Association between location of prehospital intubation, complication rates and time intervals

Alan A Garner [1,2] Andrew Scognamiglio,[3] Anna Lee [4]

Handling editor Ellen J Weber

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/emermed-2024-214285).

[1]CareFlight Australia, Northmead, New South Wales, Australia
[2]Trauma Service, Royal Hobart Hospital, Hobart, Tasmania, Australia
[3]Northern Sydney Local Health District, St Leonards, New South Wales, Australia
[4]Department of Anaesthesia and Intensive Care, Chinese University of Hong Kong, Shatin, Hong Kong

Correspondence to
Dr Alan A Garner;
alan.garner@sydney.edu.au

Received 3 June 2024
Accepted 26 November 2025

ABSTRACT

Background It has been recommended that prehospital rapid sequence intubation (PH-RSI) be performed in locations that provide 360-degree access to the patient. We aimed to examine the success and complication rate of PH-RSI by location of intubation as well as the effect on scene time.

Methods We conducted a single-centre, retrospective cohort study of patients with attempted PH-RSI over a 96-month period. Locations compared were intubation within the road ambulance, outside the vehicle on a stretcher, on the ground and in other locations. The primary outcome was the occurrence of major intubation complications by location. Secondary outcomes were first-pass success, time to intubation from patient contact and total scene time. Modified Poisson with robust SE variance and quantile regressions was used to adjust for confounding variables.

Results Of 413 patients, major intubation complications occurred in 60 (14.5%, 95% CI 11.3% to 18.3%) patients. Patients intubated on the ground were twice as likely to have complications than patients intubated on a stretcher outside the vehicle (p=0.023) in the unadjusted analysis. First-pass success intubations occurred in 400 (96.9%, 95% CI 94.7% to 98.3%). Adjusted time from contact to intubation was not different (p=0.864) but total scene time was significantly shorter for patients intubated inside an ambulance compared with outside on a stretcher (median difference −4.0 min, 95% CI −6.5 to 1.5; p=0.002).

Conclusions Intubating selected patients within an ambulance had similar complication rates to intubation on a stretcher outside the vehicle but was associated with a small reduction in on-scene time.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ It has been recommended that prehospital rapid sequence intubation be performed in locations that provide 360-degree access to the patient but there is a lack of supporting evidence.

WHAT THIS STUDY ADDS

⇒ We found that intubating selected patients inside an ambulance was not associated with increased complications, but significantly reduced scene times compared with intubation outside the vehicle on a stretcher. Patients intubated on the ground were more likely to have complications, but this was probably due to differences in underlying patient characteristics.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Selected patients can be safely intubated in the back of ambulances with resulting reductions in scene time.

INTRODUCTION

To improve safety in prehospital rapid sequence intubation (PH-RSI), it has been recommended that patients be intubated in locations with 360° access to the patient.[1 2] Achieving 360° access usually means intubation outside ambulances or helicopters due to space constraints. Some physician-staffed helicopter emergency medical services (PSHEMS) will therefore remove an already loaded patient from a road ambulance to perform PH-RSI outside the vehicle, despite possible adverse effects on scene time.

One strategy to minimise scene time is for intubation to take place onboard emergency vehicles either before scene departure or during transit. While some research indicates that PH-RSI is more likely to be successful when performed on scene before transfer,[3 4] some data also indicates PHI on-board emergency vehicles is safe and effective.[5 6] If this is the case, guidelines could be revised to improve scene time and potentially patient outcomes. Current evidence around intubating onboard ambulances or helicopters is limited, with one small study demonstrating PH-RSI could be performed safely in both moving and static ambulances. Other studies use manikins in their methodology,[7 8] which may not reflect real-world success rates and cannot assess complications.[9]

This retrospective cohort study of PSHEMS medical records aimed to examine the success and complication rate of PH-RSI by location of intubation. We hypothesised that PH-RSI can be performed safely on-board ambulances despite the lack of 360° access, and thus improve scene time.

METHODS

Study design

This study was a retrospective cohort study using data collected during routine patient care and quality assurance activities by the CareFlight Rapid Response Helicopter (CRRH) service in Sydney, Australia. The reporting of this study followed the Strengthening the Reporting of Observational Studies in Epidemiology statement.[10]

Check for updates

To cite: Garner AA, Scognamiglio A, Lee A. *Emerg Med J* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/emermed-2024-214285

Patient and public involvement

There was no patient and public involvement in the study design.

Setting

The Sydney region in Australia contains approximately 5 million people and is serviced by paramedic-staffed road ambulances and PSHEMS. The setting for this study is the CRRH service, a specialist metropolitan prehospital PSHEMS. Crew composition, experience levels and training programmes have been previously described.[11] Staffing consisted of a paramedic and either a registrar, consultant or both, that is, a two-person or three-person clinical crew. Intubators were paramedics, registrars without a consultant, registrars with a supervising consultant or consultants. Ultrasound was used to detect pneumothoraces routinely throughout the study period.

