Operator anaesthesiology training and complications after endotracheal intubation in the intensive care unit: a 3-year, prospective, observational study

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ABSTRACT

Objective: To determine whether operators with less than 3 months' formal anaesthesiology training have higher rates of complications when performing endotracheal intubation (ETI) in the intensive care unit than operators with longer formal anaesthesiology training.

Design and setting: Prospective, single-centre, observational study of consecutive ETIs performed in a general, urban, tertiary ICU between May 2005 and May 2008. Data were collected by self-reported, written questionnaire.

Participants: The two pre-defined study cohorts were ETIs performed where the initial operator had less than 3 months' formal training in anaesthesiology, and those where the initial operator had 3 months' or longer training.

Main outcome measures: The primary outcome measure was the number of ETIs where one or more pre-defined complications occurred as a result of the ETI. Secondary outcome measures were the number of ETIs where one or more respiratory, cardiovascular or trauma complications occurred as a result of the ETI, and the number where the airway was deemed difficult by the operator.

Results: Data were collected on 276 ETIs. There were no significant differences in primary or secondary outcome measures between the two main study groups. Operators with less than 3 months' formal training in anaesthesiology had a higher level of medical supervision or assistance (75% v 29%, $P<0.001$), more favourable patient pre-intubation oxygen saturation on pulse oximetry (Spo_2) (76% v 65% had $Spo_2>89\%$, $P=0.05$), and easier resultant grade of intubation (70% v 56% of intubations were Grade I, $P=0.04$), but required more operators (19% v 3% required two operators, $P<0.001$), and more attempts before ETI was successful (62% v 82% of intubations were successful on first attempt, $P<0.001$).

Conclusion: ETIs performed in the ICU where the initial operator has less than 3 months' formal training in anaesthesiology appear not to be associated with more complications. However, this may be attributable to less experienced operators having more assistance and supervision, and to patient selection.

Crit Care Resusc 2009; 11: 20–27

Endotracheal intubation (ETI) in critically ill patients has been associated with significant complications,[1-3] but few studies have examined complications in patients who undergo ETI in the intensive care unit.[4,5] A multicentre study of 253 intubations showed that ETI performed in the ICU by a junior doctor under the supervision of a senior doctor (ie, two operators) was associated with reduced rates of complications.[4] All junior medical staff in this study had at least 1 year's experience in anaesthesiology. Conversely, a single-centre study of 297 intubations showed no difference in the incidence of complications when the operator was supervised by a more experienced physician.[5] Doctors in that study had least 6 months of anaesthesia resident training before performing ETI unsupervised.

There are currently no uniform guidelines for employing junior medical ICU staff in Australia. The *Minimum standards for intensive care units* from the Joint Faculty of Intensive Care Medicine states that higher functioning ICUs, such as tertiary referral ICUs, must have 24-hour cover from junior medical staff "with an appropriate level of experience", but does not detail this experience.[6] As many junior ICU medical staff are seconded from other departments, such as emergency, anaesthesiology and medicine, and as the levels of formal anaesthesiology experience gained from the operating theatre vary, experience in managing airways is variable. Registrars may be seconded to an ICU term with no formal anaesthesiology training, although they may have had exposure to airway management from their usual duties, such as in the emergency department.

Although it might be preferable to employ junior staff who are highly experienced, mandating high minimum levels of experience would exclude many junior doctors from working in ICUs, and exacerbate staffing problems for ICUs in areas that already have difficulty attracting experienced staff.

As the outcomes of ETI in the ICU by operators with minimal formal anaesthesiology experience remain unclear, and as Australian guidelines on minimum experience for junior ICU medical staff are non-specific, a prospective survey of patient complications after ETI was undertaken. The study aimed to determine whether operators with less than 3 months' formal training in anaesthesiology had

higher rates of patient complications when performing ETI in the ICU, either supervised or unsupervised, compared with operators with longer training.

Methods

Study design

The study was a prospective, single-centre, observational study of consecutive ETIs performed in a single ICU over a 3-year period from May 2005 to May 2008. ETIs performed outside the ICU, such as in the operating theatre, emergency department or general wards, were excluded.

