



## Practice Variation in Umbilical Hernia Repair Demonstrates a Need for Best Practice Guidelines

Tiffany J. Zens, MD<sup>1</sup>, Randi Cartmill, MS<sup>2</sup>, Bridget L. Muldowney, MD<sup>3</sup>, Sara Fernandes-Taylor, PhD<sup>2</sup>, Peter Nichol, MD, PhD<sup>1</sup>, and Jonathan E. Kohler, MD, MA<sup>1,2</sup>

**Objective** To evaluate and better understand variations in practice patterns, we analyzed ambulatory surgery claims data from 3 demographically diverse states to assess the relationship between age at umbilical hernia repair and patient, hospital, and geographic characteristics.

**Study design** We performed a cross-sectional descriptive study of uncomplicated hernia repairs performed as a single procedure in 2012-2014, using the State Ambulatory Surgery and Services Database for Wisconsin, New York, and Florida. Age and demographic characteristics of umbilical hernia repair patients are described.

**Results** The State Ambulatory Surgery and Services Database analysis included 6551 patients. Across 3 states, 8.2% of hernia repairs were performed in children <2 years, 18.7% in children age 2-3 years, and 73.0% in children age ≥4 years, but there was significant variability ( $P < .001$ ) in practice patterns by state. In regression analysis, race, Medicaid insurance and rural residence were predictive of early repair, with African American patients less likely to have a repair before age 2 (OR 0.62,  $P = .046$ ) and rural children (OR 1.53,  $P = .009$ ) and Medicaid patients (OR 2.01,  $P < .001$ ) more likely to do so. State of residence predicted early repair even when holding these variables constant.

**Conclusions** The age of pediatric umbilical hernia repair varies widely. As hernias may resolve over time and can be safely monitored with watchful waiting, formal guidelines are needed to support delayed repair and prevent unnecessary operations. (*J Pediatr* 2019;206:172-7).

Umbilical hernias are extremely common, with an incidence of 15%-23% in newborns.<sup>1,2</sup> Despite their prevalence, the natural history of asymptomatic umbilical hernias has not been well described. The majority of existing literature focuses on incidence and outcomes of incarcerated or gangrenous umbilical hernias, which are rare, occurring in <0.07% of umbilical hernia patients.<sup>3</sup> Spontaneous hernia closure occurs in up to 90% of cases identified in newborns<sup>4</sup> and watchful waiting does not significantly increase the risk of complications from unrepaired pediatric umbilical hernias.<sup>4-10</sup>

To our knowledge, no formal practice guidelines currently exist to define the appropriate age for repair of uncomplicated umbilical hernias in children. The few published cohort studies that address appropriate age for repair propose minimum age recommendations ranging from over 2 to 10-12 years,<sup>5,6,11-16</sup> but no increased risk of complications has been described by waiting until patients are at least 4 years old.<sup>4</sup> A review of the websites of 63 American children's hospitals that provided age-based recommendations for umbilical hernia repair found that 44% recommended repair at age 3 years or older, 29% at age 4 years or older, and 21% at age 5 years or older.<sup>4</sup> Only 6% recommended repair at age 2 years and none recommended repair at younger ages. The American College of Surgeons has released a patient education document suggesting that parents wait until age 5 years to allow for the chance of spontaneous closure.<sup>17</sup>

Although umbilical hernia repair is a comparatively minor operation involving minimal tissue disruption, the risks of any operation are relatively high for young children. Concern about the risk of neurocognitive effects of anesthesia has been growing, particularly for very young patients. An editorial described the possible effects on children of anesthetic neurotoxicity, proposing that the risks of anesthetics for the developing brain should be carefully considered before their use on children aged 2 years or younger.<sup>18</sup> Also, the Food and Drug Administration issued a 2016 statement proposing that whenever medically appropriate, surgery requiring prolonged general anesthesia or more than 1 anesthetic should be postponed in children under age 3 years.<sup>19</sup> Umbilical hernia repairs do not commonly require prolonged anesthesia; however, an additional procedure needed by a young pediatric patient after an elective hernia repair could put the child at risk of receiving multiple anesthetics. Data describing the risks of anesthesia in young children are

From the <sup>1</sup>Division of Pediatric Surgery, Department of Surgery; <sup>2</sup>Wisconsin Surgical Outcomes Research Program, Department of Surgery; and <sup>3</sup>Division of Pediatric Anesthesiology, Department of Anesthesiology, University of Wisconsin School of Medicine and Public Health, Madison, WI

Supported in part by an unrestricted grant from the Cars Curing Kids Foundation. The foundation had no role in study design; collection, analysis or interpretation of data; writing of the report; or the decision to submit the paper for publication. The authors declare no conflicts of interest.

