

Analysis of orotracheal intubation techniques in the intensive care unit

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Airway management skills are primarily taught in controlled environments, such as simulation laboratories or operating theatres, where multiple airway tools are readily available if conventional direct laryngoscopy (cDL) is difficult.¹⁻³ Furthermore, assessment of the patient's airway is carefully evaluated before elective orotracheal intubation, so difficulties in cDL can be anticipated and appropriate measures taken.⁴⁻⁶ Outside the operating theatre, the urgency for immediate airway management often precludes this important airway evaluation, making cDL more difficult and increasing the risk of morbidity and mortality.⁷ Recently, studies have focused on the difficulty associated with cDL outside operating theatres, such as in the intensive care unit, where multiple airway tools may not be readily available.^{7,8}

In 2003, Cooper reported the clinical use of a new videolaryngoscope for a patient who had repeatedly been difficult or impossible to intubate by cDL.⁹ Following induction of general anaesthesia, laryngoscopy was performed using a GlideScope (GS) (Verathon, Bothell, Wash, USA), which provided complete glottic exposure and an easy endotracheal tube intubation of the trachea.⁹

Since Cooper's sentinel report, additional studies have compared the use of a GS with cDL; however, many of these studies were conducted in simulation laboratories or in operating theatres, comprising small groups of patients with difficult airways.¹⁰⁻²⁰ In a non-surgical setting, Wong and Ng reported a difficult airway incidence of 4% and a mean number of attempts at orotracheal intubation of 3.6 in these airways.²¹ In this study, the use of a GS was noted, but the frequency of its use was less than 1%.²¹ Moreover, the need for anaesthetists to rescue the airway was around 23% in this setting. These authors concluded that for the non-operating physician, use of a bougie or other advanced airway tools following repeated attempts at orotracheal intubation was recommended.²¹

In two studies conducted in operating theatres, GS provided a laryngoscopic view equal to or better than the view obtained with cDL, and both studies suggested that GS may have potential advantages over cDL for difficult intubations, but further clinical studies were warranted.^{14,15}

This research was presented in abstract form at the 6th Annual Research Night, Ochsner Medical Center, New Orleans, La, USA, in May 2009.

ABSTRACT

Background: The development of specialised airway tools help laryngoscopists secure the airway in intensive care units. The use of videolaryngoscopy has been suggested in simulation studies, and human studies suggest that this advanced airway tool may have an advantage for difficult airways; however, less is known about its use in the ICU.

Objective: To compare orotracheal intubation before and after acquisition of an ICU-dedicated GlideScope (GS), and to determine the incidence of complications with orotracheal intubation in an ICU.

Methods: An observational study was conducted from October 2008 to April 2009 to record the use of advanced airway tools including videolaryngoscopy before ("pre-GS") and immediately after ("post-GS") the purchase of an ICU-dedicated videolaryngoscope. Reasons for intubation, response time, type of intubation, number of attempts at intubation, reasons for delays in intubation, risk factors for difficult intubation and complications were compared between these groups.

Results: 56 patients were intubated pre-GS and 47 post-GS. Although a significant increase in videolaryngoscopy was observed in the ICU ($P=0.001$), no significant reduction in total attempts at orotracheal intubation were observed ($P=0.66$), and that the incidence of overall complications were not reduced ($P=0.21$).

Conclusions: The use of a new airway tool may not necessarily lead to immediate reduction in attempts at orotracheal intubation or in overall complication rates.

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As a recent study suggested that the use of a GS improved orotracheal intubation with a 97% success rate with one attempt,²² the a-priori aim of our study was to compare orotracheal intubation before and after acquisition of an ICU-dedicated GS at Ochsner Medical Center, a tertiary hospital in New Orleans. We also sought to determine the incidence of complications with orotracheal intubation in an ICU.

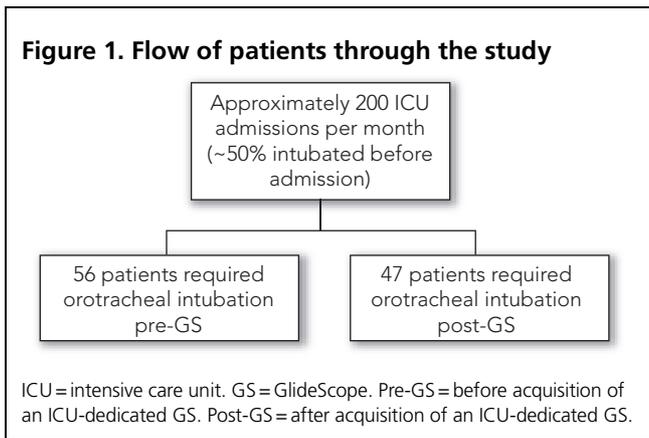


Table 1. Telecommunication data (P=0.6)

	SpectraLink phone	Pager	Senior anaesthetist present	Total
Pre-GS	29	15	11	55
Post-GS	24	9	12	45
Total	53	24	23	100

ICU = intensive care unit. GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS.

