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Variation in surgical management of asymptomatic umbilical hernia at freestanding children's hospitals

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ABSTRACT

Purpose: To examine hospital-level variation in the timing of asymptomatic umbilical hernia repair in children.
Methods: Retrospective analysis of children undergoing umbilical hernia repair at 38 children's hospitals using the Pediatric Health Information System database (01/2013–12/2017). Early repair was defined as surgery performed at 3 years of age or younger. Repairs were categorized as emergent/urgent if associated with diagnostic or procedural codes indicating obstruction or strangulation, or if they occurred within 2 weeks of an emergency department encounter. Multivariable regression was used to calculate hospital-level observed-to-expected (O/E) ratios for early repair adjusting for emergent/urgent repair and patient characteristics.
Results: 23,144 children were included, of which 30% underwent early repair (hospital range: 6.9%–54.3%, $p \ll 0.001$). Overall, 3.8% of all repairs were emergent/urgent, and higher rates of early repair did not correlate with higher rates of emergent/urgent repair across hospitals ($r = -0.10$). Following adjustment, hospital-level O/E ratios for early repair varied 8.9-fold (0.19–1.70, $p \ll 0.001$).
Conclusion: Timing of asymptomatic umbilical hernia repair varies widely across children's hospitals, and the magnitude of this variation cannot be explained by differences in patient characteristics or the acuity of repair. Many children may be undergoing repair of hernias that may spontaneously close with further observation.
Level of Evidence.: Level III (retrospective comparative study).

Umbilical hernia is a common surgical condition in childhood, affecting up to 23% of all newborns or approximately 800,000 children in the United States each year [1]. Management of incarcerated or strangulated hernias includes surgical repair at the time of presentation [2–4], or within 1 to 2 weeks if the incarcerated hernia can be manually reduced [5,6]. Management of asymptomatic umbilical hernias, however, remains less clear as robust, population-based longitudinal studies are lacking to establish evidence-based consensus guidelines. Although 2 years has been cited as the earliest age when surgical repair should be considered [3,7], it is widely accepted that most pediatric umbilical hernias will spontaneously close by 4 or 5 years of age [8–13]. Furthermore, complications such as incarceration are relatively uncommon events, with a reported incidence of less than 5% [8,12,14,15].

Based on the considerations above, the American College of Surgeons (ACS) and the American Pediatric Surgical Association (APSA, through the Not-a-Textbook education platform) have proposed that asymptomatic umbilical hernias can be safely observed until at least 4 or 5 years of age while awaiting spontaneous closure [2,3]. These recommendations, although not supported by strong epidemiological evidence, also align with summary statements derived from published systematic reviews and evidence-based clinical decision support tools such as UpToDate [4,13]. Although recommendations surrounding the timing of repair have evolved to become more conservative over time (i.e., longer observation periods), the variation associated with current practice nationally and across hospitals has not been well characterized. The purpose of this study was three-fold: 1) to examine hospital-level variation in the proportion of umbilical hernia repairs being performed in children 3 years of age or younger; 2) to examine hospital-level variation in rates of emergent/urgent umbilical hernia repair as a means to estimate differences in complicated disease across hospitals; and 3) to determine whether variation in rates of early umbilical hernia repair

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across hospitals is driven by differences in rates of emergent and urgent repair.

1. Material and methods

1.1. Study design and setting

This was a multicenter retrospective cohort study of children undergoing umbilical hernia repair over a 5-year period (2013–2017) at 38 children's hospitals participating in the Pediatric Health Information System (PHIS) database. The PHIS database is an administrative database managed by the Children's Hospital Association (Lenexa, Kansas) that contains detailed patient-care data from freestanding children's hospitals across the United States. The database includes demographic and payor information, primary and secondary *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* and *ICD-10-CM* diagnostic and procedural codes, and date-stamped billing data, including *Current Procedural Terminology* (*CPT*) codes, for a wide range of clinical services including diagnostic tests and therapeutic procedures. Data are screened quarterly for accuracy by participating hospitals, the Children's Hospital Association, and an independent data manager. The Institutional Review Board of Boston Children's Hospital approved this study (P00028420). Informed consent was not required owing to the deidentified nature of the patient data that were used.

