Validation of Test Weighing Protocol to Estimate Enteral Feeding Volumes in Preterm Infants

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Objective To evaluate the accuracy of pre- and postfeeding weights to estimate enteral feeding volumes in preterm infants.

Study design Single-center prospective cohort study of infants 28-36 weeks' corrected age receiving gavage feedings. For each test weight, 3 pre- and 3 postgavage feeding weights were obtained by study personnel, blinded to feeding volume, via a specific protocol. The correlation between test weight difference and actual volume ingested was assessed by the use of summary statistics, Spearman rho, and graphical analyses. The relationship between categorical predictive variables and a predefined acceptable difference (±5 mL) was assessed with the χ^2 or Fisher exact test.

Results A total of 101 test weights were performed in 68 infants. Estimated and actual feeding volumes were highly correlated (r = 0.94, $P < .001$), with a mean absolute difference of 2.95 mL (SD: 2.70; range: 0, 12.3 mL; 5th, 95th percentile: 0, 9.3); 85% of test weights were within ±5 mL of actual feeding volume and did not vary significantly by corrected age, feeding tube or respiratory support type, feeding duration or volume, formula vs breast milk, or caloric density. With adherence to study protocol, 89% of test weights (66/74) were within ±5 mL of actual volume, compared with 71% (19/27, $P = .04$) when concerns about protocol adherence were noted (eg, difficulty securing oxygen tubing).

Conclusions Via the use of a standard protocol, feeding volumes can be estimated accurately by pre- and postfeeding weights. Test weighing could be a valuable tool to support direct breastfeeding in the neonatal intensive care unit. *(J Pediatr 2016;178:108-12).*

Test weighing, the practice of weighing a baby before and after feeding to estimate feeding volume, is a clinically accessible and noninvasive method for quantifying milk intake in breastfed infants. As a result of its positive correlation with successful breastfeeding,[1-3] test weighing is used by many medical providers[2,4,5] and is endorsed by the World Health Organization for term newborns.[6,7]

There are disparities in breastfeeding rates for preterm infants compared with term infants.[8-10] Test weighing has the potential to increase direct breastfeeding in the neonatal intensive care unit (NICU)[2] and to help maintain a mother's milk supply.[5,9,11,12] A few small studies support the use of test weighing in the NICU[2,13,14]; however, adoption of this technique have been limited by concerns about accuracy in preterm infants.[15] The aim of this study was to determine whether test weighing via the use of a standard protocol[16] could accurately estimate feeding volumes in a cohort of preterm infants. We hypothesized that test weighing with a standard protocol can accurately estimate feeding volume in preterm infants.

Methods

This was a prospective cohort study of infants admitted to the level III NICU at the University of New Mexico (UNM) Children's Hospital between October 1, 2014, and October 8, 2015. The study protocol was approved by the UNM Health Sciences Center Human Research Protections Office, and written informed consent was obtained from parents before participation.

Infants between 28 and 36 weeks' corrected age (CA) were included in this study if they were receiving only oro- or nasogastric tube feedings. Infants were excluded if they were intubated, hemodynamically unstable, required intravenous fluids, or had a congenital anomaly that would prevent swaddling. Three CA groups were defined: 28-31$^{6/7}$ weeks; 32-33$^{6/7}$ weeks; and 34-35$^{6/7}$ weeks CA. Each infant could be included once in each CA group.

CA	Corrected age
NICU	Neonatal intensive care unit
UNM	University of New Mexico

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All weights were obtained with a single electronic scale (BabyWeigh II, Medela, Inc, McHenry, Illinois), based on previously published reports of improved accuracy and ease of use.[14,16,17] Before study initiation, the scale was calibrated by the clinical engineering department at UNM.

All weights were obtained by 1 of 3 research nurses who were blinded to the feeding volume for the infants. Before study initiation, all research nurses reviewed the published Hasse protocol and watched the attached video.[16] The principal investigator performed quality control observations of the research nurses at study initiation to ensure that the Hasse protocol was followed consistently.

Three consecutive weights were obtained and recorded within 30 minutes before beginning the feeding and again within 30 minutes of completing the feeding. To maintain blinding, the research nurse did not remain at the infant's bedside during the feeding. For each weight, monitor wires were disconnected from the monitor. The infant was diapered and swaddled in a receiving blanket, with the wires inside. Oxygen tubing (if present) was secured by the research nurse**.** The infant's diaper and clothing were not changed between the pre- and postweights. Weights were recorded by the research nurse on an index card, which was then placed in a sealed opaque envelope. A "comment" box was included on each index card to allow the research nurse to mention any concerns encountered in obtaining the weights, including unforeseen variables or concerns that could affect the measurement.

