



The Impact of Routine Evaluation of Gastric Residual Volumes on the Time to Achieve Full Enteral Feeding in Preterm Infants

Arieh Riskin, MD, MHA, Keren Cohen, MD, Amir Kugelman, MD, Arina Toropine, MD, Waseem Said, MD, and David Bader, MD, MHA

Objective To evaluate the time to full enteral feedings in preterm infants after a practice change from routine evaluation of gastric residual volume before each feeding to selective evaluation of gastric residual volume, and to evaluate the impact of this change on the incidence of necrotizing enterocolitis (NEC).

Study design Data were collected on all gavage-fed infants born at ≤ 34 weeks gestational age (GA) for 2 years before ($n = 239$) and 2 years after the change ($n = 233$).

Results The median GA was 32.0 (IQR: 29.7-33.0) weeks before and 32.4 (30.4-33.4) weeks after the change ($P = .02$). Compared with historic controls, infants with selective evaluations of gastric residual volumes weaned from parenteral nutrition 1 day earlier ($P < .001$) and achieved full enteral feedings (150 cc/kg/day) 1 day earlier ($P = .002$). The time to full oral feedings and lengths of stay were similar. The rate of NEC (stage ≥ 2) was 1.7% in the selective gastric residual volume evaluation group compared with 3.3% in the historic control group ($P = .4$). Multiple regression analyses showed that the strongest predictor of time to full enteral feedings was GA. Routine evaluation of gastric residual volume and increasing time on noninvasive ventilation both prolonged the attainment of full enteral feedings. Findings were consistent in the subgroup with birth weights of < 1500 g. Increased weight at discharge was most strongly associated with advancing postmenstrual age but avoidance of routine evaluations of gastric residual volume also was a significant factor.

Conclusions Avoiding routine evaluation of gastric residual volume before every feeding was associated with earlier attainment of full enteral feedings without increasing risk for NEC. (*J Pediatr* 2017;189:128-34).

In most neonatal intensive care units (NICUs), the routine standard care of preterm infants includes assessment of the volume and color of gastric residuals before each enteral gavage feeding.^{1,2} Preterm, especially very low birth weight (VLBW) (< 1500 g), infants frequently experience signs and symptoms, such as gastric residuals, that are related to gastrointestinal (GI) immaturity and reduced gut motility. These are usually interpreted as feeding intolerance, although these findings may be physiological.³ Although still not strongly substantiated in the literature,⁴ the early initiation and advancement of enteral feeding has been associated with more rapid maturation of the GI system, less feeding intolerance, and better neurodevelopmental outcomes^{5,6} in preterm infants, including VLBW infants. These findings as well as a decreased incidence of necrotizing enterocolitis (NEC)⁷ have led to the widely accepted recommendation for each NICU to institute and optimize local guidelines for early initiation and advancement of enteral nutrition.⁸ Recent studies question the reliability of gastric residual volumes as markers of feeding intolerance or NEC^{1,9-14} in the absence of other suspicious clinical signs, and suggest abandoning routine gastric residual volume evaluation, although this practice is still widespread.¹³

We reviewed the outcomes of preterm infants in our NICU after discontinuation of routine evaluation of gastric residual volumes before every feeding compared with a historic control group. When routine evaluation of gastric residual volumes was discontinued, we concomitantly implemented guidelines for the early detection of morbidity and NEC based on high clinical alertness to other suspicious signs and symptoms. Our hypothesis was that this change in practice was safe and could decrease time to full enteral feeding.

GA	Gestational age
GI	Gastrointestinal
LOS	Length of stay
NEC	Necrotizing enterocolitis
NICUs	Neonatal intensive care units
NIMV	Noninvasive mechanical ventilation
NPO	Nothing per os (no enteral feeding)
PN	Parenteral nutrition
PO	Per os (orally)
VLBW	Very low birth weight

From the Department of Neonatology, Bnai Zion Medical Center, Rappaport Faculty of Medicine, Technion, Israel Institute of Technology, Haifa, Israel

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Methods

This was a single center retrospective study conducted in the neonatology department of Bnai Zion Medical Center. Infants were included if they were born at ≤ 34 weeks of gestation and initially were fed by orogastric tube. Data were collected from the medical records for 2 years before and after a practice change in July 2011: routine evaluations of gastric residual volumes before every feeding were discontinued and infants were selectively evaluated for gastric residual volumes only if there were abdominal symptoms suggestive of NEC or feeding intolerance. If any of the following conditions occurred, the guidelines stated that gastric residual volume should be checked and immediately reported to the physician in charge: abdominal distention, vomiting or large regurgitation, green or bilious regurgitation or vomiting of any quantity, restlessness, somnolence or apathy, increased number of apneas and bradycardias, or other changes in vital signs.