Methods

Following approval from the Ochsner Institutional Review Board, we evaluated orotracheal intubations performed in our institution’s ICU over a 7-month interval, October 2008 – April 2009, before (“pre-GS”) and after (“post-GS”) acquisition of an ICU-dedicated GS (GlideScope Cobalt, Verathon). This ICU is a mixed unit that admits both surgical and medical patients, about 200 patients per month. The study was developed and introduced to the ICU in both formal and informal meetings.

Orotracheal intubations in the ICU were classified as “elective”, “emergency”, or “CPR” (cardiopulmonary resuscitation). After each orotracheal intubation, the charge nurse overseeing the procedure, or the patient care nurse involved, completed an on-site 11-question survey describing the procedure in detail (Appendix 1). The survey form was attached to all airway trays in the ICU. There were no restrictions placed on the laryngoscopists with regard to medications used and/or selection of airway tools used for orotracheal intubation. Laryngoscopists included anaesthesia residents and staff, medical and surgical residents, and ICU fellows and staff. There were no patient exclusion criteria.

Anaesthesia residents were called to provide airway management via a hospital-dedicated mobile phone (SpectraLink, Polycom, Pleasanton, Calif, USA), pager, or

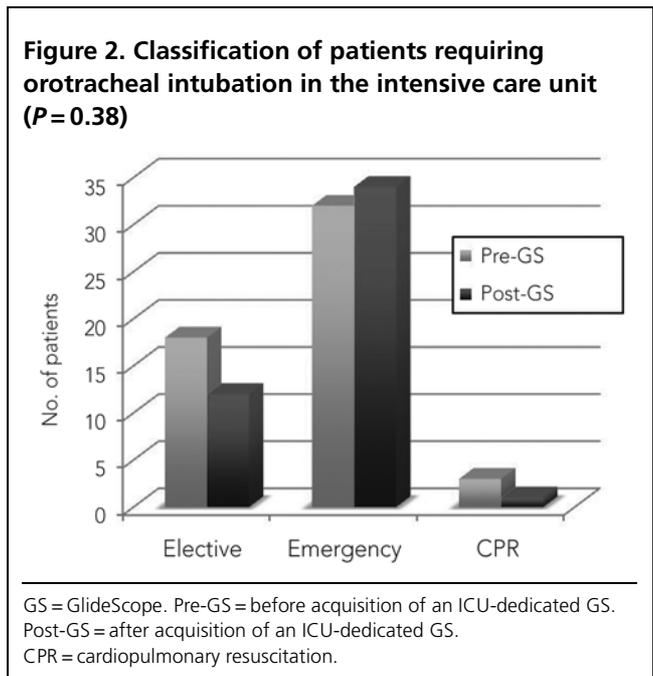


Table 2. Response-time intervals for patients in the intensive care unit requiring orotracheal intubation (P=0.06)

	< 5 min	5–10 min	> 10 min
Pre-GS*	41/54 (76%)	11/54 (20%)	2/54 (4%)
Post-GS†	42/46 (91%)	4/46 (9%)	0

GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS. * Data were missing for two patients. † Data were missing for one patient.

