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Delayed Sequence Intubation by Intensive Care Flight Paramedics in Victoria, Australia

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Abstract

Objective: Delayed sequence intubation (DSI) involves the administration of ketamine to facilitate adequate preoxygenation in the agitated patient. DSI was introduced into the Clinical Practice Guideline for Intensive Care Flight Paramedics in Victoria in late 2013. We aimed to describe the clinical characteristics of patients receiving DSI. **Methods**: A retrospective analysis was undertaken of patients who received DSI between January 1, 2014, and December 31, 2016, during both primary response and retrieval missions. Patients' clinical characteristics, DSI success rates, and complications were determined from electronic patient care records. **Results**: Forty patients received DSI during the study period. Of these, 32 were intubated to manage traumatic injury and the remaining 8 were intubated for medical reasons. On arrival of the first road ambulance, median oxygen saturation was 96.5%, and immediately prior to DSI the median was 98.0%. One patient had a period of self-limiting apnea (< 15 seconds) following ketamine administration. Oxygen saturation was either maintained or increased prior to laryngoscopy in all patients. Post-intubation, one patient experienced bradycardia (heart rate < 60 beats per minute), two patients had a systolic blood pressure drop of > 20 mm Hg, one patient experienced an increase in heart rate of > 20 beats per minute, and two patients had transient oxygen desaturation (< 85%). No patients experienced cardiac arrest or required surgical airway intervention. All patients were successfully intubated. After DSI, the median oxygen saturation was 100%. **Conclusions**: DSI provides a reasonably safe and effective approach for intensive care flight paramedics in the preoxygenation of agitated, hypoxic patients in order to decrease the risk of peri-intubation desaturation and related hypoxic injury **Key words:** rapid sequence intubation; delayed sequence intubation; prehospital intubation; emergency medical services

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Introduction

Rapid sequence intubation (RSI) involves the simultaneous administration of a sedative and neuromuscular blocking agent (NMBA), rendering the patient unconscious and paralyzed and ensuring optimal conditions for endotracheal intubation (1). RSI is utilized to secure and protect the airway in patients with actual or potential airway compromise or significant hypoxia or patients who require control of ventilation such as those with traumatic brain injury (TBI) (1–3). In the aeromedical environment, the decision to intubate a patient may be to prevent deterioration during flight or for safety in a patient who is noncompliant.

To prevent hypoxemia during the apneic period of RSI, it is critical to provide the patient with adequate preoxygenation (4). The goal of preoxygenation is to raise the patient's hemoglobin saturation levels to as close to 100% as possible and to remove nitrogen from the alveoli, resulting in a larger alveolar oxygen reservoir (2, 4). The challenge for practitioners in the uncontrolled prehospital environment is that patients may have increased metabolic demand or significant lung injury that may predispose them to rapid desaturation during an intubation attempt, making preoxygenation essential (1, 4). In patients with hypoxia or hypercapnia, agitated delirium may also make them difficult to adequately preoxygenate (5).

In such instances, delayed sequence intubation (DSI) may be used as an alternative to the regular RSI. DSI is a relatively new procedure indicated in combat-

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ive/agitated/unmanageable patients for whom normal methods of preoxygenation are unsuitable (2). The procedure involves administering a sedative agent that does not depress spontaneous ventilations or decrease airway reflexes to allow for a period of uninterrupted preoxygenation before administering the paralytic agent required for RSI (4, 6). For agitated patients requiring intubation, DSI can provide an important opportunity to increase a patient's apneic tolerance and help prevent dangerous levels of desaturation and peri-intubation morbidity and mortality (1, 2).

Current evidence surrounding the use of DSI in practice is scarce (4). One recent prospective observational study described the use of DSI in emergency departments in North America (5). The authors concluded that DSI is a feasible option to oxygenate and denitrogenate patients at high risk for critical desaturation (5).