Approval for the study was obtained from the hospital's human research ethics committee, and consent from patients and participants was waived as no new interventions were performed, no attempts were made to change practice, and the study was considered a quality assurance activity. The study was funded solely by the ICU.

Participants and setting

The two pre-defined main study cohorts were ETIs performed where the initial operator had less than 3 months' formal training in anaesthesiology, and those where the initial operator had 3 months' or more training. Formal anaesthesiology training was defined as time employed in an anaesthetic rotation practising clinical anaesthesia under supervision. The 3-month cut-off was arbitrary, and chosen to maximise numbers in a cohort considered to have minimal experience. The more experienced cohort was further arbitrarily subdivided according to length of formal training: 3 to less than 6 months, 6 to less than 12 months, 12 to less than 24 months, and 24 months or more. Subgroups of the two main study cohorts where the ETI was performed without any assistance or supervision by another doctor were also analysed.

The ETIs were performed in a general ICU in an urban, tertiary teaching hospital, which manages medical and surgical patients, and is a tertiary referral centre for burn injuries. The ICU contained 14 beds and admitted about 800 patients per year.

ETIs in the ICU were performed by ICU medical staff. The ICU was staffed during the day by intensivists, who were available on-call after hours. Senior ICU registrars were present on site from 08:00 to 23:00 on weekdays, and intermittently available on-call after hours. The ICU was also staffed with 24-hour junior ICU registrar and resident cover. Junior ICU registrars were predominantly trainees in intensive care medicine, with two positions dedicated to trainees from the emergency and anaesthetic departments, respectively. The ICU received four emergency registrars in 3-month rotations and three anaesthetics registrars in 4-month rotations annually. The experience of emergency registrars varied, with some having no formal anaesthesiology training before working in the ICU. Anaesthetics registrars had a minimum of 6 months' anaesthesiology training. Operators performing ETI were encouraged to seek assistance if they were inexperienced or perceived difficulty.

Capnography was available in all ICU bed areas. ETIs were usually performed using standard laryngoscope handles with detachable, metal, long, curved (Macintosh) blades. The ICU intubation trolley also contained introducers, short, curved (Macintosh), flexible-tip (McCoy) and straight (Miller) laryngoscope blades, standard and intubating laryngeal masks with associated equipment, shortened laryngoscope handles, and percutaneous and open cricothyroidotomy equipment. A fibreoptic bronchoscope was immediately available from the operating theatres, situated adjacent to the ICU. A mobile, erect chest x-ray was performed immediately following all ETIs when possible. Nurse to patient ratios were 1 : 1 for all patients requiring invasive or non-invasive ventilation, circulatory support or renal replacement therapy, or deemed otherwise critically ill. Ratios could be downgraded to 1 : 2 for high-dependency patients.

Data collection

De-identified, self-reported information was collected by written questionnaire, completed by all operators following all instances of ETI in the ICU. Emphasis was placed on open and transparent reporting, with a "non-blame" attitude to adverse events and complications. Participants were aware of the importance that quality data collection would have on the outcomes of the study. Significant adverse events were reported through the hospital incident management system, discussed at the departmental mortality and morbidity meeting, and managed as considered appropriate.

Basic demographic data and APACHE II scores were collected for all patients who underwent ETI. Baseline operator characteristics were also collected, comprising perceived urgency of the ETI, whether the operator was supervised or assisted by another doctor, whether the airway was perceived as difficult by the most experienced operator present, oxygen saturation by pulse oximetry (Spo_2) at the time of ETI, and capnography use.

An ETI was classified as urgent if the patient required the ETI immediately; semi-urgent if the patient did not require the ETI immediately, but required it within the next 24 hours; and elective if the patient was able to wait more than 24 hours for the ETI.

