



Clinical Research Paper

Surgeon gender and outcomes in the management of pediatric appendicitis



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ABSTRACT

Background: Adult studies suggest surgeon gender influences postoperative outcomes. The objective of this study was to assess whether surgeon gender and surgeon-patient gender concordance affect postoperative outcomes and resource use in pediatric appendectomy.

Methods: This was a retrospective cohort study of children undergoing appendectomy (7/2015–6/2020) using NSQIP-Pediatric data from 13 hospitals participating in a regional research consortium. Primary exposure was surgeon gender. Outcomes included 30-day surgical site infection (SSI), reoperation, percutaneous drainage, hospital revisits, postoperative imaging, operative duration, and length of stay. Mixed-effects multivariable regression models adjusted for patient, surgeon and hospital-level factors. **Results:** The cohort included 7695 children. Female surgeons comprised 26.3% (31/118) of surgeons, performed 30.1% (2317/7695) of appendectomies, and had fewer mean years in practice than male surgeons (8.9 vs 13.4 years; $P < 0.001$). Surgeon gender was not associated with SSI (3.8% [88/2317] vs 3.9% [212/5378]; adjusted odds ratio [aOR] 1.13; 95% CI, 0.85–1.51), reoperation (1.1% [26/2317] vs 1.2% [65/5378]; aOR, 1.09; 95% CI, 0.67–1.77), or percutaneous drainage (3.0% [70/2317] vs 3.7% [197/5378]; aOR, 1.30; 95% CI, 0.95–1.79). No associations were observed for hospital revisits (aOR, 1.07; 95% CI, 0.88–1.30), postoperative imaging (aOR, 0.98; 95% CI, 0.79–1.21), operative duration (adjusted mean ratio [aMR], 1.00; 95% CI, 0.96–1.04), or length of stay (aMR, 1.04; 95% CI, 0.96–1.13). Findings were consistent in subgroup analyses of complicated appendicitis and surgeon-patient gender concordance.

Conclusions: Surgeon gender and surgeon-patient gender concordance is not associated with postoperative outcomes or resource utilization in pediatric appendectomy.

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HIGHLIGHTS

- Adult studies suggest surgeon gender may affect postoperative outcomes.
- This is the first study evaluating surgeon gender and outcomes in pediatric surgery.
- Adverse events were comparable across surgeon gender in pediatric appendectomy.
- Resource use was comparable across surgeon gender, even in complicated appendicitis.

1. Introduction

Acute appendicitis is the most common and costly surgical emergency in childhood [1]. Despite advances in diagnosis and perioperative care, postoperative outcomes and resource utilization associated with appendectomy continue to vary across institutions and patient populations. These variations have been attributed to differences in disease severity, timing of presentation, and patient-level factors; however, surgeon-level characteristics may also contribute to differences in outcomes [2].

Recent studies in adult surgical practice have increasingly examined the impact of surgeon characteristics on patient outcomes. In particular, surgeon gender has been associated with differences in patient-physician communication, clinical decision-making, and postoperative outcomes [3–5]. Female patients undergoing elective procedures by male surgeons have been reported to experience higher rates of mortality, readmission and complications than those treated by female surgeons [6,7]. Additionally, patients managed by female surgeons show reduced postoperative resource utilization and lower healthcare costs [8,9]. Collectively, these findings suggest that gender-related differences may exist in both clinical outcomes and efficiency of care delivery.

Whether such associations exist in pediatric surgery remains unknown. Pediatric surgical encounters differ fundamentally from adult practice, as communication and decision-making are often mediated through parents or caregivers [10]. Appendectomy may represent a particularly important procedure for examining this relationship as it is among the most commonly performed operations in children, and encompasses a broad spectrum of disease severity and resource utilization [11,12]. The objective of this study was to evaluate the influence of surgeon gender, and surgeon-patient gender concordance, on postoperative outcomes and resource utilization in children undergoing appendectomy for acute appendicitis. We hypothesized that, after accounting for patient characteristics, disease severity, surgeon experience and hospital-level clustering, postoperative outcomes and resource utilization would not differ meaningfully across surgeons of differing gender.

2. Methods

2.1. Study design and data source

This was a retrospective, multicenter cohort and represents a secondary analysis of a previously established dataset designed to support multicenter comparative effectiveness research on antibiotic utilization in pediatric appendicitis [12]. The analysis utilized data from the American College of Surgeons' National Surgical Quality Improvement Program-Pediatric (ACS NSQIP-Pediatric), obtained from 13 centers participating in the Eastern Pediatric Surgery Network (EPSN) research consortium. Restrictions apply to the availability of the data used for this study, which were used under a data use agreement between hospitals participating in the EPSN research consortium and are not publicly available.