Intubations occurred in ground ambulances in one of two circumstances. First, the patient may already be loaded into the ambulance at the time of the PSHEMS clinician's arrival on the scene. In this circumstance, the patient was managed in the ambulance before departure rather than removing them from the vehicle. Alternatively, with very time-critical patients, the transport commenced while patient assessment and equipment setup was conducted, and then the ambulance pulled over briefly while intubation was performed, typically for less than 2 min. No planned intubations were conducted in the helicopter cabin either on the ground or while airborne. During the study period, almost all helicopter transports were conducted in A109E and BK117B2 airframes which had small cabins. If intubation was known or suspected to be necessary, it was always conducted at the scene before loading.

Participants

The study included all patients undergoing PH-RSI during the period from 1 January 2014 to 31 December 2022, inclusive. Patients intubated in cardiorespiratory arrest without anaesthetic and/or muscle relaxant drugs were excluded.

Exposure and outcome variables

The primary exposure variable was the location of the PH-RSI attempt. An attempt at intubation was defined as introduction into the patient's mouth of a laryngoscope blade with the intent of intubating the patient.

The primary outcome was the composite measure of major intubation complications; ALOHA (Arrest, Low Oxygen, Hypotension, Aspiration). The individual variables were defined as:

- Arrest: asystole, bradycardia or dysrhythmia with non-measurable blood pressure and/or cardiopulmonary resuscitation during or after intubation.
- Low Oxygen: oxygen saturation (SpO_2) falls to less than 90% where it was greater than 90% at commencement of intubation, or a fall of 10 or more saturation percentage points if it was below 90% at the end of maximal preoxygenation.
- Hypotension: systolic blood pressure (SBP) less than 90 mm Hg or mean arterial pressure less than 60 mm Hg, and at least 20% decrease from baseline.
- Aspiration: visualisation of newly regurgitated gastric contents below the glottis or suction removal of gastric contents via the endotracheal tube.

A complication occurring from commencement of intubation to up to 5 min after the procedure was considered an ALOHA event.

The secondary outcomes were: first pass success (FPS) rate, time to intubation from contact with the patient and total scene time.

Data sources

Data sources were the clinical records of the PSHEMS including case records created by the treating clinical team, entries into the electronic database and an airway registry completed on return to base. The airway registry included data on predictors of intubation difficulty, number of intubation attempts, location of the intubation attempt, time of intubation, adjuncts and incidence of ALOHA components.

Statistical analysis

Complete case analysis was used as imputing data was unlikely to be valid when the missing data mechanism was not random.[12] Appropriate descriptive statistics were used to describe the characteristics of the patient population. The χ^2 test or Fisher exact test was used to compare group differences in proportions. After testing for normality of the data distribution, analysis of variance or Kruskal-Wallis tests were used to compare the continuous variables between exposure groups as appropriate. Violin plots were used to describe the distributions of the time interval between contact to intubation and total scene times between locations of intubation groups.

We constructed directed acyclic graphs (DAG)[13] before data analysis, using DAGitty software (http://www.dagitty.net/), to identify confounding variables requiring adjustment for the associations between location of intubation attempts and ALOHA (online supplemental figure 1), time to intubation (online supplemental figure 2) and total scene time (online supplemental figure 3). Variables for inclusion in the DAG were drawn from previous studies identifying factors associated with complications[14,15] or scene times,[16,17] combined with physiology prior to the attempt.

We used a modified Poisson regression model with robust SEs[18] to estimate the relative risk (RR, 95% CI) of ALOHA,

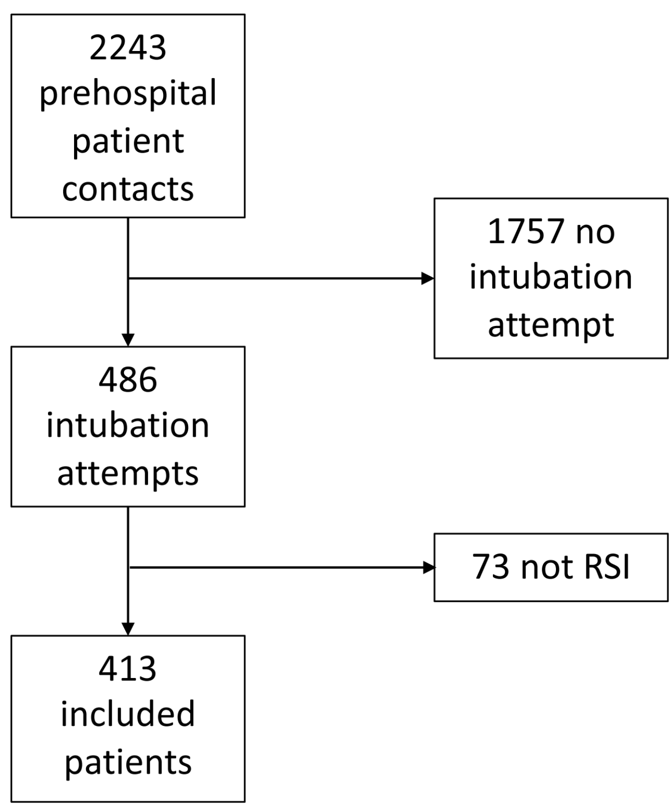

Figure 1 Flow chart of included patients. RSI, rapid sequence intubation.

