Prehospital Rapid Sequence Intubation in an Emergency Medical Services System with Two Advanced Life Support Providers

Mark A. Merlin, DO, EMT-P, FACEP;[1] Huma Safdar, MD;[2] Susan Calabrese, EMT-P;[3] Alex Lewinsky, EMT-P;[4] Joseph Manfre, EMT-P;[4] Stephen Van Pelt, MS-IV;[5] Andreia Marques-Baptista, MD[6]

1. Assistant Professor Emergency Medicine and Pediatrics, University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School; EMS/Critical Care Transport Medical Director, Robert Wood Johnson University Hospital; New Jersey EMS Fellowship Director, New Brunswick, New Jersey USA
2. Resident in Emergency Medicine, New York, New York USA
3. EMS Education Coordinator, Paramedic, Robert Wood Johnson University Hospital, New Brunswick, New Jersey USA
4. Paramedic, Robert Wood Johnson University Hospital, New Brunswick, New Jersey USA
5. Department of Medical Education, UMDNJ-Robert Wood Johnson Medical School, New Brunswick, New Jersey USA
6. NJ EMS/Disaster Medicine Fellow, Department of Emergency Medicine, UMDNJ-Robert Wood Johnson Medical School, New Brunswick, New Jersey USA

Correspondence:
Mark A. Merlin, DO, EMT-P, FACEP
1 Robert Wood Johnson Place Medical Education Building Room 104
New Brunswick New Jersey 08901 USA
E-mail: merlinma@umdnj.edu

Keywords: airway; emergency medical services; intubation; prehospital; succinylcholine

Abbreviations:
ALS = advanced life support
BLS = basic life support
EMS = emergency medical services
PCR = patient care report
RSI = rapid sequence intubation

Received: 16 March 2009
Accepted: 29 September 2009
Revised: 30 September 2009

Web publication: 26 July 2010

Abstract

Objective: A rapid sequence intubation (RSI) method was introduced to a university-based emergency medical services (EMS) system. This is a report of the initial experience with the first 50 patients in a unique, two-tiered, two-advanced life support (ALS) providers system.

Methods: The data were evaluated prospectively after an extensive RSI training period, consisting of didactic information and skills performance. Fifty consecutive patient records that documented the procedure were abstracted. Data abstracted included end-tidal CO_2, heart rate, blood pressure, and pulse oximetry at various time intervals. Intubation success rates and number of attempts were documented. The consistency of proper documentation also was noted on patient care records.

Results: No differences were noted in heart rate prior to RSI and one and five minutes after the RSI procedure was begun. No differences in blood pressure at one and five minutes were noted. Statistically significant improvements were found in pulse oximetry comparing prior to RSI and one minute after (p <0.001; 95% CI = 3.15–11.41) as well as prior to RSI and five minutes after RSI was started (p <0.0002; 95% CI = 4.60–13.33). No differences were observed in end-tidal CO_2 at one and five minutes. Overall intubation success rate was 96%, with 82% on first attempt and 92% on two or less attempts. Documentation for individual vitals was consistently <75%.

Conclusions: Patients had no significant worsening of vital signs during the RSI procedure and mild improvement in pulse oximetry. Intubation success rates were consistent with national averages. Proper documentation was lacking in more than one quarter of the charts. These data add to a body of literature that raises further concerns regarding prehospital RSI.

Merlin MA, Safdar H, Calabrese S, Lewinsky A, Manfre J, Van Pelt S, Marques-Baptista A: Prehospital rapid sequence intubation in an emergency medical services system with two advanced life support providers. ***Prehosp Disaster Med*** **2010;25(4):341–345.**

