RESEARCH ARTICLE

Impact of the Revised NRP Meconium Aspiration Guidelines on Term Infant Outcomes

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ABSTRACT

OBJECTIVES: To evaluate the association of the Neonatal Resuscitation Program, Seventh Edition changes on term infants born with meconium-stained amniotic fluid (MSAF).

STUDY DESIGN: We evaluated the effect of no longer routinely intubating nonvigorous term infants born with MSAF in 14 322 infants seen by the resuscitation team from January 1, 2014 to June 30, 2017 in a large, urban, academic hospital.

RESULTS: Delivery room intubations of term infants with MSAF fell from 19% to 3% after the change in guidelines ($P = <.0001$). The rate of all other delivery room intubations also decreased by 3%. After the implementation of the Seventh Edition guidelines, 1-minute Apgar scores were significantly more likely to be >3 ($P = .009$) and significantly less likely to be <7 ($P = .011$). The need for continued respiratory support after the first day of life also decreased. Admission rates to the NICU, length of stay, and the need for respiratory support on admission were unchanged.

CONCLUSIONS: Implementation of the Neonatal Resuscitation Program, Seventh Edition recommendations against routine suctioning nonvigorous infants born with MSAF was temporally associated with an improvement in 1-minute Apgar scores and decreased the need for respiratory support after the first day of life. There was also a significant decrease in total intubations performed in the delivery room. This has long-term implications on intubation experience among frontline providers.

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With almost 4 000 000 births in the United States,[1] it is paramount to develop guidelines, algorithms, simulations, and training programs that maximize positive outcomes during the delivery of all infants. The Neonatal Resuscitation Program (NRP) has promoted and developed these goals over the course of 30 years, and in October of 2015 the NRP published a Seventh Edition.[2] In the 2015 edition, there were multiple changes in the recommendation of delivery room (DR) management of newborns, such as delayed cord clamping, use of early continuous positive airway pressure in infants with spontaneous breathing, and use of a 3-lead electrocardiogram in certain situations. However, for many practitioners, the most significant change in practice was the recommendation that routine endotracheal suctioning of nonvigorous infants born with meconium-stained amniotic fluid (MSAF) was no longer suggested.

This recommendation represented a shift from the long-standing paradigm on how nonvigorous infants with MSAF should be resuscitated at the time of delivery.[3] In early studies on the management of infants with MSAF, it was suggested that all infants with MSAF should be intubated at birth and meconium be suctioned from below the infant's vocal cords.[4–6] Several studies in the 1990s altered how this initial recommendation was viewed,[7–11] and in 1999 the guidelines were changed so that the NRP no longer supported the routine endotracheal suctioning of vigorous infants with MSAF.[12]

The question remained if there was sufficient evidence to recommend the empirical tracheal suctioning of nonvigorous infants with MSAF to reduce risk of meconium aspiration syndrome (MAS) or meconium-related morbidity or mortality. A change in practice was supported in animal[13] and human[7,11,14,15] studies. The International Liaison Committee on Resuscitation reviewed the scientific evidence[7,11,15–19] and determined that there was insufficient evidence to maintain the previous recommendation.[20] In 2015, members of the International Liaison Committee on Resuscitation recommended that there was insufficient evidence to suggest routine intubation of infants born with MSAF, which was then adopted by the NRP Steering Committee.[21,22]

On the basis of this change, we implemented the NRP recommendations and evaluated the effects on term infants admitted to our NICU. We also hypothesized that these changes would decrease DR tracheal intubations, an intervention with potential side effects.

METHODS

This study took place in a large, urban, academic medical center. The delivery hospital has ~12 000 deliveries per year and admits sick infants to a level 4 NICU. A large group of practitioners shares responsibilities at deliveries with ~13 neonatal nurse practitioners (NNPs), 25 hospitalists, and 30 neonatologists. In addition, the hospital has >30 residents per class and 9 to 10 neonatology fellows. Residents spend at least 2 to 3 months on the delivery teams during the course of their residency. The delivery team has a complex and varied consistency but has at least 1 NICU nurse, 1 NICU respiratory therapist, and 1 hospitalist or fellow. In addition, residents and NNPs attend a large portion of all deliveries.

Northwestern University maintains a data warehouse of individual patient data from which we extracted our initial retrospective data. The data warehouse is a prospective collection of information that has been entered into the medical system's electronic medical records (EMRs). All data that have been entered into the EMR is saved by the data warehouse for a variety of administrative and research purposes. Data points can be entered by multiple providers (ie, an obstetrician and a pediatric resident) and the data warehouse will save all entries.

Any data that were inconsistent or missing were evaluated by using admission and/or DR notes in the EMR.

Information was gathered on all neonates born between January 1, 2014, and June 30, 2017. The study was divided into 2 parts: preintervention phase A (January 1, 2014, to December 31, 2015) and postintervention phase B (January 1, 2016, to June 30, 2017). Planning for the change in the NRP algorithm began at the beginning of October 2015 with the goal of making the switch to the new NRP algorithm on January 1, 2016. The unit, nursing, respiratory therapy, and fellowship directors held multiple education conferences and overview meetings and disseminated information to all members of the DR teams via multiple formats.

