NEONATAL INTUBATION: SUCCESS OF PEDIATRIC TRAINEES

TINA A. LEONE, MD, WADE RICH, RRT, AND NEIL N. FINER, MD

Objectives To review the success of pediatric trainees for neonatal intubation over a 10-year interval at a single academic center.

Study design We reviewed a database of all neonatal intubations designed as a quality assurance process at our institution. Respiratory care practitioners recorded the number of attempts at the time of each procedure. Attempts were defined as each time a laryngoscope was placed in the baby's mouth. Success rates were calculated as the number of successful intubations divided by the attempts.

Results From January 1992 through September 2002, 5051 successful intubations with 9190 attempts were performed by all practitioners. Pediatric residents intubated neonates successfully on 1676 occasions requiring 3719 attempts. The median success rates were 33% for pediatric level (PL)1 residents; 40% for PL2 and PL3 residents, and 68% for neonatal fellows ($P < .001$). The success rates for residents who had more than 20 total attempts versus those who had fewer than 20 attempts were 49% versus 37% ($P < .001$).

Conclusions Developing proficiency at intubation requires a significant amount of experience. Current pediatric residents at our institution have inadequate opportunity to achieve consistent success. *(J Pediatr 2005;146:638-41)*

The pediatric Residency Review Committee (RRC), of the Accreditation Council for Graduate Medical Education, has indicated that pediatric trainees must be competent at endotracheal intubation.[1] The minimal experience required to become competent at neonatal endotracheal intubation has not, to our knowledge, been determined. The anesthesia literature suggests that proficiency at intubation in controlled circumstances takes 40 or more procedures.[2-4]

Since 1994, changes in pediatric residency training limit the amount of time pediatric residents may spend in intensive care. The current pediatric RRC program requirements are that residents must spend a minimum of 4 months and a maximum of 6 months in intensive care training, including neonatal and pediatric intensive care and including all nighttime coverage.

We reviewed our neonatal intubation database to determine the success rates of pediatric residents throughout their training over a 10-year period. The years of the database include the time before and after the introduction of intensive care limitations.

METHODS

The University of California, San Diego (UCSD) Infant Special Care Center is a 40-bed, level III neonatal intensive care unit (NICU) with approximately 600 admissions per year. This hospital provides full perinatal care with a regional NICU and has approximately 2800 deliveries per year, of which approximately 45% are considered high risk. The NICU at UCSD has maintained a neonatal intubation database since 1991 as part of a hospital-approved quality improvement project. The neonatal intubation database contains information about all intubations of babies admitted to the UCSD Infant Special Care Center, including the date and time of intubation, the names and training levels of the operators attempting intubation, the number of intubation attempts, and the name of the operator completing the intubation.

The definitions of attempted and successful intubations have remained constant since the creation of the database. An attempt is defined as placement of the laryngoscope in the baby's mouth. A successful intubation is defined as an attempt that leads to placement of the endotracheal tube in the baby's trachea. Evidence of successful intubation includes

ANOVA	Analysis of variance	RRC	Residency Review Committee
NICU	Neonatal intensive care unit	UCSD	University of California, San Diego
PL	Pediatric level		

From the Division of Neonatology, San Diego Medical Center, University of California, San Diego, California.

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Reprint requests: Neil N. Finer, MD, University of California, San Diego Medical Center, Division of Neonatology, 200 W Arbor Drive, MPF 1-140, San Diego, CA 92103.

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auscultation of breath sounds, chest expansion, improvement in clinical condition, mist on the endotracheal tube, and since 2001, change in color of a colorimetric CO_2 detector for confirmation. A preprinted card with the information to be collected is completed by a respiratory care practitioner at the time of each intubation and entered into a computerized database. The preprinted card has remained unchanged since the initiation of the database, and the data collectors have been the respiratory care practitioners throughout the existence of the database.

