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ORIGINAL RESEARCH

Safety of rapid sequence intubation in an emergency training network

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Abstract

Objective: Rapid sequence intubation (RSI) is a core critical care skill. Emergency medicine trainees are exposed to relatively low numbers of RSIs. We aimed to improve patient outcomes by implementing an RSI checklist, electronic learning and audit, in line with current best evidence.

Methods: Prospective observational study of RSIs performed in the EDs of two Queensland hospitals between January 2014 and December 2016. Data collected included: first-pass success (FPS), predicted difficulty, indication for intubation, drugs used, positioning, number of attempts, checklist use and complications. Descriptive statistics and multivariable modelling were used to describe differences in FPS, and complications.

Results: Six hundred and fifty-five patients underwent RSI with FPS of 86.6%. Complications were reported in 15.9%, mainly hypotension (10.9%) and desaturation (4.0%). FPS improved with bougie use (88.9% *vs* 73.0% without bougie, $P < 0.001$) and video-laryngoscopy (88.2% *vs* 72.9% using standard laryngoscopy, $P < 0.001$). New desaturation was reduced with apnoeic oxygenation (2.0% *vs* 22.2%, $P < 0.001$), bougie use (2.8% *vs* 8.9%, $P < 0.001$), checklist use (2.3% *vs* 22.7%, $P < 0.001$) and achieving FPS (2.1% *vs* 16.3%, $P < 0.001$). Complications were reduced with checklist use (13.3% *vs* 43.2%, $P < 0.001$) and apnoeic oxygenation use (3.9% *vs* 31.1%, $P < 0.001$). Logistic regression found checklist use was associated with reduced desaturation (OR 0.1, 95% CI 0.04–0.27) and the composite variable of any complication (OR 0.39, 95% CI 0.17–0.89).

Conclusions: Implementation of an evidence-based care bundle and audit of practice has created a safe environment for trainees to learn the core critical care skill of RSI. In our setting, checklist use was associated with fewer complications.

Key words: *airway, intubation, rapid sequence intubation, safety*.

Key findings

- Implementation of an evidence-based care bundle, including audit, simulation, checklist and standardisation of practice, has created a safe learning environment for trainees undertaking RSI.
- Checklist use was associated with fewer complications during RSI.
- FPS approached 87%. Nearly 98% of patients were intubated in two passes.

Introduction

Rapid sequence intubation (RSI) is a high-risk procedure[1,2] and a core advanced airway skill for emergency physicians and trainees.[3] Previous studies show that the incidence of oxygen desaturation and other complications is high[4–6] but can be improved by standardising practice.[7] Influenced partly by Weingart and Levitan,[8] practice changes were introduced at our health service hospitals in 2013. The aim was to standardise care across our emergency training network and reduce complications during RSI.

All medical and nursing staff were required to complete an electronic learning package published on our departmental intranet prior to undertaking or assisting with RSI. Doctors and nurses work complex shift patterns within the ED and may have variation in skill and ability.[5] Electronic learning tools ensure staff working in a single ED are familiar with departmental practice. This practice change was reinforced by

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embedding electronic learning into the departmental simulation programme, and with the implementation of an airway checklist (Appendix S1).

Concurrently, we commenced a prospective airway registry with emphasis on facilitating the safe securing of the airway, mostly by Australasian College for Emergency Medicine trainees with varying levels of experience. The registry was maintained by the emergency college-accredited research registrar. We describe the implementation of this evidence-based care package and best practice approach to RSI in our ED, with attention to optimising first-pass success (FPS) and minimising complications.

Methods

Study design and setting

Prospective observational study of all RSI performed in the EDs of two Queensland hospitals between January 2014 and December 2016. The Gold Coast University Hospital (GCUH) and the Robina Hospital are teaching hospitals located in southeast Queensland, Australia. GCUH is a mixed adult and paediatric Level 1 trauma centre with over 100 000 ED presentations annually. Robina Hospital is a mixed urban district hospital with over 60 000 presentations annually.

In line with current best practice and literature review, standardisation of care during RSI included:

- An airway checklist secured to every intubation trolley (Appendix S1).
- The routine use of apnoeic oxygenation (ApOx) 15 L/min via nasal prongs.
- Encouraging the head up position.
- C-MAC video-laryngoscope (Karl Storz, Tuttlingen, Germany) for all first attempts.
- Routine use of a gum elastic bougie to maximise FPS in preference to other adjuncts.
- Omitting routine cricoid pressure.
- Ensuring all bag-valve mask (BVM) devices can deliver 100% oxygen during spontaneous respiration.
- Preferencing ketamine and rocuronium over other agents.

Ethical approval for the project was granted by the local hospital human research and ethics committee (HREC/15/QGC/222).

