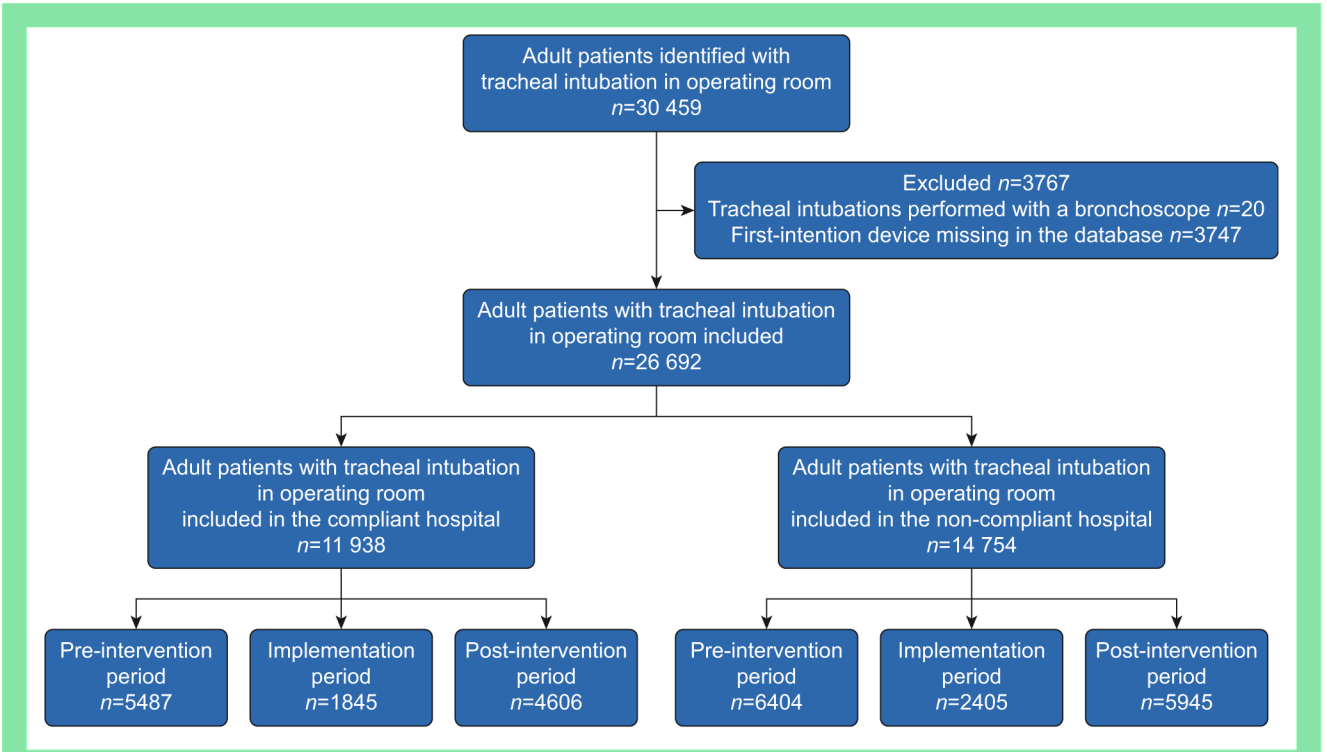

Fig 1. Flow chart of the study.

Table 1 Preoperative patient characteristics. *Tracheal intubation was predicted difficult if at least one of these criteria was present: Mallampati score ≥3, impaired mouth opening <35 mm, neck circumference >60 cm, thyro-mental distance <60 mm, retrognathia. MACE, major adverse cardiac event.