However, the prehospital environment presents unique challenges, and there is currently a paucity of prehospital studies describing experience with this procedure. We aimed to describe the characteristics of patients receiving DSI by intensive care flight paramedics (ICFPs) in Victoria, Australia, and assess the success rates and complications arising from the procedure.

Methods

Study Design

We performed a retrospective analysis of primary response and retrieval missions in cases in which DSI was clinically indicated by ICFPs in Victoria, Australia, between January 1, 2014, and December 31, 2016. Patients intubated by road intensive care paramedics or retrieval physicians were excluded.

Setting

In Victoria, Australia, Ambulance Victoria is responsible for provision of emergency and nonemergency care to the population of 6.3 million people. Air Ambulance Victoria (AAV) is a division of Ambulance Victoria and is the single provider of helicopter emergency medical services (HEMS) in the state. The HEMS has been described in detail previously (7). Essentially, AAV has a fleet of 5 Augusta Westland 139 emergency response helicopters (Leonardo, Farnborough, UK) (8). Two helicopters operate out of the air base located in the state's capital city of Melbourne. The remaining 3 operate out of air bases in the western, northern, and southeastern areas of Victoria (3). AAV helicopters are usually utilized for life-threatening emergencies requiring primary response missions or critical retrieval from remote locations.

The AAV-HEMS are staffed by ICFPs whose skill set and training have been described in detail previously (7). Briefly, paramedics are initially trained in advanced life support (ALS), which involves a 3-year tertiary degree and a 12-month in-field graduate year. ALS paramedics may use oropharnygeal and nasopharyngeal airways, a laryngeal mask airway, and assisted ventilation with a bag/valve/mask. Experienced ALS paramedics undertake a 12-month diploma in conjunction with in-field supervised training to become an intensive care paramedic. Intensive care paramedics may perform all ALS procedures and are also permitted to intubate adult patients using RSI or intubation facilitated by sedation for a variety of indications, including respiratory and cardiac arrest, Glasgow Coma Scale score < 10, airway burns, TBI, and airway protection (9). To become an ICFP, intensive care paramedics must have at least 2 years of clinical on-road experience and then undergo a stringent selection process. Applicants who are successful undertake a further 9-month postgraduate study, encompassing aeromedical rescue, the effects of altitude, winch operations, extensive safety training, as well as theoretical and clinical education. Practical education includes clinical experience during in-field supervised training (7). A qualified ICFP has an extensive clinical skill set, which includes such procedures as adult and pediatric RSI, cricothyroidotomy, both intravenous (IV) and arterial cannula insertion, blood gas analysis, prehospital ultrasonography, finger thoracostomy, advanced analgesia, and DSI (10).

There are six indications for RSI by ICFPs: (1) Glasgow Coma Scale score ≤ 12, (2) actual or potential airway compromise, (3) significant hypoxia, (4) suspected spinal cord injury with respiratory compromise, (5) combative and/or suicidal patients, and (6) severe pain that is unable to be managed with analgesic agents (3). AAV guidelines advise that DSI should be implemented in any patient in whom preoxygenation is difficult due to agitation (3). The procedure involves administering a dissociative dose of IV ketamine (1.5 mg/kg) followed by high-flow oxygen via bag/valve/mask (BVM) or a combination BVM and high-flow oxygen (12 L/min) via nasal cannula for a 3-minute period prior to administering the NMBA to facilitate intubation (1, 11). Endotracheal tube (ETT) placement is confirmed with waveform capnography, and the patient is then paralyzed and sedated. If placement is unsuccessful, the ETT is removed and replaced with an intubating laryngeal mask airway. If the laryngeal mask airway cannot be placed on the first attempt, paramedics oxygenate and ventilate with a BVM and oral airway and the patient is not sedated or paralyzed. A cuffed needle cricothyroidotomy kit is used if all other attempts prove to be unsuccessful (3).

