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Original Research

Feasibility of Prehospital Emergency Anesthesia in the Cabin of an AW169 Helicopter Wearing Personal Protective Equipment During Coronavirus Disease 2019

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A B S T R A C T

Objective: Prehospital emergency anesthesia in the form of rapid sequence intubation (RSI) is a critical intervention delivered by advanced prehospital critical care teams. Our previous simulation study determined the feasibility of in-aircraft RSI. We now examine whether this feasibility is preserved in a simulated setting when clinicians wear personal protective equipment (PPE) for aerosol-generating procedures (AGPs) for in-aircraft, on-the-ground RSI.

Methods: Air Ambulance Kent Surrey Sussex is a helicopter emergency medical service that uses an AW169 cabin simulator. Wearing full AGP PPE (eye protection, FFP3 mask, gown, and gloves), 10 doctor-paramedic teams performed RSI in a standard "can intubate, can ventilate" scenario and a "can't intubate, can't oxygenate" (CICO) scenario. Prespecified timings were reported, and participant feedback was sought by questionnaire.

Results: RSI was most commonly performed by direct laryngoscopy and was successfully achieved in all scenarios. The time to completed endotracheal intubation (ETI) was fastest (287 seconds) in the standard scenario and slower (370 seconds, $P = .01$) in the CICO scenario. The time to ETI was not significantly delayed by wearing PPE in the standard ($P = .19$) or CICO variant ($P = .97$). Communication challenges, equipment complications, and PPE difficulties were reported, but ways to mitigate these were also reported.

Conclusion: In-aircraft RSI (aircraft on the ground) while wearing PPE for AGPs had no significant impact on the time to successful completion of ETI in a simulated setting. Patient safety is paramount in civilian helicopter emergency medical services, but the adoption of in-aircraft RSI could confer significant patient benefit in terms of prehospital time savings, and further research is warranted.

The coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]) pandemic (coronavirus disease 2019 [COVID-19]) has challenged civilian helicopter emergency medical services (HEMS) operations both clinically and organizationally.[1] Prehospital critical care teams such as HEMS have adapted, overcome, and continued to deliver high-acuity trauma and medical care to patients at their time of need.[1]

SARS-CoV-2 is transmitted through droplet, contact, and aerosol routes.[2] Aerosol-generating procedures (AGPs), such as tracheal intubation or extubation, suction of the airway, and cardiopulmonary resuscitation,[3] are thought to increase the risk of virus transmission to medical teams[3-5] with a 3 to 6 times greater risk of infection.[2] Endotracheal intubation (ETI) is thought to pose the greatest risk of nosocomial transmission to health care workers[5] yet forms a significant proportion of critical care interventions provided by HEMS teams. Undertaking prehospital RSI in a safe and familiar environment contributes positively to patient safety.

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In-aircraft RSI (aircraft-on-the-ground) may confer significant time savings in patients requiring time-critical intervention.[6] Air Ambulance Kent Surrey Sussex (AAKSS) is currently exploring the feasibility of conducting more in-aircraft critical care interventions. Currently, with aircraft engines shut down, the provision of in-aircraft RSI is permitted.[7] Principally, in-aircraft RSI should afford the same level of patient safety as when performed outside the aircraft; therefore, it is not intended or suitable for all patients. Individual psychomotor skills, mental rehearsal, and simulated team-based training are pivotal to optimizing the process.

SARS-CoV-2 compelled our service to explore in-cabin RSI during the COVID-19 pandemic. The objective of this study was to assess the feasibility of in-aircraft RSI (aircraft on the ground) while wearing recommended personal protective equipment (PPE) for AGPs in a simulated setting.

Methods

Study Design

A prospective simulation study akin to our previously published work was undertaken.[7] Simulation was performed in both a "can intubate, can ventilate" (standard) and "can't intubate, can't oxygenate" (CICO) scenario, as described by McHenry et al.[7] Prespecified time points were recorded in real time. The primary end point was the time to successful ETI. Participants completed a post simulation questionnaire on their experience of the scenario.