Parameter		Compliant hospital (*n*=11 938)				Non-compliant hospital (*n*=14 754)			
		Pre-intervention period (*n*=5487)	Implementation period (*n*=1845)	Post-intervention period (*n*=4606)	*P*-value	Pre-intervention period (*n*=6404)	Implementation period (*n*=2405)	Post-intervention period (*n*=5945)	*P*-value
Weight, median (inter-quartile range), kg		73 (62–87)	72 (61–87)	73 (62–86)	0.35	74 (63–85)	75 (64–85)	74 (63–85)	0.31
Height, median (inter-quartile range), cm		170 (163–175)	170 (163–175)	170 (162–175)	0.63	170 (163–176)	170 (162–176)	170 (162–176)	0.09
BMI, median (inter-quartile range), kg m^{-2}		25.2 (21.9–29.8)	25.1 (21.6–29.9)	25.2 (22.1–29.7)	0.46	25.3 (22.5–29.0)	25.9 (22.7–29.2)	25.4 (22.5–29.1)	0.13
Age, median (inter-quartile range), yr		60 (46–70)	61 (46–71)	61 (48–71)	<0.01	59 (43–71)	59 (44–71)	60 (42–72)	0.11
Sex, no. (%)	Female	2479 (45)	848 (46)	2055 (45)	0.61	2744 (43)	1141 (47)	2754 (46)	<0.01
ASA physical status no. (%)	I	740/4105 (18)	219/1260 (17)	503/3483 (14)	<0.01	1489/5096 (29)	509/1871 (27)	1328/4594 (29)	<0.01
	II	1957/4105 (48)	571/1260 (45)	1706/3483 (49)		2438/5096 (48)	1006/1871 (54)	2163/4594 (47)	
	III	1253/4105 (31)	438/1260 (35)	1161/3483 (33)		1058/5096 (21)	328/1871 (18)	1029/4594 (22)	
	IV	155/4105 (3)	32/1260 (3)	113/3483 (4)		111/5096 (2)	27/1871 (1)	73/4594 (2)	
Mallampati score, no. (%)	I	2218/3980 (56)	629/1213 (52)	1517/3203 (47)	<0.01	2194/4476 (49)	817/1676 (49)	2153/4106 (52)	0.12
	II	1332/3980 (33)	442/1213 (36)	953/3203 (30)		1641/4476 (37)	608/1676 (36)	1398/4106 (34)	
	III	332/3980 (8.3)	120/1213 (10)	311/3203 (10)		484/4476 (11)	187/1676 (11)	428/4106 (10)	
	IV	51/3980 (2)	12/1213 (1)	46/3203 (1)		110/4476 (2)	42/1676 (3)	86/4106 (2)	
	Not assessed	47/3980 (1)	10/1213 (1)	375/3203 (12)		47/4476 (1)	20/1676 (1)	42/4106 (1)	
Mouth opening, no. (%)	≥35 mm	3821/3998 (96)	1173/1221 (96)	2856/3266 (87)	<0.01	4477/4649 (96)	1676/1731 (97)	4033/4135 (98)	<0.01
	<35 mm	139/3998 (3)	42/1221 (3)	85/3266 (3)		153/4649 (3)	46/1731 (2)	84/4135 (2)	
	Not assessed	38/3998 (1)	7/1221 (1)	325/3266 (10)		19/4649 (1)	9/1731 (1)	18/4135 (1)	
Thyro-mental distance, no. (%)	≥60 mm	2024/2110 (96)	701/733 (95)	1784/1921 (93)	<0.01	3137/3410 (92)	1053/1171 (90)	2406/2801 (86)	<0.01
	<60 mm	86/2110 (4)	32/733 (5)	137/1921 (7)		273/3410 (8)	118/1171 (10)	395/2801 (14)	
Neck circumference, no. (%)	<40 cm	1661/1881 (88)	654/705 (93)	1521/1760 (86)	<0.01	2376/3184 (75)	807/1049 (77)	1992/2592 (77)	<0.01
	40–60 cm	197/1881 (11)	41/705 (6)	188/1760 (11)		737/3184 (23)	217/1049 (21)	501/2592 (19)	
	>60 cm	23/1881 (1)	10/705 (1)	51/1760 (3)		71/3184 (2)	25/1049 (2)	99/2592 (4)	
Retrognathia, no (%)		110/2499 (4)	35/852 (4)	57/1937 (3)	0.15	84/2698 (3)	23/976 (2)	53/2234 (2)	0.38
Predicted difficult intubation*, no. (%)		602 (11)	203 (11)	540 (12)	0.16	967 (15)	366 (15)	964 (16)	0.73
MACE risk, no. (%)	Minor	2768 (50)	924 (50)	2415 (52)	0.12	2221 (35)	748 (31)	2259 (38)	<0.01
	Intermediate	2309 (42)	782 (42)	1827 (40)		3169 (49)	1304 (54)	2809 (47)	
	Major	410 (8)	139 (8)	364 (8)		1014 (16)	353 (15)	877 (15)	

Table 2 Tracheal intubation characteristics.