Data Sources

At the conclusion of each case, Victorian ICFPs complete an electronic patient care record. This record encompasses all relevant demographic and clinical information including patients' injuries, management (pharmacological and otherwise), and vital signs. All data from patient care records are uploaded and stored in the organizational data warehouse. For this study, data for all patients who underwent DSI in the care of ICFPs in Victoria were extracted for analysis. In addition, for the major trauma patients within our cohort, outcome data were obtained from the Victorian State Trauma Registry (12). The registry captures data on patients with major trauma who meet any of the following criteria: intensive care unit administration for more than 24 hours, urgent surgery, Injury Severity Score (ISS) greater than 12, or in-hospital death.

Definitions

DSI was defined as the administration of a weight- or age-appropriate dose of ketamine with the intention of inducing a dissociative state, allowing for optimal pre-oxygenation before the administration of an NMBA. An intubation attempt was defined as a laryngoscope blade passing the patient's lips after the administration of paralyzing medications. Successful intubation was defined as successful placement of the ETT on either the first or second attempt confirmed with waveform capnography. Attending paramedics carried out vital sign surveys (VSS) throughout the patients' clinical course at regular intervals. Initial VSS refers to the vital signs taken by the first ambulance crew on scene. Final VSS are taken just prior to arrival at hospital. Oxygen saturation (SpO_2) levels of > 95% were considered normal. Mild to moderate hypoxemia was defined as SpO_2 levels of 85% to 93% and necessitated administration of supplemental oxygen. Moderate to severe hypoxemia was defined as SpO_2 levels < 85% (9). End-tidal carbon dioxide ($EtCO_2$) was considered normal in the range of 35 to 45 mm Hg for patients without TBI and 35 to 40 mm Hg for patients with TBI. Scene duration refers to the time from flight paramedic arrival at scene until their departure.

Complications in this study were defined as oxygen desaturation during an intubation attempt of < 93%, a failed intubation attempt, or altered VSS (systolic blood pressure decrease of > 20 mm Hg or heart rate < 60 beats per minute [bpm]) during DSI.

Statistical Analyses

Categorical data are presented as frequencies and proportions. Continuous data are presented as a mean and standard deviation (SD) or median and interquartile range as appropriate for the distribution of the data.

Ethics

This study was approved by Monash University Human Research Ethics Committee and the Research Committee of Ambulance Victoria.

RESULTS

Baseline Characteristics

DSI was utilized in the management of 40 of 4,269 patients throughout the 2-year study period, represent-

TABLE 1. Patient and case baseline characteristics

	Overall (N = 40)
Age, mean (SD)	31.0 (16.4)
Age, n (%)	4 (10.0)
≤ 10	9 (22.5)
11–20	13 (32.5)
21–35	4 (10.0)
36–45	5 (12.5)
46–55	2 (5.0)
56–65	2 (5.0)
> 65	1 (2.5)
Age unknown	
Male gender, n (%)	30 (75.0)
Location of intubation, n (%)	
Street/car park/public roads	19 (47.5)
Hospital emergency department	6 (15.0)
Private residence	7 (17.5)
Public place	7 (17.5)
Dam	1 (2.5)
Type of incident, n (%)	
Trauma	32 (80.0)
Vehicle-related	24 (60.0)
Submersion	1 (2.5)
Falls	4 (10.0)
Hanging	1 (2.5)
Machinery	1 (2.5)
Animal-related injury	1 (2.5)
Medical	8 (20.0)
Asthma	1 (2.5)
Sepsis	1 (2.5)
Overdose	3 (7.5)
Status epilepticus	1 (2.5)
Cardiac arrest	2 (5.0)
Time on scene (mins), median (IQR)	68.0 (58.0–86.0)
Principal reason for prehospital intubation, n (%)	
TBI	25 (62.5)
Secondary brain injury	1 (2.5)
Hypoxia/agitation	4 (10.0)
Multi-trauma	1 (2.5)
Cardiac arrest	2 (5.0)
Altered conscious state	5 (12.5)
Airway protection	2 (5.0)
Reason for DSI, n (%)	
Intolerance of NRB mask	7 (17.5)
Intolerance of BVM	5 (12.5)
Intolerance of Hudson mask	2 (5.0)
Intolerance of nasal cannula	3 (7.5)
Intolerance of a combination of NIPPV	16 (40)
Intolerance to unspecified NIPPV	4 (10.0)
Inadequate pre-oxygenation due to patient condition	3 (7.5)

