Postoperative Surveillance and Detection of Postprandial Hypoglycemia after Fundoplasty in Children

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Objective To evaluate the prevalence of postprandial hypoglycemia (PPH) after fundoplasty after the initiation of a universal postoperative glucose surveillance plan in the neonatal intensive care unit (NICU).

Study design This was a retrospective chart review of children (newborn to 18 years) who underwent fundoplasty at The Children's Hospital of Philadelphia during the 2-year-period after the launch of a surveillance protocol in the NICU and other units. The rate of screening, frequency of PPH (postprandial blood glucose <60 mg/dL [3.3 mmol/L] on 2 occasions), frequency of postprandial hyperglycemia preceding PPH, timing of PPH presentation, and related symptoms were evaluated.

Results A total of 285 children were included (n = 64 in the NICU; n = 221 in other units). Of the children screened in all units, 24.0% showed evidence of PPH, compared with 1.3% of unscreened children. Hyperglycemia preceded PPH in 67.7% (21/31) of all screened children. Within the NICU, most children had PPH within 1 week, but only 53.3% exhibited symptoms of dumping syndrome.

Conclusions This study supports the use of universal postoperative blood glucose surveillance in identifying PPH in children after fundoplasty. Earlier identification of PPH would lead to earlier treatment and minimize the effects of unidentified hypoglycemic events. *(J Pediatr 2011;159:597-601)*.

Dumping syndrome is a complication of fundoplasty, an operation performed to control severe gastroesophageal reflux disease (GERD). In children, dumping syndrome is characterized by severe postprandial hypoglycemia (PPH) without the significant gastrointestinal symptoms of "early dumping" present in adults.[1,2] PPH, or "late dumping," occurs 1 to 3 hours after a meal as a result of an exaggerated insulin response, triggered by early hyperglycemia and the potent insulinotropic hormone glucagon-like peptide-1 (GLP-1).[2-4]

Although described more than 20 years ago,[5,6] most clinicians remain unaware of the risk of dumping syndrome after fundoplasty. The true prevalence of dumping syndrome in children is controversial; some studies report it as an infrequent complication,[7,8] whereas others report higher estimated frequencies.[9,10] A prospective study estimated that up to 30% of children develop dumping syndrome after fundoplasty, presenting typically in the immediate postoperative period but occasionally years later.[10] However, that study screened only symptomatic patients, many of whom had significant underlying neurologic deficits that might have made symptoms less reliable. Whether the latent presentation of some cases is related to a lack of reliable symptoms, later onset of symptoms, or failure to identify PPH in the immediate postoperative period remains unclear.

Given the unreliability of symptoms, we recommend universal postoperative screening to detect PPH in all children after fundoplasty. In July 2007, we instituted a postoperative surveillance plan in The Children's Hospital of Philadelphia (CHOP) neonatal intensive care unit (NICU) that allowed monitoring of postprandial blood glucose levels in all children after fundoplasty (see Methods). Earlier identification and treatment of children with PPH should prevent complications of undiagnosed hypoglycemia, such as seizures, developmental delays, and brain damage. We hypothesized that universal surveillance in the immediate postoperative period would improve detection of PPH in children after fundoplasty.

Methods

On July 1, 2007, we introduced a postoperative surveillance plan to the CHOP NICU as standard clinical practice. In children on goal bolus feedings, postprandial blood glucose levels were measured using a bedside glucose meter (OneTouch SureStep; LifeScan, Milpitas, California) at 60, 90, and 120 minutes after feedings for a min-

CHOP	The Children's Hospital of Philadelphia
CICU	Cardiac intensive care unit
GERD	Gastroesophageal reflux disease
GLP-1	Glucagon-like peptide-1
NICU	Neonatal intensive care unit
PPH	Postprandial hypoglycemia

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imum of 72 hours, and at additional time points if symptoms suggestive of hypoglycemia were identified. A blood glucose measurement <60 mg/dL (3.3 mmol/L) was rechecked immediately with a bedside glucose meter, and if still <60 mg/dL, was confirmed via laboratory analysis of a venous sample. Blood glucose monitoring was discontinued if no level <60 mg/dL was detected within 72 hours after initiation of full feedings. Other units do not routinely perform blood glucose monitoring unless requested by the surgeon. In all cases, critical hypoglycemia (blood glucose <60 mg/dL) was initially treated with dextrose, typically by administration of 2 mL/kg of D10 solution (intravenously or enterally), followed by a recheck of blood glucose level and a change from bolus to continuous feeds.

