Journal of Pediatric Surgery 56 (2021) 449–453

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Neonatal Condition

NICU infants who require a feeding gastrostomy for discharge

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ARTICLE INFO

Article history:
Received 12 March 2020
Received in revised form 5 July 2020
Accepted 18 July 2020

Key words:
NICU
Preterm infants
Gastrostomy tube
Feeding problems
Prematurity

ABSTRACT

Objective: To determine population data for infants receiving a gastrostomy tube (GT) in our Neonatal Intensive Care Unit (NICU) to better understand the premature infant population at risk for GT prior to discharge.
Study design: We identified all NICU infants born 2015–2016 who received a GT and determined the birth gestational age below which GTs were placed due to oral feeding failure secondary to prematurity-related comorbidities, rather than anomalies or other reasons. Aggregate data were used to compare infants born <30 weeks (w) gestation who received a GT with those who did not.
Results: GTs were placed in 117 infants. More than half of the NICU patients who receive GTs were actually >32 weeks gestation; a cut-off of <30w was a good identifier for those who failed achieving full oral feeds due to prematurity-related problems. Infants born <30w (n = 282) not receiving GTs were discharged at a significantly lower postmenstrual age (36w) and lower weight (2.3 kg) compared with infants who received a GT (49w, 5 kg).
Conclusions: The population of premature infants born <30w gestation constitute the population of infants at risk for a GT based solely on prematurity.
Levels of Evidence: III.

One of the key factors determining discharge from a neonatal intensive care unit (NICU) is an infant's ability to feed safely and reliably to achieve adequate nutrition and growth at home. Infants who are unable to orally feed or have insufficient oral intake require longer hospitalizations after birth [1,2]. There are many reasons why infants may not be able to achieve full oral feedings, including congenital anomalies, genetic conditions, neurologic injury, respiratory insufficiency and extreme prematurity [3]. These conditions can lead to laryngeal-tracheal aspiration, poor oral-motor coordination, and fatigue with feeding attempts [4]. Infants born prematurely, specifically before 28 weeks (w) gestation, have been shown to have significant delays in initiation and progression of oral feeding [1,5]. These delays are a consequence of neurologic immaturity, poor coordination of a suck-swallow-breathe pattern, cardio-respiratory compromise and negative oral experiences subsequent to medical procedures [4,6].

For infants unable to progress from gavage feedings to full oral feedings prior to discharge, nutrition can be delivered at home through a surgically-placed gastrostomy tube (GT). A number of factors in premature infants, including earlier gestational age (GA) at birth, days of cumulative or uninterrupted mechanical ventilation, sepsis episodes, and ventriculoperitoneal shunting, have been shown to be associated with GT placement [7]. In a recent analysis of more than 4500 extremely low birth weight infants, GT placement was most strongly associated with bronchopulmonary dysplasia (BPD), followed by intraventricular hemorrhage (IVH) or periventricular leukomalacia and small for gestational age status [8].

There are currently no guidelines to determine which infants will need a GT. Early identification of infants who ultimately require a GT prior to discharge may have several benefits, including reduced number of hospital days and potential financial, physical, and emotional advantages for patients, families, and third-party payers. In addition to health care cost savings, there may also be important developmental advantages for an earlier discharge, including improved neurodevelopmental outcomes, improved bonding with family, and reduced family stress [9–11].

The purpose of this current study was to describe our NICU population receiving GTs for discharge, with a future long-term plan to develop a predictive model for GTs in this population. As the first step in developing this model, we identified all infants who underwent GT placement at our institution and evaluated the primary reason these infants required a GT in order to determine a gestational age cut-off at which

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https://doi.org/10.1016/j.jpedsurg.2020.07.018
0022-3468/

oral feeding failure was related to issues of prematurity and not secondary to other conditions, such as congenital anomalies or genetic syndromes, that already carry a high risk of oral feeding failure.