The NSQIP-Pediatric database includes disease-specific clinical outcome and resource utilization variables. NSQIP-Pediatric uses a systematic 8-day sampling cycle of consecutive operations;

therefore, appendectomy cases captured in the database represent a sample of cases at each hospital rather than complete case ascertainment, with the proportion sampled depending on each hospital's relative case volume. Data are abstracted by trained surgical clinical reviewers using standardized definitions and protocols. Data quality is ensured by periodic auditing, mandatory reviewer recertification, and access to ACS clinical support for clarification of abstraction procedures [13].

2.2. Study cohort

Children aged 3–18 years who underwent appendectomy at 13 participating EPSN hospitals between July 2015 through June 2020 were included. Cases were excluded if missing surgeon identifiers precluded collection of surgeon gender data or if surgeon gender could not be determined using the method described below. To focus on appendectomies performed by pediatric surgeons regularly performing the procedure on children, cases involving surgeons without pediatric surgery fellowship training and surgeons with fewer than ten cases in the dataset were excluded. This study was deemed exempt from human participants research approval by the institutional review board of Boston Children's Hospital because it posed minimal risk of identifying patients.

2.3. Classification of exposures and outcomes

The primary exposure was surgeon gender. Surgeon gender was assigned through a manual review of pronouns used in publicly available official institutional sources (e.g., faculty biographies, press releases, conference biographies). Surgeons using she/her pronouns were categorized as female and he/him pronouns as male; no surgeons in the study cohort used they/them pronouns. Patient gender was obtained from NSQIP-Pediatric which included categories of male, female and non-binary. Although this variable was labeled "sex," its definition reflected how patients identified and non-binary is a gender identity rather than a sex category; accordingly, we treated it as gender in the present study. A secondary analysis examined outcomes associated with surgeon-patient gender concordance. In the present study, female and male terms were used to describe patient and surgeon gender to standardize terminology across adults and children and to align with NSQIP-Pediatric data, acknowledging that these categories may not completely capture the spectrum of gender identity [14].

The primary outcome was 30-day surgical site infection, including superficial incisional, deep incisional and organ space infection. Secondary clinical outcomes included 30-day reoperation, and percutaneous drainage. Measures of resource utilization included hospital revisits; postoperative abdominal imaging (computed tomography (CT), ultrasonography (US), or magnetic resonance imaging (MRI)); length of hospital stay; and operative duration.

2.4. Statistical analysis

Surgeon and case characteristics were summarized by surgeon gender group, both overall and within hospital, using counts and

percentages for categorical variables and means and standard deviations for continuous variables. Univariate regression models were used to compare characteristics by surgeon gender and included random effects for hospital to account for clustering.

To compare relative case volume between male and female surgeons, we calculated an observed-to-expected (O/E) ratio of sampled appendectomy case volume within hospitals. Because NSQIP-Pediatric uses systematic sampling rather than complete case capture, O/E ratio reflects relative sampled case volume and was not used as an inferential outcome. For each surgeon, expected sampled case volume was estimated by multiplying the hospital-specific sampled appendectomy rate by the surgeon's observation time, defined as the interval between the first and last appendectomy recorded in NSQIP-Pediatric. The O/E ratio was defined as observed divided by expected sampled cases, with values greater than 1 indicating higher-than-expected sample case volume.

For the primary multivariable analyses, mixed-effects logistic regression models were used to estimate adjusted odds ratios (aORs) for binary outcomes and adjusted mean ratios (aMR) for continuous outcomes. A logistic link was used for binary outcomes, a gamma distribution with log link for operative duration, and a negative binomial distribution with a log link for post-operative hospital length of stay (LOS). All models included random intercepts for hospital to account for clustering at the hospital level. Covariates included patient race, number of intra-operative findings representative of complicated disease (visible hole, diffuse fibrinous exudate, extraluminal fecalith, and intra-abdominal abscess), and years in practice (calculated for each case as the difference between the year of surgery and the year of clinical fellowship completion) [11,12,15,16].

To examine the effect of surgeon-patient gender concordance, separate analyses were conducted within each stratum of patient gender using the same modeling framework. To evaluate potential effect modification by disease severity, we performed a pre-specified subgroup analysis among children with complicated appendicitis using the same covariates and analytic methods.