Characteristic		Compliant hospital (*n*=11 938)				Non-compliant hospital (*n*=14 754)			
		Pre-intervention period (*n*=5487)	Implementation period (*n*=1845)	Post-intervention period (*n*=4606)	*P*-value	Pre-intervention period (*n*=6404)	Implementation period (*n*=2405)	Post-intervention period (*n*=5945)	*P*-value
First-intention device, no. (%)	Macintosh	5110 (93)	926 (50)	1500 (33)	<0.01	5838 (91)	2126 (88)	4853 (82)	<0.01
	McGrath	15 (0)	877 (48)	3050 (66)		2 (0)	39 (2)	346 (6)	
	GlideScope®	137 (3)	5 (0)	4 (0)		495 (8)	216 (9.0)	654 (11)	
	McGrath Xblade	0 (0.0)	12 (1)	10 (0)		0 (0.0)	1 (0)	24 (0)	
	Other	225 (4)	25 (1)	42 (1)		69 (1)	23 (1)	68 (1)	
Type of Macintosh blade, no. (%)	Metal	4968/5110 (97)	882/926 (95)	1426/1500 (95)	<0.01	1617/5838 (28)	541/2126 (25)	1309/4853 (27)	0.13
	Plastic	142/5110 (3)	44/926 (5)	74 (5)		4221/5838 (72)	1585/2126 (75)	3544/4853 (73)	
Rapid sequence induction, no. (%)		2127 (39)	769 (42)	2504 (54)	<0.01	452 (7)	300 (12)	906 (15)	<0.01
Night shift, no. (%)		571 (10)	171 (9)	503 (11)	0.15	767 (12)	228 (9.5)	619 (10)	<0.01
Stylet, no. (%)		696 (13)	391 (21)	1815 (39)	<0.01	184 (3)	70 (3)	333 (6)	<0.01
Neuromuscular blocking agents, no. (%)		3979 (73)	1350 (73)	3597 (78)	<0.01	2563 (40)	1361 (57)	3579 (60)	<0.01
Cricoid pressure, no. (%)		392 (7)	108 (6)	285 (6)	0.06	85 (1)	20 (1)	49 (1)	0.01

Tracheal intubation characteristics are summarised in Table 2. Use of rapid sequence induction, neuromuscular blocking agents, and stylet were more frequent in the post-intervention period than in the pre-intervention period (Table 2).

Use of the intubation devices

In the compliant hospital, whereas the videolaryngoscope was the first-intention device in only 15 of 5487 tracheal intubations (0.27%) in the pre-intervention period, its use as a first-intention device increased to 3050 of 4606 tracheal intubations (66%) in the post-intervention period (Table 2). Concomitantly, whereas the standard Macintosh direct laryngoscope was the first-intention device most widely used (5110 of 5487 tracheal intubations, 93%) in the pre-intervention period, its use as first-intention device decreased (1500 of 4606 tracheal intubations, 33%) in the post-intervention period (Table 2).

In the non-compliant hospital, the standard Macintosh direct laryngoscope was the first-intention device most used both in the pre-intervention period (5838 of 6404 tracheal intubations, 91%) and in the post-intervention period (4853 of 5945 tracheal intubations, 82%, Table 2).

Figure 2 presents videolaryngoscope use for first-attempt intubation in the compliant (Fig 2a) and in the non-compliant (Fig 2b) hospitals by trimester.

Primary outcome

In the compliant hospital, in comparison to the pre-intervention period, the proportions of easy airway significantly increased from 94.3% (5177 of 5487) to 98.7% (4547 of 4606) in the post-intervention period (+4.4% [95% CI 3.7−5.1%], *P*<0.001, Fig 3). Taking into account the proportions of easy airway by trimester (Fig 2a), the proportion of easy airway was still higher in the post-intervention period in comparison with the pre-intervention period (*P*<0.001).

After adjustment on predicted difficult intubation (OR=0.31 [95% CI 0.24−0.39] and age (OR=0.992 per year increase [95% CI 0.986−0.999]), being intubated in the post-intervention period was associated with easy airway (OR=4.79 [95% CI 3.61−6.35], Supplementary Table S1).

The sensitivity analysis regarding the proportions of need for a rescue technique or operator-reported difficulty of intubation (alternative primary outcome) showed lower proportions in the post-intervention period (87 of 4606, 1.9%) than in the pre-intervention period (296 of 5487, 5.3%, *P*<0.001, Supplementary Table S2) in the compliant hospital.

The sensitivity analysis performed after excluding patients included during the COVID-19 pandemic showed similar results. In the compliant hospital, in comparison to the pre-intervention period, the proportions of easy airway increased from 94.3% (5177 of 5487) to 98.4% (3185 of 3236) in the post-intervention period (+4.1%, *P*<0.001). Taking into account the proportions of easy airway by trimester, the proportion of easy airway was still higher in the post-intervention period in comparison with the pre-intervention period (*P*<0.001). After adjustment on predicted difficult intubation (OR=0.31 [95% CI 0.24−0.39]) and age (OR=0.992 per year increase [95% CI 0.986−0.998]), being intubated in the post-intervention period was associated with easy airway (OR=3.96 [95% CI 2.93−5.35]).