SD, standard deviation; IQR, interquartile range; TBI, traumatic brain injury; DSI, delayed sequence intubation; NRB, non-rebreather; BVM, bag/valve/mask; NIPPV, noninvasive positive pressure ventilation.

ing 1% of the HEMS caseload. Table 1 shows the demographic characteristics of the patients receiving DSI. A total of 30 (75.0%) patients were male, and the average age was 31 years (SD = 16.4). There were 32 (80.0%) patients with significant injury secondary to trauma, with 24 (60.0%) of these occurring as a result of road traffic accidents. Eight (20.0%) patients were attended for medical issues. The median scene duration for the HEMS crew was 68 minutes.

Of the patients in this study, 25 (62.5%) were intubated due to a TBI, 4 (10.0%) because of agitation secondary to hypoxia, and 5 (12.5%) due to altered conscious state. Of the remaining 6 patients, one was intubated for a secondary brain injury, one for multitrauma, 2 during cardiac arrest, and 2 for airway protection. For 37 (92.5%) patients, DSI was implemented due to intolerance of preoxygenation. For the remaining 3 patients (7.5%), DSI was used due to inadequate oxygenation by other means.

Of the trauma patients, spinal immobilization was indicated for 22 (55%), and they were therefore in the supine position for the duration of their transport. Six (15%) patients received DSI by an ICFP in a rural hospital emergency department.

Intubation Success

All patients were successfully intubated. In total, 34 (85%) were successfully intubated on the first attempt, 5 (13%) on the second attempt, and one on the third attempt. The rate of successful placement on the first or second attempt was 97.5%.

VSS

The median SpO_2 over the duration of management is presented in Figure 1. On arrival of the first ambulance crew (ALS or road intensive care unit), median SpO_2 was 96%. Immediately prior to DSI, median SpO_2 was 98%, and this trended upward to 100% post-DSI. Oxygen saturations were maintained during intubation attempts and after successful intubation. Immediately after intubation, 14 patients had $EtCO_2$ levels outside normal ranges, including 9 (22.5%) patients with $EtCO_2$ levels greater than 45 mm Hg and 5 (12.5%) with $EtCO_2$ levels less than 30 mm Hg. On arrival at hospital, all but one patient had $EtCO_2$ levels within target ranges.

The oxygen saturations of patients who were hypoxic immediately prior to DSI are shown in Figure 2. A total of 7 patients were hypoxic (SpO_2 < 93%) immediately prior to DSI. Of these, only one remained hypoxic post-DSI. This patient had original oxygen saturations of 70%, which did not improve with DSI and only increased to 73% following intubation.

Patient Outcomes

Of the 32 trauma patients, 25 were identified as sustaining major trauma by the Victorian State Trauma Registry. Of these, 19 (76.0%) had an ISS > 12. The average length of stay in the hospital was 13 (SD = 9.9) days, and 22 (88.0%) survived to discharge. The ISS of the 3 patients who died in the hospital were 29, 41, and 45.