Setting and Participants

The study was conducted in the high-fidelity simulation suite at AAKSS over a 1-month period. The simulation suite contains a replica AW169 cabin simulator (Fig. 1) in which the bespoke modular in-cabin simulator and stretcher system offers 360-degree video and audio capability. As per AAKSS aviation protocols, Alpha-Eagle 400 helmets (MEL Aviation Ltd, Sudbury, Suffolk, UK) were connected to the intercom, enabling direct communication with the investigators during each scenario (K.H./A.S.M./J.E.G.) and audio input via a continuous loop recording was played. Pre-requisite training qualifies the HEMS doctor-paramedic team to perform this level of intervention. A pragmatic, convenience sampling was used due to operational COVID-19 restrictions.

Alterations to the Standard Operating Procedures Regarding AGPs During the COVID-19 Pandemic

Infection prevention measures in-line with National Health Service England and local interpretation on PPE for ambulance services were used.[8] Level 3 PPE comprised the following: double gloves, eye protection, a fit-tested FFP3 respirator mask or powered respirator protective hood (PRPH) (Versaflo; 3M, St. Paul, MN), and either a Tyvek suit or a surgical gown.

The avoidance of bag-valve-mask ventilation during the apnoeic period because of the risk of dispersion of aerosolized virus in the health care environment is recommended. In addition, an adult endotracheal closed suction system (TRACH-CLEAR, Intersurgical, UK) was inserted into the airway circuit during ETI.

Data Collection and End Points

Prespecified timings were documented in real time by investigators (K.H./A.S.M./J.E.G). The primary end point was the time to securing the endotracheal tube (ETT) (in seconds). Successful ETI was defined as securing of the ETT with simulated confirmation of end-tidal carbon dioxide capnography. In the CICO variant, the intubator was unable to pass the ETT, and a decision was made to proceed to emergency front of neck access.

Ethical Considerations

National Institute for Health Research criteria for service evaluation were met. Internal approval by the AAKSS Research, Audit and Development Committee was gained. Written informed consent was gained. Participant information was anonymized and stored on electronic devices with technical encryption. Study registration was gained through the University of Surrey.