In the non-compliant hospital, no significant difference was noted in the proportions of easy airway, or need to resort to a rescue technique or operator-reported difficulty of

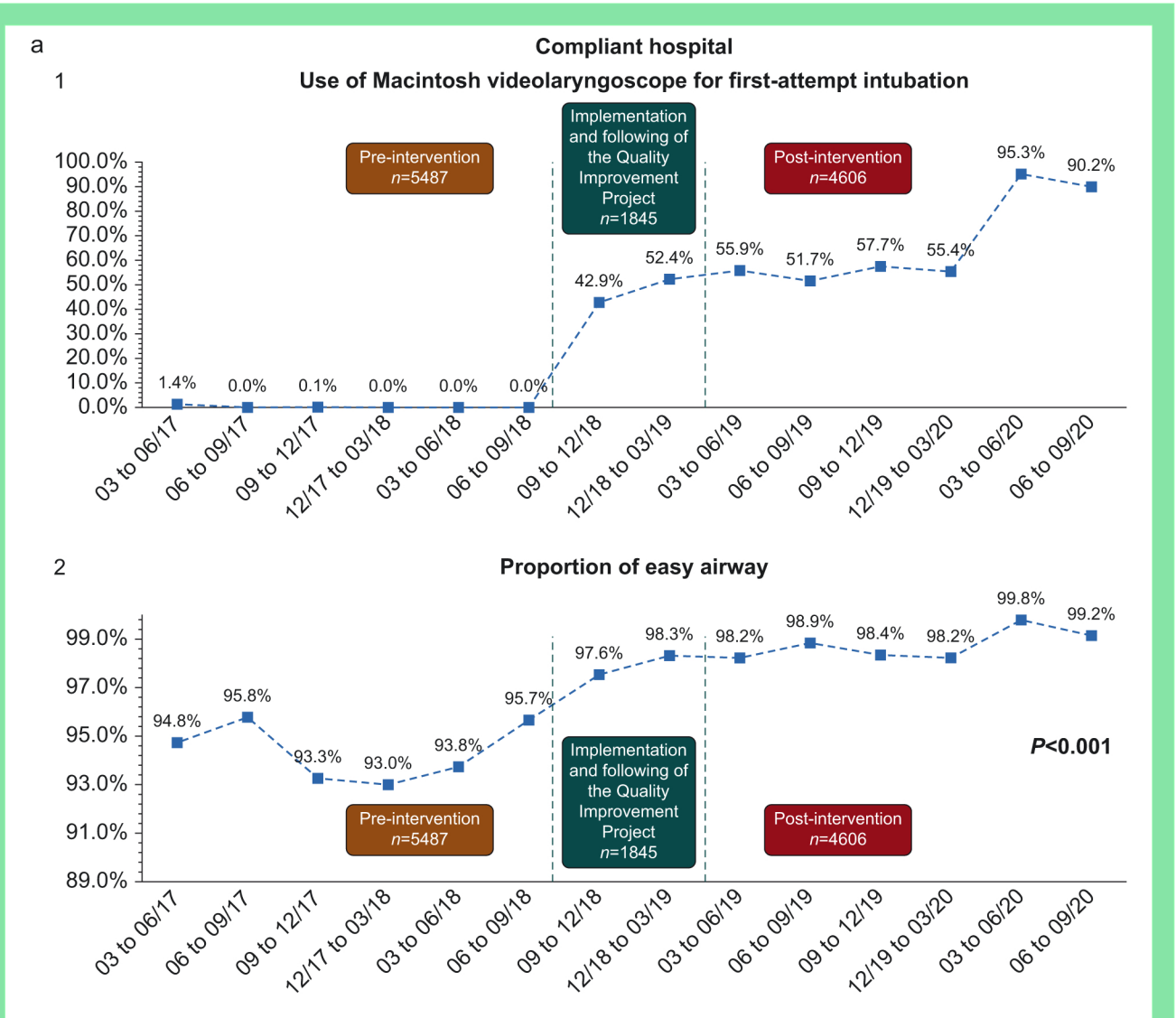

Fig 2. Videolaryngoscopy use for first-attempt intubation and proportion of easy airway by trimester and period in the compliant (a) and noncompliant (b) hospitals.

intubation, between the pre-intervention and post-intervention periods: −0.4% (95% CI −1.42 to 0.62, P=0.48), from 91.1% (5833 of 6404) to 90.7% (5393 of 5945), Figs 2b and 3, Supplementary Table S2.

Secondary outcomes

In the compliant hospital, the proportions of Cormack–Lehane grades of III or IV in the post-intervention period were lower (55 of 4560, 1.2%) than in the pre-intervention period (272 of 5314, 5.1%, P<0.001, Supplementary Table S3). The need to resort to a rescue technique was also reduced in the post-intervention period (32 of 4606, 0.7%) in comparison with the pre-intervention period (127 of 5487, 2.3%, P<0.001, Supplementary Table S2). Operator-reported difficulty of tracheal intubation was significantly lower in the post-intervention period (71 of 4606, 1.5%) than in the pre-intervention period (268 of 5487, 4.9%, P<0.001, Supplementary Table S3).