Complications

Of the 40 patients, 2 experienced severe oxygen desaturation during the intubation attempt. Oxygen in both patients desaturated to 80% during intubation; however, both had post-DSI SpO_2 levels of 100%. One of these episodes of desaturation was approximately 4 minutes and the other was 2 minutes. In addition, there were 4 instances of altered hemodynamics. Of these, one patient experienced bradycardia for approximately 2 to 3 minutes following the administration of suxamethonium. This was treated with atropine. Another patient had an increase in heart rate of 34 bpm (from 71 to 105 bpm) and a blood pressure increase of 65 mm Hg (from 115 to 180 mm Hg). This may have occurred due to a number of concurrent factors, including increased agitation, pancuronium administration, and potential undersedation. The former value was recorded before the administration of all DSI drugs, and the latter was taken immediately after successful intubation and the administration of pancuronium. One patient experienced tachycardia and hypotension in the setting of an intra-abdominal bleed, and the fourth patient experienced a decrease in blood pressure following intubation post–cardiac arrest. There were no cardiac arrests or surgical airways resulting from intubation in our cohort.

We also observed one incident of self-limiting apnea (< 15 seconds) post–IV ketamine administration; however, oxygen saturations were maintained in that patient. In addition, while 14 (35%) patients had immediate $EtCO_2$ levels outside the normal ranges after intubation, only one patient's $EtCO_2$ level remained outside this range on arrival at the hospital. This patient had an original $EtCO_2$ level of 23 mm Hg, which increased to 25 mm Hg upon arrival at the hospital.

Discussion

This study describes the use of DSI in a paramedic-staffed HEMS in Victoria, Australia. Our results demonstrate the relative efficacy and safety of this procedure for patients at risk for hypoxia who require intubation. Patient SpO_2 levels increased from a median of 98% prior to the administration of ketamine to 100% post-DSI, decreasing the likelihood of injurious levels of desaturation. In addition, 80% of patients in our study received intubation following traumatic injury. To our knowledge, this is one of the first studies to describe the use of this procedure in prehospital patients treated by a paramedic-staffed HEMS.

In our study, DSI provided an important opportunity to increase tolerance of apnea in agitated and

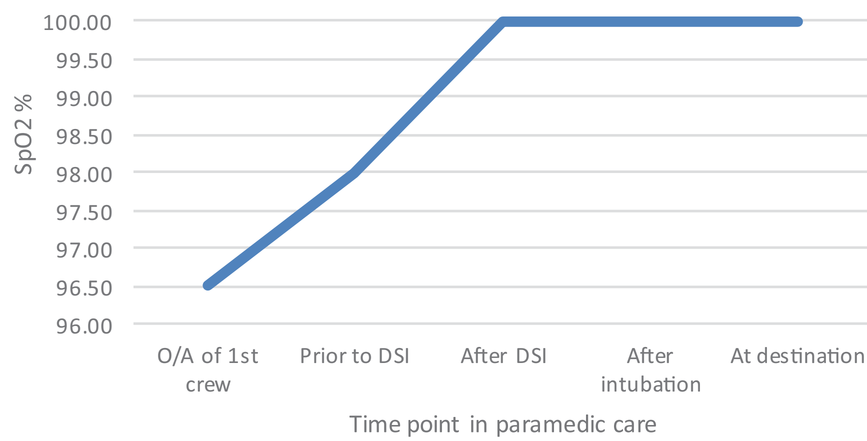

FIGURE 1. Median oxygen saturation throughout paramedic management. O/A, on arrival; DSI, delayed sequence intubation.

combative patients who were all clinically indicated for intubation. In a controlled setting such as an operating room, where patients are cooperative and able to comply with pre-intubation measures, the safe period of apnea can be up to 8 minutes without desaturation and 5 minutes in the moderately ill adult (4, 13). However, the majority of patients in this study experienced significant trauma with complex pathologies, requiring significantly more preoxygenation. These patients had not fasted, thereby increasing the risk of passive regurgitation and aspiration leading to pneumonitis. Of importance, we did not observe any cases of peri-intubation aspiration.