Our affiliated children's hospital provides extracorporeal membrane oxygenation (ECMO), and no infant was transferred for MAS or received ECMO after transfer during phase A or phase B. No infant with MSAF received inhaled nitric oxide in either phase A or B.

Only term infants seen by the delivery team were included in this study, and term was defined as being >36 and 6/7 gestational weeks. The following data were collected: gestational age, birth weight, date of birth, Apgar scores, length of stay, admission location to NICU or well newborn unit, MSAF status, respiratory support, and whether DR intubation was performed. Infants were deemed to have MSAF if any provider documented MSAF as part of their DR or admission charting. There were no consistent records on how vigorous infants were at the time of delivery.

Respiratory support was described as any infant on any type of respiratory support (ie, mechanical ventilation, continuous positive airway pressure device, high-flow or nasal cannula). Our sample size (Tables 2 and 3) was not large enough to meaningfully subdivide the data into smaller data fields. "Less respiratory support" was defined as having been on respiratory support and having been weaned to room air. Respiratory symptoms were defined as any mention of abnormal respiratory symptoms in the EMR (ie, tachypnea, increased work of breathing, increased oxygen requirement, need for respiratory support, desaturation events, or hypercapnia).

Data were analyzed by using Stata version 14 (StataCorp, College Station, TX). We used χ^2 tests or Student's t test to compare the different characteristics among participants and accepted a P value of .05 as statistically significant. χ^2 tests or Student's t test was

used to compare infants in phase A versus infants in phase B.

Expedited institutional review board approval was granted from Northwestern University's Institutional Review Board before the start of the study, and data were analyzed anonymously. The institutional review board did not require informed consent from patients' families to study the data in an anonymous fashion.

RESULTS

During the study period, 41 099 infants were born at a large urban delivery hospital. The DR team was called to the delivery of 14 322 of these births. The Seventh Edition NRP guidelines were implemented on January 1, 2016. The delivery team was present at the delivery of 8329 (34.8%) infants before the implementation of the new NRP guidelines (phase A: 24 months) and 5993 (34.9%) of infants afterward (phase B: 18 months) ($P = .89$). During phase A, 4.4% of term infants had MSAF; in phase B, 3.5% of term infants had MSAF ($P = .03$). Infant characteristics of term infants with MSAF are shown on Table 1. The mortality rate for all delivered infants was 0.2% in phase A and 0.2% in phase B ($P = .79$), and no infants died secondary to MAS in either cohort.

Over the entire study period, 302 of all infants were intubated in the DR. In phase A, 19% of term infants with MSAF were intubated in the DR, whereas during phase B, 3% of infants with MSAF were intubated in the DR ($P = .0001$), as displayed in Tables 2 and 3.

After the implementation of the new NRP guidelines, 1-minute Apgar scores were significantly more likely to be >3 ($P = .009$) and significantly less likely to be <7 ($P = .011$). Five- and 10-minute Apgar scores were unchanged.

Neither the admission rate to the NICU nor the length of stay for term infants with MSAF was altered with the implementation of the NRP changes. Term infants with MSAF were admitted to the NICU 13% of the time during phase A and 13% during phase B ($P = .98$). The average length of stay for term infants with MSAF did decrease from 66.7 (SD = 56) hours to 56 (SD = 37) hours, but this change was not clinically or statistically significant ($P = .16$). There was also no change noted when comparing length of stay ≥3 days ($P = .94$).

TABLE 1 Characteristics of Term Infants With MSAF Seen by the Delivery Team

	Phase A Preintervention	Phase B Postintervention	*P* Value
Female, % (*n*)	52 (187)	52 (108)	$P = .83$
White, %	71	74	$P = .62$
African American, %	10	9	—
Asian American, %	8	10	—
Other[a], %	7	5	—
Hispanic, %	3	2	—
Birth wt in g, range	3359 (2070–4425)	3412 (2620–4433)	$P = .21$
Gestational age in wk, range	39.5 (37–41)	39.3 (37–41)	$P = .11$

IQR, interquartile range; —, not applicable.
[a] "Other" ethnicity or race reflects both families who chose not to answer the question and families who are not categorized in the other 4 classifications.

At NICU admission in phase A, 51% of term infants with MSAF had respiratory symptoms, which was similar to phase B at 52% of term infants with MSAF ($P = .94$). There was no significant change in the percentage of infants with MSAF who required respiratory support at NICU admission (43% vs 41%, $P = .88$). However, the need for continued respiratory support after the first day of life decreased (36% vs 11%, $P = .02$).

DISCUSSION

In our study, we evaluate the effects of the Seventh Edition NRP's recommendation to discontinue routine endotracheal intubation and suctioning in nonvigorous term infants with MSAF. Successful adherence to NRP recommendations can be challenging,[23] but our delivery team was successful in implementing the recommended changes. As expected, these changes had positive effects on infants but raise the concern that practitioners will lose valuable procedural experience. This loss of procedural experience may need to be recovered via simulation.