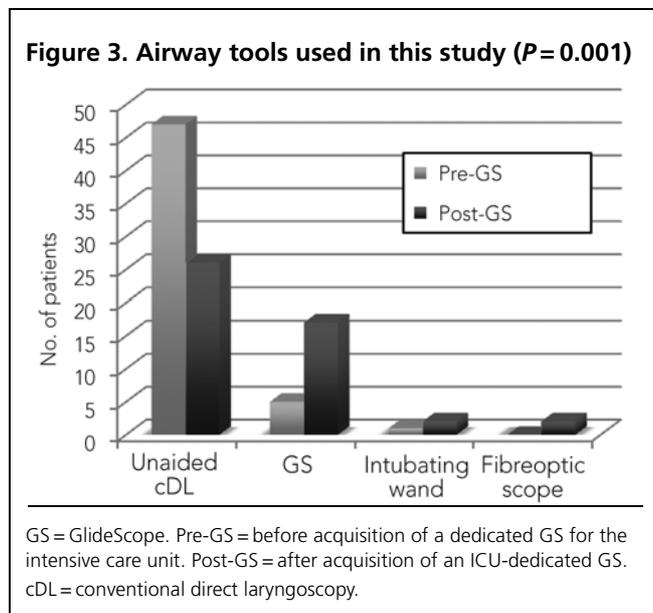
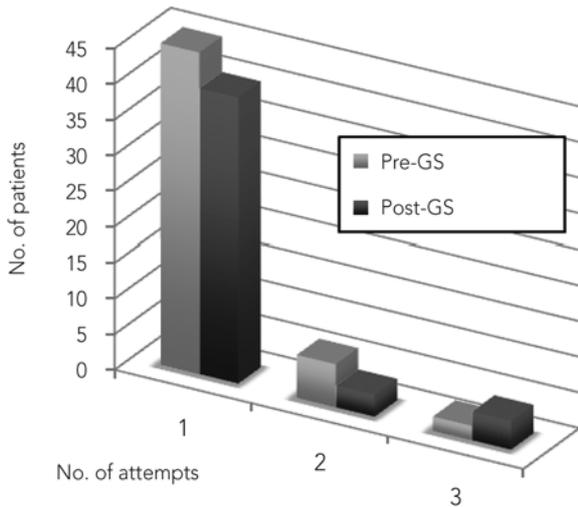
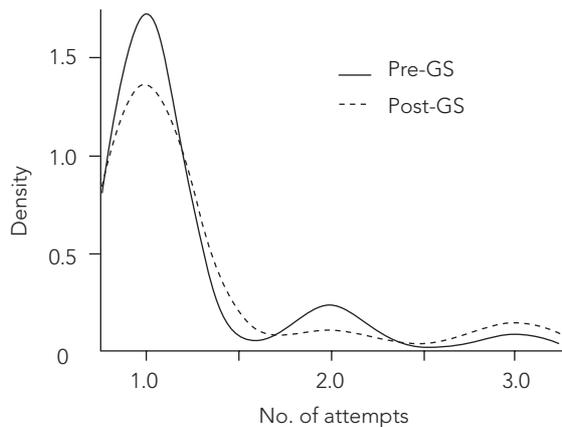


Figure 4. Number of attempts at orotracheal intubation and density estimates

A. Number of attempts at orotracheal intubation in the intensive care unit ($P=0.44$)



B. Density estimates for each group are plotted against the number of attempts at orotracheal intubation ($P=0.66$)



GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS.

overhead page. The response-time intervals for airway management with these telecommunications methods were compared in this study and categorised into <5 minute, 5–10 minute, and >10 minute intervals. Other data recorded in the survey included number of attempts at orotracheal intubation, delays in orotracheal intubation and reasons, patient risk factors for difficult intubation, method of orotracheal intubation used for patients with risk factors, and complications of orotracheal intubation.

Sample size calculation and statistical analysis

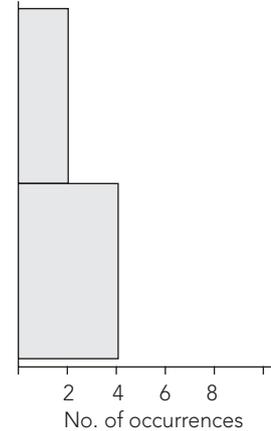
Sample size calculations for a 66% decrease in 3.6 attempts at orotracheal intubation in a non-surgical set-

Figure 5. Delays in orotracheal intubation in the intensive care unit ($P=0.04$)

Pre-GS

Waiting for personnel to arrive (ICU nurses, respiratory therapists, anaesthesia resident, back-up anaesthesia staff)

Waiting for back-up equipment (LMA, fibreoptic, GS, TubeExchanger)

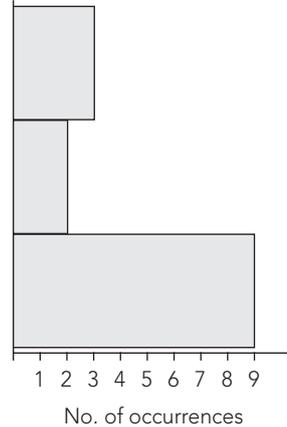


Post-GS

Non-functioning tools (suction, pulse-oximeter, ventilator, bag-valve mask, blade, handles, IV equipment)