Meanwhile, no significant change was noted in the noncompliant hospital regarding all the secondary outcomes between pre- and post-intervention periods (Supplementary Tables S2 and S3).

Discussion

In this quality improvement project performed in 26 692 tracheal intubation procedures, implementation of a videolaryngoscope as a first-intention device for all tracheal intubation procedures performed in unselected patients in the operating room was associated with an increase in the proportion of easy airway/tracheal intubation.

In line with the increase in proportion of easy airway, implementation of videolaryngoscopy was associated with less frequent need to resort to a rescue technique, an improved glottis view, and reduced operator-reported difficulty of intubation.

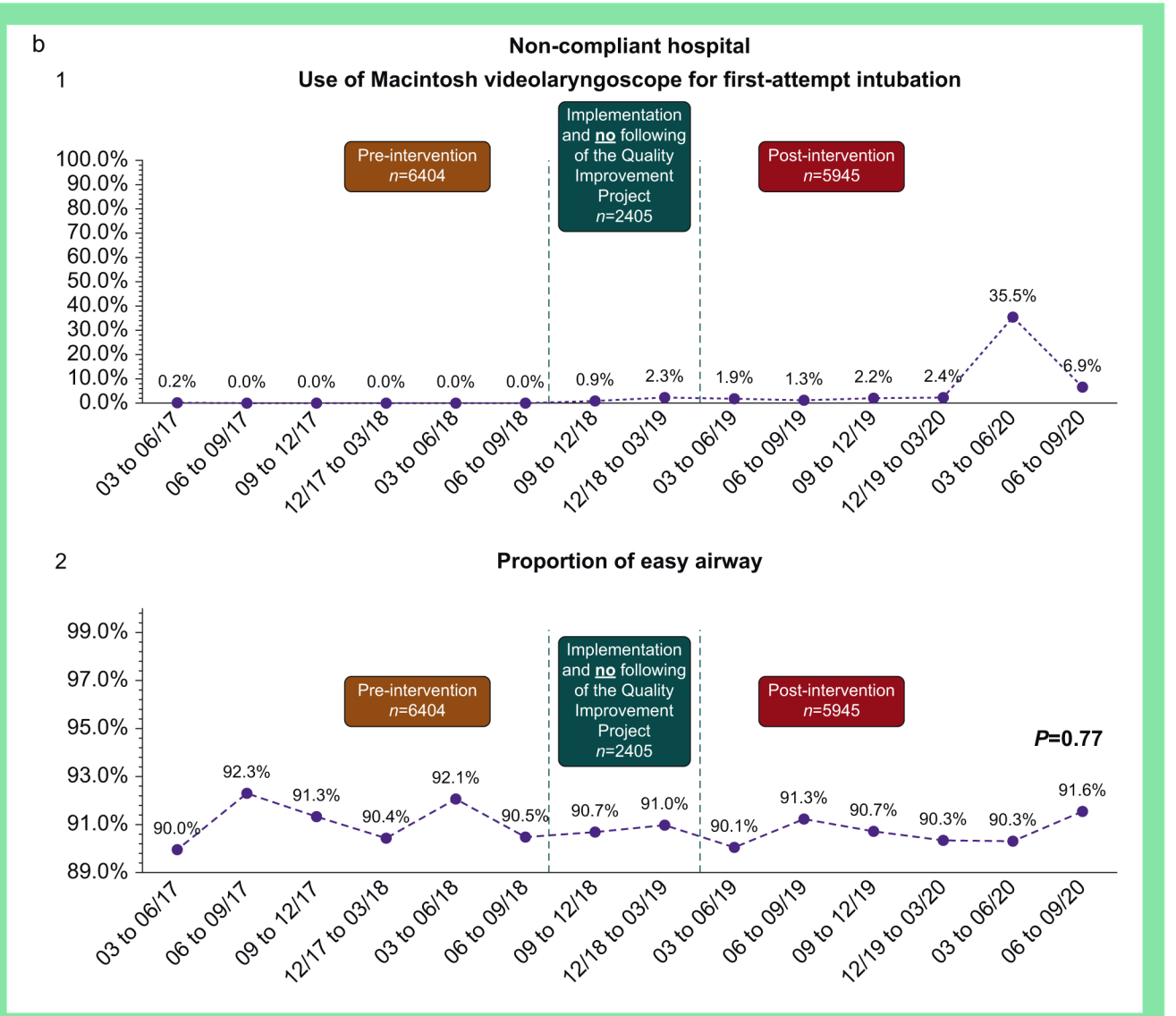

Fig 2. *(Continued)*.

