

# Appropriateness of Radiology Procedures Performed in Children With Gastrointestinal Symptoms and Conditions

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**BACKGROUND & AIMS:** Exposure to ionizing radiation from diagnostic imaging procedures (DIPs) has been associated with an increased risk of cancer in children. In particular, gastrointestinal imaging has been identified as a significant factor that contributes to exposure of children to radiation during diagnostic procedures. We performed a longitudinal assessment of gastrointestinal-associated DIPs to identify practices that might be targeted to reduce exposure of pediatric patients to radiation.

**METHODS:** DIP insurance claims from 2001 through 2009 were obtained from an Independent Physicians Association in a large US metropolitan area. We retrieved and analyzed Current Procedural Terminology codes, associated International Classification of Diseases, 9th Revision, codes specific for gastrointestinal symptoms and conditions, and patient demographics associated with DIPs from insurance claims data.

**RESULTS:** Overall, 11,473 DIPs were performed on 6550 children with gastrointestinal symptoms; 1 in 30 patients received a DIP for a gastrointestinal complaint. Over the study period, the proportion of higher-radiation DIPs (computed tomography, fluoroscopy, and angiography) increased. Higher-radiation DIPs for gastrointestinal symptoms were performed more frequently in older children and in boys in the emergency department and in inpatient settings for diagnoses of abdominal pain, appendicitis, and noninfectious gastroenteritis.

**CONCLUSIONS:** Higher-radiation diagnostic imaging accounts for an increasing proportion of imaging procedures among children with gastrointestinal symptoms, even though these often are not recommended for evaluation of gastrointestinal disorders. Clinicians should be aware of these findings when ordering DIPs for gastrointestinal complaints, and clinical practice guidelines should be created to reduce diagnostic imaging-related radiation exposure in children.

*Keywords:* Diagnostic Imaging; Radiation; Pediatrics; Appropriateness.

Diagnostic imaging procedures (DIPs) can offer significant and clinically useful information to clinicians as they diagnose, monitor, and assess various symptoms and conditions. However, certain diagnostic radiology procedures, such as computed tomography (CT), fluoroscopy, and angiography, expose patients to greater ionizing radiation than others.<sup>1,2</sup> Radiation exposure related to DIPs has been found to increase lifetime cancer risk in pediatric patients.<sup>3,4</sup> In particular, recent data have indicated that the risk of radiation-induced solid cancer is highest for DIPs targeting the abdomen and pelvis.<sup>5</sup> Increased sensitivity of children to radiation exposures has been attributed to the radiation sensitivity of cells in a growing organism with less repair of mutations in rapidly dividing cells, and to the longer

life expectancy of children relative to adults, with the accompanying longer times during which the effects of radiation exposure can manifest.<sup>6,7</sup>

The Image Gently campaign organized by the Alliance for Radiation Safety in Pediatric Imaging has effectively increased radiation awareness for pediatric patients and reduced radiation exposure in children undergoing DIPs

*Abbreviations used in this paper:* CT, computed tomography; DIP, diagnostic imaging procedure; ICD-9, International Classification of Diseases, 9th revision; IPA, Independent Physicians Association; OR, odds ratio.

through successful efforts targeting the medical imaging community.<sup>8</sup> More recent efforts have been made to include literature for parents and referring physicians ([www.imagegently.org](http://www.imagegently.org)). However, much work remains to be done with regards to improving awareness of these issues among ordering clinicians<sup>9,10</sup> and in changing how clinicians order DIPs, with the goal of reducing ionizing radiation exposure to “as low as reasonably achievable”<sup>11</sup> and limiting higher-radiation studies to case-indicated DIPs.<sup>12</sup>

One approach to mitigating the risk of radiation exposure through radiologic examinations is to identify high-risk situations and develop targeted clinical interventions that provide appropriate decision support to clinicians regarding whether certain high-radiation DIPs are indicated for their patients. Previously, our group showed that gastrointestinal complaints were associated with a significantly increased risk of having DIPs with higher ionizing radiation.<sup>13</sup> Although several studies have examined the trends in radiologic examinations performed worldwide and in the United States<sup>5,14–17</sup> for all complaints, fewer studies to date have analyzed DIPs performed specifically on patients with gastrointestinal symptoms,<sup>18–21</sup> much less in a longitudinal cohort of pediatric patients. Our objective in this study was to further evaluate the longitudinal prevalence of DIPs for children with gastrointestinal complaints and to better characterize the related ordering practices of pediatric physicians according to patient demographic and clinical variables.