Data collection

Between 2014 and 2016, doctors prospectively registered their RSI in an online submission sheet on the department intranet. Weekly reminders for both medical and nursing staff were conducted to ensure compliance. Medical records were interrogated as close to the actual time and date of the procedure. Prospective data elements collected included predicted difficulty, indication for intubation, drugs used, patient position, number of attempts at laryngoscopy, use of the checklist and complications.

A secondary check of RSIs was done weekly by the ED research registrar through a review of all Australasian Triage Scale (ATS) 1 and 2 patients and those undergoing chest radiography in ED. Any missed RSIs were flagged to the performing doctor who updated registry records. Complication data were collected by a dedicated research staff member.

Study definitions

New hypotension was defined as a systolic blood pressure (SBP) <90 mmHg and/or a change of at least 20 mmHg during or within the first hour after RSI in a person with SBP >90 mmHg prior to induction. Where a patient was already undergoing cardiopulmonary resuscitation (CPR), short bouts of haemodynamic stability (<5 min) were not considered for pre-RSI SBP observations.

New desaturation was defined as oxygen saturations <90% during or immediately following an RSI or a nadir below 90%, in a patient with oxygen saturations >90% prior to induction. Critical hypoxia was defined as saturations <85%. 'Arrest/peri-arrest' status was grouped and included traumatic or medical cardiac arrest with or without CPR, as well as CPR after return of spontaneous circulation.

We defined 'any complication' as a composite of new hypotension, new desaturation or any of the following events: cardiac arrest in a patient not previously arresting, death attributable to RSI (all deaths were reviewed by a senior clinician), requirement for a second dose of non-depolarising neuromuscular blocking medication, airway and dental trauma, anaphylaxis, bradycardia (<60 bpm), equipment failure, extravasation of drugs, laryngospasm, main stem bronchus intubation, medication error, oesophageal intubation and vomiting +/− aspiration.

An intubation attempt was defined as a single passage of the laryngoscope blade past the lips or change of operator, and FPS was defined as the intubator only requiring a single intubation attempt.

Medication data were analysed by dose/kg and categorised for non-depolarising neuromuscular blocking agents as low (<1 mg/kg), moderate (1–1.4 mg/kg), high (1.5–1.9 mg/kg) and very high (≥2 mg/kg). Fentanyl was categorised similarly, but as mcg/kg. For adults where weight was missing, the weight applied was 70 kg. For children under 12 months, the weight applied was 10 kg if missing (n = 4).

Data analysis

Data were analysed using SPSS v24 (IBM Corporation, Armonk, NY, USA). Means and proportions were presented to describe patient characteristics. Two-sample t-tests for continuous variables and χ^2-tests for binary and categorical variables were performed to identify differences in FPS as well as complications between groups. Fisher's exact tests used for cells with less than or equal to five cases. A P-value of <0.05 was considered statistically significant.

Logistic regression modelling was performed on four outcomes of interest: FPS, hypotension, desaturation and the composite outcome of any complication. Multivariable analysis assessed variables that were univariately associated with the outcome of interest using a generalised linear model and robust estimator (a detailed summary is included in Appendix S2).

TABLE 1. *Characteristics of 655 patients undergoing rapid sequence intubations (RSI) between 2014 and 2016, checklist use, first-pass success, and complications*

	n 655	% 100.0	Checklist use % (*n* = 646) 89.6	First-pass success % (*n* = 655) 86.6	Complications† (%) (*n* = 595) 15.6	New hypotension‡ (%) (*n* = 605) 10.9	New desaturation‡ (%) (*n* = 607) 4.0
Year			**				
2014	204	31.1	86.1	86.8	18.9	12.6	5.8
2015	247	37.7	87.3	87.0	16.1	12.3	3.5
2016	204	31.1	96.0	86.8	11.8	7.0	2.6
Sex				*			*
Male	390	59.5	88.1	84.1	16.7	9.6	5.6
Female	265	40.5	91.9	90.2	14.2	12.4	1.6
Age§			**	**	*	*	***
≤1	14	2.1	66.7	53.8	45.5	16.7	33.3
2–14	13	2.0	66.7	76.9	30.8	30.8	16.7
15–19	27	4.1	85.2	88.9	3.8	3.7	0.0
20–29	134	20.5	94.7	87.3	4.6	2.3	0.8
30–39	93	14.2	95.6	91.4	6.0	3.5	2.2
40–49	106	16.2	89.6	88.7	19.4	13	7.9
50–59	94	14.4	89.0	87.2	22.9	15.9	4.7
60–69	76	11.6	89.5	86.8	15.4	10.6	1.5
70–79	63	9.6	85.5	82.5	26.8	22.8	3.6
80+	35	5.3	82.9	85.7	31.0	20.7	0.0
Weight category				*	***		***
<100 kg	581	88.4	90.4	87.8	13.5	10.1	2.6
≥100 kg	70	10.8	87.1	77.1	31.3	15.4	13.6
Missing	5	0.8	ND	ND	ND		
Campus							
GCUH	561	85.3	89.4	87.5	16.2	11.3	4.1
Robina	97	14.7	90.7	81.4	12.4	7.8	3.3
Type of patient			**				
Medical	550	83.6	91.3	86.3	15.0	10.2	3.7
Trauma	108	16.4	81.3	88.0	18.9	14.0	5.1
Indication for intubation			**	*	***	***	**
Overdose	236	35.9	98.7	89	8.2	6.0	1.3
Trauma	90	13.7	86.5	88.9	19.8	14.5	4.7
Altered GCS	68	10.3	89.4	80.9	21.5	16.7	6.1
Cardiac arrest	62	9.6	72.1	82.3	35.4	17.8	8.5
Seizures	54	8.4	98.1	90.7	13.7	9.8	3.8
Respiratory failure	41	6.2	77.5	85.4	34.5	17.1	13.3
Stroke/ICH	34	5.2	88.2	94.1	0.0	0.0	0.0
Agitation	22	3.3	95.5	86.4	4.8	0.0	4.8
Sepsis	17	2.6	82.4	76.5	50.0	42.9	8.3
Medical	15	2.3	53.3	80.0	14.3	14.3	0.0