Waiting for personnel to arrive (ICU nurses, respiratory therapists, anaesthesia resident, back-up anaesthesia staff)

Waiting for back-up equipment (LMA, fibreoptic, GS, TubeExchanger)



GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS. LMA = laryngeal mask airway. IV = intravenous.

ting would require a minimum of 78 patients with an α of 0.05, and a power of 0.8.²¹ All statistical analyses were performed with JMP®, version 8.0.2 (SAS Institute, Cary, NC, USA). Categorical data were analysed using χ^2 tests, Likelihood ratios, and density estimates. Statistically significant differences and outcomes were determined as a $P < 0.05$.

Results

Our study evaluated 103 orotracheal intubations performed in the ICU over a 7-month period. Orotracheal intubations were performed in 56 patients pre-GS, and in 47 patients post-GS (Figure 1).

The urgency of airway failure is shown in Figure 2. There were no significant differences observed in the classification of orotracheal intubations pre-GS and post-GS ($P=0.38$).

Table 3. Staff back-up against attempts at orotracheal intubation in the intensive care unit ($P=0.002$)

Back-up staff present	Number of attempts at orotracheal intubation		
	1	2	3
No	66/86 (77%)	3/8	2/5
Yes	20/86 (23%)	5/8	3/5

Data on telecommunications with anaesthesia residents are shown in Table 1; there were no statistically differences between the two examination periods ($P=0.6$).

Response-time intervals for airway management are shown in Table 2. Under 5-minute response times were greater than 75% pre-GS, and greater than 91% post-GS (Table 2). Although there were no significant differences in response-time intervals in the two examination periods ($P=0.06$), an improvement in response times in all intervals were observed post-GS.

The incidence of use of different airway tools is shown in Figure 3. There were highly significant changes observed in these categories ($P=0.001$). Specifically, there was over a 50% reduction in cDL post-GS, and nearly a threefold increase in use of the GS (Figure 3). Interestingly, a small increase in use of the intubation wand and the fiberoptic scope were observed in the post-GS group (Figure 3).

The number of attempts at orotracheal intubation pre-GS and post-GS is shown in Figure 4A. When the data were analysed for density estimates (Figure 4B), there was no significant improvement in the success rates (lower number of attempts) in orotracheal intubation post-GS compared with pre-GS ($P=0.66$).

In 49/56 patients in the pre-GS group and 33/47 patients of the post-GS group, no delays in orotracheal intubation were reported (data not shown). Reasons for delay in orotracheal intubation among the remaining patients are shown in Figure 5. There were seven reported delays in the pre-GS group and 14 reported delays in the post-GS group; this difference is statistically significant and more impor-

tantly, is clinically relevant ($P=0.04$). Surprisingly, the largest increase in delay in orotracheal intubation was due to the non-availability of the specialised stylet or the disposable intubation sheath that are required for this model of the GS.

Although a formal upper airway examination cannot be ethically conducted in the ICU under urgent patient care conditions, laryngoscopists begin to develop a gestalt for the potential in difficulty of airway management in patients. The role of this gestalt and the number of attempts at orotracheal intubation are shown in Table 3 — there was a significant increase in the presence of more senior laryngoscopists (senior anaesthesia residents or anaesthesia staff) as back-up for patients who eventually required an increased number of attempts at orotracheal intubation; these findings are highly significant ($P=0.002$).

In 38/56 patients in the pre-GS group and in 26/47 patients in the post-GS group, risk factors for difficult intubation were not observed (data not shown). The factors observed in the remaining patients are shown in Table 4 (18 pre-GS; 21 post-GS). The difference in total reported conditions is not statistically significant ($P=0.15$).

The methods of orotracheal intubation used for these patients are shown in Table 5. In the pre-GS group, among patients with morbid obesity, orotracheal intubation was achieved with cDL (5/8) with a GS (2/8), and with the use of the intubating wand in the remaining patient. In patients with a full stomach, orotracheal intubation was achieved with cDL in all eight patients. In patients with a history of previous difficult intubation, two patients were intubated with a GS (Table 5). In the post-GS group, use of GS increased among patients with morbid obesity (7/11) and patients with cervical spine (C-spine) precautions (3/3), but was unchanged among patients with a history of previous difficult intubation (1/2) (Table 5). However, the latter two conditions were underpopulated for effective comparisons, as all patients with C-spine precautions were reported following acquisition of the ICU-dedicated GS (Table 5). Interestingly, even post-GS, none of the five patients with reported full stomachs underwent GS-assisted orotracheal intubation, but were intubated using cDL or an intubating wand (Table 5).