On a separate index card, the bedside nurse recorded the volume of milk administered in milliliters, the type of milk (formula vs human milk), caloric density (calories/ounce), route (orogastric or nasogastric tube), infusion time (minutes), and respiratory support (none, nasal cannula, high-flow nasal cannula, nasal continuous positive airway pressure, or noninvasive mechanical ventilation). A "comment" box also was included on this index card, to allow the bedside nurse to mention any concerns encountered in patient care during the feeding. This index card was placed in a separate sealed opaque envelope. Bedside nurses were blinded to the results of the pre- and postweights.

It was decided a priori to analyze data after the enrollment of 18 participants, to evaluate 2 methods of obtaining weights. Eight of the first 18 infants were weighed with monitor wires taped to the scale, and 10 were weighed with the monitor wires disconnected from the monitor and swaddled with the infant. When the first method was used, average difference was 6 mL, compared with 2 mL when the second method was used. Therefore, the remainder of the study was conducted with monitor wires disconnected and swaddled with the infant during weighing. Data from the 8 infants whose test weights were obtained with wires taped to the scale are not included in this analysis.

Statistical Analyses

We chose ±5 mL as a clinically acceptable difference between estimated and actual intake.[14] Test weight accuracy was assessed by determining the difference between test weight results (estimated volume, g) and actual volume (mL) based on a 1:1 relationship between weight change (g) and volume ingested (mL).[18] The mean, SD, and range of the absolute difference between estimated and actual volumes (mL), the percentage of estimates >5 mL from actual volume (%), and the mean percent error were used to determine the width of the frequency distribution between test weight and actual volume.

A sample size of 97 paired pre- and post-test weight measurements was required to detect a 5-g difference between the administered feeding volume and the test weight,[14] assuming a 15-g SD for repeated test weight measurements, 90% power, and an α of 0.05.[19] Sample size estimates and power calculations were on the basis of previous studies.[15,16] Stata SE 14 (StataCorp, College Station, Texas) was used for all statistical analyses.

Summary statistics were calculated for demographic variables and the absolute difference between the measured test weight and the actual volume delivered. Bland-Altman plots, correlation graphs, and Spearman correlation coefficients were generated to assess the correlation between test weights and actual volume.[20] The relationships between the categorical variable indicating acceptable difference (±5 g) and categorical variables indicating CA groups, respiratory support, formula vs breast milk, caloric density, route (oro- or nasogastric tube), feeding duration, feeding volume, research nurse, or protocol concerns (yes or no as indicated in "comments" on research nurse or bedside nurse index card) were assessed by use of the χ^2 test or Fisher exact test, as appropriate. In addition, percent of error was calculated as described in Meier et al, by "dividing the absolute difference between the actual and estimated volumes of intake by the actual volume of intake." The mean and range of the percent of error and the percentage of values with ≤10% error were reported.[14] One-way ANOVA was used to compare mean percent of error between CA groups, and a *t* test was used to compare mean percent of error between protocol concern categories (yes/no).

Results

Pre- and post-test weights were obtained on 101 occasions in 68 babies. Patient characteristics are shown in **Table I**. The mean actual feeding volume was 36.4 mL (SD: 9.2; range: 17, 62; 5th, 95th percentile: 21, 49) and the mean estimated volume was 34.9 mL (SD: 9.7; range: 8.7, 60.7; 5th, 95th percentile: 19.3, 53.3). Estimated and actual feeding volumes were highly correlated ($r = 0.94$, $P < .001$; **Figure 1**). The mean difference between estimated and actual volume was −1.47 mL (SD: 3.72; range: −10.7, 12.3; 5th, 95th percentile: −6.7, 4.3; **Figure 2**), and the mean absolute difference was 2.95 mL (SD: 2.70; range: 0, 12.3; 5th, 95th percentile: 0, 9.3).

Eighty-five percent of the test weights fell within ±5 mL of the actual volume. The percent of test weights within ±5 mL did not vary significantly by research nurse, CA group, use of orogastric vs nasogastric tube, type of respiratory support, feeding duration or volume, use of formula vs expressed breast milk, or higher calorie vs lower calorie feeds. Test weight estimates were more prone to error when a protocol concern was noted by either the research nurse or the bedside nurse