1. Methods

Institutional Review Board approval was obtained for this retrospective study. All infants who were admitted to the Medical University of South Carolina NICU between January 2015 and December 2016 and received a GT prior to discharge were identified using our institution's Perinatal Information System (PINS) database. Exclusion criteria included transfer to our hospital after 7 days of age, transfer to another hospital prior to discharge home and death prior to discharge. In general, our criteria for placing a GT were an inability to take in enough oral feeding volume to support adequate growth, or an inability to have any oral feeding attempts due to underlying conditions, such as significant respiratory disease requiring tracheostomy and mechanical ventilation, or significant laryngotracheal aspiration. We defined adequate growth as a 5-day growth velocity of >18 g/kg/day if weight <1.8 kg, >20–25 g/day if weight >1.8 kg, or growth along a weight percentile at or above the birth weight percentile [12]. Our surgeons use a weight of 2.8 kg as the lower limit for GT placement. During the study period, it was our group practice to allow infants a trial of oral feeding before consideration for a GT if otherwise able to attempt oral feeding. Criteria for oral feeding attempts were respiratory support of 0.5 l per minute nasal cannula or less and postmenstrual age (PMA) of at least 31 weeks. We employ occupational therapists and speech therapists to help guide with feeding safety and progression. Infants are not allowed to orally feed if on mechanical ventilation or continuous positive airway pressure (CPAP). Infants in our NICU who receive a tracheostomy always receive a GT for nutritional support, most often performed at the same time as the tracheostomy. It is not our group's practice to send infants home with nasogastric tube feedings due to safety concerns of improper placement, but we know it is done at other institutions.

The infants were grouped *a priori* into four categories based on GA at birth: <28w, 28–31 6/7w, 32–36 6/7w, ≥37w. A retrospective chart review was performed on a sample of infants in each gestational age group to determine the primary reason for GT placement in order to identify the gestational age below which infants received a GT for feeding issues related to prematurity as opposed to congenital anomalies or genetic conditions. After the upper limit gestational age at birth was identified (<30w), a more detailed retrospective chart review was performed on all infants <30w GA who received a GT (n = 46). Data collection was performed by accessing the electronic medical record for each infant. Collected data included GA at birth, birth weight, PMA and weight at the time of GT placement, PMA at time of discharge, patent ductus arteriosus treatment, necrotizing enterocolitis (NEC) and any associated surgical procedures, IVH, post-hemorrhagic hydrocephalus, reservoir placement, ventriculoperitoneal shunt placement, tracheostomy placement, reason for GT and PMA at which 2.8 kg weight was reached. Data was also collected on oral feeding attempts, including PMA at initiation and length of time working on oral feeding. The PINS database was used to obtain aggregate baseline data on infants <30w GA admitted to our NICU in 2015–2016 who did not receive a GT. This data included GA, birth weight, survival to discharge, weight at discharge and PMA at discharge, required to determine if developing a predictive model would be useful.

2. Results

We identified 117 infants born in 2015–2016 who were admitted to our NICU and received a GT prior to discharge from our institution. More than half of all infants who received a GT were born at >32w gestation (Fig. 1). We examined the associated conditions contributing to oral feeding failure and need for a GT in a sample of infants in each of the four GA categories. In a random sample of 14 patients per group, almost all infants born at ≥30w gestation had congenital anomalies, genetic conditions or neurologic injury that affected oral feeding ability and led to need for GT (Fig. 1). Specific conditions affecting oral feeding ability in these groups included congenital cyanotic heart disease, neurologic injury or dysfunction, tracheoesophageal fistula, VACTERL and Trisomy 21. There were only 13 infants in the 28–31 6/7w gestation groups who received a GT. We reviewed all 13 charts and found that all five infants born at 30-31w and one infant born at 29w had anomalies or genetic conditions contributing to their need for GT. The remaining seven infants were all born <30w GA and had issues related to their prematurity that subsequently led to their need for GT. None of the 14 randomly sampled infants born <28w had anomalies; their GTs were secondary to prematurity-related issues such as severe BPD or a history of NEC. Based on this truncated chart review by gestational age group, we found that most infants born <30w GA required a GT for issues related to prematurity and not secondary to congenital abnormalities. We therefore chose a GA cut-off of <30w to focus our data collection.