The surgical database was queried for cases of fundoplasty among all patients admitted to CHOP between July 1, 2007 and June 30, 2009, the 2-year period since the inception of the surveillance protocol. For the purpose of the present study, "fundoplasty" refers to all surgical treatment of GERD, including laparoscopic or open Nissen, Toupet, Dor, and Thal fundoplications[11] with or without gastrostomy, but not gastrojejunostomy. A detailed retrospective chart review was undertaken for all patients (newborn to age 18 years) who had undergone fundoplasty. Demographic data and detailed information on the surgical and postoperative courses were collected from the electronic medical records and summarized by unit. To prevent overrepresentation of complex cases, cases were included only if the initial surgical date fell within the study window. Cases were excluded if the patient expired before reaching goal feedings or if a preexisting hypoglycemic condition was present.

The primary outcome was the frequency of PPH in children after fundoplasty after achieving full feedings. PPH was defined as a postprandial blood glucose level <60 mg/dL measured on 2 occasions. Secondary outcome measures included the frequency of glucose monitoring after surgery, frequency of hyperglycemia preceding PPH, time after surgery at which PPH was detected, potential symptoms of dumping syndrome, potential risk factors (eg, gestational age, age, sex, comorbid conditions), and treatment. For the purpose of this study, we categorized hyperglycemia as mild-moderate (blood glucose ≥140 to 179 mg/dL [7.8 to 9.9 mmol/L]) or severe (blood glucose ≥180 mg/dL [10 mmol/L]). Comorbid conditions were subdivided into 4 categories based on discharge diagnoses: neurodevelopmental (eg, seizure disorder), cardiac (eg, congenital heart disease), respiratory (eg, chronic lung disease), and anatomic (eg, gastroschisis).

Statistical Analyses

Data were analyzed using SPSS for Windows version 16.0.1 (SPSS Inc, Chicago, Illinois). Baseline and demographic data were summarized using standard descriptive statistics. The Kolmogorov-Smirnov test was used to assess normality of distribution. Because several variables had skewed distributions, results are presented as median and range, and nonparametric tests were performed whenever applicable. Continuous variables were compared using 2-group *t* tests or analysis of variance, or their nonparametric equivalents (ie, Mann-Whitney or Kruskal-Wallis test). The χ^2 or Fisher exact test was used to examine associations between PPH and categorical variables. Statistical significance was defined as a *P* value <.05.

This study was approved by CHOP's Institutional Review Board.

Results

Between July 1, 2007 and June 30, 2009, a total of 300 children (newborn to age 18 years) underwent fundoplasty in all hospital units at CHOP. Of these, 285 cases were included in our analysis. Fifteen cases were excluded, due to death before reaching full feedings (n = 10) or repeat surgeries (n = 5) (**Figure 1**; available at www.jpeds.com).

Demographic and clinical data are summarized in the **Table**. Overall, 45.9% of the subjects were premature (<37 weeks gestational age), with 23.9% extremely premature (<32 weeks gestational age). Overall, 42.1% of the subjects had multiple comorbidities, with neurodevelopmental (53.7%) and respiratory (46.7%) conditions most commonly found. The majority of fundoplasties (71.6%) were performed laparoscopically.

Within the NICU, 71.9% of the subjects were premature, with 43.8% extremely premature. Most of these children had comorbid respiratory conditions (67.2%), with 48.4% having more than one comorbid condition. The majority of fundoplasties were performed laparoscopically (79.7%).

Within the cardiac intensive care unit (CICU), a unit devoted to the care of children with severe congenital heart disease, only 28.2% of the subjects were premature, with 9.4% extremely premature. These children had a similar rate of multiple comorbidities (44.7%), but a much higher

Table. Clinical and demographic data for children after fundoplasty

Locations	n	Age, months, median (range)	Male/female	Gestational age, weeks			Multiple comorbidities (≥2)	Surgical type, open/laparascopy
				<32	32–36	≥37		
NICU	64	3 (1-10)	35 (54.7%)/29 (45.3%)	28 (43.8%)	18 (28.1%)	18 (28.1%)	31 (48.4%)	13 (20.3%)/51 (79.7%)
Other units: CICU	38	3.5 (1-69)	22 (57.9%)/16 (42.1%)	3 (9.4%)*	6 (18.8%)	23 (71.9%)	17 (44.7%)	27 (71.1%)/11 (28.9%)
PICU/Surgery/ miscellaneous	183	15 (1-271)	100 (54.6%)/83 (45.4%)	31 (19.0%)*	33 (20.2%)	99 (60.7%)	72 (39.3%)	41 (22.4%)/142 (77.6%)
Totals	285	6 (1-271)	157 (55.1%)/128 (44.9%)	62* (23.9%)	57 (22.0%)	140 (54.1%)	120 (42.1%)	81 (28.4%)/204 (71.6%)

PICU, pediatric intensive care unit.
*26 unknown: (6 in CICU, 9 in PICU, 8 in Surgery, and 3 in miscellaneous units).