Although the decreased intubation rate in both infants with MSAF and those without MSAF is positive for infants and their families, it does significantly decrease the number of intubations that are done by all members of the DR team. This decrease in the number of intubations has the potential to impact the intubation skills of trainees, NNPs, neonatologists, and hospitalists. It is clear that without ongoing repetition, NRP knowledge is lost,[24] and significant practice and experience is required to master intubation skills.[25–27] Konrad et al[25] demonstrate that first year anesthesia residents require >50 intubations before achieving a 90% success rate for intubations. Leone et al[26] showed in a study that neonatal intubation skills improved during the course of residency and fellowship, and trainees with >20 intubations were significantly more likely to be more successful. O'Donnell et al[27] also showed that DR intubation success and duration were directly tied to the experience of the person intubating. There is a need to reexamine what skills our current group of trainees and practitioners have and if there is a need to provide additional learning opportunities to all levels of experience. Further prospective studies are needed to see how much the paradigm has shifted, if our trainees have sufficient experience

TABLE 2 Term Infants With MSAF Seen by the Delivery Team

	Phase A, $n = 364$	Phase B, $n = 208$	*P* Value
Intubated in DR, % (*n*)	19 (69)	3 (6)	$P < .001$
NICU admission rate, % (*n*)	13 (47)	13 (27)	$P = .98$

TABLE 3 Term Infants With MSAF Admitted to the NICU

	Phase A, $n = 47$	Phase B, $n = 27$	*P* Value
Respiratory symptoms on NICU admission, % (*n*)	51 (24)	52 (14)	$P = .94$
Respiratory support on NICU admission, % (*n*)	43 (20)	41 (11)	$P = .88$
Respiratory support >24 h, % (*n*)	36 (17)	11 (3)	$P = .02$
Admitted to NICU ≥3 d, % (*n*)	11 (5)	11 (3)	$P = .94$
Length of stay in h, mean (±SD)	66.7 (±56)	56.12 (±37)	$P = .16$

when graduating training, and if there is a drop off in skills among hospitalists, neonatologists, and NNPs. Evaluating how hospitalist and neonatology fellowships teach procedures to their trainees will become paramount, and discovering what type and frequency of simulation provides the most benefit will be important research to continue.

The improvement of the 1-minute Apgar score is reassuring because a significant intervention, intubation of infants with MSAF, was removed from the NRP algorithm. It has been shown in history that changes in medical management do not always generate results that are expected and beneficial. The improvement of the 1-minute Apgar may have come by simplifying the initial steps in the NRP algorithm by removing a high-skill procedure from early in the algorithm. This may have led to earlier stimulation of the infant, therefore initiating their innate respiratory drive sooner.

After implementation of the Seventh Edition NRP recommendations, we observed a small positive temporal association among the study population, with a decrease in intubation rate, improvement in 1-minute Apgar score, and reduced need for respiratory support. Equally important, there were no adverse effects noted. This is compelling evidence that the Seventh Edition NRP recommendations for management of term infants with MSAF has the potential to improve patient outcomes.

Chiruvolu et al[28] compared outcomes among nonvigorous ≥35-week infants with MSAF before and after the change in guidelines. They found an increase in NICU admission and the need for increased respiratory support among nonvigorous infants after the implementation of the guidelines. Our study differs because we have a low rate of MSAF, looked only at term infants, and did not differentiate between vigorous and nonvigorous infants. These differences in patient characteristics, practice habits, classification of MSAF, and the inclusion of only term infants with MSAF may account for some of the difference of findings.

Our study has several limitations. First, data were collected retrospectively, and as such we did not have the ability to consistently ascertain if infants were vigorous or nonvigorous at time of delivery. This limited our ability to know if there were simply less nonvigorous term infants born with MSAF during phase B of our study. The study was performed in a single center with a large white population, which may lead to altered outcomes in different populations. Our rate of MSAF is low compared with other studies, with ranges of 8.5% to 16% for term infants,[7,29,30] but close to the rate seen in large white populations.[30] Even with 41 099 infants born during our study period, we were unable to evaluate the effect of the Seventh Edition NRP changes on term infants that had significant MAS, required ECMO, and who required significant NICU care and admission. Historically, our obstetric colleagues have called the delivery team to all MSAF deliveries. We did not evaluate infants who were not seen by the delivery team and, therefore, do not know if there were infants with MSAF that we did not evaluate. After the implementation of the guidelines, the delivery team encountered almost 1% less term infants with MSAF. This may be a result of being called less frequently to MSAF deliveries by the obstetrics team. In future studies, researchers should look for changes in obstetric practice brought on by the new version of NRP.

Decreased intubation of term infants with MSAF had a positive effect on the 1-minute Apgar score and decreased the need for continued respiratory support after the first day of life. However, the large decrease in DR intubations has the potential to significantly impact the expertise of trainees and practitioners in a critical lifesaving procedure. Training programs, researchers, and hospitals should consider additional efforts to teach and maintain this vital skill set.

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