1.2. Study participants

Patients 17 years of age or younger with a primary diagnosis code of any umbilical hernia (*ICD-9-CM*: 551.1, 552.1, 553.1; *ICD-10-CM*: K42.0, K42.1, K42.9) who underwent umbilical hernia repair (*ICD-9-CM* procedure code: 5349; *ICD-10-CM* procedure code: OWQFOZZ; *CPT* codes: 49580, 49,582, 49,585, 49,587) between January 1, 2013 and December 31, 2017 were identified. Patients undergoing multiple procedures, inpatients with a preoperative length of stay greater than two days, and those undergoing surgical repair of recurrent umbilical hernias were excluded. Hospitals were excluded if they had a mean annual caseload of fewer than 50 umbilical hernia repairs or were missing billing data for identifying emergency department (ED) encounters.

1.3. Exposure and outcome classification

Patients were categorized as having an early umbilical hernia repair if they underwent surgical repair at 3 years of age or younger in accordance with more contemporary recommendations that suggest delaying repair of asymptomatic umbilical hernias until at least 4–5 years of age while awaiting spontaneous closure [2–4]. Repairs were further categorized as emergent or urgent (now on referred to as a combined emergent/urgent group) if: 1) repair was associated with *ICD* diagnosis or *CPT* procedural codes indicating obstruction or strangulation (*ICD-9-CM*: 551.1, 552.1; *ICD-10-CM*: K42.0, K42.1; *CPT*: 49582, 49,587) or repair was performed during the same encounter as an ED visit (emergent repair); or 2) repair was performed within 2 weeks of an ED encounter if discharged without immediate repair (urgent repair). Delayed repairs following ED presentation were included to capture children undergoing early repair that may have been indicated on the basis of previous incarceration, but where *ICD* or *CPT* codes may have indicated an uncomplicated hernia at the time of actual repair. In this regard, urgent repairs within 2 weeks of an ED visit were included based on the reported practice of delaying repair for patients who present incarcerated but undergo successful manual reduction [5]. Sensitivity analyses were performed using 1-week and 4-week time intervals to define urgent repair (from ED presentation to repair following ED discharge) in order to account for variation in delayed repair timeframes following ED presentation between hospitals and among surgeons. This combined emergent/urgent repair definition was validated following an internal audit of 263 umbilical hernia repairs at the authors' institution. Compared to *ICD* codes alone for identifying children undergoing early repair on the basis of incarceration at the time of presentation or owing to a recent incarceration, the combined emergent/urgent definition had higher sensitivity (62.5% vs 41.7%), higher positive predictive value (88.3% vs 76.9%), higher negative predictive value (96.3% vs 94.4%), and a lower false negative rate (37.5% vs 58.3%). Specificity (98.7% vs 98.7%) and false positive rates (1.3% vs 1.3%) were equivalent.

1.4. Statistical analysis

Median age in years at the time of umbilical hernia repair was compared across hospitals using the Kruskal–Wallis test. Hospital-specific unadjusted rates of early repair were estimated with mixed-effects logistic regression models. Hospital-specific unadjusted rates of emergent/urgent repair performed in children 3 years of age or younger were estimated in a similar fashion. At the hospital level, the relationship between unadjusted rate of early repair and emergent/urgent repair was assessed using Spearman's correlation coefficient. Multivariate mixed-effects logistic regression was then used to calculate hospital-specific observed-to-expected (O/E) ratios for early repair after adjusting for emergent/urgent repair and patient characteristics (sex, race/ethnicity, presence of chronic conditions, median household income by zip code, and insurance type). Hospitals with O/E ratios and 95% confidence intervals that did not include 1.0 were considered to be statistical outliers relative to their peer group of hospitals. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC), and 2-sided P values $\ll 0.05$ were considered statistically significant.

2. Results

The final study cohort included 23,144 children from 38 freestanding children's hospitals representing 26 different states (median [interquartile range] annual case volume: 112 [76–156] per hospital) (Fig. 1). The median age (interquartile range) of the overall cohort was 5.1 (3.5–6.8) years, ranging from 3.8 (2.1–5.6) to 5.9 (5.2–7.4) years across hospitals ($p \ll 0.001$). For patients who underwent early repair at 3 years of age or younger, the median age (interquartile range) was 2.6 (1.6–3.3) years, ranging from 1.5 (1.1–2.8) to 3.2 (2.6–3.5) years across hospitals ($p \ll 0.001$). Forty-six percent of children were male, 49% were black, 53% were publicly insured, and the median (interquartile range) household income was $42,105 ($32,756–$55,918).