(*Continues*)

TABLE 1. *Continued*

	n 655	% 100.0	Checklist use % (n = 646) 89.6	First-pass success % (n = 655) 86.6	Complications† (%) (n = 595) 15.6	New hypotension‡ (%) (n = 605) 10.9	New desaturation‡ (%) (n = 607) 4.0
Burns	7	1.1	85.7	100.0	0.0	0.0	0.0
Airway obstruction	6	0.9	83.3	33.3	0.0	0.0	0.0
Drowning	4	0.6	75.0	75.0	25.0	25.0	25.0
Patient status			***	*	**	***	***
Arrest/peri-arrest	35	5.3	40.0	74.3	94.7	66.7	27.3
Other	620	94.7	92.5	87.3	13.0	9.6	3.5
Pre-intubation vital signs							
Unrecordable SBP	15	2.3					
SBP <90	34	5.2					
Unrecordable O_2 sats	17	2.6					
O_2 sats <90	30	4.6					
Initial disposition post-ED							
ICU	527	80.1					
Children's critical care	26	4.0					
Another hospital ICU	22	3.3					
OT/angio	48	7.3					
Ward	3	0.5					
Home	2	0.3					
Died in ED	30	4.6					
Extubated in ED?							
Yes, discharged alive	5	0.8					
Yes, died in ED	30	4.6					
No	623	94.7					

*P < 0.05, **P < 0.01, ***P < 0.001. †Composite variable including new hypotension, new desaturation, cardiac arrest, aspiration, includes patients with known complications and all others where systolic blood pressure and saturations were known pre-RSI and post-RSI. ‡Only includes cases where both pre- and post-measurements were recorded and recordable. §Categorised as <1 year, 2–14 years, 15+ years for statistical test.

Results

RSI was performed on 655 patients presenting between January 2014 and December 2016. This group of patients was predominantly male (59.5%) and medical (83.6%). The most common indications for intubation were overdose (35.9%) and trauma (13.7%). Patients ranged from 1 month to 93 years old, with a median age of 44 years

TABLE 2. *Initial intubation techniques for 655 patients undergoing rapid sequence intubations (RSI)*

	n	%	Checklist use % (*n* = 646)	First-pass success % (*n* = 655)	Complication† (%) (*n* = 595)	New hypotension‡ (%) (*n* = 605)	New desaturation‡ (%) (*n* = 607)
Valid %	655	100.0	89.6	86.6	15.6	10.9	4.0
Position of head			***				
Head up	460	70.2	94.5	86.5	14.5	10.7	3.2
Not head up	190	29.0	78.4	86.3	18.8	11.0	6.1
Unknown	5	0.8	60.0	100.0	NA	NA	NA
High flow oxygen via nasal prongs used			***		***		***
Yes	552	84.3	95.6	87.7	13.9	10.4	2.0
No	81	12.4	55.1	79.0	31.1	14.3	22.2
Unknown	22	3.4	75.0	86.4	NA	NA	
Position			***				
Head-up	327	49.9	94.7	85.6	12.3	8.7	2.9
Ramped	58	8.9	91.4	89.7	21.6	15.1	7.3
Reverse trendelenberg	75	11.5	96.0	88.0	16.9	15.3	0.0
Supine	181	27.6	78.1	86.2	19.9	11.6	6.5
Unknown	14	2.1	75.0	92.9	10.5	7.1	7.7
Pre-oxygenation method (*n* = 623)			***		**		
BVM (any)	260	41.7	86.0	87.3	17.3	11.3	4.3
NRBM	253	40.6	96.0	87.4	10.8	8.3	2.8
HFNO	29	4.7	100.0	89.7	7.7	7.4	0.0
NIV (any incl neopuff)	81	13.0	89.9	79.0	27.6	18.7	8.3
First adjunct used			***	***		***	
Bougie and unknown	578	88.2	92	88.9	15.2	10.7	2.8
Stylet	14	2.1	76.9	50.0	28.6	7.1	28.6
Nil	63	9.6	70.5	73.0	17.0	12.5	8.9
First laryngoscope			**	***			
Video	585	89.3	91.7	88.2	15.3	10.5	3.5
All other and unknown	70	10.7	71.6	72.9	19.0	12.7	8.5
Team leader specialty			***				
Emergency	648	98.9	90.1	86.6	15.4	10.7	3.8
ICU	7	1.1	42.9	85.7	33.3	14.3	20.0
RSI checklist used					***	*	***
Yes	579	88.4	NA	87.6	13.3	9.7	2.3
No	67	10.2	NA	82.1	43.2	20.8	22.7
Unknown	9	1.4					
First-pass success					**		***
Yes	567	86.6	90.2	NA	14.0	11.3	2.1
No	88	13.4	85.9	NA	25.9	7.5	16.3