Introduction

Many emergency medical service (EMS) agencies have implemented the use of prehospital rapid sequence intubation (RSI) for out-of-hospital victims of traumatic brain injury and other medical and traumatic conditions with the belief that it improves patient care and survival. Rapid sequence intubation uses a sedative or induction agent that is administered relatively simultaneously with a paralyzing dose of a neuromuscular blocking agent to facilitate rapid tracheal intubation. The technique protects against aspiration, provides excellent access to the airway, and permits pharmacologic control as well as maintaining sedation and paralysis post-intubation. The technique originated from the operating room and initial studies in Pittsburgh, San Diego, and Boston of RSI intubation yielded promising results.[1–4] Follow-up studies of non-RSI intubation questioned paramedics ability to perform in a prehospital setting.[5–9] Despite this, demand from the prehospital community resulted in the development of RSI protocols. While prehospital RSI began to grow exponentially, studies such as by Gausche *et al,* continued

to question intubation in the prehospital setting.[5] This pediatric, prospective trial evaluated bag-valve-mask ventilation versus intubation in the prehospital setting. No survival or neurological differences were found in the endotracheal group vs. the bag-valve-mask group. Wang and Yealy found that first-pass RSI success was only 54%.[10] Dunford observed frequent bradycardia and desaturation during paramedic performance of RSI.[11] Davis found that prehospital RSI worsened the likelihood of survival for victims suffering from traumatic brain injury when compared with non-intubated historical controls.[12,13] These results have prompted medical directors to recommend that EMS agencies using RSI implement the highest standards of airway management education, training, practice, and quality assurance. The National Association of Emergency Medical Services Physicians recommends that RSI programs should include close medical oversight, standardized protocols, and appropriate equipment and training.[14]

In this preliminary report, early experience with the quality of RSI performed by ground-based paramedics in this EMS system was evaluated. The specific objectives were to evaluate RSI success rates, number of laryngoscopies, hemodynamic changes, adverse event reports, and compliance with reporting requirements.

Methods

Design

This study was a prospective quality assurance evaluation of a clinical RSI program. It was approved by the Robert Wood Johnson Medical School Institutional Review Board, which has a collaborative agreement with Robert Wood Johnson University Hospital.

Setting

This study was conducted at Robert Wood Johnson University Hospital Emergency Services. The two-tiered EMS system is comprised of six Advanced Life Support (ALS) Units that contain either two paramedics or one paramedic and a *prehospital registered nurse*, a RN with 100 additional hours of intubation training in the operating room. Both of these providers are able to perform RSI. The ability to perform RSI in the prehospital setting was implemented in this EMS agency 01 April 2007.[15]

Basic life support (BLS) providers include both career and volunteer operators. Career operators are licensed BLS providers that charge fees for services provided. These agencies originally operated primarily within larger cities, but in recent years have spread into suburban and rural areas. Volunteer agencies do not charge for services and are not regulated by the state. Advanced life support services in the State of New Jersey are provided by paramedics and Mobile Intensive Care Registered Nurses through hospital-based Mobile Intensive Care Units (MICU) and helicopters. Nurses are used in the critical care transport units that back up the paramedic units when unavailable. All paramedic units convey patients to multiple hospitals.

The county population of approximately 800,000 residents is contained in 323 square miles within a combination of urban cities, suburban communities, and rural farmlands. This system consists of 90 paramedics, 140 basic emergency medical technicians, one full-time medical director, and two EMS Fellows. New Jersey has multiple standing order protocols whereby the paramedic can initiate treatment; however, RSI is not a standing order and an order for attempting RSI must be given by medical control. Supervisors respond on all "critical calls" as defined by the medical communicator. The system at Robert Wood Johnson had approximately 30,000 requests for medical aid in 2007.

Education and training consisted of a 16-hour course encompassing intubation procedures and RSI medications. The course included simulations using a mannequin and a 25-question, written post-course test. After completing the written test, a practical examination was given to each ALS provider. Each ALS provider must complete at least five intubations in the operating room during initial training. During the training period, sedation and paralytic medications were reviewed including dosages, indications, and contraindications.

The RSI protocol included succinylcholine and etomidate or ketamine with vecuronium and versed post-intubation. All attempted RSIs used succinylcholine as the primary paralytic agent. An intubation attempt was defined as the tip of the endotracheal tube passing the central incisors. The protocol limited intubation attempts to 30 seconds. The protocols required the use of end-tidal capnography and repeat vital signs at one and five minutes after intubation. The protocol allowed RSI attempts only if two ALS providers were present during the entire procedure. Paramedics were required to have intubated five times within the last year to be eligible to complete the RSI training program.

Data Collection and Processing

Data were recorded on Patient Care Reports (PCRs) that were transferred to a Microsoft Excel Spread Sheet (2007 Microsoft, Inc., Redmond, WA). The study team reviewed all patient charts in which RSI was attempted. If information was missing from the PCR, the ALS providers received a reminder prior to chart completion to complete the data form.