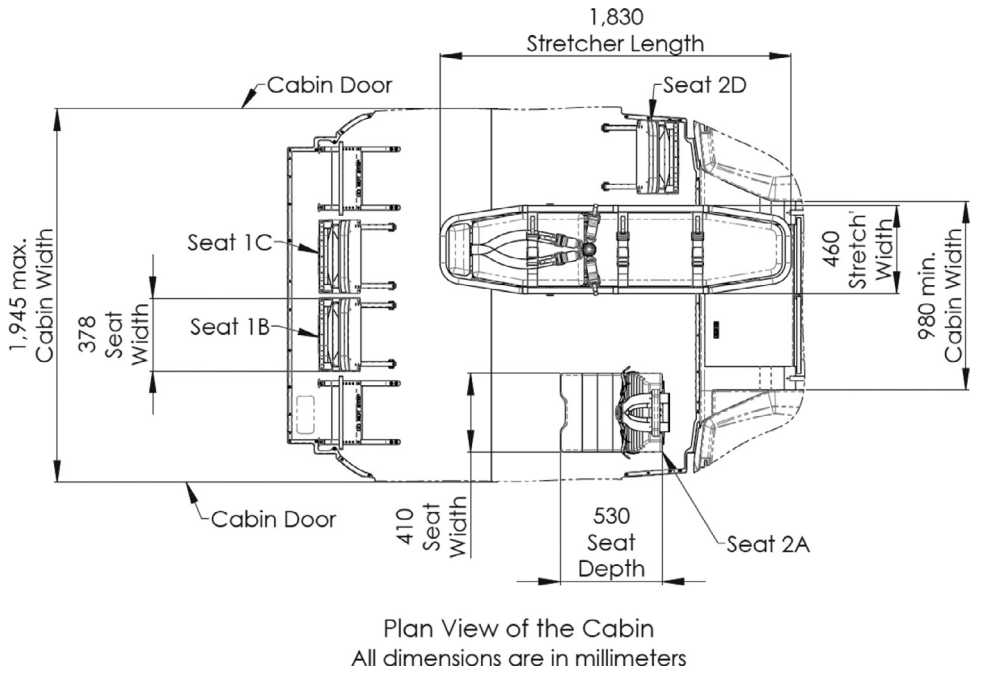

Figure 1. The dimensions of the AW169 simulator. The height of the translating patient loading system, aircraft ceiling, and seating are annotated. The airway assistant and airway kit dump are positioned in front of seat 2A.

Table 1
The Time to Endotracheal Intubation in the Standard Variant

	Standard Variant									
Primary device	DL	VL	DL	DL	DL	VL	VL	DL	DL	DL
Start of checklist	0	0	0	0	0	0	0	0	0	0
End of checklist	90	88	108	130	108	111	123	210	161	160
Rocuronium	94	162	162	182	168	162	213	290	244	245
Surgical airway decision point										
ETT in airway	199	177	238	282	182	246	274	381	335	317
Bougie removed	201	178	239	285	232	246	282	387	336	324
Cuff inflated	205	180	242	287	234	248	283	391	340	326
BVM connected	210	185	244	298	244	258	287	401	344	342
Position checked	240	190	260	306	260	275	299	409	351	348
Seconds	240	190	260	306	260	275	299	409	351	348

BVM = bag valve mask; DL = direct laryngoscopy; ETT = endotracheal tube; VL = video laryngoscopy.

Statistical Analysis

Descriptive statistics with frequencies, the median, and the associated interquartile ranges (IQRs) are reported. The Wilcoxon signed rank and Mann-Whitney *U* tests were used to assess the differences between each group for paired and unpaired data, respectively, with $P < .05$ regarded as statistically significant. All analyses were completed using SPSS Version 26.0 (IBM Corp, Armonk, NY).

Results

The time taken for each doctor-paramedic team to perform ETI in the standard scenario (Table 1) and the CICO scenario (Table 2) is reported. In each scenario, an ETI was successfully achieved. The average time to ETI was 287 seconds (IQR, 260-338 seconds) in the standard variant and 370 seconds (IQR, 359-416 seconds) in the CICO scenario. Previously, we reported the average time to RSI in the standard (non-PPE) scenario as 243 seconds (median = 14 seconds), and the average time to RSI in the CICO (non-PPE) scenario as 360 seconds (median = 41 seconds).

As expected, the time to ETI in the standard (PPE) scenario versus the CICO (PPE) scenario was significantly different ($P = .01$). The time to ETI in the standard (non-PPE) scenario was not significantly different to the standard (PPE) variant ($P = .19$) and not significantly different between the CICO (PPE) scenario and the CICO (non-PPE) scenario (P = .97) (Table 3).

Questionnaires

Seventeen participant questionnaires were completed. Professional registration varied to include HEMS paramedics and medical specialities including emergency medicine, anesthetics, general practice, and intensive care medicine. The average doctor prehospital experience was 5 years (IQR, 1-27 years) and 16 years for paramedics (IQR, 5-22 years).

Seven intubators chose direct laryngoscopy, and 3 chose video laryngoscopy. Eye protection consisted mainly of the helmet visor (19/20) and protective glasses (1/20); the PRPH was not used by anyone. Surgical gowns were worn in every scenario (20/20). Four of 17 participants felt that PPE affected the ability to perform RSI. Communication challenges were reported and included the following: the visor fogging up, speech distorted by the FFP3 mask, harder to be heard, and microphone position on the FFP3 moved. Efforts to mitigate the challenges to communication included raising their voice, the suggestion that PRPH may have been beneficial, prior planning of unanticipated events, the use of hand signals, closed-loop communication, and reliance on nonverbal cues. Other challenges reported included background noise reduced bandwidth and limited access to their personal kit, which were mitigated by ensuring a good brief between the crew with verbalization of crew positions and preferred equipment in the event of thoracostomy/surgical airway.