(*Continues*)

TABLE 2. *Continued*

	n	%	Checklist use % (n = 646)	First-pass success % (n = 655)	Complication† (%) (n = 595)	New hypotension‡ (%) (n = 605)	New desaturation‡ (%) (n = 607)
Valid %	655	100.0	89.6	86.6	15.6	10.9	4.0
Cricoid pressure used?					*	*	*
Yes	23	3.5	95.5	73.9	31.8	27.3	13.0
No	623	95.1	86.6	87.2	14.9	10.1	3.6
Unknown	9	1.4					
First intubator experience			***	***			
<10 prior RSI	138	21.1	97.1	78.3	15.5	10.9	4.5
10–50 RSI	198	30.2	94.4	84.3	13.2	9.4	2.1
>50 RSI	310	47.3	83.7	91.6	17.1	11.3	4.7
Unknown	9	1.4					
Number of attempts before success			**		**		***
1	567	86.6	90.2	100.0	14.0	11.3	2.1
2	78	11.9	90.8	0.0	22.2	7.0	13.9
3+	10	1.5	44.4	0.0	55.6	11.1	37.5

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. †Composite variable including new hypotension, new desaturation, cardiac arrest, aspiration, includes patients with known complications and all others where systolic blood pressure and saturations were known pre-RSI and post-RSI. ‡Only includes cases where both pre and post-measurements were recorded and recordable.

(interquartile range 28–60.5 years). The majority of patients were admitted to ICU (87.4%). Twenty-seven RSIs were performed in children under 15 years of age.

FPS was 86.6%; 78 patients required two attempts (12.0%) and 10 (<1%) required three or more attempts (Table 2). Characteristics univariately associated with an unsuccessful FPS were weight ≥100 kg, male sex, younger age and arrest/peri-arrest status (Table 1). The RSI teams were usually led by an emergency doctor (98.9%) (Table 2). First attempt at RSI was commonly performed by a non-consultant ED doctor.

The patient was usually positioned ‘head-up’ (70.3%), and ApOx was commonly used (84.3%). A bougie was the first adjunct of choice for 568 RSIs (86.0%), and video laryngoscopy was used 89.3% of the time (Table 2).

In 579 (88.4%) intubations, the RSI checklist was used and was significantly more frequently used for adults, medical patients (Table 1) and when the team leader was an ED consultant (Table 2). The checklist was significantly less frequently used in children <15 years and in arrest/peri-arrest situations (Table 1). In patients where more than two attempts at intubation were required, the checklist was less frequently used (Table 2).

16% of patients undergoing RSI experienced a complication: the most common being the onset of new hypotension (10.9%). Critical hypoxia (3.3%) and cardiac arrest (1.5%) were uncommon (Table 3). There were no cases where a surgical airway was performed.

Univariate analyses for FPS

Certain presentations, including airway obstructions, drownings and

TABLE 3. *Complications (*n *= 655)*

More than one attempt required	88	655	13.4
New desaturation (O_2 sats <90%)	24	607	4.0
Critical hypoxia noted (<85%)	20	607	3.3
New hypotension (SBP <90 mmHg)	66	605	10.9
Cardiac arrest post-RSI with no pre-RSI arrest	10	655	1.5
Other complications			
Failed intubation	2	655	0.3
Aspiration	6	655	0.9
Surgical airway	0	0	0