The second PINS database query (aggregate data collection) found there was a total of 282 infants born <30w GA in 2015 to 2016 admitted to our NICU; 241 of those survived to discharge. Approximately 19% (46 out of 241) of infants born <30w GA who survived to discharge received a GT. The characteristics and co-morbidities of these 46 infants born <30w who required a feeding GT for discharge are described in Table 1. The median PMA at discharge was 49.0w (Table 2) for the <30w GT population. These infants required significantly longer hospitalizations than infants <30w without GTs, which is not unexpected. However, the median PMA at the time of GT was 46w and the median weight at the time of GT placement was 4.3 kg. The GT procedure can be performed at our institution at weights as low as 2.8 kg (personal communication). The infants <30w with a GT reached a weight of 2.8 kg at a median of 38.9w PMA (data not shown), which is 7 weeks earlier than the median PMA at GT placement. Infants born <30w without a GT were discharged at significantly earlier PMA and lower weights. Infants born ≥30w requiring a GT in cases of congenital anomalies or other conditions had GT placement sooner after birth and at an earlier PMA (Table 2).

For infants <30w with a GT (n = 46), we investigated the length of time infants were given to work on oral feeding, as well as factors that contributed to oral feeding failure and conditions when oral feeding was contraindicated (Table 3). Only 26 (57%) had oral feeding attempts and this was often later in the NICU course due to respiratory disease and other comorbidities that prevented earlier attempts. Of these 26 infants with feeding attempts, some had additional risk factors for oral feeding failure (Table 3). The 20 infants with no oral feeding attempts prior to GT had significant respiratory disease that inhibited safe oral feeding. Fourteen of these infants required tracheostomy for severe BPD and had a GT placed at time of tracheostomy. Two infants had surgical NEC with functional short gut syndrome that caused significant delays in oral feeding attempts and they received a GT prior to any true oral feeding attempts.

Post-discharge data for infants <30w with GT, including survival and GT removal by 12 months of age (Table 4) showed that four infants died after discharge secondary to complications with their tracheostomies. At the time of chart review, almost half of the surviving infants with follow up data available had achieved full oral feeding and no longer needed a GT.

3. Discussion

While it is known that premature infants born at lower gestational ages are at higher risk for feeding difficulties, it is often hard to determine which of these infants will ultimately need a GT for reliable nutrition after discharge. Our goal was to evaluate the characteristics of our NICU population receiving GTs due to prematurity-related issues specifically to design a study to create a model that can predict in advance