Portions of this study were presented at the American Pediatric Surgical Association annual meeting, May 4-7, 2017, Hollywood, Florida.

0022-3476/\$ - see front matter. © 2018 Elsevier Inc. All rights reserved.

<https://doi.org/10.1016/j.jpeds.2018.10.049>

CPT Current procedural terminology  
HCUP Healthcare Cost and Utilization Project  
SASD State Ambulatory Surgery and Services Database

found in meta-analyses of human and animal studies, which show long-term effects including academic performance deficits, behavioral problems, cognitive and language delays, and learning disabilities, although these results may be confounded by patient selection bias.<sup>20-29</sup> The risks of acute surgical or anesthetic complications are also higher in young children. One study of children undergoing elective surgical procedures found that the likelihood of an adverse respiratory event declined 8% with each year of age.<sup>30</sup> Anesthesia research has also described the long-term sequelae for young children of brain hypoperfusion and intraoperative hypotension, such as encephalopathy or seizures.<sup>31-34</sup>

Thus, operative repair of umbilical hernia in young children with a high likelihood of spontaneous closure may expose patients to unnecessary anesthetic and operative risk.<sup>20-22,35</sup> Unnecessary operations may also place a burden on healthcare systems with limited resources, as well as financial pressure on parents, insurers, and society. To evaluate and better understand the variation in age of umbilical hernia repair, we used all-payer databases in 3 demographically diverse states (Florida, New York, and Wisconsin) to determine the ages at which umbilical hernia repairs are performed and assess their relationship to patient, hospital, and geographic characteristics.

## Methods

We performed a cross-sectional descriptive study using an all-payer database of 3 states (Wisconsin, New York, and Florida) over the years 2012-2014. The data source was the State Ambulatory Surgery and Services Database (SASD) of the Healthcare Cost and Utilization Project (HCUP), by the Agency for Healthcare Research and Quality.<sup>36</sup> The SASD contains de-identified patient data for ambulatory surgery and outpatient services. In the absence of a national outpatient-procedure claims database, we chose these states to represent large-population states with both urban and rural areas from geographically diverse areas of the country (Midwest, Northeast, and South). Furthermore, the data variables provided to the SASD by these specific states are comprehensive and include all payers and ambulatory surgery procedures. All analyses are in compliance with the HCUP Data Use Agreement.

We included children aged 17 years or younger who underwent an umbilical hernia repair, as defined by *International Classification of Diseases, Ninth Revision* (ICD-9) procedure codes 53.49 and 53.41 (Wisconsin) or current procedural terminology (CPT) codes 49580, 49582, 49585, and 49587 (Florida and New York). All associated procedure and CPT codes for each child's encounter date were examined. Because umbilical hernias can be repaired as a component of another procedure (such as laparoscopy) or while the patient was under a general anesthetic for other reasons, children undergoing multiple procedures on the same day were excluded. Children with complicated umbilical hernias were also excluded, specifically those with diagnosis codes of "umbilical hernia with obstruction or gangrene" (551.1, 552.1) or CPT codes "repair of umbilical hernia, incarcerated or strangulated" (49582 and 49587). After applying our exclusion criteria,

only single procedure, uncomplicated pediatric umbilical hernia repairs were included in our analysis.

Demographic data including patient age, sex, race, and rural residence were abstracted. Age was categorized into clinically relevant groups: children less than 2 years old, 2-3 years old, and 4 years old or older. To characterize any chronic conditions of children undergoing hernia repair, we used the chronic condition indicator included in the HCUP databases for the years 2012-2013, which classified the conditions by body system.<sup>37</sup> These data are excluded from the logistic regression analysis because they are not available for 2014. A variable on type of insurance was created based on the expected primary payer for the claim, specifically private insurance, Medicaid and other, which includes self-pay, Medicare, and other government programs.