TABLE 4. *Medication and dosages used during rapid sequence intubation (RSI), use of checklist and association of medication use† with first-pass success and complications*

	n	%	Checklist use % (*n* = 620)	First-pass success % (*n* = 629)	Complication‡ (%) (*n* = 586)	New hypotension§ (%) (*n* = 594)
Valid %	629	100.0	91.8	86.6	14.5	10.1
Propofol dose (mg/kg)						
Not used	472	75.0	92.0	85.8	15.7	10.3
<1	65	10.3	92.2	86.2	9.7	9.4
1–1.4	51	8.1	92.2	92.2	12.0	7.8
1.5–1.9	16	2.5	93.8	93.8	0.0	0.0
≥2	25	4.0	84.0	88.0	20.8	20.8
Fentanyl dose (mcg/kg)			**			
Not used	167	26.6	87.1	86.8	14.7	8.8
<1	58	9.2	82.8	84.5	10.2	5.5
1–1.4	145	23.1	95.8	89.0	11.3	8.4
1.5–1.9	50	7.9	98.0	86.0	22.0	14.3
≥2	209	33.2	93.7	85.6	15.8	12.6
Midazolam dose (mg/kg)						
Not used	494	78.5	92.0	86.8	14	9.7
≤0.05	59	9.4	93.2	86.4	25.5	16.1
0.055–0.10	57	9.1	91.2	87.7	7.0	7.0
0.11–0.19	15	2.4	85.7	73.3	21.4	13.3
≥0.2	4	0.6	75.0	100.0	0.0	0.0
Suxamethonium dose (mg/kg)			***	*		
Not used	605	96.2	93.0	86.9	14.1	9.8
≤1.25	7	1.1	71.4	100.0	28.6	28.6
1.26–1.49	4	0.6	100.0	100.0	0.0	0.0
1.5–1.99	4	0.6	50.0	50.0	33.3	0.0
≥2	9	1.4	28.6	66.7	28.6	25.0
Rocuronium dose (mg/kg)			***			
Not used	29	4.6	59.3	93.1	20.8	18.5
<1	49	7.8	85.4	89.8	17.4	8.5
1–1.25555	304	48.4	93.0	84.2	15.6	10.5
1.26–1.99	233	37.1	94.8	87.6	12.6	9.5
≥2	13	2.1	100.0	100.0	0.0	0.0
Ketamine dose (mg/kg)						
Not used	310	49.3	90.5	87.4	15.0	11.3
≤0.5	16	2.5	75.0	87.5	14.3	13.3
0.55–1.25	145	23.1	92.3	87.6	17.3	8.3
1.26–2.0	126	20	96.8	83.2	11.1	9.4
>2.0	33	5.2	90.3	87.9	10.3	6.7

**P* < 0.05, ***P* < 0.01, ****P* < 0.001. †A combination of sedatives/analgesics may have been used. χ^2-test for trend by increasing dose (five categories) was used for each medication. ‡Composite variable: new hypotension, new desaturation, cardiac arrest, aspiration. Includes cases with known complications and all others where systolic blood pressure and oxygen saturations were known pre-RSI and post-RSI. §Only includes cases where both pre- and post-measurements were recorded and recordable.

TABLE 5. *Multivariable modelling results for complications (any complication composite variable, new hypotension, new desaturation or failed first pass) in a series of rapid sequence intubations*

Model 1: Dependent variable: any complication (records in final model = 584)					
Variable	Coefficient	Standard error	*P*-value	Odds ratio	95% confidence interval
Checklist use	−0.945	0.4209	<0.025	0.39	(0.17–0.89)
Arrest/peri-arrest status	4.59	1.0707	<0.000	98.5	(12.1–803.5)
Weight ≥100 kg	1.253	0.3083	<0.000	3.5	(1.9–6.4)

Model 2: Dependent variable: new hypotension (records in final model = 607)					
Variable	Coefficient	Standard error	*P*-value	Odds ratio	95% confidence interval
Sepsis (yes)	1.606	0.5959	0.007	5	(1.5–16.0)
Age (continuous)	−0.02	0.007	0.004	0.98	(0.97–0.99)

Model 3: Dependent variable: new desaturation (records in final model = 596)					
Variable	Coefficient	Standard error	*P*-value	Odds ratio	95% confidence interval
Weight ≥100 kg	2.151	0.6351	0.001	8.6	(2.5–29.8)
Age (continuous)	0.033	0.0146	0.023	1.03	(1.0–1.1)
First pass unsuccessful	1.951	0.4997	0	7	(2.6–18.7)
Checklist used	−2.298	0.4993	0	0.1	(0.04–0.27)

Model 4: Dependent variable: first-pass success (FPS) (records in final model = 643)					
Variable	Coefficient	Standard error	*P*-value	Odds ratio	95% confidence interval
Male sex	−0.62	0.2608	0.017	0.54	(0.32–0.90)
First adjunct: Stylet	−1.82	0.5817	0.002	0.16	(0.05–0.51)
First adjunct: Nil	−1.29	0.3771	0.001	0.28	(0.13–0.58)
First adjunct: Bougie				1.0	(reference)
First intubator experience: <10 RSI	−1.554	0.3357	<0.001	0.217	0.11–0.41)
First intubator experience: 10–50 RSI	−1.058	0.3214	0.001	0.35	(0.19–0.65)
First intubator experience: >50 RSI				1.0	(reference)
Arrest/peri-arrest status (yes)	−1.154	0.5028	0.022	0.31	(0.12–0.85)
First laryngoscope not video	−0.895	0.3486	0.010	0.41	(0.21–0.81)
Weight ≥100 kg	−0.976	0.3378	0.004	0.38	(0.19–0.73)

sepsis, were associated with lower FPS (Table 1). FPS with a video-laryngoscope was higher compared to other blades (88.2% *vs* 72.9%). The application of cricoid pressure was associated with lower FPS (87.2% without cricoid *vs* 73.9% with cricoid), and FPS increased with operator experience (Table 2). There were no differences in FPS based on type or dosage of medication (Table 4).