excluding the 'Other location' category for the location of intubation attempts, as the outcome was common (>10%) and the RR is more interpretable than the OR from a logistic regression. The sample size was insufficient to support a direct effect model analysis (online supplemental figure 1) to estimate the RR of ALOHA (and FPS) while maintaining the recommended minimum of 10 events per predictor in binary outcome regression models[19] thus avoiding potential model[19] overfitting.

Quantile regressions[20] were performed to assess the association between the location of intubation attempts group and time to intubation or total scene times, excluding the 'Other location' category due to small numbers in this group. Finally, we included the 'Other location' category in the multivariable analyses for sensitivity analysis to examine the robustness of the major results. Statistical analyses were performed using Stata V.18.0 (StataCorp, College Station, Texas, USA) and SPSS V.27.0 (IBM, Armonk, New York, USA). The level of significance was set at $p<0.05$.

RESULTS

Of the 2243 prehospital patients treated by CRRH between 1 January 2014 and 31 December 2022, 413 were in the final analysis after applying the exclusion criteria (figure 1). The median (IQR) age was 38 (22–57) years. Most patients were males (76.5%). All patients were intubated on either the first or second attempt.

Prehospital intubations occurred mainly on the stretcher outside the vehicle (65.1%) but also inside the ambulance (25.9%), on the ground (5.3%) and in 'other locations' (3.6%).

Table 1 Patient characteristics by location of intubation attempt groups

	Stretcher outside vehicle (n=269)	Inside ambulance (n=107)	On the ground (n=22)	Other (n=15)	P value
Median (IQR) age, years	40 (25–56)	32 (14–56)	32 (10–50)	57 (36–70)	0.004
Males, n (%)	211 (78.4)	77 (72.0)	18 (81.8)	10 (66.7)	0.401
Median (IQR) estimated weight, kg*	80 (70–90)	70 (50–80)	75 (30–96)	80 (70–90)	0.006
Entrapment, n (%)*	36 (13.4)	9 (8.5)	5 (22.7)	2 (13.3)	0.280
Paramedic/supervised registrar first intubator, n (%)	254 (94.4)	105 (98.1)	19 (86.4)	14 (93.3)	0.120
First pass success, n (%)	260 (96.7)	105 (98.1)	20 (90.9)	15 (100)	0.300
Cormack and Lehane Grade 3 or 4, n (%)	15 (6.2)	7 (7.8)	3 (15)	1 (7.1)	0.347
Physiology immediately prior to intubation attempt					
Median (IQR) prehospital GCS	7 (4–12)	7 (4–11)	4 (3–7)	9 (6–14)	0.043
Median (IQR) RR, breaths/minute†	18 (14–24)	18 (14–24)	14 (12–20)	18 (12–22)	0.040
Median (IQR) SpO2, %‡	98 (93–100)	98 (95–100)	98 (77–100)	99 (95–100)	0.319
Median (IQR) SBP, mm Hg§	132 (110–154)	130 (117–146)	124 (94–145)	144 (90–155)	0.477
Median (IQR) heart rate per minute	99 (86–120)	106 (87–128)	103 (76–118)	95 (90–115)	0.159
Median (IQR) shock index¶	0.77 (0.62–0.96)	0.82 (0.65–1.00)	0.76 (0.66–1.02)	0.74 (0.58–1.01)	0.499
Predictors of intubation difficulty					
Formal airway assessment done, n (%)**	207 (77.2)	82 (76.6)	18 (81.8)	14 (93.3)	0.486
Predicted to be difficult, n (%)	103 (38.3)	30 (28.0)	9 (40.9)	5 (33.3)	0.281
Median (IQR) number of difficult airway predictors	0 (0–1)	0 (0–1)	0 (0–2)	0 (0–1)	0.433
Limited mouth opening, n (%)	22 (8.2)	4 (3.7)	0 (0.0)	0 (0.0)	0.152
Soiled airway, n (%)	40 (14.9)	16 (14.9)	6 (27.3)	1 (6.7)	0.340
Short thyromental distance, n (%)	11 (4.1)	5 (4.7)	0 (0.0)	2 (13.3)	0.264
Obesity, n (%)	26 (9.7)	0 (0.0)	2 (9.1)	1 (6.7)	0.011
Cervical spine immobilisation, n (%)	43 (16.0)	13 (12.1)	6 (27.3)	1 (6.7)	0.238
Limited neck mobility, n (%)	6 (2.2)	4 (3.7)	1 (4.5)	0 (0.0)	0.710
Facial/neck trauma, n (%)	29 (10.8)	8 (7.5)	1 (4.5)	0 (0.0)	0.351
Airway oedema/burns, n (%)	15 (5.6)	4 (3.7)	0 (0.0)	2 (13.3)	0.280
Large tongue/teeth, n (%)	16 (5.9)	4 (3.7)	2 (9.1)	0 (0.0)	0.531
Unable to adequately position patient, n (%)	0 (0.0)	0 (0.0)	2 (9.1)	0 (0.0)	<0.001
Other difficult airway predictor, n (%)	3 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	0.655
Chest decompression and transport					
Prehospital chest decompression, n (%)*	47 (17.5)	8 (7.5)	2 (9.1)	1 (6.7)	0.057
Transport mode, n (%)*					0.172
Road	161 (60.1)	71 (67.0)	12 (54.5)	5 (33.3)	
Helicopter	103 (38.4)	35 (33.0)	10 (45.5)	10 (67.7)	
Not transported	4 (1.5)	0 (0.0)	0 (0.0)	0 (0.0)	