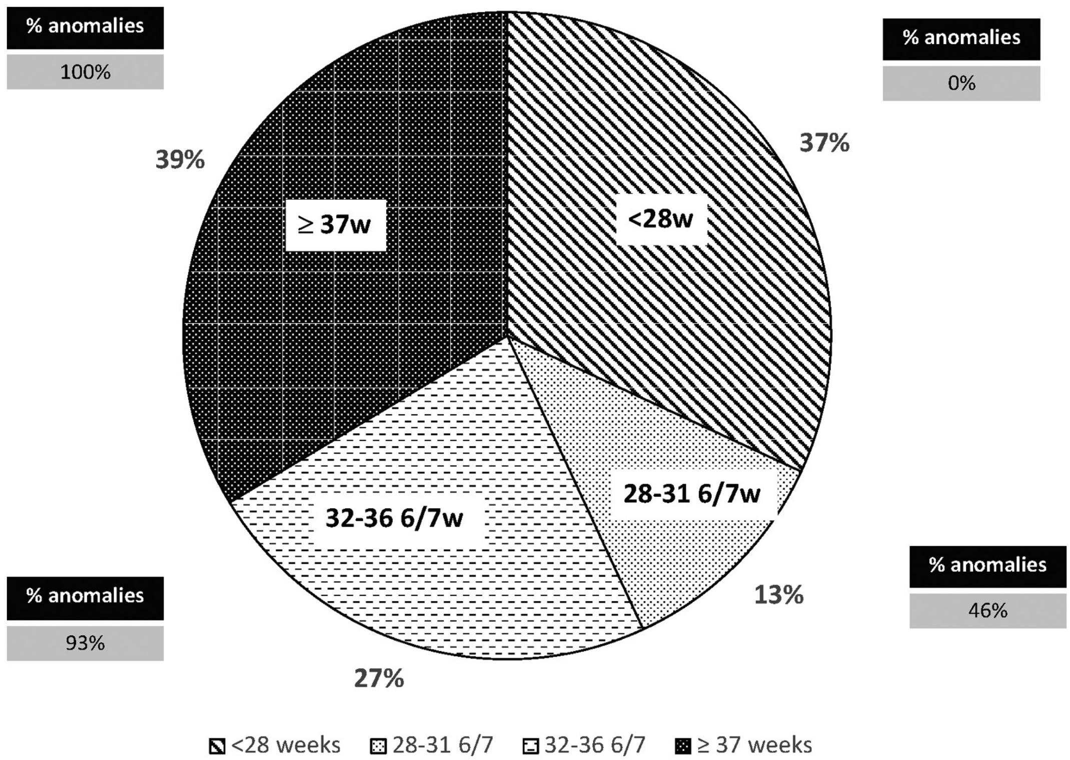

Fig. 1. Percentage of gastrostomy tubes placed in 2015 and 2016 divided by gestational age group (n = 117), and percentage of infants with congenital or genetic anomalies within each group (based on n = 14 sampled per gestational age category).

which premature infants will eventually need a GT. We first had to identify the at-risk population for whom a predictive model would be beneficial. Such a model would allow us to provide more timely guidance for placing a GT and possibly earlier discharge home.

Table 1
Characteristics of infants <30w GA with gastrostomy tube.

Infants <30w with GT (N = 46)	
Characteristic	Median (Q1, Q3)
GA at birth (weeks)	26.4 (24.4, 27.4)
Birth weight (grams)	675 (590, 938)
	n (%)
Gender	
Male	29 (63%)
Race	
White	13 (28%
Black	28 (61%)
Other	5 (11%)
Inborn	38 (83%)
Small for gestational age	13 (28%)
Twin/multiple	15 (33%)
BPD	44 (96%)
PDA treated with medication	24 (53%)
PDA ligated	14 (30%)
NEC	10 (22%)
Surgical NEC	8 (18%)
IVH (any Grade)	25 (54%)
Grade of IVH:	
Grade I	8 (32%)
Grade II	9 (36%0
Grade III	3 (12%)
Grade IV	5 (20%)
Post-hemorrhagic hydrocephalus	7 (15%)
Reservoir and/or VP shunt placement	5 (11%)
Tracheostomy	14 (30%)

w, weeks; GA, gestational ag; GT, gastrostomy tube; BPD, bronchopulmonary dysplasia; PDA, patent ductus arteriosus; NEC, necrotizing enterocolitis; IVH, intraventricular hemorrhage; VP, ventriculoperitoneal.

There is no consensus for the optimal timing of gastrostomy placement. For infants <30w GA in this study, GT placement occurred at a median age of 46w PMA and at a median weight of 4.3 kg. Our surgical colleagues prefer laparoscopic gastrostomy, which has been found to be advantageous to open or percutaneous endoscopic techniques [13,14], and can be done closer to 3 kg, particularly using mini-laparoscopic instruments. There is not a published minimum weight at which laparoscopic gastrostomy can be performed, though one retrospective study documents laparoscopic GT placement at a mean weight of 3.4 kg [13] . Our surgeons have agreed that a minimum weight for laparoscopic gastrostomy should be no less than 2.8 kg. In this study, infants <30w GA reached 2.8 kg around 39w PMA, approximately 7 weeks earlier than when the GT was actually placed. If we can identify the most important factors determining need for a GT, we can identify these high-risk infants sooner in their hospital course, allowing for timelier discussion with families, earlier GT procedure and decreased length of stay. We hope to use these data as a first step in developing a predictive model for needing a GT at discharge. An earlier discharge equates to a number of benefits including fewer hospital days, improved utilization of hospital resources, less financial burden and emotional stress on the family, and more interaction with the primary caregiver, which could lead to improved neurodevelopmental outcomes for these infants [15] . Earlier discharge has been shown *via* randomized studies to improve parental emotional well-being and quality of home life [9]. In contrast, prolonged hospitalization has been associated with poorer parent–child relationships, failure to thrive, child abuse, parental grief and feelings of inadequacy [15].

The decision to proceed with gastrostomy tube placement in a premature infant is a complex one for both physician and family. Parents, physicians, and nursing staff all enter into the decision-making process with varying biases and opinions, with many families expressing reluctance for the procedure [16]. Unfortunately, there are no consensus guidelines regarding GT placement in preterm infants and there is significant variation in GT placement across NICUs [17]. With improved survival of very low birth weight infants, the incidence of GTs has

Table 2
Characteristics of infants with and without gastrostomy tube in 2015 and 2016.