2.1. Overall and hospital-level rates of early umbilical hernia repair

Overall, 29.9% (6920/23,144) of all children who underwent umbilical hernia repair during the study period were 3 years of age or younger (Fig. 2). This proportion was unchanged during the five-year study period (annual range: 28.8%–31.0%, $p = 0.21$). Across hospitals, unadjusted rates of early repair ranged from 6.9% to 54.3%, reflecting a 7.9-fold variation ($p \ll 0.001$, Fig. 3). Following adjustment for emergent/urgent repair and patient characteristics, hospital O/E ratios for rates of early repair ranged from 0.19 to 1.70, reflecting an 8.9-fold variation across hospitals ($p \ll 0.001$, Fig. 4). Following adjustment, 14 of the 38 hospitals (37%) were found to have statistically higher O/E ratios relative to the aggregate benchmark established from all hospitals included in the study.

2.2. Overall and hospital-level rates of emergent/urgent repair

The overall rate of emergent/urgent repair was 3.8% (878/23,144), ranging from 1.9% to 10.0% across hospitals. Emergent repairs comprised 3.3% of all repairs, while urgent repairs within 2 weeks of an ED visit represented 0.5% of all repairs. The rate of emergent/urgent repair in children 3 years of age or younger was higher than that in children

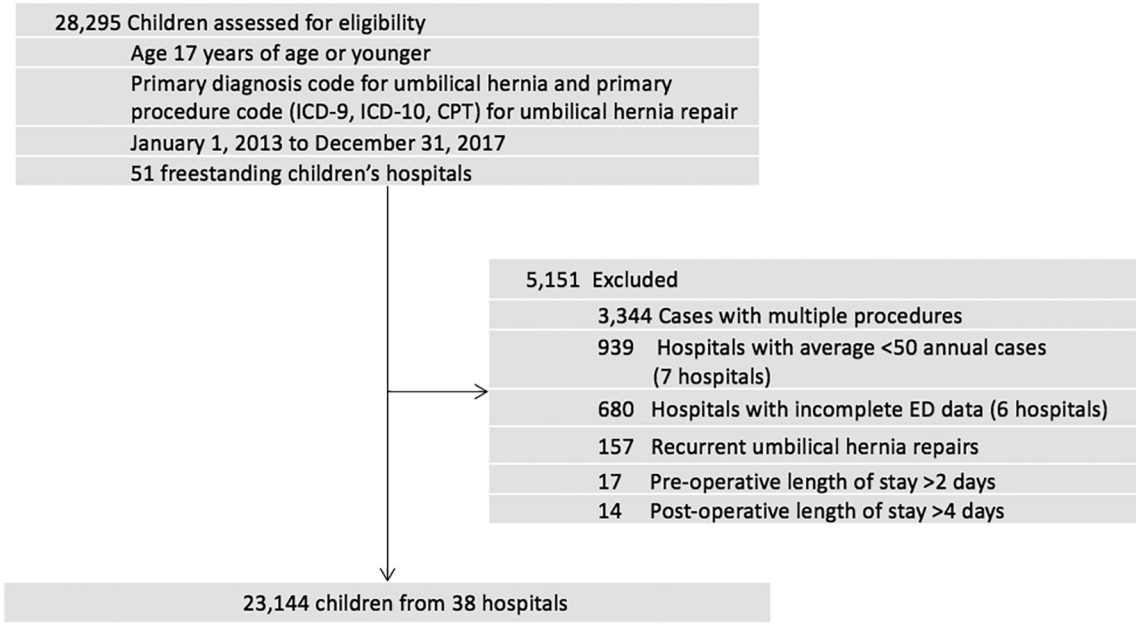

Fig. 1. "Final Study Cohort." Inclusion and exclusion criteria applied to assemble final study cohort.

4 years of age or older (5.5% vs. 3.0%, $p \ll 0.001$), and ranged from 2.2% to 23.2% across hospitals (Fig. 3). No correlation was observed between higher rates of emergent/urgent repair and higher rates of early repair at the hospital level ($r = -0.10$, $p = 0.58$). In sensitivity analysis, the overall rate of emergent/urgent repair was not significantly different when using different time intervals to define urgent repair (1-week: 3.6% vs. 4-weeks: 4.0%).