Multivariable analyses

The following variables were significantly associated with FPS: types of first adjunct and laryngoscope used, operator experience, arrest/peri-arrest status, patient's weight and sex (Table 5). Doctors who had performed >50 intubations were more likely have FPS, compared to those operators with <10 RSIs (Table 5).

In the multivariable model, arrest/peri-arrest status and weight ≥100 kg was associated with an increase of any complication with an odds ratio (OR) of 3.5 (95% CI 1.9–6.4). Arrest/peri-arrest status and sepsis were significantly associated with new hypotension. Excluding arrest/peri-arrest status from the model, increasing age and sepsis remained significantly associated with hypotension (Table 5).

For the complication new desaturation, weight ≥100 kg had the greatest association in multivariable modelling, followed by unsuccessful first pass. Checklist use predicted lower likelihood of new desaturation after adjusting for other variables (Table 5).

Discussion

Our training network has a high number of emergency medicine trainees of varying grades, many who have not yet undertaken formal anaesthetic training. It is recognised that learners may need at least 50 endotracheal intubations to achieve a 90% success within two attempts but also accepted that ED RSI can be associated with a difficult airway or failed intubation.[9]

Inexperienced providers may have a lower FPS and are more likely to encounter (more challenging) Cormack-Lehane grade 3 or 4 views.[4] Additionally, international[1,2,10–15] and Australian[4,6,7] registry data have shown that complications from emergency RSI are frequent, and it is accepted that lack of FPS is associated with increasing complications including hypoxia.[13,16,17]

Restricting RSI to those practitioners who have at least 3 months of formal anaesthetic experience can result in FPS over 90% and reduce complications;[7] however, this reduces opportunities for trainees who are not able to access anaesthesia rotations until later in training.

Our training package supports trainees of all levels conducting RSI. In contrast with many other Australian EDs,[6] this has resulted in a cohort of patients intubated by an emergency medicine trainee using video-laryngoscopy first line, in a head elevated position, with ApOx applied, omitting cricoid pressure, with rocuronium as relaxant of choice. There were no restrictions on inexperienced providers attempting RSI, at the judgement of the team leader.

The importance of FPS in reducing complications such as hypoxia is well-established.[17] Our overall FPS is 86.7%, comparing favourably with a mean FPS rate of 84.1% over 42 000 intubations over 16 years in a recent systematic review.[18] Most patients were intubated on first (86.7%) or second attempt (12.0%) and FPS was more likely if a bougie was used, a finding in agreement with a recent prospective observational study by Driver *et al.*[19] and a benefit that persisted in the multivariable model (Table 5).

The use of a video-laryngoscope device was predictive of FPS that persisted in the multivariable analysis (Table 5). The benefit of video-laryngoscopy is not uniformly accepted and a meta-analysis in 2017 showed no improvement in FPS despite improving grade of view.[20] At our institutions, we use non-disposable C-MAC blades, which have a Macintosh blade shape. Anecdotally, our trainees are most successful when optimising the direct view before using video view. The supervising consultant monitors via the video screen, visualising tube placement prior to confirmation by capnography and intervening as required.

In the regression models, checklist use was associated with a lower risk of new desaturation and the composite variable any complication. Use of the checklist was associated with fewer oxygen desaturations even after adjusting for age, weight and whether first pass was successful (Table 5).

Although implementing intubation checklists and protocols have been previously shown to reduce desaturation and complications,[21] a more recent multi-centre randomised controlled trial suggested there may be no benefit from a verbal checklist over standard care.[22] The Australian and New Zealand Airway Registry[6] also failed to show benefit, nor did a recent meta-analysis.[23] We found checklist use was associated with a reduction of intubations requiring multiple attempts (Table 2) and showed an association with lower likelihood of complications (Table 5).

The checklist has been embraced by our staff. Its benefit may be due to the orientation and training of its use – both online and embedded in the department simulation programme – and the challenge-response (cockpit-style) design. Our checklist is read aloud, which has a positive effect on team dynamics, planning and communication. Importantly, checklists also vary in content, and the purpose of our checklist was to promote practices that maximise FPS and reduce complications.[8]

ApOx with nasal prongs running at an oxygen flow rate of 15 L/min was considered routine. ApOx is low cost and may increase first pass without hypoxaemia.[24–26] In our study, ApOx was univariately associated with a lower frequency of desaturation and was associated with a reduction in any complication (Table 2).