A difficult airway is usually defined as a clinical situation in which a conventionally trained anaesthesiologist experiences difficulty with face-mask ventilation of the upper airway, with tracheal intubation, or with both.[7] However, in this

Table 1. Baseline characteristics of patients who underwent endotracheal intubation (ETI) in the ICU, by operator's formal training (months)

		Main study groups*			Subgroups*				
	All operators ($n = 276$)	< 3 ($n = 89$)	⩾ 3 ($n = 187$)	*P*	3 to < 6 ($n = 37$)	6 to < 12 ($n = 12$)	12 to < 24 ($n = 18$)	⩾ 24 ($n = 120$)	*P*
Average patient age, years (SD)	68 (16)†	70 (15)	67 (17)	0.16	69 (15)	73 (16)	68 (15)	65 (18)	0.34
No. of men (%)	180 (65%)	56 (63%)	124 (66%)	0.68	21 (57%)	8 (67%)	14 (78%)	81 (68%)	0.45
Average patient APACHE II score (SD)	25 (8)	25 (9)	25 (8)	0.95	26 (8)	28 (8)	22 (8)	25 (8)	0.16

* n = no. of patients intubated by operators in the study group. † Age range = 17 to 95 years.

Table 2. Baseline operator characteristics for patients who underwent endotracheal intubation (ETI) in the ICU, by operator's formal training (months)

		Main study groups*			Subgroups*				
	All operators ($n = 276$)	< 3 ($n = 89$)	⩾ 3 ($n = 187$)	*P*	3 to < 6 ($n = 37$)	6 to < 12 ($n = 12$)	12 to < 24 ($n = 18$)	⩾ 24 ($n = 120$)	*P*
Perceived urgency of ETI†				0.99					0.66
Urgent	225 (82%)	72 (81%)	153 (82%)		28 (76%)	10 (83%)	16 (89%)	99 (83%)	
Semi-urgent	50 (18%)	17 (19%)	33 (18%)		8 (22%)	2 (17%)	2 (11%)	21 (18%)	
Elective	1 (0.4%)	0	1 (0.5%)		1 (3%)	0	0	0	
Time of ETI				0.65					0.68
08:00–15:59	96 (35%)	29 (33%)	67 (36%)		11 (30%)	5 (42%)	9 (50%)	42 (35%)	
16:00–23:59	112 (41%)	35 (39%)	77 (41%)		19 (51%)	5 (42%)	5 (28%)	48 (40%)	
00:00–07:59	68 (25%)	25 (28%)	43 (23%)		7 (19%)	2 (17%)	4 (22%)	30 (25%)	
Immediate assistance or supervision by another operator				< 0.001					< 0.001
Yes	122 (44%)	67 (75%)	55 (29%)		27 (73%)	5 (42%)	6 (33%)	17 (14%)	
No	154 (56%)	22 (25%)‡	132 (71%)		10 (27%)	7 (58%)	12 (67%)	103 (86%)	
Difficult airway§	37 (13%)	10 (11%)	27 (14%)	0.59	6 (16%)	1 (8%)	2 (11%)	18 (15%)	0.89
Pre-intubation SpO_2				0.05					0.79
⩾ 90%	190 (69%)	68 (76%)	122 (65%)		23 (62%)	6 (50%)	12 (67%)	81 (68%)	
< 90%	79 (29%)	18 (20%)	61 (33%)		13 (35%)	5 (42%)	6 (33%)	37 (31%)	
Unknown or unable to detect	7 (3%)	3 (3%)	4 (2%)		1 (3%)	1 (8%)	0	2 (2%)	
Capnography used for ETI	198 (72%)	62 (70%)	136 (73%)	0.7	27 (73%)	7 (58%)	13 (72%)	89 (74%)	0.71

SpO_2 = oxygen saturation on pulse oximetry. * n = no. of patients intubated by operators in the study group.
† Perceived urgency of procedure: urgent = patient required ETI immediately; semi-urgent = patient did not require ETI immediately, but required it within the next 24 hours; elective = patient could wait more than 24 hours for ETI.
‡ Timing of ETIs performed by operators with less than 3 months' experience and with no assistance or supervision immediately available was: 08:00–15.59, 4 ETIs (18%); 16:00–23.59, 9 (41%); and 00:00–07:59, 9 (41%). These ETIs were deemed urgent in 20 (91%) patients and semi-urgent in two (9%).
§ As perceived by the most experienced operator present.

study we defined difficult airway according to the opinion of the most senior operator present at the time of ETI.

