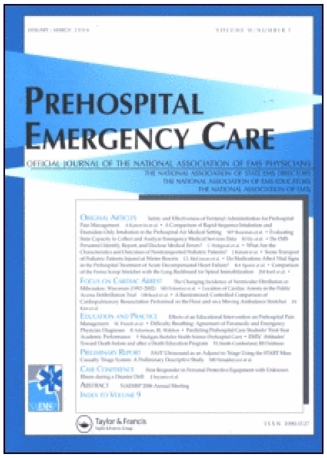

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PREHOSPITAL RAPID-SEQUENCE INTUBATION: A PILOT TRAINING PROGRAM

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PREHOSPITAL RAPID-SEQUENCE INTUBATION:
A PILOT TRAINING PROGRAM

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ABSTRACT

Objective. To develop a training program enabling paramedics to use sedation and paralytic medications to facilitate endotracheal intubation in patients who otherwise could not be successfully intubated. **Methods**. Paramedics underwent a training program consisting of six hours of didactic education, two four-hour mannequin labs, one four-hour animal intubation lab, and operating room experience. Rapid-sequence intubation (RSI) runs were reviewed for appropriateness in patient selection and medication use. Non-RSI runs were reviewed to determine whether appropriate patients were being missed. Intubation success rates continue to be followed. Long-term quality assurance includes monthly run reviews, periodic quizzes, and unannounced on-site practical tests. **Results**. 101 patients have been intubated using RSI, including medical, trauma, pediatric, and adult cases. Of all patients receiving RSI drugs, 100 of 101 were successfully intubated. There were no undetected esophageal intubations. Paramedics were able to demonstrate proper patient selection and appropriately administer RSI medications. The use of sheep labs was a critical component of this training because it permitted multiple intubations in a live model possessing an airway quite similar to that of the human. The gum elastic bougie was felt to be critical in the intubation of three patients. **Conclusion**. This RSI training model can serve as a template for other agencies seeking to implement RSI. Limitations of this model include the availability of live animal labs and the expense of conducting the training. Intense medical director involvement has been key to the success of this prehospital RSI program.
Key words: paramedic; intubation; emergency medical services; conscious sedation; etomidate; succinylcholine.

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The importance of maintaining a patent airway and providing adequate oxygenation has long been accepted as a critical aspect in the care of seriously ill and injured patients.[1-6] Endotracheal intubation has been the accepted "gold standard" for protecting and maintaining the airway. This procedure is generally successful in cardiac arrest patients and those with severely depressed mental status. There are, however, patients who would benefit from endotracheal intubation but in whom, due to their mental status or medical condition, the procedure cannot be successfully performed. Medications that sedate and/or chemically paralyze the patient can enhance the likelihood of successful intubation.[4,7-11]

Rapid-sequence intubation (RSI), previously the sole domain of anesthesiology, has now become the standard of airway care by emergency physicians across the country. Prehospital RSI has largely been restricted to specially trained intensive care transport teams.[10-13] Until recently, many medical directors were reluctant to allow the use of these medications by 911 ground-based paramedics. There has been significant concern that use of these medications by paramedics may result in adverse effects due to the medications themselves, inability to intubate following chemical paralysis, and increased scene times due to the performance of RSI. Wayne and Friedland have demonstrated that paramedics can successfully use succinylcholine to facilitate intubation in the field.[14] Various preparalytic sedation agents have been suggested for use in the prehospital setting.[15]

Quality assurance data at our institution revealed low prehospital intubation rates for trauma patients with Glasgow Coma Scores (GCSs) of 4–9 and others requiring intubation with an intact gag reflex. Like Wang et al.,[16] we found this to be largely due to inadequate relaxation.

The decision was made to pilot RSI in one paramedic service prior to implementing it at other agencies. As we proceeded with plans to instruct this pilot group of ground 911 paramedics in RSI, no preexisting curriculum could be found. The goal of this project was to prepare a training program that would enable 911 ground-based paramedics to use sedation and paralytic agents to facilitate intubation in patients who otherwise could not be successfully endotracheally intubated. This paper describes the training curricula and resultant field experience of our pilot project, and may serve as a template for others preparing paramedics for RSI in the field.