*Data missing for 2 patients.
†Data missing for 3 patients.
‡Data missing for 13 patients.
§Data missing for 6 patients.
¶Data missing for 11 patients.
**Data missing for 1 patient.
GCS, Glasgow Coma Scale; RR, respiratory rate; SBP, systolic blood pressure; SpO2, oxygen saturation.

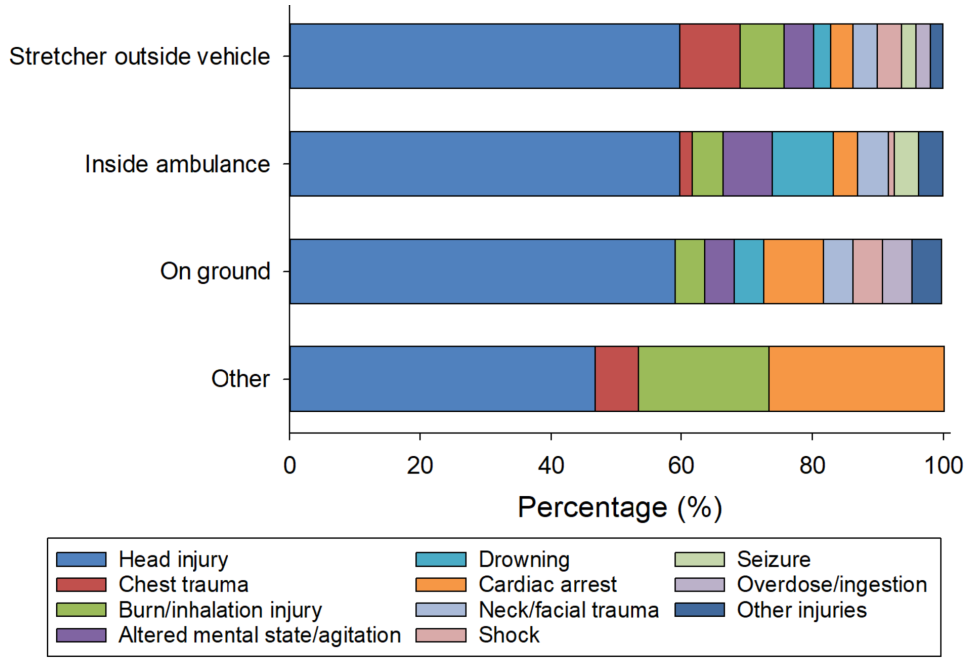

Figure 2 Indication for intubation by the location of intubation attempt groups.

17 (15.9%) of the intubations inside the ambulance occurred in transit. Three patients intubated inside the ambulance deteriorated post intubation and required immediate thoracic decompression. Two were right-sided decompressions and one left-sided; all decompressions were managed within the ambulance with no documentation indicating technical difficulty. One patient in the 'other location group' became combative during helicopter transport and was intubated outside the helicopter after landing in a field.

The difference in patient characteristics between the location of intubation attempt groups is shown in table 1. There was a difference in the proportion of COVID-19 precautions taken between locations of intubation attempt groups (17.8% stretcher outside vehicle vs 4.7% inside ambulance vs 9.1% on the ground vs 20.0% 'other locations'; p=0.008). Indications for intubations (one missing data) were different between the location of intubation attempt groups (p=0.008; figure 2).