The database for the time period from January 1992 through September 2002 was reviewed, evaluating the number of attempted and successful intubations performed by pediatric residents and neonatal fellows. Two of the authors independently reviewed the database to ensure a uniform interpretation. When differences were found, all authors looked at the data again to resolve the differences. Success rates were calculated as the total number of successful intubations divided by the total number of attempted intubations. Success rates were evaluated by individual and by training level. Because success cannot be confirmed during intubations for meconium, success rates were also determined for all nonmeconium indications. Pediatric level (PL)-2 and PL-3 residents were grouped together as a training level because the "senior" rotation in the NICU was done in either the PL-2 or PL-3 year. These residents all previously had experience in the NICU at the PL-1 level. Before any experience in the NICU, pediatric trainees are all instructed in the Neonatal Resuscitation Program and in Pediatric Advanced Life Support. Practice with intubation of manikins occurs in both courses. Trainees also are taught intubation in a cat lab for a half day before experience in the NICU. Throughout the NICU rotation, residents participate in our video review conference, which is a bimonthly meeting in which videotaped performances of delivery room resuscitations and NICU intubations are reviewed.[5] Proper techniques, including handling of the laryngoscope and positioning of the infant, are discussed. Trainees are taught to maintain a controlled and safe environment during the procedure. Trainees are able to see their own performances as well as those of others and will be able to apply this education to improvement of their technique with subsequent intubation experiences. With every intubation a nurse, respiratory care practitioner, and fellow or attending are present to assist and supervise residents with the procedure. Residents are generally allowed 2 to 3 attempts at intubation, provided the baby is stable before the fellow or attending performs the procedure.

The total numbers of attempted and successful intubations performed by each resident throughout training were determined from the database. To evaluate whether the amount of experience influenced success, success rates were compared for residents with 0 to 10 intubation attempts, 10 to 20 attempts, and more than 20 attempts.

Approval to review the database was obtained from the institution's Human Subjects Research Review Board. Unique patient identifiers and names of trainees were removed from the database in compliance with the Health Insurance Portability and Accountability Act regulations before any analyses.

Statistical analyses for data were performed using SigmaStat for Windows (SPSS, Chicago, Ill) statistical software. Data were compared by using 1-way analysis of variance (ANOVA) for normally distributed data with a Tukey test post hoc analysis and by Kruskal-Wallis 1-way ANOVA on ranks with Dunn method post hoc analysis, in which data were not normally distributed. Comparisons were considered significant if the probability value was $<.05$.

RESULTS

From January 1992 through September 2002, a total of 5051 successful intubations were documented, with 9190 (55% success rate) attempts at intubation performed by all practitioners including pediatric trainees, respiratory care practitioners, neonatal nurse practitioners, attending neonatologists, and anesthesiologists. In addition, 24 infants had unsuccessful attempts at intubation for nonmeconium indications by any provider. The majority of those encounters (21/24) were abandoned because of improvement in the infant's status. Of the remaining three infants, attempts at intubation were abandoned because of severe lethal airway anomaly (1), the clinical diagnosis of trisomy 13 (1), and extreme prematurity (1).

In the delivery room, 2676 intubations were successfully completed by all operators, including 1877 intubations for meconium. Coinciding with the revised Neonatal Resuscitation Program guidelines in the fourth edition of the textbook (2000) recommending selective intubation for suctioning meconium stained infants,[6] our number of intubations per year decreased from 810 in 1992 with 376 (46%) for meconium to 344 intubations in 2001 with 43 (12%) for meconium.

Pediatric residents (208) intubated neonates successfully on 1676 occasions, requiring 3719 attempts (overall 45% success rate). An additional 1412 successful intubations with 2167 attempts (65% success rate) were performed by neonatal fellows. Median success rates (25th to 75th quartiles) by training level were PL-1 residents, 33% (17 to 50); PL-2 and PL-3 residents, 40% (25 to 60); and neonatal fellows, 68% (57 to 78). Kruskal-Wallis 1-way ANOVA on ranks showed a difference among groups ($P < .001$. Post hoc analysis using the Dunn method showed that PL2 residents had higher success rates than PL1 residents, and fellows had higher success rates than PL1 and PL2 residents. Success rates for pediatric residents were not significantly different for delivery room nonmeconium intubations than for NICU intubations (36% vs 36.5%).