METHODS

Regions Hospital is a level 1 trauma center serving the city of St. Paul, Minnesota, the surrounding metropol-

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TABLE 1. Rapid-sequence Intubation (RSI) Guidelines (Abbreviated Form—Full Document May Be Accessed at: regionsems.net)

Indications:

1. Respiratory insufficiency (patients with $SaO_2 < 88\%$ who have failed to respond to other interventions)
2. Respiratory arrest that cannot be intubated due to non-flaccid state
3. Suspected closed head injury with GCS < 9
4. Unconsciousness or altered mental status with airway compromise
5. Potential for airway compromise due to acute burns or anaphylaxis

Contraindications:

1. Known anatomical deformities: fat/bull neck, throat cancer, ankylosis
2. Non-arrested croup or epiglottitis

Procedure:

1. Maintain spinal immobilization in the trauma patient.
2. Assemble and check required equipment.
3. Calculate and prepare doses of premedication (as indicated), sedative, and paralytic in labeled syringes. Verify all doses.
4. Assure that IV is patent and secure.
5. Monitor patient ECG.
6. Attempt to raise to and/or maintain SaO_2 at 94% prior to intubation by allowing the patient to breathe 100% oxygen by mask or assisting ventilations as necessary.
7. Premedicate patient as appropriate:
   A. Atropine (for ages newborn–7 years): 0.01 mg/kg IV push; minimum dose is 0.1 mg and maximum dose of 0.5 mg.
   B. Lidocaine (for intracranial pressure [ICP] in CNS insults such as head injuries, hypertensive crisis, CVA): 1.0 mg/kg IV.
8. Sedate patient if not hypotensive: Etomidate 0.3 mg/kg IV.
9. Chemically paralyze patient: Succinylcholine 2.0 mg/kg IV.
10. Apply cricoid pressure and maintain until intubation is successfully completed.
11. Wait 30–60 seconds, announcing time and SaO_2 sats at 15-second intervals or with change.
12. Fasciculations may or may not occur. After fasciculations stop (or approximately 30– 45 seconds after succinylcholine is given), wiggle the mandible. Jaw relaxation correlates with cord paralysis.
13. Perform ET intubation: A maximum of two attempts per medic and total of four attempts are allowed. Maintain oxygen saturations above 90%.
14. If patient cannot be intubated, ventilate with BVM, then insert the Combitube.
    If unable to place Combitube, ventilate with BVM and oral airway.
    If unable to adequately ventilate and oxygenate with above measures, perform cricothyrotomy.
15. Confirm tube placement with usual methods (Table 2).
16. Secure tube with appropriate screw down or slip lock device. Position all patients on backboard and immobilize with cervical collar.
17. Insert gastric tube.
18. Frequently reassess ET tube placement.
19. If sedation is necessary following intubation, administer Versed: titrate to maximum dose of 0.1 mg/kg. If additional paralysis is necessary following intubation, administer vecuronium 0.1 mg/kg IV.
20. Treat bradycardia occurring during intubation with proper oxygenation (halting intubation if needed). Give atropine 0.5 mg IV if bradycardia is not promptly resolved by oxygenation.

Pediatric note: if RSI is repeated, do not repeat atropine dosing. Treat bradycardia with oxygenation.

SaO_2 = oxygen saturation; GCS = Glasgow Coma Score; IV = intravenous; ECG = electrocardiogram; CNS = central nervous system; CVA = cerebrovascular accident; ET = endotracheal; BVM = bag–valve–mask.

itan area, and western Wisconsin. Lakeview Hospital EMS was selected to be the beta sight for the RSI pilot training program. Lakeview EMS is a hospital-based, single-role advanced life support ambulance provider to suburban and rural communities in Minnesota and Wisconsin.

