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Delayed repeat enemas are safe and cost-effective in the management of pediatric intussusception☆,☆☆,★,★★

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ABSTRACT

Background/purpose: The purpose of the study is to compare outcomes between delayed repeat enema (DRE) and immediate surgery (IS) in children with ileocolic intussusception who fail initial enema reduction.
Methods: Retrospective cohort study of children <6 years-of-age from 2008 to 2012 in the Pediatric Health Information System (PHIS) database. Outcomes measured were bowel resection, length of stay (LOS), and adjusted hospital costs (AHC).
Results: 4980 of 6889 (72.3%) children with intussusception were discharged without operation following a single successful enema. 1407 of 1909 (73.7%) remaining patients underwent IS while 502 (26.3%) had a DRE. Bowel resection was required in 372 of 1407 (26.4%) patients in IS group compared to 59 of 502 (11.8%) in the DRE group ($p < 0.001$). The number of patients needed to treat by DRE to prevent a bowel resection was 7. In multivariable analysis, the IS patients had a 2.5 times greater likelihood of undergoing bowel resection than the DRE patients (adjusted odds ratio [OR] 2.50, 95% confidence interval [CI] 1.83–3.41, $p < 0.001$). The DRE group had a mean LOS of 3.2 days (95% CI 2.9–3.6) and mean AHC of $9205 (95% CI $7673–$10,735). The IS group had a longer LOS (4.4 days, 95% CI 4.0–4.8, $p \leq 0.001$) and higher AHC ($14,422, 95% CI $12,631–$16,214, $p < 0.001$).
Conclusion: Delayed repeat enemas for ileocolic intussusception increase the success of nonoperative reduction, decrease the rate of bowel resection and reduce mean hospital length of stay and costs.

Ileocolic intussusception is the most common cause of intestinal obstruction in infants and young children. In the year 2009, an estimated 3400 children were hospitalized in the United States for this condition, resulting in aggregate hospital costs of more than 21 million dollars [1]. Fortunately, intussusceptions are successfully reduced by hydrostatic or pneumatic enema in the majority (74–79%) of children [2–4]. In children presenting without peritonitis, an initial attempt at enema reduction is accepted as standard practice. Options for those with persistent intussusception after the initial enema attempt include immediate surgery or delayed repeat enema (DRE). Published data on DRE are limited and the safety and efficacy of this approach are incompletely characterized. The current study employed a national database of free-standing children's hospitals over a 5-year period to examine nearly 2000 children under the age of 6 years who failed initial enema reduction for intussusception. We hypothesized that the utilization of delayed repeat enemas (DRE) would not be associated with a higher frequency of bowel resection, increased length of stay (LOS) or increased hospital costs.

1. Patients and methods

1.1. Study design and data source

This retrospective cohort study used data from the Pediatric Health Information System (PHIS), an administrative database that includes resource utilization data from 44 tertiary care pediatric hospitals in the US. Participating hospitals are freestanding children's hospitals located in 27 states and the District of Columbia. PHIS data include patient demographics, diagnoses, and procedures as well as all medication, diagnostic imaging, laboratory, and supply charges to each patient. Data are de-identified prior to inclusion; encrypted medical record numbers allow identification of individual patients across all emergency department visits and hospitalizations to the same hospital. The Children's Hospital Association (Overland Park, KS) and participating hospitals jointly assure the quality and integrity of the data as previously described [5].

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★★ Contributors' Statement Page: Timothy B. Lautz, David H. Rothstein: Drs. Lautz and Rothstein conceptualized and designed the study, performed validating chart reviews, drafted the initial manuscript, and approved the final manuscript as submitted. Cary W. Thurm: Dr. Thurm designed the database search and data procurement strategies, carried out the statistical analyses, drafted the Methods section, reviewed the manuscript, and approved the final manuscript as submitted.
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1.2. Study population and outcome variables

We reviewed all patients <6 years of age discharged from a PHIS participating hospital between 2008 and 2012 with a discharge ICD-9-CM diagnosis (560.0) of intussusception and charge code(s) corresponding to one or more reduction enemas. The study cohort was composed of those patients who had a delayed repeat enema and/or an operation for reduction or resection of the intussusception. A DRE was defined as any enema having a separate charge code (indicative of an independent radiology encounter) on the same day or next day after the initial enema. One hospital with 45 intussusception discharges was excluded owing to insufficient charge-related data.

Outcome variables included a) need for bowel resection; b) length of stay (LOS); and c) adjusted hospital costs (AHC). Patients undergoing bowel resection were identified using ICD-9-CM procedures associated with either open or laparoscopic bowel resection (open – 45.72, 45.73, 45.79, 45.62; laparoscopic – 17.32, 17.33, 17.39). LOS was defined as the date of arrival to the ED to the date of discharge. Actual charges were recorded in PHIS and adjusted by the HCFA wage/price index (published annually in the Federal Register) for the hospital location, to reduce the variability of cost of living for a particular area. These adjusted charges were then converted to AHC using Thomson Reuters ratio of costs-to-charges (RCC) methodology.