Further information was collected on the number of operators required before ETI was successful, the total number of attempts at ETI, the Cormack–Lehane (CL) intubation grade,[8] and use of the rapid-sequence induction intubating technique. The latter was defined as use of suxamethonium chloride in combination with a short-acting induction agent, and application of cricoid pressure (Sellick manoeuvre)[9] to secure the airway without insufflation. An ETI attempt was defined as insertion and subsequent removal of a device into the pharynx for attempting ETI or to enable insufflation, or an insertion attempt that resulted in successful ETI.

Table 3. Operator and procedure characteristics for patients who underwent endotracheal intubation (ETI) in the ICU, by operator's formal training (months)

		Main study groups*			Subgroups*				
	All operators	< 3 (*n* = 89)	⩾ 3 (*n* = 187)	*P*	3 to < 6 (*n* = 37)	6 to < 12 (*n* = 12)	12 to < 24 (*n* = 18)	⩾ 24 (*n* = 120)	*P*
No. of operators required before successful ETI				< 0.001					
1	253 (92%)	72 (81%)	181 (97%)		33 (89%)	11 (91.7%)	17 (94%)	120 (100%)	0.007
2	23 (8%)	17 (19%)	6 (3%)		4 (11%)	1 (8.3%)	1 (6%)	0	
Total no. of attempts by all operators before successful ETI				< 0.001					0.44
1	209 (76%)	55 (62%)	154 (82%)		29 (78%)	10 (83%)	15 (83%)	100 (83%)	
2	55 (20%)	26 (29%)	29 (16%)		6 (16%)	1 (8%)	3 (17%)	19 (16%)	
3	9 (3%)	6 (7%)	3 (2%)		1 (3%)	1 (8%)	0	1 (0.8%)	
4	2 (0.7%)	2 (2%)	0		0	0	0	0	
5	1 (0.4%)	0	1 (0.5%)		1 (3%)	0	0	0	
Grade of ETI†				0.04					0.05
I	166 (60%)	62 (70%)	104 (56%)		23 (62%)	11 (92%)	10 (56%)	60 (50%)	
II	47 (17%)	11 (12%)	36 (19%)		5 (14%)	0	4 (22%)	27 (23%)	
III	12 (4%)	1 (1%)	11 (6%)		0	0	3 (17%)	8 (7%)	
IV	0	0	0		0	0	0	0	
Not recorded	51 (18.5%)	15 (17%)	36 (19%)		9 (24%)	1 (8%)	1 (6%)	25 (21%)	
Rapid sequence induction used for first ETI attempt	165 (59.8%)	45 (51%)	120 (64%)	0.04	23 (62%)	9 (75%)	13 (72%)	75 (63%)	0.72

* *n* = no. of patients intubated by operators in the study group. † Cormack–Lehane (CL) grade of ETI.

Outcomes

The primary outcome measure was the number of ETIs where one or more pre-defined complications occurred as a result of the ETI. Secondary outcome measures were the number of ETIs where one or more complications occurred as a result of the ETI in specific categories — respiratory, cardiovascular or traumatic — and the number of ETIs where the airway was deemed difficult by the operator.

The pre-defined complications were:

- respiratory — airway obstruction, aspiration, barotrauma (pneumothorax, pneumomediastinum, pneumopericardium, or subcutaneous emphysema as seen on chest x-ray following ETI), bronchospasm or laryngospasm, any decrease in SpO_2 below baseline, oesophageal intubation, endobronchial intubation (observed on chest x-ray following ETI), and premature extubation;
- cardiovascular — unexpected cardiac arrest following and attributable to ETI, hypotension requiring administration of an intravenous fluid bolus, and hypotension requiring new administration or an increased dose of vasopressor or inotropic medication; and
- traumatic — epistaxis (in nasal ETIs), or trauma to mouth or pharynx.