Some authors have argued that DSI is unnecessary and simply delays a definitive airway; however, their focus is on SpO_2 levels alone (14). This argument does not take into consideration the advantage of denitrogenation, the main goal of preoxygenation in a critically ill patient. In the prehospital environment, denitrogenation cannot be measured and pulse oximetry does not reflect the degree to which a patient experiences denitrogenation (1, 5). Davis et al. (15) and Bodily et al. (16) demonstrated a predisposition of prehospital patients with SpO_2 levels $< 93\%$ to experience desaturation more rapidly than those with SpO_2 levels $> 93\%$, reporting desaturation to critical levels in 84% of hypoxic patients. Bodily et al. (16) and Farmery and Roe (17) established that the time to desaturation to SpO_2 levels of 85% in patients with an initial $SpO_2 > 93\%$ during apnea may be as little as 80 to 84 seconds in a critically ill adult. These recent studies highlight the necessity of preoxygenation in critically ill patients.

In patients with TBI, there is a well-established association between hypoxia and mortality, with one previous study reporting an increase in mortality from 27% to 33% with just one episode of out-of-hospital hypoxia (18, 19). Based on this association, it is possible that the agitated patients with TBI who underwent DSI in our study may have derived additional benefit from this procedure. Safe placement of an ETT using DSI in trauma patients may also provide an important opportunity for flight paramedics to continuously and

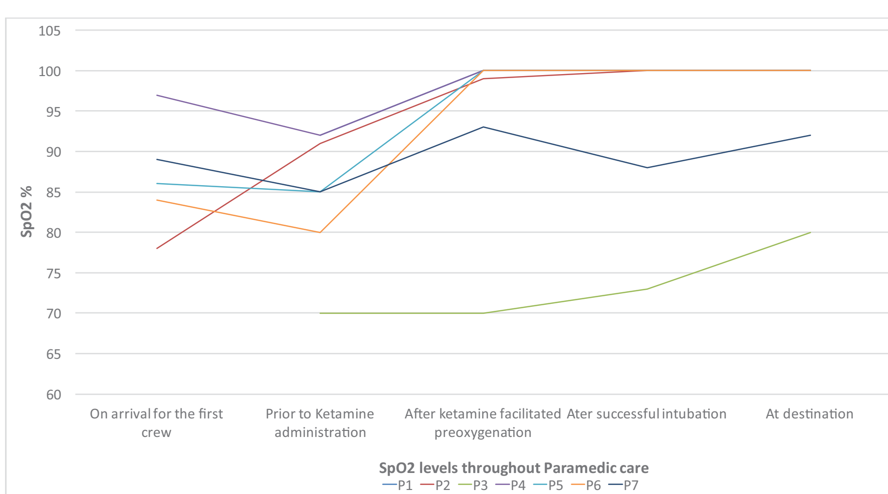

FIGURE 2. Oxygen saturation trends throughout paramedic care for patients who were hypoxic immediately prior to delayed sequence intubation. P1, patient 1; P2, patient 2; etc.

noninvasively monitor the severity of patient injury (20). In a study by Childress et al., the mean $EtCO_2$ of patients who died was 18 mm Hg, compared with 34 mm Hg in those who survived. Such results suggest that lower $EtCO_2$ may be associated with greater in-hospital mortality. As such, expediting successful intubation through DSI may afford flight paramedics the opportunity for early control and monitoring of $EtCO_2$.

The majority of the patients involved in our study were spinally immobilized, and these patients are required to remain supine throughout the duration of ICFP care. On the other hand, a more optimal position for preoxygenation for intubation is a 20-degree head-up position. Supine positioning may increase the difficulty for the patient to take normal breaths and may increase posterior lung atelectasis (4, 21). As such, it is likely that the patients cared for in the supine position in our cohort had an increased risk of desaturation due to their positioning. Having the option to perform DSI in the prehospital environment for these patients may be an unforeseen but additional benefit of the procedure.