Complications from orotracheal intubation are shown in Table 6. There was no significant difference in complication rates between groups ($P=0.21$). In total, 14 complications occurred in the pre-GS group and 12 in the post-GS group ($P=0.21$) (Table 6).

Finally, the survey prompted the respondents with "How could the intubation be more safe, more efficient, or less traumatic for the

Table 4. Reported clinical risk factors for difficult intubation in the intensive care unit ($P=0.15$)

	None	Morbid obesity	Full stomach	Prior difficult intubation	C-spine precautions
Pre-GS	38 (68%)	8 (14%)	8 (14%)	2 (4%)	0
Post-GS	26 (55%)	11 (23%)	5 (11%)	2 (4%)	3 (6%)

GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS. C-spine = cervical spine.

patient?" (Appendix 1). Written responses included observations of the skill experience of the laryngoscopists, the need for point-of-care medications, and the need for all of the GS components (disposable laryngoscope shield and specialised stylets) to be immediately available.

Discussion

Difficult orotracheal intubation is defined as tracheal intubation requiring "multiple intubation attempts by one laryngoscopist in the presence or absence of tracheal pathological features".²³ The definition of difficult orotracheal intubation is, however, complicated because of the potential variations in the expertise of the laryngoscopist, the equipment at the patient's bedside, and the number of attempts. Nevertheless, Mort found that with over two attempts at intubation, complication rates rose dramatically.⁸ We found that attempts at orotracheal intubation were successful with one attempt among 85% of patients, in two attempts among 9% of patients, and in three attempts among the remaining 6% of patients, and that these findings are comparable to other non-operating

theatre studies.^{24,25} There was 100% orotracheal intubation — no surgical airways were required. The need for advanced airway tools other than equipment for cDL may also define success in attempts at orotracheal intubation.²⁶⁻³¹ In our study, advanced airway tools were used in 27% of the patients, and our results are comparable with the findings in other studies.^{29,31,32}

The introduction of the GS as reported by Cooper,⁹ and a subsequent report in over 700 patients,²⁰ suggested that successful orotracheal intubation with the GS was achieved even when cDL was predicted to be moderately or considerably difficult. In another study of over 100 patients in an operating theatre setting, successful orotracheal intubation was achieved with the first attempt in 99% of patients.³³ In contrast, we did not observe a decrease in number of attempts once the ICU-dedicated GS was obtained. The reasons for this difference are unclear and may be due to the patient population of the ICU when compared with patients in the operating theatre. Proper positioning of the airway axis is more difficult in the ICU when compared to the operating theatre.³⁴ The upper airway in the ICU may be more oedematous due to recent insertion of an endotracheal tube and/or recent history of previous airway instrumentation.³⁴ The need to minimise movement of the airway axis in a potentially unstable cervical spine adds to the difficulty of cDL.³⁵ Finally, in the ICU patient, the urgency of medical conditions, when compared with patients in the operating theatre, may allow only a short period of time to secure the airway if significant hypoxaemia, hypercarbia, or haemodynamic instability are to be avoided.³⁴ Nevertheless, the addition of an ICU-dedicated GS did not decrease the number of attempts in orotracheal intubation or the overall incidence of complications.

The use of videolaryngoscopy in difficult airways has been examined in simulation studies, and in human studies

Table 5. Risk factors for difficult intubation and advanced airway tools used in the intensive care unit (P = 0.13)

		cDL	GS	Intubating wand	Fibreoptic scope
Morbid obesity	Pre-GS	5	2	1	0
	Post-GS	3	7	0	1
Full stomach	Pre-GS	8	0	0	0
	Post-GS	4	0	1	0
Prior difficult intubation	Pre-GS	0	2	0	0
	Post-GS	0	1	0	1
C-spine precautions	Pre-GS	0	0	0	0
	Post-GS	0	3	0	0
None of the above	Pre-GS	36	2	0	0
	Post-GS	19	6	1	0

GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS. cDL = conventional direct laryngoscopy. C-spine = cervical spine.