No change in the proportion of easy airway, resort to a rescue technique, glottis view, or operator-reported difficulty of intubation was observed in the non-compliant hospital that did not implement videolaryngoscopy, despite assessment during the same periods.

A previous study determined the feasibility of conversion from direct laryngoscopy to videolaryngoscopy as a first-intention technique showed that a departmental conversion to universal videolaryngoscopy is perceived by operators to be beneficial to patient safety, team dynamics, human factors, quality of care, and quality of training.[12] Several authors have called for videolaryngoscopy to be used either as a first-intention approach or for all tracheal intubations,[11,12] but its use is currently much lower,[2] as shown in the compliant hospital before intervention and in the non-compliant hospital before and after intervention.

The COVID-19 pandemic has modified intubation practices in operating rooms and in ICUs. Videolaryngoscopes are now more widely used to limit the risk of contamination of operators.[13,15] As the COVID-19 pandemic has changed the nature of surgery, who performs intubation, and intubation practices such as use of neuromuscular blocking agents, we performed a sensitivity analysis excluding the period of COVID-19 from the post-intervention period. The results were consistent even after excluding this COVID-19 period. In this respect, the results of the present study, showing that implementation of videolaryngoscopy is feasible and efficient in routine daily clinical practice, should encourage hospitals to adopt the videolaryngoscope as a first-intention device. The period of inclusion in the present study included the beginning of the COVID-19 pandemic, from March, 2020 to September, 2020. Over the 6-month period after March, 2020 (COVID-19 pandemic period), use of a videolaryngoscope in the compliant hospital was almost complete (92%). Use of a videolaryngoscope in the non-compliant hospital reached a peak of 35.5% from March, 2020 to June, 2020 (first-wave of COVID-19 pandemic in France). It is worth noting that use of a neuromuscular blocking agent, stylet or rapid sequence induction increased in the post-intervention

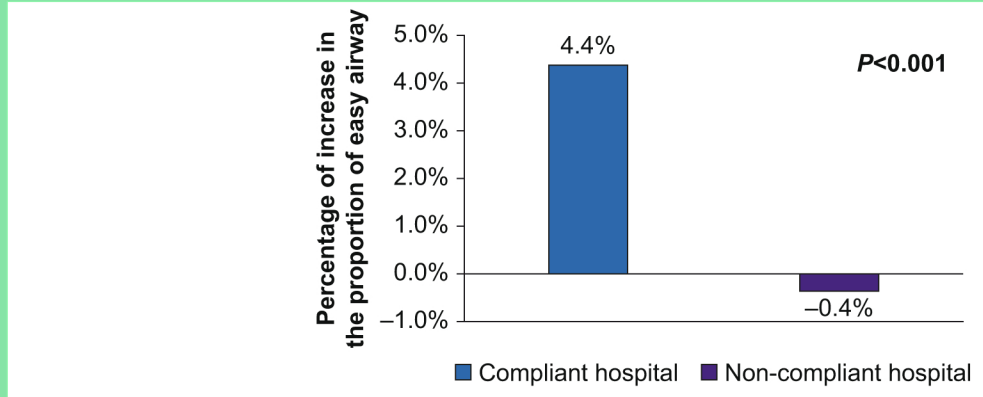

Fig 3. Easy airway proportion difference between post- and pre-intervention periods in the compliant and the non-compliant hospitals.

period in the compliant hospital. Since the beginning of the COVID-19 pandemic, rapid sequence induction with neuromuscular blocking agents has been strongly advised,[16] which can explain the increased proportions of these techniques. Regarding the increased usage of stylets, this can be explained by the higher proportion of use of a videolaryngoscope, which often requires use of a stylet.[18]

The increase observed in the proportion of easy airway was associated with reduced need to resort to rescue techniques, including use of a hyperangulated blade or a long intubating stylet. These results combined potentially reduce the occurrence of severe complications that can be associated with tracheal intubation such as death and brain damage.[27]

The present study has several strengths. First, we enrolled a large number of consecutive tracheal intubations (26 692) over a 3-yr period. Studies using the proportion of easy airway as their primary outcome measure require many subjects in each arm to effectively demonstrate superiority of one device over another.[19] This need for large numbers has led to several studies that used surrogates of intubation difficulty, such as time to intubation.[28] Similarly, studies have chosen to use manikins,[29] that do not reflect the upper airway anatomy of actual patients,[30] or a simulated difficult airway.[31] A myriad of inclusion criteria has led to some potentially conflicting results.[32] Another strength was the broad spectrum of operators (senior anaesthesiologists, juniors, nurse anaesthetists, student nurse anaesthetists), of time of intubation (night and day shifts), and of level of emergency (scheduled or emergency surgeries), allowing extrapolation of the results to all operators and operating room settings (Table 1). It is also worth noting that the studied periods and seasons were the same in the pre-intervention and post-intervention periods.