On the other hand, the presence of maxillofacial injuries can complicate RSI, and patients with such injuries have been established as potentially warranting emergency cricothyroidotomy (22, 23). We observed only 7 patients with maxillofacial injury in our cohort and all were successfully intubated. However, Blostein et al. and Davis et al. report on the effectiveness of using alternate rescue airways in these patients, including the esophageal tracheal Combitube (22, 24). In both studies, Combitube insertion was attempted after 2 to 3 RSI attempts. Blostein et al. reported a success rate of 100% and Davis et al. reported 95%. These studies highlight an interesting opportunity to use DSI with rescue airway devices with proven efficacy in facial trauma and warrant further research.

Finally, we observed one patient to have a 15-second self-limiting episode of apnea following IV ketamine administration. The current literature suggests that apnea associated with IV ketamine administration is rare and has been previously reported in predominantly pediatric patients (3, 25). Recently, rapid IV administration of ketamine has been reported to cause respiratory depression and apnea in adult patients. A recent published guideline suggests that IV ketamine should be administered over 30 to 60 seconds to negate the risk of apnea in patients (25).

This study has several limitations. It is a retrospective observational study with the known limitations of this methodology. In addition, it is descriptive in nature and does not compare patients receiving DSI to a comparator group. The sample size is relatively small and this may limit the generalizability of our findings. The documentation of paramedic care for critically ill patients is completed retrospectively and times of procedures, drug administration, and other managements may be subject to recall errors. On the other hand, the data are collected electronically and it is likely that all patients who received DSI during the observation period are included in the study.

Conclusion

Our study demonstrates that DSI can be used to preoxygenate patients indicated for intubation in the prehospital setting, where normal preoxygenation methods are not feasible. DSI was associated with an overall increase in oxygen saturations in high-risk, critically ill patients and may prevent peri-intubation desaturation. DSI may be an effective alternative to normal preoxygenation methods in medical and trauma patients who are combative.

References

1. Weingart SD. Preoxygenation, reoxygenation, and delayed sequence intubation in the emergency department. J Emerg Med. 2011;40(6):661–667. doi:10.1016/j.jemermed.2010.02.014.
2. Lockey DJ, Crewdson K, Lossius HM. Pre-hospital anaesthesia: the same but different. Br J Anaesth. 2014;113(2):211–219. doi:10.1093/bja/aeu205.
3. Air Ambulance Victoria. Air Ambulance Victoria clinical practice guidelines. Victoria, Australia: Air Ambulance Victoria; 2016. p. 1–4.
4. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. Ann Emerg Med. 2012;59(3):165–175. doi:10.1016/j.annemergmed.2011.10.002.
5. Weingart SD, Trueger S, Wong N, Scofi J, Singh N, Rudolph S. Delayed sequence intubation: a prospective observational study. Ann Emerg Med. 2015;65(4):349–355. doi:10.1016/j.annemergmed.2014.09.025.
6. Weingart SD. Re: preoxygenation, reoxygenation and delayed sequence intubation in the emergency department. J Emerg Med. 2013;44(5):993–994. doi:10.1016/j.jemermed.2012.11.083.
7. Andrew E, de Wit A, Meadley B, Cox S, Bernard S, Smith K. Characteristics of patients transported by a paramedic-staffed helicopter emergency medical service in Victoria, Australia. Prehosp Emerg Care. 2015;19(3):416–424. doi:10.3109/10903127.2014.995846.
8. Leonardo. AW139 [cited November 16, 2017]. Available from: http://www.leonardocompany.com/en/-/aw139.
9. Ambulance Victoria. Clinical practice guidelines for ambulance and MICA paramedics. Victoria (Australia): Ambulance Victoria; 2016. p. 1–3.
10. Meadley B, Heschl S, Andrew E, de Wit A, Bernard SA, Smith K. A paramedic-staffed helicopter emergency medical service's response to winch missions in Victoria, Australia. Prehosp Emerg Care. 2016;20(1):106–110. doi:10.3109/10903127.2015.1037479.
11. Reynolds SF, Heffner J. Airway management of the critically ill patient: rapid sequence intubation. Chest. 2005;127(4):1397.
12. Cameron P, Gabbe B, McNeil J, Finch C, Smith K, Cooper D, Judson R, Kossmann T. The trauma registry as a statewide quality improvement tool. J Trauma. 2005;59(6):1469–1476. doi:10.1097/01.ta.0000198350.15936.a1.
13. Benumof J, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalysed state following 1 mg/kg intravenous succinylcholine. Anesthesiology. 1997;87:979–982. doi:10.1097/00000542-199710000-00034.