Hospitals were divided into high- and low-volume centers to help identify whether practice patterns differed between surgeons who routinely perform umbilical hernia repairs in children, such as pediatric surgeons at children's hospitals, and those who perform them as part of an all-age general surgical practice. A high-volume center was defined as a hospital performing 100 or more pediatric umbilical hernia repairs in the period 2012-2014 and a low volume center as one that performed fewer.

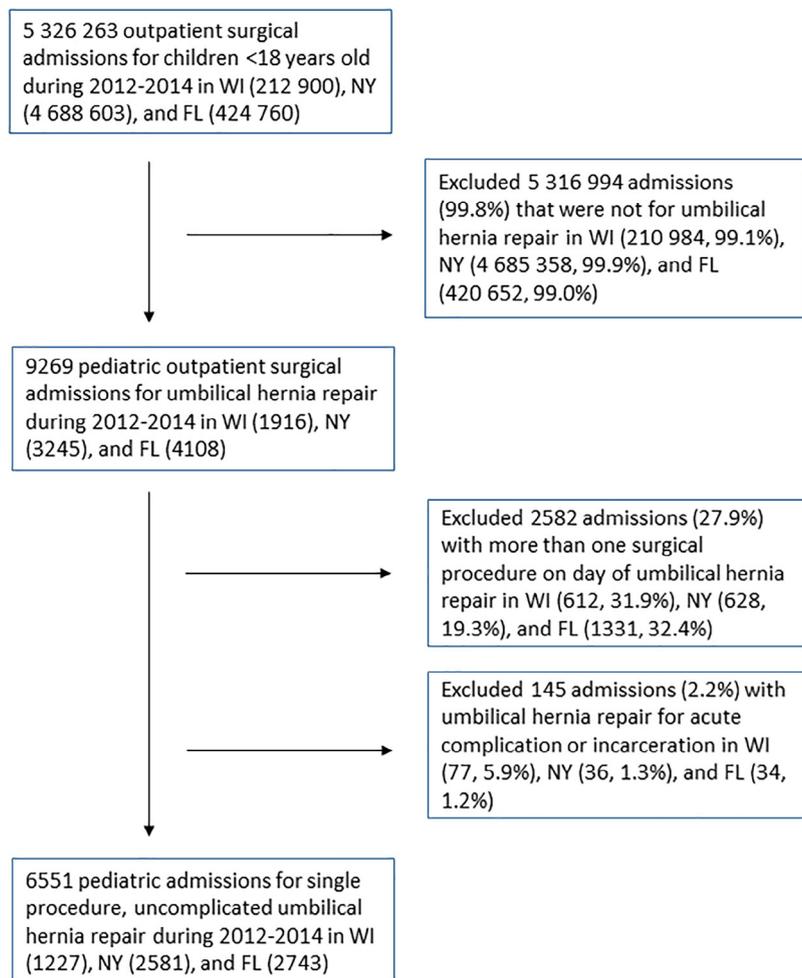
## Statistical Analyses

We conducted descriptive analyses, including Pearson  $\chi^2$  tests to identify significant relationships between age of repair and characteristics of the patient or facility. We calculated the rates of umbilical hernia repair per 1000 children using 2013 state population data by single years of age.<sup>38</sup> We also used logistic regression to examine the predictors of early umbilical hernia repair. Analysis was performed using Stata v 15 (StataCorp, College Station, Texas).<sup>39</sup> Independent variables were state (Wisconsin, Florida, and New York), year (2012, 2013, and 2014), demographic characteristics (sex, race/ethnicity, and rural residence), payer type and the hospital's volume of umbilical hernia repairs. *P* value of less than .05 was considered statistically significant.

## Results

The SASD databases for Wisconsin, Florida, and New York contained 9269 children who underwent umbilical hernia repair from 2012 to 2014. Of these, 2571 children (28%) were excluded for having multiple procedures on the day of umbilical hernia repair. An additional 147 children (2.2%) were excluded for having an umbilical hernia with incarceration or acute complication. The remaining 6551 children who underwent a single procedure, uncomplicated umbilical hernia repair were included in our analysis (**Figure 1**).