Selection of Subjects

This preliminary analysis included patients receiving RSI during the period 01 April 2007 through 31 December 2007. Only patients receiving succinylcholine to facilitate prehospital RSI were included.

Primary Outcomes and Measures

The primary endpoints were compliant with RSI protocol, success rates of endotracheal intubation, and adverse effects. Compliance was defined as the ability to document end-tidal CO_2, oxygen saturation by pulse oximetry, heart rate, and blood pressure. Successful intubation was defined as proper tube placement within the trachea confirmed by at least two methods and checked by the emergency department physician. These methods are end-tidal CO_2, breath sounds with absence over the epigastrum, and direct visualization.

The secondary endpoints evaluated differences in pulse oximetry, blood pressure end-tidal CO_2, and heart rate between pre-RSI measured, one minute and five minutes

Comparison of end tidal CO2 at various time intervals (mean)	*p*-values (95% Confidence Intervals)
1 minute (41 mmHg), 5 minutes (42 mmHg)	$p = 0.37$ (-6.78–2.58)

Table 1—End-tidal CO_2 comparison (1 minute = one minute after rapid sequence intubation; 5 minutes = five minutes after intubation)

Heart Rate Time Comparisons	*p*-value (95% Confidence Intervals)
Prior (92 bpm), 1 minute (94 bpm)	$p = 0.46$ (-6.94–3.21)
Prior (92 bpm), 5 minutes (88 bpm)	$p = 0.33$ (-8.53–2.93)
1 minute (94 bpm), 5 minutes (88 bpm)	$p = 0.59$ (-6.58–3.81)

Table 3—Heart rate comparison (bpm = beats-per-minute; Prior = prior to rapid sequence intubation; 1 minute = one minute after rapid sequence intubation; 5 minutes = five minutes after intubation)

after RSI completed. Time points for end-tidal CO_2 measurements were available at only one minute and five minutes. If the measures were within the normal range for that initial sign in a given interval, a matched-pair test was performed.

Data Processing

The data were analyzed using descriptive statistics. For trends in vital signs, paired t-tests were used, applying a Bonferroni-adjusted *p*-value of 0.017 to account for three comparisons of pre-RSA intervention, one minute after intervention, and five minutes after invention. Cumulative success rates were determined based upon previous recommendations in the literature.[16] Statistical calculations were performed using SAS 9.1 TS level 1M0, XP_PRO platform (SAS Institute Inc., Cary, NC) and MINITAB 15 (MINITAB Inc., State College, PA).

Results

There were 50 patients who had RSI attempted during the study. Cumulative success rates for the first three endotracheal intubation attempts were 82%, 92%, and 92%, respectively. Cumulative, overall RSI success (including all endotracheal intubation attempts) was 96% (two were unsuccessful). The cumulative success rates at three attempts were similar to overall success rates (OR = 3.27; 95% CI = 0.63–17.07). No patients received sedation only during this initial analysis period.

Comparisons of Pulse Oximetry at Various Time Intervals	*p*-values (95% Confidence Intervals)
Prior (90%), 1 minute (98%)	$p < 0.001$ (3.15–11.41)
Prior (90%), 5 minutes (100%)	$p < 0.0002$ (4.60–13.33)
1 minute (98%), 5 minutes (100%)	$p = 0.49$ (-1.47–2.97)

Table 2—Pulse oximetry comparison (% = percent oxygen saturation; Prior = prior to rapid sequence intubation; 1 minute = one minute after rapid sequence intubation; 5 minutes = five minutes after intubation)

Comparison of Blood Pressures (Mean) at Different Time Intervals	*p*-values (95% Confidence Intervals)
Prior (162 mmHg), 1 minute (170 mmHg)	$p = 0.09$ (-17.40–1.40)
Prior (162 mmHg), 5 minutes (140 mmHg)	$p = 0.06$ (-28.92–0.82)
1 minute (170 mmHg), 5 minutes (140 mmHg)	$p = 0.09$ (-26.08–2.08)

Table 4—Systolic blood pressure systolic comparison (mmHg = millimeter of mercury;Prior = prior to rapid sequence intubation; 1 minute = one minute after rapid sequence intubation; 5 minutes = five minutes after intubation)