Table 6. Reported complications from orotracheal intubation in the intensive care unit (P = 0.21)

	None	Traumatic (blood present)	Oesophageal intubation	Emesis	Other*	Endobronchial intubation	All
Pre-GS	42	2	3	1	8	0	56
Post-GS	35	5	0	1	5	1	47
Total	77	7	3	2	13	1	103

GS = GlideScope. Pre-GS = before acquisition of an ICU-dedicated GS. Post-GS = after acquisition of an ICU-dedicated GS. * Complications of bradycardia, increased secretions, aspiration before orotracheal intubation, and endotracheal tube rupture.

that included small groups of patients with real histories of difficult airway or when difficult airways were artificially produced in patients.¹⁰⁻²⁰ These studies postulated that the use of videolaryngoscopy is advantageous in these settings.¹⁰⁻²⁰ In one study comparing the use of videolaryngoscopy with cDL (Macintosh blade) in anticipated difficult airways, Stroumpoulis and colleagues were able to improve the success of orotracheal intubation to over 98%, with 90% of successful intubation occurring with the first attempt.³⁶ Moreover, in the report by Serocki and colleagues, although the use of the GS improved the glottic view of patients with predicted difficult airways, orotracheal intubation failed in four cases that although not reported, suggested that multiple attempts to secure the airway were performed.³⁷ However, in our study, with a significant increase in GS use in the ICU, no significant reduction in attempts at orotracheal intubation were observed, and our results are in agreement with other studies.³⁸ Although use of the GS improves the glottic view of the trachea,^{36,37} the laryngoscopists in our institution reported difficulties during placement of the orotracheal tube and these observations are similar to those reports by Lim and Goh, who also observed difficulties in angulating the endotracheal tube for proper insertion through the glottis.³⁸ In contrast to other success rates of orotracheal intubation with the GS, we were able to obtain 100% orotracheal intubation with the GS.^{36,37}

Limitations of this study include the small size of the control group. However, delaying the introduction of the GS to obtain a larger number of control patients would not be ethical. Moreover, a randomised controlled trial would not be ethical in this clinical setting, as laryngoscopists should be allowed unrestricted access to a variety of advanced airway tools to facilitate orotracheal intubation. A second limitation is the lack of individual comparisons of complications in both groups — again, a limitation of the sample size of the control group. Nevertheless, the a-priori hypothesis was sufficiently powered to detect a reduction in the attempts in orotracheal intubation in the ICU, but that improvement did not occur in this study.

The reason for the lack of improvement may be due to the simultaneous requirement of the specialised stylet and/or intubation sheath necessary to facilitate orotracheal intubation with the GS, as well as operator experience. At our institution, anaesthesia residents must have 6 months of operating theatre experience in airway management (> 100 intubations) before advancing to airway management duties outside the operating theatre. During this initial operating theatre experience, the resident begins to develop basic knowledge in airway management in seminars, in airway skills clinics, and most importantly in the operating theatre under direct physician supervision. In two

studies, novice personnel demonstrated a rapid acquisition of skills necessary to facilitate orotracheal intubation in simulation environments.³⁹⁻⁴¹ However, in two comparative airway tool studies, novice personnel were observed to have steeper learning curves with the use of the GS when compared with other airway tools;^{42,43} this unmeasured learning curve may have played a role in our study. We are in agreement with an editorial by Crosby that airway management requires a period of exposure to both cognitive and skills techniques to give the laryngoscopist a “sense” or gestalt of what may be the appropriate approach in implementation of orotracheal intubation.⁴⁴ Therefore, the use of a new airway tool may not necessarily lead to an immediate reduction in attempts at orotracheal intubation in the ICU, as reported in different clinical settings.³⁹⁻⁴¹

In summary, the introduction of an ICU-dedicated GS unit into an ICU setting can have benefits, as the GS has been reported to assist in the management of very complex intubations.⁴⁵⁻⁵³ There were no differences in success rates with the use of the GS, and clinical risk factors did not play a role. Moreover, the use of the GS did not alter complication rates, but none of the patients with full stomachs underwent GS-assisted orotracheal intubation. This finding may be due to familiarity with cDL in this clinical condition; however, emesis occurred with cDL, and no reported oesophageal intubations occurred with the use of advanced airway tools (GS, intubating wand, fiberoptic scope). Finally, these results suggest that advanced airway tools should be immediately available in patient care settings outside the operating theatre, and most importantly, this equipment must be maintained in full working condition at all times.

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