Primary outcomes

ALOHA occurred in 60 (14.5%, 95% CI 11.3% to 18.3%) of patients. Age and sex were not associated with the risk of ALOHA (p=0.942 and p=0.530, respectively). Obesity was associated with the risk of ALOHA (RR 2.04, 95% CI 1.07 to 3.87; p=0.039). There was no association between the grade of intubator and risk of ALOHA (55/392 (14.0%) paramedic/supervised registrar vs 5/21 (23.8%) solo registrar/consultant; p=0.209). ALOHA was not associated with mode of transport (p=0.722); road 38/249 (15.3%), helicopter 21/158 (13.3%) and not transported 1/4 (25.0%). Median (IQR) SpO_2 before intubation attempt was lower in patients with ALOHA than those without ALOHA (94% (87–99%) vs 98% (95–100%), p<0.001). However, the median (IQR) of prior SBP (mm Hg) was no different between those with ALOHA or without ALOHA (130 (110–143) vs 132 (110–150); p=0.373). Patients with ALOHA had longer median (IQR) total scene time (30 min (20–37) vs 25 min (19–32); p=0.036).

No adjustment for confounders was necessary to estimate the total effect of intubation location attempts on ALOHA (online supplemental figure 1). Location of intubation attempt was associated with the risk of ALHOA (p=0.032). Patients intubated on the ground were twice as likely to have ALOHA than patients intubated on a stretcher outside the vehicle (p=0.023; table 2). The sensitivity analysis with inclusion of the 'Other location' group showed similar results (table 2).

Secondary outcomes

The overall median (IQR) time from contact to intubation was 17 (12–23) minutes in 402 patients. There was no association between location of intubation attempt and time from contact to intubation in the unadjusted (figure 3) and adjusted analysis (table 3). Similar results were found for the sensitivity analysis that included the 'other location' group, with no association

Table 2 Unadjusted risk of ALOHA by location of intubation attempt groups

Outcome	Event (n, %)	Unadjusted relative risk (95% CI)	P value	Unadjusted relative risk (95% CI) including 'Other location'	P value
Location of intubation attempt	60 (100)		0.032		0.073
Stretcher outside vehicle (n=269)	39 (14.5)	1.00		1.00	
Inside ambulance (n=107)	12 (11.2)	0.77 (0.42 to 1.42)	0.408	0.77 (0.42 to 1.42)	0.408
On the ground (n=22)	7 (31.8)	2.19 (1.11 to 4.32)	0.023	2.19 (1.11 to 4.32)	0.023
Other (n=15)	2 (13.3)	–		0.92 (0.24 to 3.46)	0.901

ALOHA, Arrest, Low Oxygen, Hypotension, Aspiration.

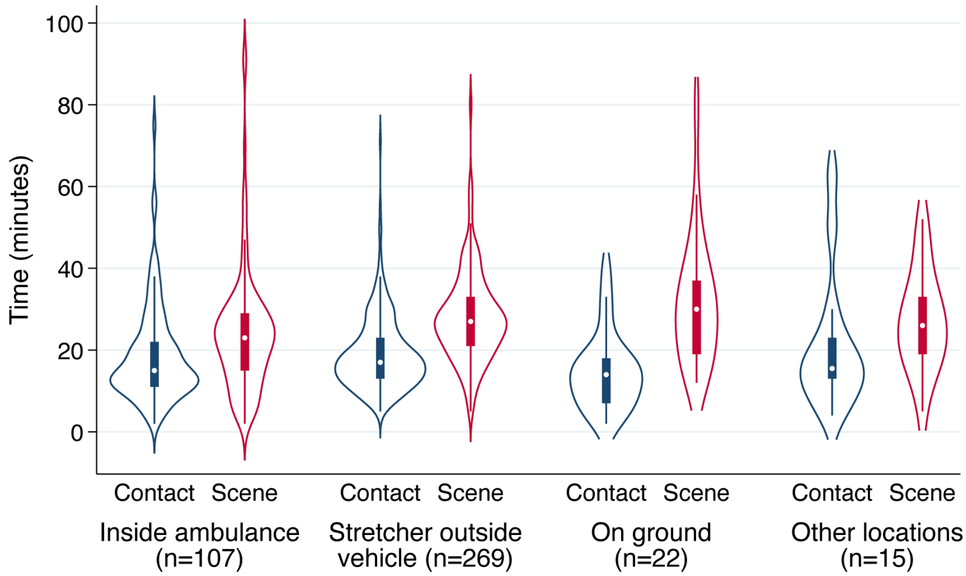

Figure 3 Violin plots for unadjusted time intervals from contact to intubation and total scene times between location of intubation attempt groups. Contact=time from patient contact to intubation. Scene=time from patient contact to scene departure.

between location of intubation attempt and time to intubation (p=0.829).

Of the 413 patients, 400 (96.9%, 95% CI 94.7% to 98.3%) had first-pass success intubations. First pass failure occurred in 9 (3.3%), 2 (1.9%), 2 (9.1%) and none, in patients on a stretcher outside the vehicle, inside the ambulance, on the ground and at 'other locations', respectively (p=0.302). Multivariable analysis was not performed given the potential problem of overfitting the model due to the low number of first-pass failure events.