Patient age at the time of umbilical hernia repair is shown in **Table 1**. Early umbilical hernia repairs (under age 2 years) were performed in 538 cases (8.2% of pediatric repairs). The percentage of repairs performed at this young age varied significantly across the 3 states studied, from 13.9% in Wisconsin to 5.4% in New York (*P* < .001). **Figure 2** shows the rate



**Figure 1.** Study design and excluded patients, SASD (2012-2014).

of uncomplicated umbilical hernia repairs per 1000 children for each state, demonstrating that the rate of early repair is much higher in Wisconsin (with a peak at 2 years) than in New York and Florida (with peaks at 5 years). The overall rate of

pediatric uncomplicated umbilical hernia repairs in Wisconsin (0.94 repairs per 1000 children under age 18 years) was also significantly higher than the rates in Florida (0.68) and New York (0.61) ( $P < .001$  for both).

**Table I.** Age of umbilical hernia repair and chronic conditions of patients undergoing repair by age

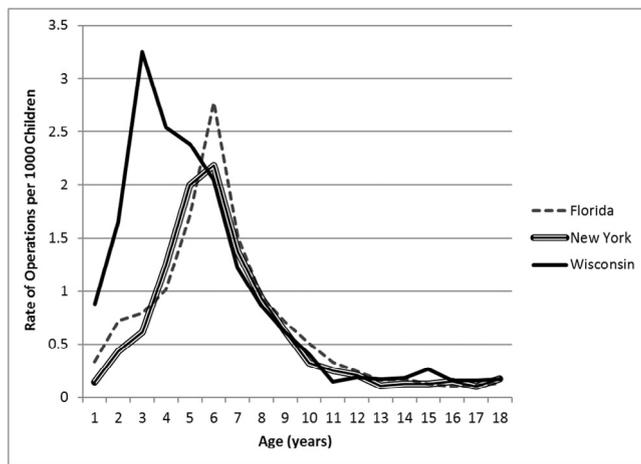
Characteristics	Total (n = 6551)	Wisconsin (n = 1227)	Florida (n = 2743)	New York (n = 2581)	P value*
Age <sup>†</sup> :					<.001
<2 y old	538 (8.2%)	171 (13.9%)	228 (8.3%)	139 (5.4%)	
2-3 y old	1227 (18.7%)	402 (32.8%)	388 (14.2%)	437 (16.9%)	
≥4 y old	4786 (73.1%)	654 (53.3%)	2127 (77.5%)	2005 (77.7%)	
Chronic conditions <sup>‡</sup> :					
Any system	1090 (24.3%)	235 (31.3%)	466 (24.0%)	389 (21.9%)	<.001
<2 y old	111 (10.2%)	32 (13.6%)	52 (11.1%)	27 (6.9%)	<.001
2-3 y old	223 (20.5%)	85 (36.2%)	79 (16.9%)	59 (15.2%)	
≥4 y old	756 (69.3%)	118 (50.2%)	335 (71.9%)	303 (77.9%)	
Respiratory	482 (10.8%)	93 (12.3%)	189 (9.7%)	200 (11.2%)	.1026
<2 y old	30 (6.2%)	—	—	—	
2-3 y old	77 (16.0%)	—	—	—	
≥4 y old	375 (77.8%)	—	—	—	

Note that cell sizes of 10 cases or fewer were excluded from table as required by the data use agreement for the HCUP state databases.

\*Pearson  $\chi^2$  tests of independence were performed. P values of  $\leq .05$  are significant.

<sup>†</sup>Age data are presented for the period 2012-2014.

<sup>‡</sup>Because of limited availability, data on chronic conditions are presented for the period 2012-2013.



**Figure 2.** Rates of uncomplicated umbilical hernia repair by age.

Chronic conditions were present in 24.3% of patients undergoing hernia repair, including 10.2% of children under age 2 years and 30.7% of children under age 4 years. The percentage of under 2 years of age repairs in patients with chronic conditions varied significantly across the 3 states, with the percentage in Wisconsin (13.6%) twice as high as New York (6.9%) ( $P < .001$ ). For 22.2% of the patients with chronic respiratory conditions, repairs were performed before age 4 years. These conditions are most likely to be associated with anesthetic complications.<sup>40</sup>

**Table II** describes the demographic, insurance and hospital characteristics for umbilical hernia repairs by age. Early repairs (under age 2 years) are performed on girls and boys at similar rates, and the differences between high- and low-volume centers are also small (8.4% in high volume and 7.9% in low volume centers). However, white children were more

likely to have an early repair (10.2%) than those in other racial and ethnic groups. Pediatric patients living in rural areas and those with Medicaid insurance were also more likely to have early repairs.