2015–2016 babies	<30w with GT (N = 46)	<30w without GT (N = 282)	≥30w with GT (N = 71)
		Median (Q1, Q3)	
Age (in days) at time of GT	139 (114, 167)	N/A	45 (28, 70)
PMA at time of GT (weeks)	46.0 (42.9, 50.1)	N/A	43.3 (40.4, 45.9)
Weight at time of GT (grams)	4333 (3458, 4957)	ND	ND
PMA at discharge (weeks)	49.0 (46.1, 58.0)*	36.3 (33.0, 38.7)	46.0 (42.4, 49.1)
Weight at discharge (grams)	5065 (4163, 6825)	2343 (1782, 2900)	3960 (3340, 4995)
PMA at 2800 g (weeks)	38.9 (38, 40.9)	ND	ND

w, weeks; GT, gastrostomy tube; PMA, postmenstrual age; N/A, not applicable; ND, not determined.
* $p < 0.05$ by Wilcoxon rank sum test, compared with infants < 30w without GT.

doubled [18]. Practice variations surrounding GT placement likely represent individual provider opinion, varying feeding protocols specific to a particular NICU, perceived safety of long term nasogastric tube feedings at home, and medical management that may change complication rates associated with prematurity including IVH, NEC and BPD [17]. Ideally, every infant would receive a chance to work on oral feeding. However, for some preterm infants with significant comorbidities including BPD, NEC and IVH, who still require high respiratory support or other critical therapies, oral feeding may not be safe due to possible aspiration, oral-motor dysfunction and risk of decompensation with feeding attempts. In addition, once a provider introduces the possible need for a GT with the infant's family, family beliefs can further complicate the decision and delay the procedure.

To our surprise, we found that over half of the GTs placed in our NICU population were in infants ≥32 w GA and were largely attributable to congenital anomalies, chromosomal abnormalities or neurologic injury associated with feeding difficulty. For these conditions, oral feeding failure and the need for a GT are usually determined early in the NICU course, facilitating earlier GT placement and reducing possible delays in discharge. A predictive model is not necessary for these infants.

This study has several limitations. Since the chart review was a single site study, the results reflect practices and clinical decision-making specific to our institution. Additionally, we did not collect data to analyze how family preference and beliefs affected the decision-making timeline to place a GT.

Table 3
Oral feeding attempts in infants <30w GA prior to gastrostomy tube.

Infants <30w with GT (N = 46)		
Number of infants with and without oral feeding attempts prior to GT		
26 (57%)		20 (43%)
Median PMA at first oral feeding attempt (weeks)	38.6w (Range 32-51w)	N/A
Number of days oral feeding attempted prior to GT	42 days (Range 3–98)	N/A
Factors that could have contributed to oral feeding failure		Reasons for no oral feeding attempts prior to GT placement:
Chromosomal anomaly and craniofacial syndrome (n = 1)		Significant BPD requiring tracheostomy (n = 14)
NEC requiring bowel resection/ileostomy (n = 6)		Significant BPD without tracheostomy (n = 1)
Significant IVH requiring VP shunt (n = 2)		BPD and subglottic stenosis (n = 1)
Congenital cardiac anomaly (n = 1)		BPD and bronchotracheomalacia (n = 1)
Cardiopulmonary resuscitation event (n = 1)		BPD and vocal cord paralysis (n = 1)
		NEC with functional short gut and feeding delays (n = 2)

w, week; GA, gestational age; GT, gastrostomy tube; PMA, postmenstrual age; N/A, not applicable; BPD, bronchopulmonary dysplasia; NEC, necrotizing enterocolitis; IVH, intraventricular hemorrhage; VP, ventriculoperitoneal.