Although several studies suggest benefit from head-up positioning,[27] we were unable to demonstrate benefit from elevation of the head of the bed, reverse Trendelenburg or ramping. Positioning showed no statistically significant association with FPS or any complication (Table 2).

Cricoid pressure is seldom used in our department and was not part of the checklist because of unproven effectiveness in preventing pulmonary aspiration, and potential to complicate airway management.[21,28] On the infrequent occasions where cricoid pressure was used, it was associated with lower FPS (73.9%), increased complications (31.8%) and increased desaturation (13.0%) (Table 2).

Although hypotension appeared to be unrelated to any medication choice or dose, it was associated with sepsis and increasing age. Despite concerns about the use of propofol[29] in critically unwell patients, we saw no association between hypotension, complications and the use of propofol.

In our cohort of patients, rocuronium was used in 95.0% of intubations and this contrasts with many other Australian departments where suxamethonium is more commonly used.[6] There were no recognised or reported cases of anaphylaxis to rocuronium in our study.[30] There were no cases of sugammadex usage to reverse rocuronium.

We have been able to safely implement a bundle of practice changes in a training environment. Checklist use, first line video-laryngoscopy, bougie and apnoeic oxygenation appear to be of benefit. We have a relatively high FPS, combined with a low incidence of desaturation and complications. Adherence to this process allows relatively inexperienced trainees to undertake RSI safely.

Limitations

Despite being a prospective observational study, when data were missing investigators asked the proceduralist to complete a form retrospectively, or by obtained additional information by telephone or via the electronic medical record. It is possible this led to a degree of reporting bias because of a reluctance to report significant problems or to overstate success.

For some variables, such as oxygen saturations and blood pressure recordings, hand-written records may not have captured or recorded all significant changes. We used a relatively high cut-off for the definition of hypotension to ensure complete capture of complications, which may have led to over-estimation; nonetheless, our study complication rate compared favourably with other studies.[4–6]

The study was conducted in one health service, which may lead to limitations in generalisability. Despite multivariable analysis, in the absence of a randomised controlled trial, we cannot definitively show causation. Missed cases of RSI were unlikely as compliance with form submission was audited for the duration of the study.

Conclusions

Implementation of a evidence-based care bundle (standardisation of care using an RSI checklist, electronic learning and audit of practice) has created a safe environment for emergency trainees to learn the core critical care skill of RSI. Checklist use in our setting was associated with fewer complications. We have promoted key practice changes, associated with reduced incidence of desaturation and other complications, while maintaining FPS across two sites in our emergency training network.

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Author contributions

SG conceived the study. SG, GK, MS were involved in the study design and implementation. SG, FK, SRP, RAFP undertook data collection. ALS provided statistical advice and analysed the data. SG drafted the manuscript and all authors substantially contributed to revisions. SG takes responsibility for the paper as a whole.

Competing interests

GK is a section editor for *Emergency Medicine Australasia*.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Simpson GD, Ross MJ, McKeown DW, Ray DC. Tracheal intubation in the critically ill: a multi-Centre national study of practice and complications. *Br. J. Anaesth*. 2012; **108**: 792–9.
2. Cook TM, Woodall N, Harper J, Benger J. Major complications of airway management in the UK: results of the fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *Br. J. Anaesth*. 2011; **106**: 632–42.
3. Australasian College for Emergency Medicine. Curriculum framework. [Cited 2 Jan 2021.] Available from URL: https://acem.org.au/getmedia/fae9de05-e9c2-40d3-bee9-be1e66b3b84f/ACF440_0-5.aspx
4. Fogg T, Annesley N, Hitos K, Vassiliadis J. Prospective observational study of the practice of endotracheal intubation in the emergency department of a tertiary hospital in Sydney, Australia. *Emerg. Med. Australas*. 2012; **24**: 617–24.
5. Phillips L, Orford N, Ragg M. Prospective observational study of emergent endotracheal intubation practice in the intensive care unit and emergency department of an Australian regional tertiary hospital. *Emerg. Med. Australas*. 2014; **26**: 368–75.
6. Alkhouri H, Vassiliadis J, Murray M *et al*. Emergency airway management in Australian and New Zealand emergency departments: a multicentre descriptive study of 3710 emergency intubations. *Emerg. Med. Australas*. 2017; **29**: 499–508.
7. Fogg T, Alkhouri H, Vassiliadis J. The Royal North Shore Hospital Emergency Department airway registry: closing the audit loop. *Emerg. Med. Australas*. 2016; **28**: 27–33.
8. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. *Ann. Emerg. Med*. 2012; **59**: 165–75.e1.
9. Buis ML, Maissan IM, Hoeks SE, Klimek M, Stolker RJ. Defining the learning curve for endotracheal intubation using direct laryngoscopy: a systematic review. *Resuscitation* 2016; **99**: 63–71.
10. Sakles JC, Laurin EG, Rantapaa AA, Panacek EA. Airway management in the emergency department: a one-year study of 610 tracheal intubations. *Ann. Emerg. Med*. 1998; **31**: 325–32.
11. Sagarin MJ, Barton ED, Chng YM, Walls RM. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. *Ann. Emerg. Med*. 2005; **46**: 328–36.
12. Phelan MP, Glauser J, Yuen HW, Sturges-Smith E, Schrump SE. Airway registry: a performance improvement surveillance project of emergency department airway