3. Discussion

In this multicenter study of 23,144 patients from 38 children's hospitals, significant variation was observed in rates of asymptomatic umbilical hernia repair performed in children 3 years of age or younger. Emergent and urgent repairs accounted for a relatively low proportion of all early repairs, and a 9-fold variation in rates of early repair was observed across hospitals after adjustment for patient characteristics and the acuity of repair. Greater than 50% of children at some hospitals were 3 years of age or younger at the time of repair.

Recommendations suggesting delayed repair of asymptomatic umbilical hernias in children until 4 or 5 years of age are based on epidemiological data suggesting that the risk of incarceration is low during the period when spontaneous closure is expected, regardless of hernia defect size [8,16–22]. Other studies have proposed even more conservative recommendations for expectant management, with some

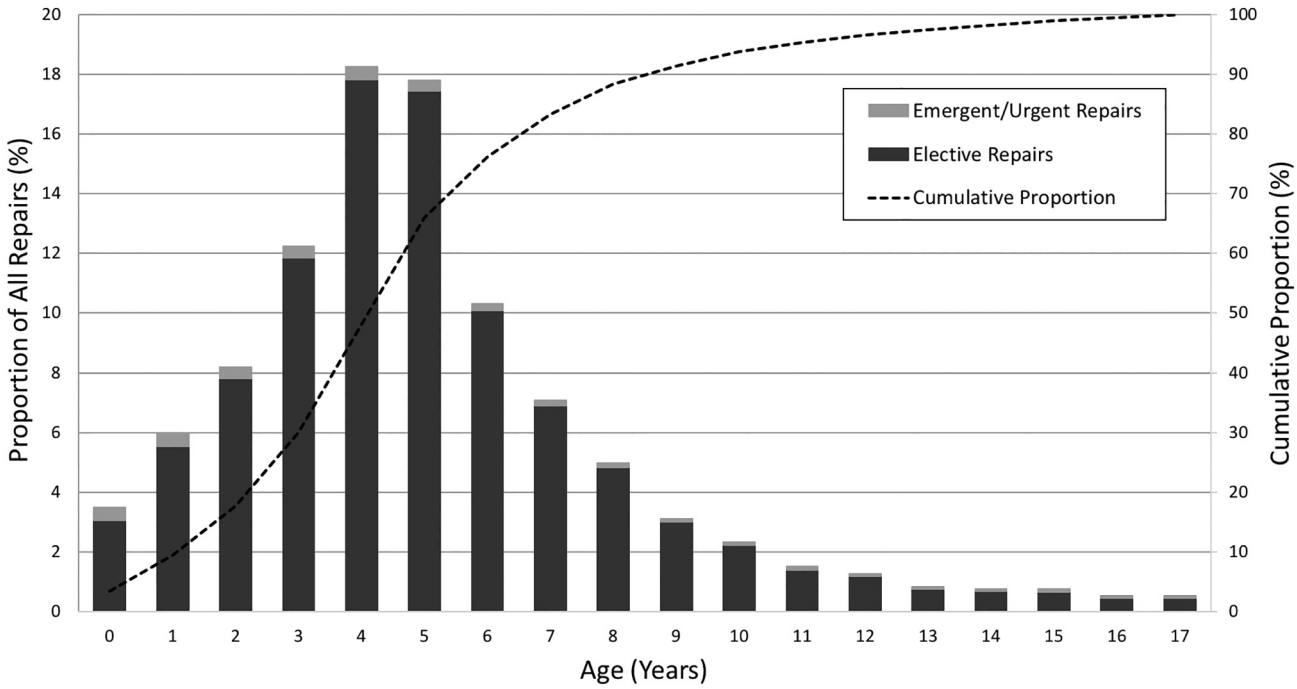

Fig. 2. "Distribution of Umbilical Hernia Repairs by Age at Repair." Influence of age on the relative distribution of all repairs performed at 38 children's hospitals from 1/2013 to 12/2017.