The mean (standard deviation) total number of successful intubations a graduating resident accomplished throughout the entire 3 years of training decreased from 24 (±14) in 1994 to 4 (±2) in 2002. Similarly, the mean number of intubation attempts per resident throughout training decreased from 38 (±19) in 1994 to 12 (±6) in 2002 (Figure). The success rate for residents who had more than 20 total attempts (49%) was

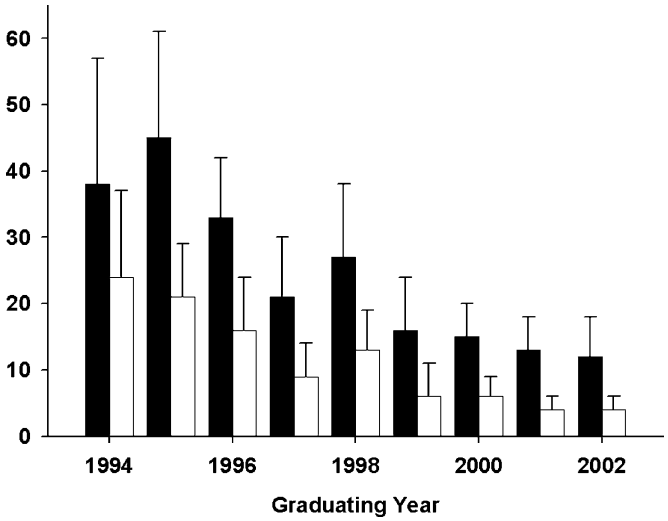

Figure. Mean number of intubation attempts *(black bars)* and mean number of successful intubations *(white bars)* by pediatric trainees during their residency program are plotted against the year of training completion (with standard deviations).

significantly better than the success rates for residents who had 0 to 10 attempts (37%) and for those who had 10 to 20 attempts (38%, $P < .001$). The mean number of intubations attempted by fellows throughout training was 90 (±34).

There was a significant decrease in overall success rates throughout training for each graduating class of residents during the period of the study (ANOVA, $P < .001$). Significant differences existed between year 1 (60% success rate) and years 6 (35.3%), 7 (36.6 %), 8 (32.9%), and 9 (31.7%) by post hoc analysis with the Tukey test.

DISCUSSION

To our knowledge, this review of our neonatal intubation database represents the largest recorded compilation of neonatal intubation experience that has been described. Although we have evaluated these data retrospectively, the information was collected in a prospective manner by using preprinted data collection forms at the time of each event and the results are remarkably similar to our prospective observations using videotaped intubations.[7]

We have used a consistent definition of intubation attempt and success. Our definition of an attempt included any encounter during which a laryngoscope was placed in the baby's mouth for the purpose of intubation, regardless of passage of the endotracheal tube. We have used this definition of attempt because it is the laryngoscope being in the mouth that causes many of the adverse effects associated with intubation such as bradycardia and hypertension.[8] Our success rates appear lower than many others cited because we include every attempt in the calculation of success rate as opposed to the determination that an operator successfully intubated a patient irrespective of the numbers of attempts as has been reported by others.[9,10]

Although this experience is from a single institution, our results are consistent with the data reported in a recent review of neonatal intubation skills by pediatric residents in another single institution over a 3-year period. Falck et al[11] defined competence as success at intubation on the first or second attempt ≥80% of the time and reported that none of the trainee levels who participated in the study were deemed competent by that definition. We reviewed our data using their definition and found similar success rates: for PL-1 residents, UCSD = 49.6%, Falck = 50%; for PL-2 and PL-3 residents, UCSD = 67.4%, Falck, PL-2 = 55% and PL-3 = 62%.