In 409 patients, the overall median (IQR) total scene time was 25 (19–32) minutes. There were associations between location of intubation attempt and scene times in the unadjusted (figure 2) and adjusted quantile regressions (table 3). In the unadjusted analysis, the scene time was shorter inside an ambulance than on a stretcher outside the vehicle (median difference −4 min, 95% CI −6 to −2; p=0.001, figure 2, table 3). After adjusting for mode of transport and obesity, the scene time was shorter inside an ambulance than on a stretcher outside the vehicle (median difference −4 min, 95% CI −7 to −2; p=0.002, table 3). Scene times were similar between intubations on the ground and on a stretcher outside the vehicle in the adjusted analysis (median difference 2 min, 95% CI −3 to 7; p=0.410, table 3). Similar results were found for the sensitivity analysis that included the 'other location' group, with an association between location of intubation attempt and scene time (p=0.013) with the scene time shorter inside an ambulance than on a stretcher outside the vehicle (median difference −4 min, 95% CI −7 to −1; p=0.002).

DISCUSSION

In this single-centre, retrospective study, one in seven patients had a major intubation complication. Although we were unable to demonstrate a significant difference in major complications associated with the location of PH-RSI, some caution is required in interpreting this finding as the model was less than ideal. Low numbers of complications in locations other than 'Stretcher outside vehicle" resulted in wide CIs for the primary outcome. The FPS rate for intubation was high across the cohort, also with no observable differences by location, which is consistent with previous prehospital studies[2 6 21] and a recent systematic review.[22] After adjusting for the mode of transport and obesity,

Table 3 Unadjusted and adjusted time to intubation and total on-scene times by location of intubation attempt groups

Outcome	Unadjusted median time (95% CI)	P value	Adjusted median time (95% CI)	P value
Time to intubation from contact, min				
Location of intubation attempt		0.103		0.864*
Stretcher outside vehicle (n=261)	17 (16 to 18)	reference	17 (16 to 18)	reference
Inside ambulance (n=104)	15 (13 to 17)	0.046	18 (15 to 20)	0.648
On the ground (n=22)	15 (11 to 19)	0.296	18 (13 to 22)	0.731
On-scene time, minutes				
Location of intubation attempt		<0.001		0.003†
Stretcher outside vehicle (n=265)	27 (26 to 28)	reference	27 (25 to 28)	reference
Inside ambulance (n=106)	23 (21 to 25)	0.001	23 (21 to 25)	0.002
On the ground (n=22)	30 (26 to 34)	0.183	29 (24 to 34)	0.410

*Quantile regression model in 330 patients adjusted for ALOHA (p=0.183), Cormack and Lehane III/IV (p=0.401), COVID precautions (p=0.297), FPS (p=0.282), first intubator grade (p=0.372), indication (p=0.128), obesity (p=0.011), chest decompression (p=0.849).
†Quantile regression model in 393 patients adjusted for transport mode (p<0.001), obesity (p<0.001).
ALOHA, Arrest, Low Oxygen, Hypotension, Aspiration; FPS, first pass success.

scene times were significantly faster when PH-RSI took place inside the ambulance, compared with outside on a stretcher.

Although these findings challenge the mandatory 360° access requirement (with wide CIs around the primary outcome), they do align with a recent multicentre study from Scandinavia, where conditions often necessitate intubation within helicopters on the ground due to adverse weather.[21] Intubations performed inside the aircraft were non-inferior to intubations outside the vehicle and mean scene time for in-cabin procedures was significantly shorter.

Access to the left side of the patient is limited in ambulances in our system with the patient's left side against the cabin wall. Although three patients required urgent thoracic decompression post intubation, this was managed without apparent technical difficulty, including the patient requiring left-sided intervention. That intubation can be performed with low complication rates within the cabin of stationary ambulances supports our current practice of 'play on the way' where the patient and equipment are prepared while the vehicle is in motion, then the vehicle pulls over for 2 min while the intubation is completed. This technique can dramatically decrease scene time in unstable patients, with particular benefit in non-compressible truncal haemorrhage where haemostasis is only achievable in the trauma centre.

Our study indicates the careful selection of patients by the clinical team for in-ambulance intubations, however. For example, no obese patient had intubation attempted within a vehicle. Our data is therefore unable to confirm the safety of in-cabin intubation in this group. Rates of thoracic decompression were also lower in patients intubated within the ambulance. It is possible that at least some of these patients had the decompression performed before loading into the ambulance and subsequent intubation, but the location of decompression is not specifically recorded in the medical record, a possible source of measurement bias.