To examine the predictors of early repair while holding potentially confounding variables constant, we performed a logistic regression model predicting a repair being performed when the patient is younger than 2 years old (**Table III**). No significant differences were seen in the incidence of early hernia repair based on year of operation, patient sex, or hospital volume. The last finding indicates that the likelihood of early repair is similar for general surgeons at community hospitals and for pediatric specialists at children’s hospitals. In the logistic regression, patient race remains a significant predictor of early hernia repair. Relative to white children, black patients are less likely to have an umbilical hernia repaired early (OR 0.62,  $P < .001$ ). Other racial and ethnic groups were not significantly different from whites. Rural residence continues to be associated with early repair (OR 1.53,  $P = .009$ ), even holding constant the effect of surgical volume. Patients with Medicaid insurance were more likely to have umbilical hernias repaired early (OR 2.01,  $P < .001$ ). Holding constant differences in racial composition, rural population, and other characteristics, living in the state of Wisconsin is positively associated with early repair (compared with living in Florida), while living in New York is negatively associated with early repair. This suggests that practice patterns in each state are related to factors not included in our model or in the HCUP state outpatient data, such as cultural expectations, physician training, and individual practice patterns.

## Discussion

This study described the widely variable practice patterns for the timing of uncomplicated pediatric umbilical hernia repair.

**Table II.** Demographic, insurance, and hospital characteristics by age at time of umbilical hernia repair

Age at time of repair	<2 y	2-3 y	≥4 y	P value*
Total	538 (8.2%)	1227 (18.7%)	4786 (73.1%)	
Sex:				.005
Female	284 (8.0%)	714 (20.2%)	2543 (71.8%)	
Male	254 (8.4%)	513 (17.0%)	2243 (74.5%)	
Race/ethnicity:				<.001
White	192 (10.2%)	316 (16.8%)	1372 (73.0%)	
Black	241 (7.1%)	661 (19.6%)	2472 (73.2%)	
Hispanic	59 (8.4%)	148 (21.1%)	493 (70.4%)	
Other	32 (6.3%)	85 (16.8%)	388 (76.8%)	
Location of residence:				<.001
Urban	479 (7.8%)	1169 (19.0%)	4491 (73.2%)	
Rural	59 (14.5%)	57 (14.0%)	291 (71.5%)	
Payer type:				<.001
Private insurance	162 (6.4%)	430 (16.9%)	1952 (76.7%)	
Medicaid	357 (9.8%)	735 (20.1%)	2567 (70.2%)	
Other	19 (5.6%)	61 (17.8%)	262 (76.6%)	
Volume of Procedures:				.001
High volume center	368 (8.4%)	875 (19.9%)	3153 (71.7%)	
Low volume center	170 (7.9%)	352 (16.3%)	1633 (75.8%)	

\*Pearson  $\chi^2$  tests of independence were performed. P values of <.05 are significant.

**Table III.** Logistic regression predicting early repair

Covariate	OR	SE	z	P value
Year:				
2012 (reference)				
2013	0.95	0.11	-0.47	.640
2014	0.91	0.10	-0.87	.386
Sex:				
Male (reference)				
Female	0.96	0.09	-0.43	.665
Race/ethnicity:				
White (reference)				
Black	<b>0.62</b>	0.07	-4.08	<.001
Hispanic	0.76	0.13	-1.65	.098
Other	0.71	0.15	-1.66	.097
Rural residence:				
Urban (reference)				
Rural	<b>1.53</b>	0.25	2.63	.009
Payer type:				
Private (reference)				
Medicaid	<b>2.01</b>	0.22	6.35	<.001
Other	1.04	0.27	0.14	.886
Hospital type:				
Low volume (reference)				
High volume center	1.13	0.12	1.13	.260
State:				
Florida (reference)				
New York	<b>0.68</b>	0.08	-3.25	.001
Wisconsin	<b>1.81</b>	0.21	5.01	<.001
Constant	0.07	0.01	-15.48	

Bold text indicates effects are statistically significant at  $P < .05$ .

Our findings demonstrate that elective umbilical hernia repairs are routinely performed in very young children.