14. Skupski R, Miller J, Binz S, Lapkus M, Walsh M. Delayed sequence intubation: danger in delaying definitive airway? Ann Emerg Med. 2016;67(1):143–144. doi:10.1016/j.annemergmed.2015.08.012.
15. David DP, Hwang JQ, Dunford JV. Rate of decline in oxygen saturation at various pulse oximetry values with pre-hospital rapid sequence intubation. Prehosp Emerg Care. 2008;12(1): 46–51. doi:10.1080/10903120701710470.
16. Bodily J, Webb H, Weiss S, Braude D. Incidence and duration of continuously measured oxygen desaturation during emergency department intubation. Ann Emerg Med. 2016;67(3): 389–395. doi:10.1016/j.annemergmed.2015.06.006.
17. Farmery A, Roe P. A model to describe the rate of oxyhaemoglobin desaturation during apnoea. Br J Anaesth. 1996;76(2):284–291. doi:10.1093/bja/76.2.284.
18. Chestnut RM, Marshall LF, Klauber MR, Blunt BA, Baldwin N, Eisenberg HM, Jane JA, Marmarou A, Foulkes MA. The role of secondary brain injury in determining outcome from severe head injury. J Trauma. 1993;34(2):216–222. doi:10.1097/00005373-199302000-00006.
19. Denninghoff K, Nuño T, Pauls Q, Yeatts S, Silbergleit R, Palesch Y, Merck LH, Manley GT, Wright DW. Prehospital intubation is associated with favorable outcomes and lower mortality in ProTECT III. Prehosp Emerg Care. 2017;21(5):539–544. doi:10.1080/10903127.2017.1315201.
20. Childress K, Arnold K, Hunter C, Ralls G, Papa L, Silvestri S. Prehospital end-tidal carbon dioxide predicts mortality in trauma patients. Prehosp Emerg Care. 2017;1–5. doi:10.1080/10903127.2017.1356409.
21. Lane S, Saunders D, Schofield A, Padmanabhan R, Hildreth A, Laws D. A prospective, randomised controlled trial comparing the efficacy of pre-oxygenation in the 20° head-up vs supine position. Anaesthesia. 2005;60(11):1064–1067. doi:10.1111/j.1365-2044.2005.04374.x.
22. Blostein P, Koestner A, Hoak S. Failed rapid sequence intubation in trauma patients. J Trauma Inj Infect Crit Care. 1998;44(3):534–537. doi:10.1097/00005373-199803000-00021.
23. Ochs M, Davis D, Bailey D, Marshall L, Rosen P. Paramedic-performed rapid sequence intubation of patients with severe head injuries. Ann Emerg Med. 2002;40(2):159. doi:10.1067/mem.2002.126397.
24. Davis D, Valentine C, Ochs M, Vilke G, Hoyt D. The Combitube as a salvage airway device for paramedic rapid sequence intubation. Ann Emerg Med. 2003;42(5):697–704. doi:10.1016/S0196-0644(03)00396-2.
25. Green SM, Roback MG, Kennedy RM, Krauss B. Clinical practice guideline for emergency department ketamine dissociative sedation: 2011 update. Ann Emerg Med. 2011;57(5): 449–461. doi:10.1016/j.annemergmed.2010.11.030.