Of the 36 patients with a documented end-tidal CO_2, four (11%) had a one-minute end-tidal CO_2 value <30 mmHg. At five minutes, four of 41 patients (9.8%; 95% CI = 0.68–18.85) reported an end-tidal CO_2 value <30 mmHg (Table 1). Documentation of end-tidal CO_2 values were 72% and 82% at one and five minutes, respectfully. Documentation rate for pulse oximetry was 62%, 58%, and 60% upon first patient contact, and one and five minutes respectfully (Table 2). Pulse oximetry comparison prior to intubation was 90% prior to intubation and 98% at one minute ($p < 0.001$; 95% CI = 3.15–11.41), 100% at five minutes ($p < 0.0002$; 95% CI = 4.60–13.33). There were no differences with the heart rate or systolic blood pressure pre-RSI, one-minute, and five-minutes after RSI (Tables 3 and 4). Compared with pre-RSI, one- and five-minute SaO_2 improved.

Four patients died and 46 were admitted to critical care setting. No patients experienced cardiac arrest during the procedure. No unrecognized esophageal intubations were observed upon emergency department arrival and transfer of care. Two patients were not successfully intubated. These patients received bag-valve-mask and subsequent alternate airway insertion; one with a combitube and one with a laryngeal-mask airway.

Discussion

In this preliminary evaluation of a ground EMS RSI program, there were numerous concerns. Protocol adherence was low (including the inconsistent use of end-tidal CO_2 to verify endotracheal tube placement). The paramedics also did not fully comply with reporting requirements.

The San Diego RSI Trial, which had an overall success rate of 84.2%, described increased incidences of inadvertent hyperventilation, bradycardia, and desaturation. This trial had documented hyperventilation described as end-tidal CO_2 <30mmHg in 79% of patients and severe hyperventilation (end-tidal CO_2 <25 mmHg) in 59% of patients during intubation. In this trial, lower rates of hyperventilation, desaturation, and bradycardia were experienced. End-tidal CO_2 <30 mmHg was observed in only 11% of patients at one minute (n = 36 with documented end-tidal CO_2) and in 10% of patients at five minutes (n = 41). At one minute, patients experiencing severe hyperventilation was 8% while at five minutes, this number decreased even further to 2.4%. No significant change in end-tidal CO_2 at one minute after intubation versus five minutes was recorded. A statistically significant difference was found between pre-RSI, one minute after RSI, and five minutes after RSI.

Prior to intubation, more than half of the patients with a documented saturation (53%, n = 38) experienced saturations below 93%. At one minute, this number was cut almost in half to 27% (n = 30) and even lower to 9.7% (n = 31) at five minutes. This is lower than the 38% observed in trauma patients following intubation in the San Diego RSI Trial. In part this could be due to the higher success rate in this EMS system (96%) in comparison to the San Diego study (84.2%). This not only indicates a reduction in desaturation due to intubation with RSI, but also signifies a trend towards normalization for oxygen saturation. This same improvement was observed with heart rate the normal proportion improved from prior to intubation to one minute.

The ALS system is tiered, with paramedics practicing in high volume, high acuity settings. The system required at least two ALS providers at every RSI to ensure compliance with clinical protocols and documentation. Shortcomings were observed despite these safeguards.

These findings illustrate the difficulty in documenting a new procedure along with selecting out critical patients who required a labor intensive intervention. Since the paramedics must draw up these medications at the same time they are intubating and assessing the patient, the likelihood of proper documentation might be difficult. Even in the less chaotic setting of the emergency department, multiple personnel perform these tasks.

Given these findings, a detailed review is continued of every RSI chart by the EMS medical director and EMS Fellow. Intubation success rates and attempts are evaluated for each paramedic. End-tidal CO_2, although initially only optional, has become a mandate for all patients receiving RSI and documentation of outliers are being remediated.

Limitations

An intubation attempt was defined as the tip of the endotracheal tube passing the central incisors. Although this definition is criticized by many authors, it seemed to be a realistic method of what is happening in the prehospital arena. The paramedics were instructed that an intubation attempt is limited to 30 seconds. Subsequently, if no blade was inserted into the mouth and suctioning was done for 30 seconds, it counted as an attempt. There was a degree of subjectivity, since paramedics were deciding for themselves when 30 seconds expired.