Mortality was recorded as a complication only when it directly followed and was attributable to the ETI. Pre-existing cardiac arrest, where the ETI was performed in the course of resuscitation, was not considered a complication.

Data analysis

An observational period of 3 years was chosen to obtain sufficient numbers of operators. Parametric data were analysed by an independent statistician using an independent samples *t* test and Levene's test for equality of variances (SPSS version 13.0, SPSS Inc, Chicago, Ill, 2004). Non-parametric data were analysed using χ^2 tests with continuity correction, Pearson's χ^2 test and Fisher's exact test.

Results

Baseline data

Information was collected on 276 ETIs over the 3-year period. During this time, 12 emergency registrars, nine anaesthetics registrars and 20 ICU-based registrars rotated through the ICU. The duration of formal anaesthesiology training of the initial operator was less than 3 months for 89 ETIs, and 3 months or more for 187 ETIs. The baseline

Table 4. Complications in patients who underwent endotracheal intubation (ETI) in the ICU, by operator's formal training (months)

		Main study groups*				Subgroups*				
	All operators ($n=276$)	< 3 ($n=89$)	⩾ 3 ($n=187$)	*P*	Odds ratio (95% CI)†	3 to < 6 ($n=37$)	6 to < 12 ($n=12$)	12 to < 24 ($n=18$)	⩾ 24 ($n=120$)	*P*
No. of patients with:										
1 or more complications	140 (51%)	41 (46%)	99 (53%)	0.35	0.76 (0.46–1.27)	18 (49%)	6 (50%)	10 (56%)	65 (54%)	0.93
1 or more respiratory complications	69 (25%)	21 (24%)	48 (26%)	0.82	0.89 (0.62–1.39)	8 (22%)	5 (42%)	5 (28%)	30 (25%)	0.57
Subgroups of respiratory complications										
Airway obstruction	2 (0.7%)	1 (1%)	1(0.5%)			0	0	0	1 (0.8%)	
Aspiration	5 (2%)	0	5 (3%)			0	1 (8%)	0	4 (3%)	
Barotrauma‡	1 (0.4%)	0	1(0.5%)			0	0	0	1 (0.8%)	
Broncho/laryngospasm	6 (2%)	2 (2%)	4 (2%)			0	0	0	4 (3%)	
Fall in Spo_2 below baseline	43 (16%)	14 (16%)	29 (16%)			5 (14%)	2 (17%)	4 (22%)	18 (15%)	
Oesophageal intubation	14 (5%)	4 (5%)	10 (5%)			2 (5%)	1 (8%)	2 (11%)	5 (4%)	
Endobronchial intubation	5 (2%)	1 (1%)	4 (2%)			1 (3%)	1 (8%)	0	2 (2%)	
Premature extubation	4 (1%)	1 (1%)	3 (2%)			1 (3%)	1 (8%)	0	1 (0.8%)	
1 or more cardiovascular complications	89 (32%)	29 (33%)	60 (32%)	> 0.99	1.02 (0.60–1.75)	13 (35%)	1 (8%)	6 (33%)	40 (33%)	0.34
Subgroups of cardiovascular complications										
Unexpected cardiac arrest after ETI	1 (0.4%)	0	1(0.5%)			0	0	0	1 (0.8%)	
Hypotension requiring bolus fluid administration	49 (18%)	15 (17%)	34 (18%)			9 (24%)	0	2 (11%)	23 (19%)	
Hypotension requiring vasopressor or inotrope administration	76 (28%)	25 (28%)	51 (27%)			11 (30%)	1 (8%)	6 (33%)	32 (27%)	
1 or more traumatic complications	3 (1%)	0	3 (2%)	0.56	–	1 (3%)	0	0	2 (2%)	0.86
Subgroups of traumatic complications										
Epistaxis§		0	1(0.5%)			0	0	0	1 (0.8%)	
Trauma to mouth or pharynx		0	2 (1%)			1 (3%)	0	0	1 (0.8%)	
Actual difficult airway	21 (8%)	9 (10%)	12 (6%)	0.40	1.64 (0.66–4.05)	3 (8%)	0	2 (11%)	7 (6%)	0.63