Statistical significance threshold was defined as 2-sided $p < 0.05$. Because this was a retrospective cohort study of eligible

pediatric appendectomy cases from participating hospitals during the study period, no formal a priori sample size calculation was performed. To contextualize the precision of the analyses, we performed a post hoc assessment of minimum detectable absolute difference using the available sample size, and observed outcome rates. Based on the available sample size and baseline SSI rate, the overall cohort had 80% power to detect an absolute difference in SSI of approximately 1.3 percentage points between surgeon gender groups. Analyses were performed using SAS statistical software, version 9.4 (SAS Institute Inc.). Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting were used.

3. Results

3.1. Cohort characteristics

A total of 7695 children who underwent appendectomy at 13 NSQIP-Pediatric hospitals were included (median hospital case volume, 553; interquartile range [IQR]: 460–779) after exclusions of missing surgeon identifiers (971 of 9008; 11%), surgeon gender that could not be ascertained (67 of 9008; 0.7%), and surgeon eligibility criteria based on fellowship training and case volume (275 of 9008; 3%). Overall, 61.1% of the patients (4703 of 7695) were male, 35.7% (2748 of 7695) were White, and 20.2% had at least one finding of complicated appendicitis.

3.2. Surgeon characteristics and operative distribution

Among 118 surgeons from all hospitals performing appendectomies during the study period, 26% were female and this proportion ranged from 0 to 57% across hospitals (Table 1). At the time of appendectomy, mean surgeon years in practice was 12.0 years and this differed significantly across genders (female surgeons: 8.9 vs. male surgeons: 13.4 years; $p < 0.001$). Female surgeons performed 30.1% of all appendectomies sampled by NSQIP-Pediatric during the study period (2317 of 7695), and no differences were found in observed-to-expected sampled case volume ratios

Table 1
Case distribution and characteristics by site and surgeon gender.

Site	Surgeon characteristics					Case volume and case mix by surgeon gender			
	Surgeons, no. (%) ^a			Years in practice, mean (SD) ^b		Mean O/E case ratio ^c		Complicated appendicitis, No. (%) ^d	
	Female	Male	Total	Female	Male	Female	Male	Female	Male
1	0 (0)	10 (100)	10	NA	7.4 (6.4)	NA	1.03	NA	127 (28)
2	1 (14)	6 (86)	7	19.2 (1.5)	9.2 (7.6)	1.33	0.90	14 (18)	63 (13)
3	1 (10)	9 (90)	10	6.7 (1.4)	15.2 (6.4)	1.01	1.00	28 (33)	118 (27)
4	1 (17)	5 (83)	6	9.4 (0.9)	22.6 (7.3)	0.98	1.00	9 (19)	38 (17)
5	1 (17)	5 (83)	6	6.8 (1.5)	7.8 (5.4)	1.06	0.99	20 (14)	100 (16)
6	4 (24)	13 (76)	17	14.3 (6.6)	12.2 (8.2)	0.96	1.08	21 (18)	78 (22)
7	3 (27)	8 (73)	11	17.3 (2.2)	8.1 (4.5)	1.02	0.95	52 (24)	105 (16)
8	3 (30)	7 (70)	10	5.0 (3.5)	22.0 (8.3)	0.87	1.05	58 (28)	163 (28)
9	3 (43)	4 (57)	7	3.0 (3.1)	18.1 (10.1)	1.58	0.84	16 (16)	49 (20)
10	5 (36)	9 (64)	14	8.3 (6.0)	16.3 (9.2)	1.29	0.85	86 (25)	79 (19)
11	3 (33)	6 (67)	9	8.2 (1.9)	14.7 (10.5)	0.96	0.99	57 (14)	66 (15)
12	2 (50)	2 (50)	4	4.5 (1.7)	16.6 (6.4)	1.31	0.98	42 (21)	36 (18)
13	4 (57)	3 (43)	7	8.7 (5.3)	17.1 (8.8)	0.94	0.99	82 (23)	48 (18)
Total	31 (26)	87 (74)	118	8.9 (5.6)^e	13.4 (9.2)^e	1.12	0.97	485 (21)	1070 (20)

Abbreviations: NA, not applicable; O/E, observed to expected.

^a Percentages for surgeon distribution represent the percentage of surgeons at each site.

^b Years since clinical fellowship completion to the time of appendectomy.