The study contained only a small number of patients intubated on the ground or 'other locations'. Intubation on the ground suggests pressure to proceed which is supported by the lower-Glasgow Coma Scale score and respiratory rates in this group, as well as the higher first attempt rate by the most senior doctor present. Intubation on the ground was associated with twice the risk of an ALOHA event, although the adjusted analysis suggests that this may be due to greater physiological derangement in these patients before the attempt, further supporting pressure to proceed as the reason intubation was attempted in this location. Intubation on the ground is generally discouraged due to the difficulty in positioning the patient,[2] a problem also observed in our data.

Decision-making regarding the intubation location is complex and includes logistical as well as patient factors. Intubation on the stretcher outside the ambulance is frequently part of inherent mission workflow, particularly where the team has rendezvoused with a road ambulance and the patient is subsequently transported by helicopter. In this case, the patient is removed from the ambulance, necessary procedures are performed and then the patient is loaded into the helicopter. The temperate climate in the Sydney region means that environmental concerns encountered in other jurisdictions such as Scandinavia[21] do not usually drive the choice of intubation location, although crowd behaviour and other potential scene dangers must be considered in the PH-RSI plan. Although not official protocol, road crew in Sydney are increasingly waiting for physician teams with the patient outside the rear of the vehicle. Although time to intubation from patient contact was independent of location, patients who were intubated earlier in the transport process had longer total scene times, that is, the longest scene times were in those intubated on the ground followed by those on a stretcher outside the ambulance, and the shortest occurring in those already loaded. Given the uncertainty raised by this and other studies, further research is required on the practice of waiting outside the vehicle given the observed effect on scene times.

We have demonstrated an adjusted total scene time that is 4 min shorter for patients intubated inside an ambulance compared with those intubated outside on a stretcher, a small difference which will not be clinically significant in many patients. Although a small difference, 4 min may be relevant for patients requiring emergency interventions that can only be delivered in hospital, such as those with non-compressible haemorrhage,[23] time-critical head injuries[24] and those requiring primary percutaneous coronary intervention.[25] Our service does not have a policy of removing patients from the ambulance for intubation if the patient is already loaded at the time of patient contact. Services that have such a policy may accrue larger prehospital time gains than demonstrated in this study.

Our study has limitations. It is a single-centre study which may limit generalisability and may not translate to other settings or regions with different protocols, equipment, crew composition or vehicle cabin configurations. There is evidence of selection for location based on patient factors, but there may also be other unrecognised factors. Being a retrospective study, there may be inconsistencies in data recording or missing data, which can introduce measurement bias. There are no surgical airways in our study, a situation where complete access around the patient may be important. Given the number of patients and low complication rate, there may be inadequate power to detect small but clinically significant differences. Small numbers in the intubated on the ground and 'other locations' groups particularly hampered our analysis of these locations. We have no data on intubating in a helicopter in flight as no intubations were performed in this context. International reports[26 27] have demonstrated an association between higher physician case volumes and shorter scene times. Our data set includes physicians with comparatively small annual prehospital intubation volumes. Larger data sets would be required to determine if there are interactions between physician prehospital intubation volume, intubation location, complication rates and time intervals. There are additional potential benefits of in-ambulance intubation not directly assessed in this study, such as temperature control in patients with major haemorrhage or burns.

In summary, our study suggests that intubating selected patients in an ambulance had similar complication rates to a stretcher outside the vehicle but was associated with slightly reduced scene times. Conversely, intubations performed on the ground had a higher rate of adverse events but were typically conducted in more unstable patients.

Acknowledgements The authors thank Elwyn Poynter for her assistance in accessing data required for the study.

Contributors AAG: Conceptualisation, Methodology, Data Curation, Writing—Review and Editing. Guarantor. AS: Methodology, Writing—Original Draft. AL: Methodology, Formal analysis, Writing—Review and Editing, Visualisation, Supervision.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the Nepean Blue Mountains Local Health District Human Research Ethics Committee (Reference 2023/PID01465).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data are available upon reasonable request and appropriate formal Ethics approval.

ORCID iDs
Alan A Garner https://orcid.org/0000-0002-4010-9137
Anna Lee https://orcid.org/0000-0003-2864-0045