Some limitations can also be discussed. First, some data were lacking. However, they were clearly stated in all tables, and considered missing at random. Consequently, the complete case analysis was unbiased.[33] Second, the design was observational and not randomised. However, the assessment of a large sample size in a real-life setting with a real-life control group also has strengths. There is a well-known discrepancy between trials demonstrating efficacy (the intervention works in clinical trials under optimum conditions) and studies assessing effectiveness (the intervention works in the real world).[11] Further studies on medico-economic aspects are needed to assess the relative cost-effectiveness of the implementation of videolaryngoscopy for first-attempt intubation. Third, the data regarding work-acquired COVID-19 among airway managers in the compliant and non-compliant hospitals were not recorded. Further studies are needed to termine whether videolaryngoscopy protects airway managers against COVID-19 contamination. Fourth, as we did not record the operators in the database, we cannot provide the relative proportions of uptake of laryngoscopy for the different staff groups, such as trainees and younger physicians. Fifth, even if the surgical specialties differed between compliant and non-compliant hospitals, this was probably not a confounding factor, as neither of the studied hospitals performed neck and face surgery. Moreover, the patients were older in the compliant hospital than in the non-compliant hospital, and risk factors for difficult intubation did not clinically differ between hospitals.

To conclude, this study showed that using videolaryngoscopy for first-attempt intubation allowed improvement in the proportion of easy airway management compared with usual care with the standard Macintosh direct laryngoscope. In line with the increase in the proportion of easy airway, surrogates of success of tracheal intubation such as Cormack–Lehane grades, need for a rescue technique, and operator-reported difficulty of intubation were also improved by using videolaryngoscope as a first-intention device. These results could have major implications in clinical practice and have the potential to change the first-intention intubation practices worldwide.

Authors' contributions

Analysis of the data: ADJ, TS, YP, SJ
Drafting the submitted article: all authors
Provide final approval of the version to be published: all authors
Conception and design of the study: TS, GC, SJ
Acquisition of the data: TS, JP, AR, SJ

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Declarations of interest

SJ reports receiving consulting fees from Drager, Medtronic, Fresenius, Baxter, and Fisher & Paykel. ADJ reports receiving consulting fees from Medtronic. All other authors declare that they have no conflicts of interest.