One key factor influencing our outcomes was the feeding practice at our institution during the study period. While we use infant-driven cue-based oral feeding protocols, including feeding readiness scores, non-nutritive sucking, early oral-motor stimulation and early oral feeding initiation at 31-32w PMA, which have been shown to promote oral feeding progression [6,19–21], we typically do not offer oral feeding attempts if a patient is requiring respiratory support greater than 0.5 l per minute nasal cannula due to safety concerns of feeding on higher support. This practice may delay oral feeding in infants who are otherwise showing appropriate feeding cues. This practice is supported by studies showing that, in infants with symptomatic lung disease, feeding on nasal CPAP increases the risk of aspiration [22]. However, a pilot study of infants with BPD who were 37-42w PMA and orally fed while still receiving CPAP support showed that these infants achieved full oral feeds a median of 17 days sooner than infants who were only gavage fed while on CPAP [23]. There are no studies demonstrating safety of oral feeding in preterm infants requiring high flow nasal cannula (HFNC) support and there is conflicting opinion whether this practice is safe [24]. A recent survey of NICU practice in Australia and New Zealand revealed that most units do not routinely feed infants on CPAP, but feeding on HFNC was more common [24]. For infants with BPD, use of HFNC has been shown to have higher mortality and morbidity compared with nasal CPAP [25], so our practice is to use CPAP preferentially and limit the use of HFNC. Oral feeding in the setting of significant respiratory distress and underlying BPD can lead to increased tracheal aspiration events and dysphagia [26]. However, missed oral feeding opportunities during critical periods of brain development can have a detrimental effect on oral feeding skills [2]. More research is needed to determine the safety of feeding infants on moderate respiratory support in the setting of chronic lung disease of prematurity.

Most of our faculty do not want to commit to a GT without at least a trial of oral feeding in infants in whom it is safe to do so. In our study, the range of days of oral feeding attempts varied greatly (3–98 days) in infants born <30w who ultimately received a GT. Some of these infants were not able to start oral feeding attempts until after 40w PMA due

Table 4
Survival and ongoing need for GT at 12 months of age.

Infants <30w with GT (N = 46)	
Survival to Discharge (n)	46
Death after Discharge[1] (n)	4
GT removed by age 12 months (n = 44)[2] (n)	5 (11%)
Attained full oral feeding after discharge (n = 41)[3] (n)	19 (46%)
Median length of time GT in place before removal (n = 19)[4]	13 months (Range 4–22 months)

GT, gastrostomy tube; w, week
[1] At the time data obtained during study period. All infants were at least 12 months old. The 4 infants who died all had tracheostomies and died from complications with their tracheostomies.
[2] Two infants did not have follow-up at our institution.
[3] Post-discharge data only available for 41 surviving infants.
[4] Only infants able to attain full oral feeds by the time of data collection.

to the degree of respiratory support they required. Many premature infants reach full oral feeds between 35 to 37w PMA [1]. Infants unable to begin working on oral feeding until much later PMAs might miss important brain development milestones, significantly contributing to oral feeding failure. There may be an opportunity to determine a certain PMA and a limit for the number of days of oral feeding attempts, after which the likelihood of needing a GT far exceeds the ability for achieving full oral feeds.

Some centers discharge infants home with nasogastric tube (NGT) feedings; however, our NICU does not offer this due to the high risk of accidental removal and malposition with replacement that can lead to serious pulmonary complications [27]. Radiographic imaging is the recommend standard for verifying NGT placement, which is not available in a home setting [27]. Prolonged need for NGT feeding can also lead to oral aversion [28]. However, GTs have been shown to have higher complication rates compared with NGTs and have resulted in a higher number of tube-related emergency room visits [11,29]. A recent study demonstrated that, in a specific subset of infants who were able to take >50% of feeds by mouth prior to discharge, more than 60% were able to successfully transition to full oral feeds within 60 days after discharge, but these infant were born at later gestational ages (mean 35.7w) and more than 20% eventually needed a GT to support adequate nutrition [29]. There may be infants who could avoid surgical GT placement by use of home NGT feedings, but more studies are needed to identify this population and determine the safety of home NGT feedings.

4. Conclusion

In summary, this study describes the clinical characteristics of 117 NICU infants who underwent GT placement over a two-year period. Not surprisingly, these infants go home significantly later than infants who do not require a GT. A subset analysis identified that patients born <30w GA underwent GT placement mostly for complications of prematurity rather than congenital abnormalities, which allowed us to determine the ideal gestational age cut-off to use in the future development of a predictive model. By identifying infants most at-risk for oral feeding failure, there seems to be a significant opportunity to place GTs earlier in the hospital course and possibly result in earlier discharge to home.

Acknowledgments

Research funded by the Division of Neonatology at MUSC.

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