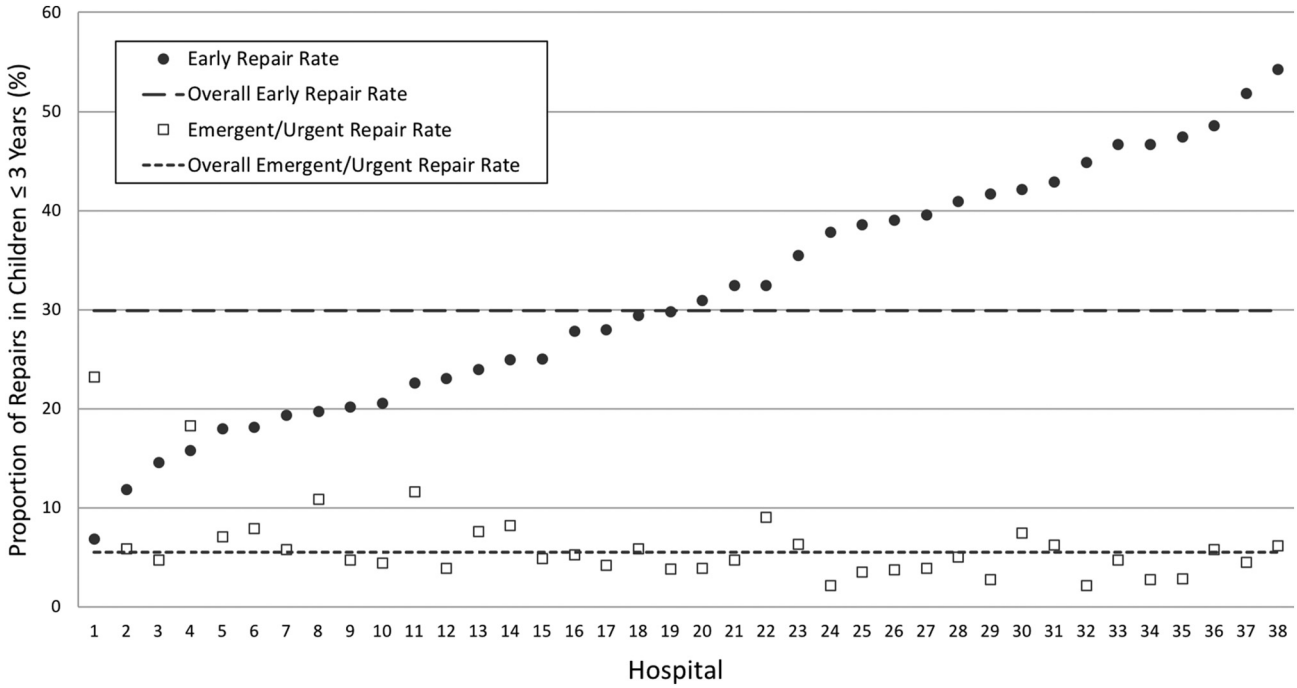

Fig. 3. "Hospital Variation in Rates of Early Umbilical Hernia Repair and Emergent/Urgent Repair." Hospital-level variation in rates of early repair performed in children 3 years of age or younger (overall and emergent/urgent) at 38 children's hospitals from 1/2013 to 12/2017.

suggesting that repair is not indicated for children with asymptomatic defects until adolescence [16,23,24]. In a prospective study of 2542 children [24], Meier et al. reported spontaneous closure of umbilical hernias in children up to 14 years of age; in a subsequent retrospective analysis, the investigators identified only 2 children presenting with incarcerated hernias over a 15-year period that required emergent repair [24]. The results of the present study are in alignment with existing data suggesting a very low risk of incarceration, with only 3.8% of all cases associated with an emergent/urgent repair. Although the present study found the relative proportion of emergent/urgent repairs in children 3 years of age or younger to be higher than those associated with older children (5.5% vs. 3.0%), it is important to emphasize that these rates reflect the proportion of emergent/urgent repairs among children who underwent surgical repair; they do not reflect the rates of emergent/urgent repair among all children with umbilical hernias. The true incidence of emergent/urgent repairs among all children with umbilical hernias is likely to be considerably lower owing to the potentially large number children with umbilical hernias that were not captured in this study (i.e., did not