Discussion

In-aircraft, aircraft on-the-ground, simulated RSI wearing PPE is feasible in a simulated setting. Use of the replica bespoke AW169 cabin coupled with the real-time audio and visual distractions during simulation makes us feel that the simulation was of sufficient quality to infer real-world feasibility. The addition of PPE provided a degree of communication challenge, but medical teams felt this could be mitigated to a degree. The expected and observed, and perhaps worthy, increase in time was perhaps enough to indicate the due diligence the team was giving to such a critical intervention. This was noted in the standard scenario more so than the CICO scenario, where perhaps a practice effect occurred. There was no significant effect on the time to successful ETT placement.

Real-life simulation training, which was afforded by the exact replica AW169 simulator, ensures the refinement of protocols, the

Table 2
The Time to Endotracheal Intubation in the "Can't Intubate, Can't Oxygenate" (CICO) Variant

	CICO Variant									
Primary device	DL	VL	DL	DL	DL	VL	VL	DL	DL	DL
Start of checklist	0	0	0	0	0	0	0	0	0	0
End of checklist	102	90	114	150	108	106	115	123	84	134
Rocuronium	140	108	134	219	160	160	150	183	130	199
Surgical airway decision point	345	252	260	355	344	290	150	338	259	370
ETT in airway	346	279	295	427	378	330	357	443	345	454
Bougie removed	348	282	310	428	380	339	365	449	346	456
Cuff inflated	348	282	314	430	383	346	366	458	347	462
BVM connected	350	290	316	438	385	357	367	424	355	468
Position checked	364	298	320	448	395	360	375	425	357	478
Seconds	364	298	320	448	395	360	375	425	357	478

BVM = bag valve mask; DL = direct laryngoscopy; ETT = endotracheal tube; VL = video laryngoscopy.

Table 3
The Time to Endotracheal Intubation in Personal Protective Equipment (PPE) Versus Non-PPE Scenarios in Both the Standard and the "Can't Intubate, Can't Oxygenate" (CICO) Variants

Scenario Comparison	Median Difference (Seconds)	*P* Value
Standard PPE versus CICO PPE	83	.01
Standard non-PPE[a] versus standard PPE	44	.19
CICO non-PPE[a] versus CICO PPE	10	.97

[a] Previous scenario timings as reported in McHenry et al.[7]

facilitation of practice changes, and the identification of safety gaps in which to apply corrective actions immediately,[9,10] which has proven irreplaceable during the COVID-19 pandemic. Simulation studies of paramedic ETI (wearing PPE) and intubating through a box barrier showed no difference to first-pass success[11]; however, Cağlar et al[12] reported an increased time to intubation and a reduced overall first-pass success rate. The authors reported the limitations of their work, highlighting that manikins were intubated at floor level and therefore were initially not optimized, unlike our simulations. The limitations of the current study included the relatively small number of HEMS team participants and the standard limitations associated with simulation research.

Prehospital airway management or the ETI success rate is an important measure of provider and emergency medical services system success but more importantly a marker of patient safety.[13] Communication between the medical team is critical. Speech discrimination scores between normal and PPE-wearing subjects highlight the difficulty in the interpretation of speech[14] and the importance of clear concise spoken words with additional hand signaling as required.

Infection control measures required by health care professionals performing ETI during COVID-19 have forced HEMS and critical care services to implement rapid operational change to long-withstanding standard operating procedures. We report that wearing PPE did not significantly change to the time to RSI. Nevertheless, it did provide communication challenges and logistical and equipment considerations.

Conclusion

In-aircraft RSI (aircraft on-the-ground) while wearing PPE for AGPs had no significant impact on the time to successful completion of ETI in a simulated setting. A civilian HEMS service must always have patient safety as the paramount goal, but the adoption of in-aircraft RSI could confer significant patient benefit in terms of prehospital time savings; further research is warranted in this area.

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