We compared the timing of repair for patients in 3 clinically relevant age categories. Umbilical hernias in children younger than age 2 years have a high likelihood of spontaneous closure, and elective repair at this age is not supported by the literature or consensus practice.<sup>4</sup> We found that across the 3 states studied in 2012-2014, 538 hernia repairs (8.2% of all pediatric repairs) were performed on children in this age group. We found that 1227 hernia repairs (18.7%) were performed on children aged 2-3 years. Older children ( $\geq 4$  years old) are less likely to have their hernias close spontaneously, and we found 4786 repairs (73.1%) in children in this age group. The number of repairs under age 4 years suggests that some umbilical hernia repairs may have been performed unnecessarily, potentially exposing these children to unnecessary operative and anesthetic risks.

Our results also show that the rate of early repairs (performed on children under age 2 years) varies significantly across the 3 states studied; they were more likely in Wisconsin and less likely in New York, even when differences in race and ethnicity, rurality, insurance type, and hospital volume were held constant. Other findings indicate that white children, rural residents, and those with Medicaid insurance were more likely to undergo hernia repairs early.

Umbilical hernia size was not reflected in this administrative database, so we were unable to assess the relationship between hernia size and the timing of operative repair. Some surgeons have advocated a practice of repairing “giant” umbilical hernias earlier than smaller hernias, though there are

no consistent guidelines on what constitutes a “giant” umbilical hernia. One reason for this practice may be because larger defects are less likely to close spontaneously.<sup>14,16,41</sup> However, the available literature suggests that there is no correlation between hernia size and risk of complications, and that in fact smaller hernia defects are more likely to become incarcerated.<sup>5,6,42,43</sup> Thus, without a risk of complications related to delay, the potential risks of early repair may not be warranted.

Our study has several limitations. No comprehensive national database of outpatient procedures exists, so we determined practice patterns by examining granular, all-payer data for only 3 states, Florida, New York, and Wisconsin. Our results, therefore, may not represent national trends. Also, studying retrospective data from administrative databases has inherent limitations. Although the SASD for these 3 states includes data from all payers, claims databases contain coding errors, and have a small amount of missing data. We identified chronic conditions using the HCUP chronic condition indicator, which is based on *International Classification of Diseases, Ninth Revision* diagnoses in claims data. Inaccuracies in this method are well known.<sup>44</sup> The SASD database also does not contain comprehensive outpatient data, so we cannot know the total number of umbilical hernias present in the population that were not repaired. We aimed to exclude any patient having 2 surgical procedures in 1 day and umbilical hernias with obstruction, incarceration, strangulation, or gangrene, as these conditions should be repaired immediately. These exclusions also required us to rely on the accuracy and completeness of the coding.

For most children, umbilical hernias often close spontaneously and can be monitored safely through watchful waiting. Evidence-based clinical practice guidelines are needed to help to standardize indications for the appropriate timing of repair of asymptomatic umbilical hernias. Such guidelines could encourage both referring pediatricians and surgical providers to avoid unnecessary operations and operative and anesthetic risks. ■

Submitted for publication Jun 19, 2018; last revision received Sep 8, 2018; accepted Oct 24, 2018

Reprint requests: Randi Cartmill, MS, Department of Surgery, University of Wisconsin School of Medicine and Public Health, 600 Highland Ave K6/117S, Madison, WI 53792-7375. E-mail: [cartmill@surgery.wisc.edu](mailto:cartmill@surgery.wisc.edu)

## References

1. Arias E. United States life tables, 2011. *Nat Vital Stat Rep* 2015;64:63.
2. Keshtgar AS, Griffiths M. Incarceration of umbilical hernia in children: is the trend increasing? *Eur J Pediatr Surg* 2003;13:40-3.
3. Papagrigoriadis S, Browse DJ, Howard ER. Incarceration of umbilical hernias in children: a rare but important complication. *Pediatr Surg Int* 1998;14:231-2.
4. Zens T, Cartmill R, Nichol P, Kohler J. Management of asymptomatic pediatric umbilical hernias: a systematic review. *J Pediatr Surg* 2017;52:1723-31.
5. Lassaletta L, Fonkalsrud EW, Tovar JA, Dudgeon D, Asch MJ. The management of umbilical hernias in infancy and childhood. *J Pediatr Surg* 1975;10:405-9.
6. Zendejas B, Kuchena A, Onkendi EO, Lohse CM, Moir CR, Ishitani MB, et al. Fifty-three-year experience with pediatric umbilical hernia repairs. *J Pediatr Surg* 2011;46:2151-6.