An RSI steering committee was formed to ascertain costs, provide risk management, develop a curriculum of initial and continuing education and develop continuous quality improvement/quality assurance (CQI/QA) procedures. This committee had representation from medical direction, anesthesia, the ambulance service, and CQI/QA representatives from Regions EMS and Lakeview hospital as well as hospital administration. The cost sharing and risk sharing were agreed upon up front. Tight on-line and off-line medical control as well as prospective, concurrent, and retrospective CQI/QA measures were established. Guidelines were written based on input from emergency medical services (EMS) medical direction, and the departments of emergency medicine and anesthesia (Table 1). It was agreed that the medical directors would maintain the authority to remove any paramedic, at any point during the training or in the future, for deficits in knowledge or performance. Regions Hospital Institutional Review Board granted exemption for the training, animal lab, and reporting of the CQI/QA data analysis.

Prior to the start of the didactic training, each paramedic completed assigned readings from the book *Anyone Can Intubate*, 4th edition, by Christine E. Whitten.[17] They answered more than 300 self-study questions from these readings. Students were permitted to work in groups using the open text.

Both full-time and part-time paramedics participated in the initial six-hour didactic training. This ensured that everyone would participate in pre-class preparations, learn the medications, and understand the "team" approach to RSI. The full-time paramedics continued on to complete the mannequin lab, animal lab, and operating room (OR) experience. Part-time paramedics were encouraged to participate in the mannequin lab. Both groups were integrated as "teams" throughout the training. Only full-time paramedics who completed all portions of training were able to function as "RSI team leaders."

During the mannequin lab, various scenarios were practiced to reinforce the procedure elements, including indications/contraindications, medication selection, dose calculations, and actual medication administration. Only one mannequin lab was originally planned, but initial performance dictated that more training would be beneficial prior to progression to the next phase. Two optional labs were offered by medical direction at no cost to the ambulance service. The students were not required to attend and no compensation was given to the paramedics for their time. Despite this, all students attended one or both of the additional labs. The performance at these labs substantially improved. A 4:1 student to physician ratio provided a close working relationship and assessment of the individual student's skills. Each student received immediate feedback. Deficiencies and ambiguities in the initial training were quickly corrected in these small-group sessions. Common errors were discussed with the entire group.

The next phase of training used sedated sheep as intubation models, as the sheep's airways closely resembles that of the human. Male sheep weighing 25–30 kg were most ideal. The animal intubation labs were also conducted with a 4:1 student to physician ratio.

In the lab, students practiced correct techniques for intubation using different blades and airway adjuncts, including the endotracheal tube introducer (gum elastic bougie). Post-intubation procedures were rehearsed until they were automatic (Table 2). Once the technical intubation performance was correct, case scenarios were presented. The scenarios included medical and trauma, and adult and pediatric cases. Students decided whether the patient should be intubated, whether RSI was indicated, and whether there were any contraindications. When appropriate to the case, RSI was performed in its entirety. This included drug selection, dose calculations, drug administration, intubation, post-intubation checks and post intubation drugs as indicated by each particular case scenario. The students were required to manage the entire patient, not just the airway. They were expected to prepare for and treat complications that arose. These included such things as pneumothorax, endotracheal tube malfunctions, poor lighting conditions, change in patient condition, and need for intraosseous access. Vomiting, a common airway problem, was simulated by preparing an oatmeal mixture ahead of time and without warning, instilling it in the airway prior to or during intubation. Placebo drugs in the actual medication containers were used during the lab session. The animal was moved to the floor and to gurney height to simulate intubations in these conditions. A cervical collar was placed in trauma cases. This reinforced proper technique of anterior collar removal and in-line stabilization for intubation. Oxygen saturation and cardiac monitors provided real-life anxiety, as desaturation occurred if intubation was not accomplished in a timely manner. Each student was required to possess thorough knowledge of the guidelines, critical thinking skills, and technical intubation skills prior to proceeding to the operating room experience.

TABLE 2. Post-intubation Tube Checks

1. Visualize endotracheal tube passing through the cords
2. Tube check B
3. Auscultation of stomach and lungs
4. End-tidal carbon dioxide
5. Oxygen saturation

The final teaching phase was the operating room. Here the students were taught methods of preoperative assessment of airways and how to predict which patients would likely present difficult intubations. They performed cricoid pressure, mask ventilation, and human intubations under the supervision of the anesthesia department.