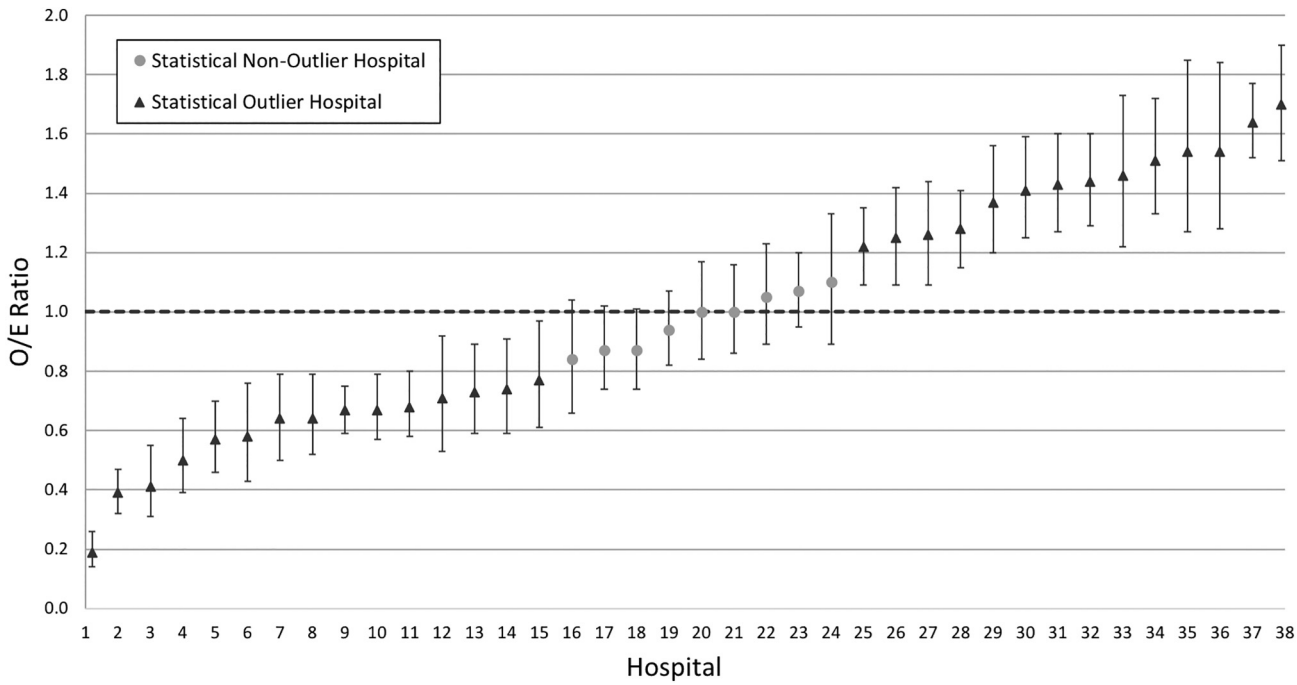

Fig. 4. "Hospital Variation in Observed-to-Expected Ratios for Early Umbilical Hernia Repair." Hospital-level variation in O/E ratios for early repairs performed in children 3 years of age or younger at 38 children's hospitals following adjustment for emergent/urgent repair and patient characteristics. High statistical outlier hospitals performed relatively higher rates of early repairs compared to the aggregate benchmark established from all hospitals included in the study.

undergo surgical repair). These include children with undiagnosed umbilical hernias and those with asymptomatic hernias being managed expectantly (nonoperatively) by primary care providers. The latter consideration is particularly relevant to the cohort of children 3 years of age or younger owing to the relatively larger proportion likely being managed expectantly compared to older children. Although some references suggest that umbilical hernia repair should be considered as early as 2 years of age, the findings of this study further support the ACS, APSA and UpToDate recommendations for longer expectant management in asymptomatic children.

The results of the present study build on previously reported data demonstrating a high rate of early umbilical hernia repair in asymptomatic children [25–27]. In a retrospective study of 6551 children undergoing umbilical hernia repair from 3 states during 2012–2014, 26.9% of all nonemergent repairs were performed in children less than 4 years of age with a 2-fold variation in rates of early repair across states [27]. The present study provides further insight into the scope of the problem using more contemporary data, a more liberal definition for complicated disease where early repair may have been indicated, and a more granular analysis of practice variation at the level of individual hospitals throughout the United States. In this regard, surgical management varied 9-fold across all hospitals and more than 3-fold across hospitals even within the same state, suggesting that practice variation at individual hospitals is more dependent on local factors rather than state-level differences in reimbursement policy.