Since 1996, our residents have not completed more than 20 attempts at intubation throughout training. Investigators in anesthesia have shown that 40 or more intubations are required to become proficient. de Oliveira Filho[2] used the cumulative sum method to create learning curves for basic procedures. An "acceptable failure rate" of 20% on the first attempt was set as an appropriate level of proficiency. Only half of the participating anesthesia residents achieved this level of proficiency after an average of 43 attempts. Mulcaster et al[3] trained nonanesthesia students without previous intubation experience how to intubate and recorded their subsequent progress. Using statistical modeling, it was found that trainees had a 90% probability of being successful after 47 attempts. Konrad et al[4] created learning curves for anesthetic procedures and found that success rates for intubation were 90% after a mean of 57 procedures. After training on manikins, emergency medical technicians have been about 50% successful at intubating adult patients in the field.[9,10]

We document a significant reduction in the number of intubations for meconium in the delivery room consistent with the revised Neonatal Resuscitation Program guidelines.[6] The major reduction in numbers of intubation opportunities occurred after the first 2 years of our review, and the numbers of intubations remained relatively constant thereafter. This difference after the first 2 years is related to the changes in meconium practices. We have also had a reduction in the amount of time spent in the NICU by pediatric trainees coinciding with the change in RRC guidelines. Together, these changes have decreased the opportunities available for pediatric trainees to learn intubation and are reflected in lower success rates. The neonatal unit alone, in our experience, provides an inadequate exposure to intubation for pediatric residents to become competent. The same level of proficiency expected of anesthesiologists and neonatologists should not necessarily be applied to pediatric residents. However, if a higher level of proficiency is desired than is currently being achieved, additional training opportunities are necessary. Other areas such as the operating room, emergency room, and pediatric intensive care unit may add to a trainee's experience.

CONCLUSIONS

Pediatric trainees are currently provided inadequate experience to allow development of proficiency at neonatal intubation. The determination of competency at intubation for general pediatricians requires further consideration.

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REFERENCES

1. Accreditation Council for Graduate Medical Education. http://www.acgme.org/RRC/PedReq_Comp.asp. Program Requirements/Pediatrics-Competencies.

2. de Oliveira Filho GR. The construction of learning curves for basic skills in anesthetic procedures: an application of the cumulative sum method. Anesth Analg 2002;95:411-6.

3. Mulcaster JT, Mills J, Hung OR, MacQuarrie K, Law JA, Pytka S, et al. Laryngoscopic intubation: learning and performance. Anesthesiology 2003; 98:23-7.

4. Konrad C, Schüpfer G, Wietlisbach M, Gerber H. Learning manual skills in anesthesiology: is there a recommended number of cases for anesthetic procedures? Anesth Analg 1998;86:635-9.

5. Carbine DN, Finer NN, Knodel E, Rich W. Video recording as a means of evaluating neonatal resuscitation performance. Pediatrics 2000;106:654-8.

6. Kattwinkel J, ed. The Textbook of Neonatal Resuscitation. 4th edition. Elk Grove Village, Illinois: American Academy of Pediatrics and American Heart Association; 2000.

7. Lane B, Finer N, Rich W. Duration of intubation attempts during neonatal resuscitation. J Pediatr 2004;145:67-70.

8. Kelly MA, Finer NN. Nasotracheal intubation in the neonate: physiologic responses and effects of atropine and pancuronium. J Pediatr 1984;105:303-9.

9. Sayre MR, Sakles JC, Mistler AF, Evans JL, Kramer AT, Pancioli AM. Field trial of endotracheal intubation by basic EMTs. Ann Emerg Med 1998; 31:228-33.

10. Bradley JS, Billows GL, Olinger ML, Boha SP, Cordell WH, Nelson DR. Prehospital oral endotracheal intubation by rural basic emergency medical technicians. Ann Emerg Med 1998;32:26-32.

11. Falck AJ, Escobedo MB, Baillargeon JG, Villard LG, Gunkel JH. Proficiency of pediatric residents in performing neonatal endotracheal intubation. Pediatrics 2003;112:1242-7.