Upon completion of training, each paramedic was tested by the medical directors with case scenarios performed on a mannequin in various situations. Students were required to demonstrate knowledge of the guidelines, critical thinking skills, technical intubation skills, and the ability to deal with various complications that presented before, during, or after intubation. They were also required to deal with the whole patient encounter, not simply the RSI. Any student who did not perform adequately was given a second testing opportunity approximately one week later. Following the successful completion of testing, the paramedic was allowed to perform RSI in the field within the defined guidelines (Table 3).

Following each RSI attempt, paramedics completed a CQI form and contacted an on-call EMS coordinator. This contact provided immediate feedback on the case, and the ability to answer questions and discuss any difficulties encountered. All RSI cases were later reviewed by a physician medical director. Other critical cases were reviewed to assess whether appropriate RSI cases had been missed.

TABLE 3. The Rapid Sequence Intubation (RSI) Pocket Card

1. Pre-oxygenate and place monitors
2. Prepare equipment
3. Premedications
   - Pediatric intubations:
     - Atropine 0.01/mg.kg (minimum dose 0.1/mg)
   - CNS injuries:
     - Lidocaine 1 mg/kg
4. Cricoid pressure
5. Sedation agent:
   - Etomidate 0.3 mg/kg
   - Thiopental 2–4 mg/kg (Table 4)
6. Paralytic agent:
   - Succinylcholine 1.5–2 mg/kg
7. Passive oxygenation (active if still hypoxic)
8. Intubate when paralyzed (about 30–90 sec)
9. Check ET placement
   - Tube check B
   - Auscultation
   - End-tidal CO_2
   - SaO_2
10. Secure tube and check CXR
11. Long-term sedation
    - Midazolam (if not used earlier)
12. Long-term paralytic agent if needed
    - Vecuronium 0.1 mg/kg
13. Decompress stomach (NG or OG)
14. Monitor patient and check tube placement frequently

Avoid succinylcholine in the following patients:
- Hyperkalemia
- Pseudocholinesterase deficiencies
- Recent burns (>24 hr)
- Neuromuscular diseases (MS, ALS, MD, etc.)

CNS = central nervous system; ET = endotracheal tube; CO_2 = carbon dioxide; SaO_2 = oxygen saturation; CXR = chest x-ray; NG = nasogastric; OG = orgastric; MS = multiple sclerosis; ALS = amyotrophic lateral sclerosis; MD = muscular dystrophy.

TABLE 4. Thiopental Dosing by Systolic Blood Pressure (SBP) in Adults

SBP	Dose
< 7 mm Hg	0 mg/kg
70–90 mm Hg	1 mg/kg
90–120 mm Hg	2 mg/kg
120–160 mm Hg	3 mg/kg
> 160mm Hg	4 mg/kg

RESULTS

All 12 initial paramedics completed the program. An additional four have been trained in a second program that was similar but did not include the OR experience. The paramedics have preformed 99 field RSIs to date. They have been called to their own emergency department to perform two additional RSI intubations. There has been one instance where RSI drugs were given but the patient was not intubated due to inability to visualize the vocal cords. The airway was successfully managed using standard airway techniques. All other RSIs were successful. There have been no undetected esophageal intubations.

Prior to the removal of thiopental, it had been used in the majority of intubations. There have been five pediatric intubations (patients under 16 years of age). The paramedics considered three intubations to have been successful only because of the use of the gum elastic bougie.

DISCUSSION

Prehospital RSI is not the current standard of care in the United States ground 911 EMS community. The clinical need for prehospital RSI was suggested by our trauma CQI/QA data. Making this a reality was a significant political and educational undertaking.

There were variable levels of support within our anesthesia department. They felt strongly that thiopental be the induction agent of choice for its cerebroprotective properties. Though admittedly less expensive, thiopental had some significant drawbacks in the prehospital environment. Thiopental dosing is not only weight-based, but also dependent on the patient's blood pressure and cardiovascular status (Table 4). Hypotension and bronchospasm are known complications of thiopental use.[18] Thiopental requires mixing at the scene, which adds additional scene time and increases the possibility of drug administration errors.