References

1. De Jong A, Molinari N, Pouzeratte Y, et al. Difficult intubation in obese patients: incidence, risk factors, and complications in the operating theatre and in intensive care units. *Br J Anaesth* 2015; **114**: 297–306
2. Cook TM, Kelly FE. A national survey of videolaryngoscopy in the United Kingdom. *Br J Anaesth* 2017; **118**: 593–600
3. Frerk C, Mitchell VS, McNarry AF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth* 2015; **115**: 827–48
4. Apfelbaum JL, Hagberg CA, Connis RT, et al. 2022 American society of Anesthesiologists practice guidelines for management of the difficult airway. *Anesthesiology* 2022; **136**: 31–81
5. Cook F, Lobo D, Martin M, et al. Prospective validation of a new airway management algorithm and predictive features of intubation difficulty. *Br J Anaesth* 2019; **122**: 245–54
6. Schiff JH, Welker A, Fohr B, et al. Major incidents and complications in otherwise healthy patients undergoing elective procedures: results based on 1.37 million anaesthetic procedures. *Br J Anaesth* 2014; **113**: 109–21
7. Joffe AM, Aziz MF, Posner KL, Duggan LV, Mincer SL, Domino KB. Management of difficult tracheal intubation: a closed claims analysis. *Anesthesiology* 2019; **131**: 818–29
8. De Jong A, Molinari N, Terzi N, et al. Early identification of patients at risk for difficult intubation in ICU: development and validation of the MACOCHA score in a multicenter cohort study. *Am J Respir Crit Care Med* 2013; **187**: 832–9
9. Langeron O, Bourgain JL, Francon D, et al. Difficult intubation and extubation in adult anaesthesia. *Anaesth Crit Care Pain Med* 2018; **37**: 639–51
10. Nørskov AK, Rosenstock CV, Wetterslev J, Astrup G, Afshari A, Lundstrøm LH. Diagnostic accuracy of anaesthesiologists' prediction of difficult airway management in daily clinical practice: a cohort study of 188 064 patients registered in the Danish Anaesthesia Database. *Anaesthesia* 2015; **70**: 272–81
11. De Jong A, Pouzeratte Y, Laplace A, et al. Macintosh videolaryngoscope for intubation in the operating room: a comparative quality improvement project. *Anesth Analg* 2021; **132**: 524–35
12. Cook TM, Boniface NJ, Seller C, et al. Universal videolaryngoscopy: a structured approach to conversion to videolaryngoscopy for all intubations in an anaesthetic and intensive care department. *Br J Anaesth* 2018; **120**: 173–80
13. De Jong A, Pardo E, Rolle A, Bodin-Lario S, Pouzeratte Y, Jaber S. Airway management for COVID-19: a move towards universal videolaryngoscope? *Lancet Respir Med* 2020; **8**: 555
14. El-Boghdadly K, Wong DJN, Owen R, et al. Risks to healthcare workers following tracheal intubation of patients with COVID-19: a prospective international multicentre cohort study. *Anaesthesia* 2020; **75**: 1437–47
15. Patwa A, Shah A, Garg R, et al. All India difficult airway association (AIDAA) consensus guidelines for airway management in the operating room during the COVID-19 pandemic. *Indian J Anaesth* 2020; **64**: S107–15
16. Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19: guidelines from the difficult airway society, the association of anaesthetists the intensive care society, the faculty of intensive care medicine and the royal college of anaesthetists. *Anaesthesia* 2020; **75**: 785–99
17. *Certification of hospitals for the quality of care* 2020. Available from: https://www.has-sante.fr/upload/docs/application/pdf/2021-06/manual_has_-_certification_of_hospitals_for_the_quality_of_care_-.pdf. [Accessed 24 February 2021]
18. Tsunoda N, Asai T. A double-curved tube for McGrath® MAC videolaryngoscope-guided tracheal intubation. *Br J Anaesth* 2022; **128**: e14. –e6
19. McNarry AF, Patel A. The evolution of airway management - new concepts and conflicts with traditional practice. *Br J Anaesth* 2017; **119**: i154. –i66
20. Jung B, Daurat A, De Jong A, et al. Rapid response team and hospital mortality in hospitalized patients. *Intensive Care Med* 2016; **42**: 494–504
21. Taboada M, Doldan P, Calvo A, et al. Comparison of tracheal intubation conditions in operating room and intensive care unit: a prospective, observational study. *Anesthesiology* 2018; **129**: 321–8
22. Aziz MF, Abrons RO, Cattano D, et al. First-attempt intubation success of video laryngoscopy in patients with anticipated difficult direct laryngoscopy: a multicenter randomized controlled trial comparing the C-MAC D-Blade versus the GlideScope in a mixed provider and diverse patient population. *Anesth Analg* 2016; **122**: 740–50
23. Tuerlinckx F, Rijmen F, Verbeke G, De Boeck P. Statistical inference in generalized linear mixed models: a review. *Br J Math Stat Psychol* 2006; **59**: 225–55
24. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. *J Am Coll Cardiol* 2014; **64**: e77–137
25. Jaber S, Rollé A, Godet T, et al. Effect of the use of an endotracheal tube and stylet versus an endotracheal tube alone on first-attempt intubation success: a multicentre, randomised clinical trial in 999 patients. *Intensive Care Med* 2021; **47**: 653–64
26. Sedgwick P. Multiple significance tests: the Bonferroni correction. *BMJ* 2012; **344**: e509
27. Schulz CM, Burden A, Posner KL, et al. Frequency and type of situational awareness errors contributing to death and brain damage: a closed claims analysis. *Anesthesiology* 2017; **127**: 326–37
28. Ander F, Magnuson A, Berggren L, Ahlstrand R, de Leon A. Time-to-intubation in obese patients. A randomized study comparing direct laryngoscopy and videolaryngoscopy in experienced anesthetists. *Minerva Anestesiol* 2017; **83**: 906–13

29. Carassiti M, Zanzonico R, Cecchini S, Silvestri S, Cataldo R, Agrò FE. Force and pressure distribution using Macintosh and GlideScope laryngoscopes in normal and difficult airways: a manikin study. *Br J Anaesth* 2012; **108**: 146–51
30. Schebesta K, Hüpfl M, Rössler B, Ringl H, Müller MP, Kimberger O. Degrees of reality: airway anatomy of high-fidelity human patient simulators and airway trainers. *Anesthesiology* 2012; **116**: 1204–9
31. Kleine-Brueggeney M, Greif R, Schoettker P, Savoldelli GL, Nabecker S, Theiler LG. Evaluation of six videolaryngoscopes in 720 patients with a simulated difficult airway: a multicentre randomized controlled trial. *Br J Anaesth* 2016; **116**: 670–9
32. Lewis SR, Butler AR, Parker J, Cook TM, Schofield-Robinson OJ, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation: a Cochrane Systematic Review. *Br J Anaesth* 2017; **119**: 369–83
33. Vesin A, Azoulay E, Ruckly S, et al. Reporting and handling missing values in clinical studies in intensive care units. *Intensive Care Med* 2013; **39**: 1396–404