* n = no. of patients intubated by operators in the study group. † Odds ratio for operators with less than 3 months' formal anaesthesiology training.
‡ Included pneumothorax, pneumomediastinun, pneumopericardium, and subcutaneous emphysema. § Epistaxis resulting from nasal intubation.

characteristics of the patients who underwent ETI are shown in Table 1. There was no statistically significant difference in average age, sex, or APACHE II score of the patients who underwent ETI between either the main study groups or the subgroups.

The baseline characteristics of the ETIs are detailed in Table 2. Most were deemed urgent (82%), and there was no statistically significant difference in the number of urgent ETIs between either the main study groups or the subgroups, nor any significant difference in the time of day that the ETIs were performed. There was also no statistically significant difference in the perceived difficulty of the airway or in the use of capnography between the groups.

Operators with less than 3 months' formal anaesthesiology training were significantly more likely to be assisted or supervised by another doctor (75% versus 29%, $P<0.001$), and were more likely to be performing ETI in a patient with more favourable Spo_2 (76% v 65% with $Spo_2 \geqslant 90\%$, and 20% v 33% with $Spo_2 < 90\%$, $P=0.05$).

Table 5. Characteristics of endotracheal intubations (ETIs) performed by operators without supervision or assistance, by operator's formal training (months)

	⩾ 3 months (n = 132)*	< 3 months (n = 22)*	P
No. of patients with:			
Pre-intubation Spo_2 ⩾ 90%	89 (67%)	17 (77%)	0.50
Grade I intubations	71 (54%)	15 (68%)	0.30
1 or more complications	72 (55%)	13 (59%)	0.87
1 or more respiratory complications	35 (27%)	7 (32%)	0.81
Subgroups of respiratory complications			
Airway obstruction	1 (0.8%)	0	
Aspiration	4 (3%)	0	
Barotrauma†	1 (0.8%)	0	
Broncho/laryngospasm	3 (2%)	1 (5%)	
Desaturation	22 (17%)	4 (18%)	
Oesophageal intubation	8 (6%)	1 (5%)	
Endobronchial intubation	2 (2%)	1 (5%)	
Premature extubation	1 (0.8%)	0	
1 or more cardiovascular complications	43 (33%)	9 (41%)	0.60
Subgroups of cardiovascular complications			
Unexpected cardiac arrest following ETI	1 (7%)	0	
Hypotension requiring bolus fluid administration	22 (17%)	4 (18%)	
Hypotension requiring vasopressor or inotrope	36 (27%)	8 (36%)	
1 or more traumatic complications	2 (2%)	0	> 0.99
Actual difficult airway	7 (5%)	2 (9%)	0.62

* n = no. of patients intubated by operators in the study group.
† Included pneumothorax, pneumomediastinun, pneumopericardium, and subcutaneous emphysema.

Operator and procedure characterstics

The characteristics of operators for patients undergoing ETI are listed in Table 3. No ETIs required more than two operators. Successful performance of ETI in patients where the initial operator had less than 3 months' formal anaesthesiology training required significantly more operators (19% v 3% requiring two operators, $P < 0.001$). The number of successful ETIs in this group on first attempt was also significantly lower (62% v 82%, $P < 0.001$). However, ETIs in patients where the initial operator had less than 3 months' formal anaesthesiology training were associated with a significantly higher proportion of favourable intubation gradings (70% v 56% deemed Grade I, $P = 0.04$).