7. Ezomike UO, Ituen MA, Ekpemo SC, Eke CB, Eke BC. Profile of paediatric umbilical hernias managed at Federal Medical Centre Umuahia. *Niger J Med* 2012;21:350-2.
8. Chirdan LB, Uba AF, Kidmas AT. Incarcerated umbilical hernia in children. *Eur J Pediatr Surg* 2006;16:45-8.
9. Mawera G, Muguti GI. Umbilical hernia in Bulawayo: some observations from a hospital based study. *Cent Afr J Med* 1994;40:319-23.
10. Ireland A, Gollow I, Gera P. Low risk, but not no risk, of umbilical hernia complications requiring acute surgery in childhood. *J Paediatr Child Health* 2014;50:291-3.
11. Sibley WL, Lynn HB, Harris LE. A twenty-five year study of infantile umbilical hernia. *Surgery* 1964;55:462-8.
12. Morgan WW, White JJ, Stumbaugh S, Haller JA. Prophylactic umbilical hernia repair in childhood to prevent adult incarceration. *Surg Clin North Am* 1970;50:839-45.
13. Blumberg NA. Infantile umbilical hernia. *Surg Gynecol Obstet* 1980;150:187-92.
14. Meier DE, OlaOlorun DA, Omodele RA, Nkor SK, Tarpley JL. Incidence of umbilical hernia in African children: redefinition of "normal" and re-evaluation of indications for repair. *World J Surg* 2001;25:645-8.
15. Brown RA, Numanoglu A, Rode H. Complicated umbilical hernia in childhood. *S Afr J Surg* 2006;44:136-7.
16. Walker SH. The natural history of umbilical hernia. A six-year follow up of 314 Negro children with this defect. *Clin Pediatr (Phila)* 1967;6:29-32.
17. American College of Surgeons. Pediatric umbilical hernia repair [Internet]. <https://www.facs.org/~media/files/education/patient%20ed/pediatricumbilical.ashx>. Accessed March 8, 2018.
18. Rappaport BA, Suresh S, Hertz S, Evers AS, Orser BA. Anesthetic neurotoxicity—clinical implications of animal models. *N Engl J Med* 2015;372:796-7.
19. Center for Drug Evaluation and Research. Drug safety and availability—FDA Drug Safety Communication: FDA review results in new warnings about using general anesthetics and sedation drugs in young children and pregnant women [Internet]. [https://www.fda.gov/Drugs/DrugSafety/ucm532356.htm?source=govdelivery&utm\\_medium=email&utm\\_source=govdelivery](https://www.fda.gov/Drugs/DrugSafety/ucm532356.htm?source=govdelivery&utm_medium=email&utm_source=govdelivery). Accessed May 18, 2018.
20. Flick RP, Katusic SK, Colligan RC, Wilder RT, Voigt RG, Olson MD, et al. Cognitive and behavioral outcomes after early exposure to anesthesia and surgery. *Pediatrics* 2011;128:e1053-61.
21. Wang X, Xu Z, Miao C-H. Current clinical evidence on the effect of general anesthesia on neurodevelopment in children: an updated systematic review with meta-regression. *PLoS ONE* 2014;9:e85760.
22. Zhang H, Du L, Du Z, Jiang H, Han D, Li Q. Association between childhood exposure to single general anesthesia and neurodevelopment: a systematic review and meta-analysis of cohort study. *J Anesth* 2015;29:749-57.
23. Ing C, DiMaggio C, Whitehouse A, Hegarty MK, Brady J, von Ungern-Sternberg BS, et al. Long-term differences in language and cognitive function after childhood exposure to anesthesia. *Pediatrics* 2012;130:e476-85.
24. Ing CH, DiMaggio CJ, Malacova E, Whitehouse AJ, Hegarty MK, Feng T, et al. Comparative analysis of outcome measures used in examining neurodevelopmental effects of early childhood anesthesia exposure. *Anesthesiology* 2014;120:1319-32.
25. McGowan FX, Davis PJ. Anesthetic-related neurotoxicity in the developing infant: of mice, rats, monkeys and, possibly, humans. *Anesth Analg* 2008;106:1599-602.