management. *Am. J. Med. Qual.* 2010; **25**: 346–50.
13. Hasegawa K, Shigemitsu K, Hagiwara Y *et al*. Association between repeated intubation attempts and adverse events in emergency departments: an analysis of a multicenter prospective observational study. *Ann. Emerg. Med.* 2012; **60**: 749–754.e2.
14. Brown CA, Bair AE, Pallin DJ, Walls RM, NEAR III Investigators. Techniques, success, and adverse events of emergency department adult intubations. *Ann. Emerg. Med.* 2015; **65**: 363–370.e1.
15. Kerslake D, Oglesby AJ, Di Rollo N, James E, McKeown DW, Ray DC. Tracheal intubation in an urban emergency department in Scotland: a prospective, observational study of 3738 intubations. *Resuscitation* 2015; **89**: 20–4.
16. Mort TC. Emergency tracheal intubation: complications associated with repeated laryngoscopic attempts. *Anesth. Analg.* 2004; **99**: 607–13.
17. Sakles JC, Chiu S, Mosier J, Walker C, Stolz U. The importance of first pass success when performing orotracheal intubation in the emergency department. *Acad. Emerg. Med.* 2013; **20**: 71–8.
18. Park L, Zeng I, Brainard A. Systematic review and meta-analysis of first-pass success rates in emergency department intubation: creating a benchmark for emergency airway care. *Emerg. Med. Australas.* 2017; **29**: 40–7.
19. Driver B, Dodd K, Klein LR *et al*. The Bougie and first-pass success in the emergency department. *Ann. Emerg. Med.* 2017; **70**: 473–478.e1.
20. Jiang J, Ma D, Li B, Yue Y, Xue F. Video laryngoscopy does not improve the intubation outcomes in emergency and critical patients - a systematic review and meta-analysis of randomized controlled trials. *Crit. Care* 2017; **21**: 288.
21. Jaber S, Jung B, Corne P *et al*. An intervention to decrease complications related to endotracheal intubation in the intensive care unit: a prospective, multiple-center study. *Intensive Care Med.* 2010; **36**: 248–55.
22. Janz DR, Semler MW, Joffe AM *et al*. A multicenter randomized trial of a checklist for endotracheal intubation of critically ill adults. *Chest* 2017; **153**: 816–24.
23. Turner JS, Bucca AW, Propst SL *et al*. Association of checklist use in endotracheal intubation with clinically important outcomes. *JAMA Netw. Open* 2020; **3**: e209278.
24. Oliveira JE, Silva L, Cabrera D, Barrionuevo P *et al*. Effectiveness of apneic oxygenation during intubation: a systematic review and meta-analysis. *Ann. Emerg. Med.* 2017; **70**: 483–494.e11.
25. Sakles JC, Mosier J, Patanwala AE, Arcaris B, Dicken J. First pass success without hypoxemia is increased with the use of apneic oxygenation during RSI in the emergency department. *Acad. Emerg. Med.* 2016; **23**: 703–10.
26. Sakles JC, Mosier JM, Patanwala AE, Dicken JM. Apneic oxygenation is associated with a reduction in the incidence of hypoxemia during the RSI of patients with intracranial hemorrhage in the emergency department. *Intern. Emerg. Med.* 2016; **11**: 983–92.
27. Dixon BJ, Dixon JB, Carden JR *et al*. Preoxygenation is more effective in the 25 degrees head-up position than in the supine position in severely obese patients: a randomized controlled study. *Anesthesiology* 2005; **102**: 1110–5.
28. Algie CM, Mahar RK, Tan HB, Wilson G, Mahar PD, Wasiak J. Effectiveness and risks of cricoid pressure during rapid sequence induction for endotracheal intubation. *Cochrane Database Syst. Rev.* 2015: CD011656.
29. Reid C. The propofol assassins. ERcast Rant-Off. 2011.
30. Reddy JI, Cooke PJ, van Schalkwyk JM, Hannam JA, Fitzharris P, Mitchell SJ. Anaphylaxis is more common with rocuronium and succinylcholine than with atracurium. *Anesthesiology* 2015; **122**: 39.

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. RSI checklist.
Appendix S2. Multivariate data analysis.