The findings of this study are both compelling and potentially alarming with respect to the magnitude of hospital-level variation and may be explained in part by several considerations. Differences may exist among hospitals with respect to patient populations and the relative proportion of children who present with symptomatic disease. However, it is noteworthy that the rate of early repair associated with an emergent/urgent presentation in this study was only 5.5%, and no correlation was found between higher rates of emergent/urgent repair and higher rates of early repair at the hospital level. Other considerations may depend on a surgeon's knowledge and interpretation of current recommendations. Surgeons may differ in their threshold to operate based on relative indications for early repair, which include a fascial defect greater than 2 cm, enlargement of the defect over time (or failure of progressive resolution), or the presence of a proboscoid hernia [28]. Surgeons may also differ in their response to patient and parent-related factors (e.g. socioeconomic status, insurance type), or parental anxiety associated with the perceived risk of incarceration or cosmetic appearance. Surgeons may base their practice on what was learned during fellowship training, consensus practice within their hospital group, or recommendations surrounding relative indications for repair that are no longer supported by contemporary evidence. For example, surgeons might quote prior evidence that recommended repair for all females more than 2 years of age to avoid both short-term and long-term complications [29,30]. However, current recommendations no longer consider female sex an indication for early repair [2–4]. It is also important to consider that surgeons may be incentivized to optimize clinical revenue, or motivated or comply with expectations set by a referring provider that early repair should be performed. Finally, it should be noted that although recommendations have become more conservative over time with respect to longer observation periods (e.g., waiting until 4–5 years versus 2 years of age), the strength of epidemiological data in support of any specific recommendation remains poor.

The results of this study may have important public health ramifications. Many children undergoing early umbilical hernia repair at 3 years of age or younger may be undergoing procedures that would have been unnecessary with further observation [25–27,31]. This is potentially significant not only with respect to patient safety considerations (unnecessary anesthesia exposure and potential for operative morbidity), but also from the standpoint of fiscal implications for the health care system and society. Given the high prevalence of umbilical hernias in children, reducing the number of potentially unnecessary early repairs could translate into significant cost-savings for the health care system, while also eliminating out-of-pocket expenses and lost productivity on behalf of parents and caregivers.

3.1. Limitations

The findings of this study should be considered within the context of its limitations. Data contained in the PHIS database are retrospectively collected and may be subject to inherent data quality issues, including miscoding or missing data. The PHIS database does not include symptoms or other clinical data that may have influenced the surgeon's decision-making or justification to perform an early repair. Timing of umbilical hernia repair following an ED presentation was used as a surrogate for incarcerated or recently incarcerated disease, which may have resulted in the misclassification of some elective and emergent/urgent repairs. It is possible that some children may have been followed in an ambulatory surgery clinic for increasingly symptomatic hernias and subsequently undergone early, elective repairs. Similarly, other children may have undergone early repair for incarcerated hernias following presentation to ambulatory surgery clinic rather than the ED. If *ICD* or *CPT* codes for complicated disease were not assigned to these cases, such patients would be misclassified as early, uncomplicated cases in this study, therefore leading to an underestimation of the proportion of repairs performed for symptomatic or previously incarcerated hernias. However, it is unlikely that differences in these unmeasured and potentially misclassified cases could explain both the relative and absolute magnitude of variation in rates of early repair observed across hospitals. The number of children 3 years of age or younger that were managed expectantly across hospitals was not known, as only patients who underwent repair were included in this study. As a result, the true overall and hospital-level rates of early repair could not be calculated. However, when considering the significant variability in the proportions of early repairs performed across hospitals, these findings likely provide a reasonable surrogate for the true magnitude of practice variation that exists across hospitals.

4. Conclusions

The results of this study demonstrate significant variation in the rates of early umbilical hernia repair at freestanding children's hospitals, and that many children may be undergoing repair of asymptomatic hernias that may close spontaneously with further observation. Further investigation should explore the nature of this variation, including parent, surgeon, and system-level factors as the magnitude of practice variation observed is not explained by differences in patient characteristics or the acuity of repair across hospitals. Perhaps as important, the results of this study support the premise that more robust epidemiological data are sorely needed to characterize the natural history of asymptomatic umbilical hernias in children and true risk of incarceration over time. Such efforts could serve as the basis for evidence-based consensus guidelines for both primary care referral and subsequent surgical repair.

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