26. Stratmann G. Review article: neurotoxicity of anesthetic drugs in the developing brain. *Anesth Analg* 2011;113:1170-9.
27. Glatz P, Sandin RH, Pedersen NL, Bonamy A-K, Eriksson LI, Granath F. Association of anesthesia and surgery during childhood with long-term academic performance. *JAMA Pediatr* 2017;171:e163470.
28. Ing C, Wall MM, DiMaggio CJ, Whitehouse AJO, Hegarty MK, Sun M, et al. Latent class analysis of neurodevelopmental deficit after exposure to anesthesia in early childhood. *J Neurosurg Anesthesiol* 2017;29:264-73.
29. Sun LS, Li G, Miller TLK, Salorio C, Byrne MW, Bellinger DC, et al. Association between a single general anesthesia exposure before age 36 months and neurocognitive outcomes in later childhood. *JAMA* 2016;315:2312-20.
30. Mamie C, Habre W, Delhumeau C, Argiroffo CB, Morabia A. Incidence and risk factors of perioperative respiratory adverse events in children undergoing elective surgery. *Paediatr Anaesth* 2004;14:218-24.
31. de Graaff JC, Pasma W, van Buuren S, Duijghuisen JJ, Nafu OO, Kheterpal S, et al. Reference values for noninvasive blood pressure in children during anesthesia: a multicentered retrospective observational cohort study. *Anesthesiology* 2016;125:904-13.
32. McCann ME, Schouten ANJ, Dobija N, Munoz C, Stephenson L, Poussaint TY, et al. Infantile postoperative encephalopathy: perioperative factors as a cause for concern. *Pediatrics* 2014;133:e751-7.
33. Vavilala MS, Lee LA, Lam AM. The lower limit of cerebral autoregulation in children during sevoflurane anesthesia. *J Neurosurg Anesthesiol* 2003;15:307-12.
34. Rhondali O, Juhel S, Mathews S, Cellier Q, Desgranges F-P, Mahr A, et al. Impact of sevoflurane anesthesia on brain oxygenation in children younger than 2 years. *Paediatr Anaesth* 2014;24:734-40.
35. Chemaly M, El-Rajab MA, Ziade FM, Naja ZM. Effect of one anesthetic exposure on long-term behavioral changes in children. *J Clin Anesth* 2014;26:551-6.
36. HCUP State Ambulatory Surgery and Services Databases (SASD). Healthcare Cost and Utilization Project (HCUP). 2012-2014 [Internet]. Agency for Healthcare Research and Quality, Rockville, MD. <https://www.hcup-us.ahrq.gov/sasdooverview.jsp>. Accessed May 18, 2018.
37. Agency for Healthcare Research and Quality. HCUP-US tools & software page [Internet]. <https://www.hcup-us.ahrq.gov/toolssoftware/chronic/chronic.jsp>. Accessed May 18, 2018.
38. Annie E Casey Foundation. KIDS COUNT data center [Internet]. <https://datacenter.kidscount.org/>. Accessed June 6, 2018.
39. StataCorp. Stata statistical software: release 15. College Station (TX): StataCorp LLC; 2017.
40. von Ungern-Sternberg BS, Boda K, Chambers NA, Rebmann C, Johnson C, Sly PD, et al. Risk assessment for respiratory complications in paediatric anaesthesia: a prospective cohort study. *Lancet* 2010;376:773-83.
41. Mack NK. The incidence of umbilical herniae in Africans. *East Afr Med J* 1945;22:369-71.
42. Komlatè A-NG, Anani M-AK, Azanledji BM, Komlan A, Komla G, Hubert T. Umbilicoplasty in children with huge umbilical hernia. *Afr J Paediatr Surg* 2014;11:256-60.
43. Vrsansky P, Bourdelat D. Incarcerated umbilical hernia in children. *Pediatr Surg Int* 1997;12:61-2.
44. U.S. Department of Health & Human Services Office of the Assistant Secretary for Planning and Evaluation (ASPE). Defining diagnosis of chronic condition [Internet]. <https://aspe.hhs.gov/report/understanding-high-prevalence-low-prevalence-chronic-disease-combinations-databases-and-methods-research/defining-diagnosis-chronic-condition>. Accessed August 29, 2018. 2015.