Most of the study results were determined by the accuracy of provider documentation. Since a second ALS provider reviewed the chart, it is believed that the vital signs and end-tidal CO_2 were accurate, however, this cannot be confirmed. Because the documentation was poor, the results obtained may not truly have reflected the efficacy of the procedure introducing a bias into the results.

It was not possible to measure the end-tidal CO_2 prior to intubation. This would have been important to be able to judge if levels decreased during the intubation process, representing worsening tissue perfusion.

Conclusions

In this preliminary evaluation of RSI implementation in a two-tiered, two-ALS provider system, first-pass endotracheal intubation success rates were marginally acceptable, but similar to other studies. With incomplete documentations and poor protocol compliance, the overall utility of RSI remains questionable in this setting. These findings highlight the challenges of implementing RSI in the prehospital setting.

Acknowledgements

The authors thank Henry Wang, MD for his review of this manuscript prior to submission.

References

1. Jacobs LM, Berrizbeitia LD, Bennett B, Madigan C: Endotracheal intubation in the prehospital phase of emergency medical care. *JAMA* 1983;250(16):2175–2177.
2. Stewart RD, Paris PM, Winter PM, Pelton GH, Cannon GM: Field endotracheal intubation by paramedical personnel. Success rates and complications. *Chest* 1984;85(3):341–345.
3. DeLeo BC: Endotracheal intubation by rescue squad personnel. *Heart Lung* 1977;6(5):851–854.
4. Guss DA, Posluszny M: Paramedic orotracheal intubation: A feasibility study. *Am J Emerg Med* 1984;2(5):399–401.
5. Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, Poore PD, McCollough MD, Henderson DP, Pratt FD, Seidel JS: Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: A controlled clinical trial. *JAMA* 2000;283(6):783–790.
6. Lockey D, Davies G, Coats T: Survival of trauma patients who have prehospital tracheal intubation without anaesthesia or muscle relaxants: observational study. *BMJ* 2001;323:141. [abstract].
7. Cooper A, DiScala C, Foltin G, Tunik M, Markenson D, Welborn C: Prehospital endotracheal intubation for severe head injury in children: A reappraisal. *Semin Pediatr Surg* 2001;10(1):3–6.
8. DiRusso SM, Sullivan T, Risucci D, Nealon P, Slim M: Intubation of pediatric trauma patients in the field: Predictor of negative outcome despite risk stratification. *J Trauma* 2005;59(1):84–90.
9. Sloane C, Vilke GM, Chan TC, Hayden SR, Hoyt DB, Rosen P: Rapid sequence intubation in the field versus hospital in trauma patients. *J Emerg Med* 2000;19(3):259–264.
10. Wang HE, Yealy DM: Out-of-hospital rapid sequence intubation: Is this really the "success" we envisioned? *Ann Emerg Med* 2002;40(2):168–171.
11. Davis DP, Hwang JQ, Dunford JV: Rate of decline in oxygen saturation at various pulse oximetry values with prehospital rapid sequence intubation. *Prehosp Emerg Care* 2008;12(1):46–51.
12. Davis DP, Hoyt DB, Ochs M, Fortlage D, Holbrook T, Marshall LK, Rosen P: The effect of paramedic rapid sequence intubation on outcome in patients with severe traumatic brain injury. *J Trauma* 2003;54:444–453.
13. Davis DP, Peay J, Sise MJ, Vilke GM, Kennedy F, Eastman AB, Velky T, Hoyt DB: The impact of prehospital endotracheal intubation on outcome in moderate to severe traumatic brain injury. *J Trauma* 2005;58(5):933–939.
14. Wang H, Davis D, Wayne MA, Delbridge T: Prehospital rapid-sequence intubation—What does the evidence show? Proceedings from the 2004 national association of EMS physicians annual meeting. *Prehosp Emerg Care* 2004;8(4):366–377.
15. *Policy and Procedure Manual.* New Brunswick, New Jersey: Robert Wood Johnson University Hospital, 2008.
16. Wang HE, Yealy D: How Many attempts are required to accomplish prehospital endotracheal intubation? Presented at the annual meeting of the National Association of EMS Physicians, Registry Resort, Naples FL. 2008.