Included infants were born at ≤ 34 weeks of gestation and divided into 2 groups based on the date of admission to our NICU: The historic control group consisted of infants born between July 1, 2009 and June 30, 2011 who had routine evaluation of gastric residual volume before each feeding. The study group consisted of infants admitted between July 1, 2011 and June 30, 2013 who had selective evaluation of gastric residual volumes based on the NICU guidelines. Infants were excluded if they were critically ill and died before any gavage feedings were given, or if they had congenital anomalies (especially in the GI tract) that could be associated with delayed enteral feedings. The study was approved by the hospital's ethics committee. All infants were identified using the hospital's medical records manager system (v 5.66.4; Max Software Ltd, Haifa, Israel), and their full medical records were retrieved from archives. Data collected included gestational age (GA), birth weight, sex, Apgar scores, and morbidities during the NICU course, including late onset infections and number of days on antibiotics. Data on GI and enteral feeding maturation included parenteral nutrition (PN) days, age at initiation of enteral gavage feedings, the total number of no enteral feeding (NPO) days, the number of NPO episodes (ie, the number of times enteral feeds were discontinued), the time to full enteral feeds (the number of days needed to attain enteral feedings of 150 mL/kg/d, counted from the first day feedings were introduced), the time to full nipple (per os or orally, [PO]) feeds, the length of stay (LOS), and GI morbidities, specifically NEC graded following Bell criteria^{15,16} and the treatment given.

The primary outcome measure was time to full enteral feeds. Secondary outcome measures included incidence of NEC, number of NPO and PN days, age at full PO feeds, LOS, and weight at discharge.

Data were statistically analyzed using SigmaPlot v 11.0 (Systat Software Inc, San Jose, California) and Minitab v 16.2.2 (Minitab Inc, State College, Pennsylvania and Coventry, United Kingdom). Statistical analysis included descriptive statistics, Mann-Whitney rank sum test for comparison of groups with nonparametric distributions, and χ^2 test for comparisons of

categorical variables. Data was presented as median (IQR), and *P* values of $<.05$ were considered statistically significant. Significantly different variables between the 2 study groups were entered into multiple forward stepwise regression models. These multivariable models were also tested on the subgroup of VLBW infants.

Results

The study group (selective evaluations of gastric residual volume) included 233 infants compared with 239 infants in the historic (routine evaluations of gastric residual volume) control group. The mean GA in the study group (selective evaluations of gastric residual volume) was slightly but significantly older than that of the historic control group (Table I). There were no significant differences in birth weight, demographic data, or morbidities between the groups (Table I). Infants in the control group with routinely evaluated gastric residual volumes were supported longer by noninvasive mechanical ventilation (NIMV). The age at the introduction of the first feeding was younger in the selective gastric residual volume evaluation group (Table I). Infants in the selective gastric residual volume evaluation group reached full (150 mL/kg/day) enteral nutrition at younger ages (Table II). The time to full enteral feeds was significantly shorter in the selective gastric residual volume evaluation group (Table II). Time to full PO feeding and LOS were not different. The rates of NEC and Bell stage ≥ 2 NEC were lower in the second period, but the differences were not statistically significant (Table II). Subgroup analysis of VLBW infants showed that the findings were consistent in this group of more premature infants. Median time to full enteral feeds (IQR) was 12 (9.0-16.0) days in VLBW infants with selective gastric residual volume evaluations, significantly shorter than the 13 (10.5-19.0) days needed for the VLBW infants with routine gastric residual volume evaluations ($P = .037$).

Multiple stepwise forward linear regression models showed that although GA was the most significant predictor of the age at which full enteral feeding was attained, avoiding routine gastric residual volume evaluations also contributed to earlier attainment of full enteral gavage feeding (Tables III and IV). Longer time on NIMV also prolonged time to full enteral feeds (Tables III and IV). To evaluate whether the differences in weight at discharge could be attributed to the effects of selective vs routine gastric residual volume evaluations or if they were related primarily to differences in postmenstrual age at discharge (Table II), a multiple regression model included all the significant variables outlined above as well as neonatal morbidities that may affect weight gain at discharge. The model explained 64% of the variance in weight at discharge ($P < .001$). The most significant variable contributing to weight gain was older postmenstrual age at discharge (delta R-square 56.4%, $P < .001$), but avoiding routine gastric residual volume evaluation also contributed to weight gain at discharge (delta R-square 2.6%, $P < .001$). Other significant factors were fewer PN days, younger age at attainment of full PO feeds, feeding

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