Rapid sequence induction (RSI) was used significantly more often in ETIs where the initial operator had 3 months' or more training (64% v 51%, $P = 0.04$). Non-RSI techniques were not analysed by subgroup because of the many different combinations, but overall a sedative (eg, midazolam) was used in 60% of non-RSI intubations, a general anaesthetic agent (eg, propofol) in 27%, and a topical anaesthetic agent in 34%. Overall, the most common non-RSI technique was sedation alone (34%), followed by topical anaesthesia combined with sedation (17%), and general anaesthesia alone (15%). No anaesthesia was used in 9% of non-RSI intubations. Fibreoptic intubation was performed in two non-RSI patients (2%), and blind nasal intubation in five non-RSI patients (5%).

Outcomes

The complications of ETI for the main study groups and subgroups are detailed in Table 4. There was no statistically significant difference in the number of patients with one or more complications between ETIs where the initial operator had less than 3 months' formal anaesthesiology training and ETIs where the initial operator had longer training (46% v 53%, $P = 0.35$). There was also no statistically significant difference in the number of patients who had respiratory complications (24% v 26%, $P = 0.82$), cardiovascular complications (33% v 32%, $P > 0.99$), or traumatic complications (0 v 2%, $P = 0.56$), nor was there any statistically significant difference in the numbers of actual difficult airways (10% v 6%, $P = 0.40$). Similarly, the subgroups also showed no statistically significant differences in all major complication categories.

The only death that occurred immediately after ETI and was deemed possibly related to the ETI was a cardiac arrest. In this case, the operator had over 24 months' formal anaesthesiology training. Before the procedure, the patient was receiving an adrenaline infusion (50 μg per min) for shock and had worsening respiratory failure.

Twenty-two ETIs (25%) were performed in patients where the initial operator had less than 3 months' anaesthesiology training and was not assisted or supervised by another doctor at the time. A further analysis of the main study groups was performed to examine complications where the ETI was unassisted or unsupervised, and the results are detailed in Table 5. Although operators who were unassisted and unsupervised and had less than 3 months' training appeared to have a higher proportion of patients with pre-intubation Spo_2 ⩾ 90%, and also a higher proportion of Grade I intubations, these differences did not reach statistical significance.

There were no statistically significant differences in total or respiratory, cardiovascular or traumatic complications between patients where ETI was performed without assist-

ance or supervision in either of the two main study groups, nor in the incidence of actual difficult airway.

Of the 22 ETIs performed by less experienced operators without assistance or supervision, four were performed during the day, nine were performed between 16:00 and midnight, and nine were performed between midnight and 08:00. The ETIs were deemed to be urgent in 20 (91%) of the cases.

Discussion

As far as we are aware, this is the first study to specifically examine the rates of complications following ETI performed in the ICU by operators with very little formal anaesthesiology training. In the two largest previous studies of ETI in the ICU, no operators performed ETI without supervision unless they had at least 6 months' formal training in anaesthesiology.[4,5]

Intuitively, given the potential problems associated with the procedure, less experienced medical personnel performing ETI would be expected to have higher complication rates. This study demonstrated that ETIs performed on patients in the ICU where the initial operator had less than 3 months' formal anaesthesiology training were not associated with statistically significant differences in rates of complications, when compared with those where the initial operator had 3 months' or longer experience. However, this does not necessarily mean that less experienced operators should perform ETI with complete freedom in the ICU.

The results may be partly explained by the less experienced operators having significantly more immediate supervision and assistance from other doctors. The less experienced operators also seemed to have more favourable intubating conditions, with significantly higher rates of Grade I intubations, and possibly patients who were less unwell, as significantly more had a pre-intubation Spo_2 of 90% or higher. This may indicate that the less experienced operators were more likely to perform ETI in "easier" patients, and that the more difficult or sicker patients were intubated by operators with more experience. This study did not examine how many ETIs were deferred to a more experienced colleague because of perceived difficulty.

The subgroup analysis of complications resulting from ETIs performed where an assistant or supervisor was not immediately available showed no statistically significant differences between the two main study groups, but was significantly underpowered. Again, this lack of difference might be explained by the less experienced operators having patients who were less unwell, but the apparently higher proportions of patients for this subgroup with pre-intubation Spo_2 of 90% or more and with Grade I intubations did not reach statistical significance.