The advantages of using etomidate as the sole agent for induction are multiple. Since etomidate dosing is weight-based and much less influenced by the patient's blood pressure, cardiovascular status, or volume status, the likelihood of dosing errors is decreased. Etomidate is available in premixed, dose-marked syringes, reducing the likelihood of medication mixing or administration errors. Etomidate can be safely used in trauma and central nervous system injuries.[19,20] It has no contraindications in asthma/bronchospasm, thus reducing potential patient selection errors. The use of a single induction agent greatly simplifies training and the actual field procedure. The increased cost per dose of etomidate is offset by the simplicity of stocking only one agent, as well as the ease of administration and reduced risk of medication errors. For these reasons, as the project progressed, medical direction favored eliminating the use of thiopental and using only etomidate for induction.

The mannequin lab is an important starting place for RSI practice, but is not a panacea. This lab allows for slow, deliberate rehearsal of RSI intubation routines. Drug selection, administration, and calculations can be practiced until proficient. In our opinion, however, mannequins do not provide adequate technical practice.

We found the sheep lab to be critical for airway training and have not found any other non-primate animal that presents a satisfactory airway teaching model. Airway adjuncts, including the esophageal tracheal Combitube and the gum elastic bougie, can be practiced. Unlike the OR, multiple intubations can be accomplished in a very short time. This repetition, under close supervision, provides an arena where complex tasks can be practiced until they are performed flawlessly. The student can learn from failures without potential harm to patients.

Nothing teaches human intubation like human intubation. In a perfect system, supervised RSI in an OR setting would be plentiful. Reality can be somewhat different. Typically two to three OR intubations per student were performed in a six-hour day. This is markedly less than the intubations available in an animal teaching lab. The OR clinical experience was expensive and our paramedics did not feel that it enhanced their education beyond that of the sheep intubation lab. We believe it is possible to omit the OR experience if a sheep lab is available. Since the completion of the initial pilot project, we have trained paramedics without the use of the OR and intend to publish the comparative success rates.

The endotracheal tube introducer (gum elastic bougie) was felt to be a critical intubation tool and should be included in all phases of the training and available for all field intubations whether or not RSI is used.[21] Three field intubations were felt by the paramedics to have been successful only because of the gum elastic bougie.

The esophageal tracheal Combitube is used as the rescue airway of choice. The Combitube has been shown to be an effective method of airway control in trauma patients who fail RSI.[22] Emergency department experience reveals its effectiveness in medical patients as well. Needle and surgical cricothyrotomies are also taught but have not been used since instituting RSI.

We feel a minimum of three rescuers are needed for medical RSI and four for the traumatized patient. Two of these should be paramedics trained in RSI, though the others can be emergency medical technicians or first responders trained in assisting RSI. The first responders need to be familiar with the team approach to RSI and generally assist with the basic airway cares of self-inflating bag ventilation, suctioning, and in-line cervical stabilization. They also provide the cricoid pressure during RSI.

LIMITATIONS

We see several significant limitations to our RSI training program. Cost can be a significant constraint to a system planning to emulate our curriculum. The 22 hours of paid training time per paramedic did not include pre-didactic reading, or the additional optional mannequin labs. Intensive physician time is critical. If multiple instructors are involved, care should be taken to agree on all guidelines and procedures ahead of time to eliminate inconsistencies in training. We also found that a program coordinator is imperative. This may be a nearly full-time focus throughout the planning and training process. Additional equipment must also be included in the budget. Union issues may further complicate the cost of this training for some services.

The availability of the sheep lab is crucial, but not readily available in many systems. Travel to a university teaching institution may be needed to satisfy this portion of the training.

Continuous quality improvement/quality assurance is an important aspect of the program and must be continuous. The importance of documentation cannot be overemphasized. All RSI runs must be reviewed. We have yet to perfect a method to ensure that all potential RSI cases can be identified to evaluate cases where RSI was indicated but not attempted. Close physician supervision was mandatory during the training process and beyond. Long-term CQI/QA includes monthly run reviews with the paramedics as a group, as well as periodic quizzes and unannounced on-site practical tests.

The sheep lab is an integral part of our RSI training and has been added to the education of our non-RSI paramedic services as well. The OR experience can be beneficial but is not a replacement for the sheep lab.

CONCLUSION

We have described what we believe to be a viable model for training of RSI to ground 911 paramedics. Further studies with larger numbers are necessary to thoroughly evaluate this training model.

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