REFERENCES

1 Lockey DJ, Crewdson K, Davies G, *et al*. AAGBI: Safer pre-hospital anaesthesia 2017: Association of Anaesthetists of Great Britain and Ireland. *Anaesthesia* 2017;72:379–90.
2 Crewdson K, Lockey D, Voelckel W, *et al*. Best practice advice on pre-hospital emergency anaesthesia & advanced airway management. *Scand J Trauma Resusc Emerg Med* 2019;27:6.
3 McIntosh SE, Swanson ER, McKeone AF, *et al*. Location of Airway Management in Air Medical Transport. *Prehosp Emerg Care* 2008;12:438–42.
4 Stone CK, Thomas SH. Is oral endotracheal intubation efficacy impaired in the helicopter environment? *Air Med J* 1994;13:319–21.
5 Slater EA, Weiss SJ, Ernst AA, *et al*. Preflight versus En Route Success and Complications of Rapid Sequence Intubation in an Air Medical Service. *J Trauma* 1998;45:588–92.
6 Maeyama H, Naito H, Guyette FX, *et al*. Intubation during a medevac flight: safety and effect on total prehospital time in the helicopter emergency medical service system. *Scand J Trauma Resusc Emerg Med* 2020;28:89.
7 Wong KB, Lui CT, Chan WYW, *et al*. Comparison of different intubation techniques performed inside a moving ambulance: a manikin study. *Hong Kong Med J* 2014;20:304–12.
8 Karaca O, Bayram B, Oray NC, *et al*. Comparison of the airway access skills of prehospital staff in moving and stationary ambulance simulation: A randomized crossover study. *Turk J Emerg Med* 2017;17:35–41.
9 Nakstad AR, Sandberg M. Airway management in simulated restricted access to a patient - can manikin-based studies provide relevant data. *Scand J Trauma Resusc Emerg Med* 2011;19:1–5.
10 Elm E von, Altman DG, Egger M, *et al*. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007;335:806–8.
11 Garner AA, Bennett N, Weatherall A, *et al*. Physician-staffed helicopter emergency medical services augment ground ambulance paediatric airway management in urban areas: a retrospective cohort study. *Emerg Med J* 2019;36:678–83.
12 Hughes RA, Heron J, Sterne JAC, *et al*. Accounting for missing data in statistical analyses: multiple imputation is not always the answer. *Int J Epidemiol* 2019;48:1294–304.
13 Attia JR, Oldmeadow C, Holliday EG, *et al*. Deconfounding confounding part 2: using directed acyclic graphs (DAGs). *Medical Journal of Australia* 2017;206:480–3.
14 Caruana E, Duchateau F-X, Cornaglia C, *et al*. Tracheal intubation related complications in the prehospital setting. *Emerg Med J* 2015;32:882–7.
15 Le Bastard Q, Pès P, Leroux P, *et al*. Factors associated with tracheal intubation-related complications in the prehospital setting: a prospective multicentric cohort study. *Eur J Emerg Med* 2023;30:163–70.
16 Fok PT, Teubner D, Purdell-Lewis J, *et al*. Predictors of Prehospital On-Scene Time in an Australian Emergency Retrieval Service. *Prehosp Disaster Med* 2019;34:317–21.
17 Fuchs A, Huber M, Riva T, *et al*. Factors influencing on-scene time in a physician-staffed helicopter emergency medical service (HEMS): a retrospective observational study. *Scand J Trauma Resusc Emerg Med* 2023;31:1–12.
18 Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. *Am J Epidemiol* 2004;159:702–6.
19 Harrell FE. *Regression Modeling Strategies: With Applications to Linear Models, Logistic and Ordinal Regression, and Survival Analysis*. 2nd edn. Springer, 2015.
20 Staffa SJ, Kohane DS, Zurakowski D. Quantile Regression and Its Applications: A Primer for Anesthesiologists. *Anesth Analg* 2019;128:820–30.
21 Broms J, Linhardt C, Fevang E, *et al*. Prehospital tracheal intubations by anaesthetist-staffed critical care teams: a prospective observational multicentre study. *Br J Anaesth* 2023;131:1102–11.
22 Hayes-Bradley C, McCreery M, Delorenzo A, *et al*. Predictive and protective factors for failing first pass intubation in prehospital rapid sequence intubation: an aetiology and risk systematic review with meta-analysis. *Br J Anaesth* 2024;132:918–35.
23 Yamamoto R, Suzuki M, Yoshizawa J, *et al*. Physician-staffed ambulance and increased in-hospital mortality of hypotensive trauma patients following prolonged prehospital stay: A nationwide study. *J Trauma Acute Care Surg* 2021;91:336–43.
24 Dinh MM, Bein K, Roncal S, *et al*. Redefining the golden hour for severe head injury in an urban setting: the effect of prehospital arrival times on patient outcomes. *Injury* 2013;44:606–10.
25 Żurowska-Wolak M, Piekos P, Jąkała J, *et al*. The effects of prehospital system delays on the treatment efficacy of STEMI patients. *Scand J Trauma Resusc Emerg Med* 2019;27:39.
26 Sollid SJM, Bredmose PP, Nakstad AR, *et al*. A prospective survey of critical care procedures performed by physicians in helicopter emergency medical service: is clinical exposure enough to stay proficient? *Scand J Trauma Resusc Emerg Med* 2015;23:45.
27 Saviluoto A, Pappinen J, Kirves H, *et al*. Association between physician's case volume in prehospital advanced trauma care and 30-day mortality: A registry-based analysis of 4,032 patients. *J Trauma Acute Care Surg* 2023;94:425–32.