## Patients and Methods

We conducted an investigator-initiated, retrospective cohort study evaluating patient claims data from an Independent Physicians Association (IPA) comprising 160 pediatricians and 284 pediatric specialists linked with a tertiary-care pediatric hospital in the Greater San Diego area. After removing all personal identifiers, data were provided to the investigators for independent analysis and interpretation. The study protocol was reviewed and approved by the Institutional Review Boards at the University of California, San Diego, and at Rady Children’s Hospital. Data were collected between January 1, 2001, and December 31, 2009, and included gastrointestinal-related Current Procedural Terminology codes, associated International Classification of Diseases, 9th revision (ICD-9) codes, performance site, and basic patient demographics of all DIPs performed on patients during the specified period as recorded from patient claims data. Radiology Current Procedural Terminology codes were classified further according to the presence or absence of associated ionizing radiation. ICD-9 codes were categorized by organ or system-related diseases or symptoms, and those codes were classified as gastrointestinal symptoms or conditions were extracted for analysis. The study population included all individuals covered by the IPA from 2001 to 2009.

## Statistical Analysis

All statistical analyses were performed with STATA statistical software (version 10.0; College Station, TX). All gastrointestinal codes were examined and assembled into clinically appropriate categories for examination of associations between diagnostic categories and other demographic and clinical variables in the database. The 15 diagnostic categories included abdominal mass, abdominal pain, appendicitis, biliary tree disorders, constipation, diarrhea, dysphagia, flatulence/eructation/gas pain, gastroesophageal reflux disease, gastrointestinal hemorrhaging, inflammatory bowel disease/intestinal inflammation, intestinal obstruction, liver disorders, noninfectious gastroenteritis, and vomiting. Descriptive demographic and clinical frequencies were obtained for all radiology procedures and then specifically for high-radiation procedures, CT, fluoroscopy, and angiography examinations. Univariate logistic regression was used to test trends over time in the proportions of procedures performed during the study period. The DIP data then were stratified to obtain similar descriptive frequencies of sex, insurance coverage, procedures, diagnostic categories, and clinical sites of order across age groups. Univariate logistic analyses were performed to test associations between the performance of higher-radiation procedures, patient variables, and categories of gastrointestinal diagnoses. Finally, a saturated multivariate model was developed, using backward stepwise regression, to calculate adjusted odds ratios (ORs) and 95% confidence intervals.

## Results

A total of 11,473 DIPs were performed on 6550 children with gastrointestinal symptoms from 2001 to 2009, with 2796 higher-radiation DIPs performed on 1305 of those patients. The base study population (from whom these data were extracted) included 195,753 patients (51% male), with a mean age of 7 years (standard deviation, 6 y) at enrollment to a health care plan, and primarily covered by health maintenance organizations (87%). One in 30 patients underwent a DIP for a gastrointestinal complaint during the study period.

Demographic characteristics, all types of radiology procedures performed for gastrointestinal diagnoses, and the most frequent associated ICD-9 codes (using only the primary listed ICD-9 code) are listed in [Table 1](#). Plain film, CT, and ultrasound were the 3 most common DIPs performed, and all types of DIP were performed most often in the outpatient setting (includes both outpatient clinic and office visits). Abdominal pain (45%), constipation (11%), and appendicitis (8%) were the 3 most common gastrointestinal diagnostic categories for which DIPs were performed in this study population.

Numbers and proportions of procedures performed each year, by type of procedure, are listed in [Table 2](#).

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