1.3. Validation of registry data

A single center chart review was performed to assess the validity of the PHIS registry data for determining utilizing of delayed reduction enemas and operative intervention, as well as for distinguishing surgery with and without resection. All 250 children who underwent hydrostatic or pneumatic enema at Ann & Robert H. Lurie Children's Hospital of Chicago (formerly Children's Memorial Hospital) during the 5-year study period were identified in PHIS and unblinded after obtaining IRB approval (#2013-15422).

1.4. Statistical analyses

Categorical variables were summarized using frequencies and percentages with 95% confidence intervals. Characteristics were compared across groups (IS versus DRE) using chi-square tests. The Cochran–Armitage test for trend was used to determine whether the rate of DRE attempts changed over the study period. A multivariable model was constructed based on bowel resection frequencies and adjusting for IS versus DRE groups, age, race/ethnicity, payer type (commercial, government or other), and year of discharge. We used generalized linear mixed effects model with hospital as a random effect to account for the presence of correlated data (within hospitals), non-constant variability (across hospitals), and binary responses. Adjusted bowel resection frequencies for each hospital and 95% confidence intervals were generated from the model. All statistical analyses were performed with SAS version 9.3 (SAS Institute Inc., Cary, NC). For the multivariable modeling, a 2-sided $p < 0.01$ was considered statistically significant to account for multiple comparisons (Bonferroni adjusted level of significance = .01). In all other cases, 2-sided p-values <0.05 were considered statistically significant.

2. Results

2.1. Patient cohort

We found 6889 patients with a diagnosis of intussusception, undergoing one (n = 6387), two (n = 458) or three (n = 44) reduction enemas, for a total of 7435 enema attempts. Of the original group, 4980 patients (72.3%) were discharged without operation following a single successful enema reduction. Among the 1909 remaining patients who form our study cohort, 1407 (73.7%) underwent immediate surgery (IS Group) while 502 (26.3%) had a delayed reduction enema (DRE group). In the DRE group, 323 (64.3%) of the 502 patients avoided surgery (Fig. 1).

Patient demographics in the IS and DRE groups are compared in Table 1. Children in the two groups were similar except in regards to age and insurance status. Those undergoing DRE tended to be younger and commercially insured.

The utilization of DRE did not vary appreciably over the 5 years of the study (Fig. 2) but varied considerably between different hospitals (Fig. 3).

2.2. Frequency of bowel resection

Bowel resection was required in 372 of 1407 (26.4%) patients in the IS group compared to 59 of 502 (11.8%) in the DRE group ($p < 0.001$). Therefore, the number of patients needed to treat with DRE to avoid one instance of bowel resection is 7. Comparing only those patients in these groups who required surgery (all 1407 patients in the IS group and 179 patients in the DRE group), the frequency of bowel resection was 26.4% in the IS group and 33.0% in the DRE group ($p = 0.07$).

2.3. Adjusted hospital costs and length of stay

Patients in the DRE group had mean LOS of 3.2 days (95% CI 2.9–3.6) and mean AHC of $9,205 (95% CI $7674–$10,735). Those in the IS group had a longer LOS (4.4 days, 95% CI 4.0–4.8, $p \leq 0.001$) and higher AHC ($14,422, 95% CI $12,631–$16,214, $p < 0.001$).

2.4. Multivariable analysis

A mixed model analysis was performed to identify independent predictors of bowel resection (Table 2). The model accounted for treatment in the IS versus DRE groups, as well as patient age, race/ethnicity, primary payer, discharge year, and hospital. The adjusted odds of bowel resection were significantly increased in patients treated in the IS group (OR 2.57, $p < 0.001$) compared to those who underwent DRE. Additionally, the adjusted odds of bowel resection were significantly reduced in patients aged two (OR 0.28, $p < 0.001$) or three (OR 0.43, $p = 0.03$) compared to a reference group age five, and in those who were non-Hispanic black (OR 0.58, $p < 0.001$) or Hispanic (OR 0.53, $p < 0.001$) compared to a reference group of non-Hispanic white children.

2.5. Validation of registry data

In the subset of patients whose charts were reviewed for validation, 52 (20.8%) required surgery, including resection in 18 (7.2%). Manual chart review demonstrated that our PHIS algorithm had 100% accuracy both for identifying patients who underwent surgery and distinguishing those who required resection from those who underwent reduction without resection.

We did, however, find that 4 patients (1.6%) did not have intussusception (incorrect diagnosis) and 2 patients (0.8%) had an incorrect enema count (1 undercounted and 1 overcounted). Most significantly, 8 of the 36 patients (22%) identified as having undergone DRE, actually had a successful initial enema reduction and subsequently developed a recurrence requiring a second enema within one day after the initial reduction. Therefore we conclude that our PHIS algorithm may be overestimating the number of successful DRE reductions by as much as 25%.

2.6. Sensitivity analysis

Based on the results of our single-center data validation, we repeated the analysis to determine whether our conclusions would change if up to 25% of successful DRE reductions were assumed to be erroneous.