Most of the ETIs performed by operators with less than 3 months' anaesthesiology training were deemed urgent (20/22, 91%), but the study did not examine how many of these operators deferred other ETIs until a more experienced colleague was available. Only one of the 20 urgent ETIs was expected by the operator to be difficult before it was performed, as opposed to seven of 52 ETIs performed urgently by the less experienced operators with assistance or supervision. This also suggests that unassisted and unsupervised less-experienced operators had "easier" intubating conditions.

As expected, the operators with less than 3 months' formal training in anaesthesiology required significantly more operators before ETI was eventually successful, but, despite this, only one operator was required in 81% of attempts. However, this still means that a less experienced operator would potentially require assistance in performing ETI for one out of every five patients.

Operators with less than 3 months' formal training in anaesthesiology also made significantly more attempts before ETI was successful, but 91% of patients were intubated with one or two attempts. Obviously, some attempts at ETI were associated with complications (such as oesophageal intubation) before being successful, but this study was not designed to examine whether the total number of attempts was associated with more complications.

Interestingly, the group with 3 months' or longer formal training in anaesthesiology performed significantly more rapid sequence induction procedures. The reason is not clear, but may be explained by this group having more confidence in their ability to successfully perform ETI, and therefore more confidence in using a short-acting muscle relaxant. Only one operator was required in 97% of all ETIs performed by the more experienced group.

An alternative explanation for the similarity in complications between the two main study groups is that we underestimated the competence of the less experienced group. Several of the registrars seconded to the ICU from the emergency department had already completed emergency training and were rotating through critical care and anaesthesiology terms to complete their fellowship requirements. Despite little formal anaesthesiology training, these and the other registrars may have had significant experience in airway management in the emergency department before joining the ICU.

Limitations of the study

The study had several limitations. Although the design was prospective, the study was observational, and both the baseline characteristics of patients and the level of supervision and assistance differed between the main study

groups. As a randomised study of reduced levels of supervision would be unethical, this type of observational study is probably the most realistic method to achieve the study objective. Given that 32% of the operators in this study performing ETI had less than 3 months' formal training in anaesthesiology, and only 25% of these operators were unsupervised, to adequately power a study to detect a 10% difference in total complications among unsupervised operators would require a sample size of 5000 ETIs.

Another limitation of this study was the reliance on self-reporting. Although a "non-blame" attitude to open disclosure of complications was emphasised, operators may have under-reported problems. Complications may also have been missed, or became apparent only some time after the ETI, such as trauma to the pharynx. The list of pre-defined complications was also not exhaustive, and less common complications, such as drug allergy, may not have been reported.

This study was conducted in a general ICU in an Australian teaching hospital. It is uncertain whether the results can be generalised to other hospital environments, such as other types of ICU or general wards, or to other countries where the training of ICU medical staff may differ. It is also uncertain what effect operator anaesthesiology training had on the usual conventional measures of ICU outcome, such as mortality and length of stay. The study was not designed to specifically examine these outcomes, because of the presence of confounders.

Conclusions

This study of 276 patients in a general ICU compared ETIs where the initial operator had less than 3 months' formal training in anaesthesiology with those where the initial operator had 3 months' or more training. It found no statistically significant difference in the rate of pre-defined complications. Less experienced operators had significantly more supervision and assistance, and probably more favourable intubating conditions. Subgroup analysis of ETIs performed with no assistance or supervision also showed no statistically significant difference in complication rates, but was underpowered to detect differences, in both baseline characteristics and outcomes.

The current Australian practice of allowing ICU registrars with less than 3 months' formal training in anaesthesiology to perform ETIs, and encouraging them to seek supervision or assistance, appears not be associated with worse outcomes. However, this does not mean that inexperienced operators should have complete freedom to perform this procedure independently.

Limitations in study design prevent rigorous conclusions or recommendations, but further large-scale observational studies in this area are unlikely to be performed because of the large numbers of patients that would be required.

Acknowledgements

We thank Jennifer Peat (Concord Repatriation General Hospital, Sydney, NSW), for her assistance with the statistical analysis.

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