^c Observed-to-expected case ratio represents surgeons' average case volume relative to expected based on hospital-specific NSQIP abstraction case rates; values > 1 indicate higher-than-expected volume.

^d Percentages for complicated appendicitis represent the percentage of appendicitis cases within each surgeon-gender group. NA indicates that no female surgeons were included at that site.

^e $p < 0.0001$.

between male and female surgeons (Table 1). The proportion of children diagnosed with complicated appendicitis was similar between male and female surgeons (Table 1), as was the mean number of findings of complicated disease (female: 1.57 vs. male: 1.67, $p = 0.12$).

3.3. Outcomes and surgeon gender

3.3.1. Adverse events

In unadjusted analyses, SSI rates were similar between male and female surgeons (male: 3.9% vs. female: 3.8%, $p = 0.62$), reoperation (male: 1.2% vs. female: 1.1%, $p = 0.93$), and percutaneous drainage (male: 3.7% vs. female: 3.0%, $p = 0.32$). This lack of association remained after adjusting for race, number of intra-operative findings of complicated disease, and years in practice (Fig. 1a). No differences in unadjusted and adjusted outcomes were found between male and female surgeons in the subgroup analysis limited to children with complicated disease (Fig. 1b).

3.3.2. Resource utilization

In unadjusted analyses, no differences were observed between male and female surgeons in rates of hospital revisit (male: 8.3% vs. female: 8.0%, $p = 0.84$), postoperative imaging (male: 7.5% vs. female: 8.2%, $p = 0.35$), operative duration (mean male: 47.7 vs. female: 46.0 min, $p = 0.80$) or length of stay (mean male: 1.76 vs. female: 1.71 days, $p = 0.39$). After adjustment, surgeon gender was not associated with significant differences across any resource utilization outcomes in the overall cohort (Fig. 2a). These findings remained unchanged in subgroup analyses limited to children with complicated appendicitis (Fig. 2b).

3.4. Outcomes and surgeon-patient gender concordance

3.4.1. Adverse events

In unadjusted analyses, no differences in rates were observed between gender-concordant and gender-discordant surgeon-patient pairs for SSI for female patients (concordant: 4.0% vs discordant 3.5%, $p = 0.46$) and male patients (concordant: 4.2% vs discordant 3.7%, $p = 0.24$), reoperation for female patients (concordant: 1.7% vs. discordant: 0.9%, $p = 0.05$) and male patients (concordant: 1.5% vs. discordant 0.8%, $p = 0.11$) or percutaneous drainage for female patients (concordant: 2.6% vs. discordant: 3.7%, $p = 0.20$) and male patients (concordant: 3.6% vs. discordant: 3.3%, $p = 0.72$). After adjustment, surgeon–patient gender

concordance was not associated with any adverse outcomes (Fig. 3a). No differences in unadjusted or adjusted outcomes were observed in subgroup analyses limited to children with complicated appendicitis (Fig. 3b).

3.4.2. Resource utilization

In unadjusted analyses, no differences were observed between gender-concordant and gender-discordant surgeon-patient pairs in rates of hospital revisit for female patients (concordant: 8.5% vs. discordant: 8.3%, $p = 0.56$) and male patients (concordant: 8.3% vs. discordant: 7.7%, $p = 0.46$), postoperative imaging for female patients (concordant: 8.4% vs. discordant: 7.0%, $p = 0.08$) and male patients (concordant: 7.7% vs. discordant: 8.2%, $p = 0.96$), operative duration for female patients (concordant: 46.2 vs. discordant: 47.5 min, $p = 0.36$) and male patients (concordant: 47.9 vs. discordant: 45.9 min, $p = 0.86$), or length of stay for female (concordant: 1.7 vs discordant: 1.7 days, $p = 0.73$) or male patients (concordant: 1.8 vs. discordant: 1.7 days, $p = 0.30$). After adjustment, surgeon-patient gender concordance was not associated with any resource utilization outcomes in the overall cohort (Fig. 4a). These findings remained unchanged in subgroup analyses limited to children with complicated appendicitis (Fig. 4b).

4. Discussion

In this multicenter cohort study of 7695 children undergoing appendectomy for acute appendicitis, surgeon gender was not associated with postoperative adverse events or resource utilization. These findings were consistent in both the overall cohort and among children with complicated appendicitis, a subgroup with higher disease severity and greater resource use [11,16,17]. Furthermore, surgeon-patient gender concordance was not associated with adverse clinical outcomes or postoperative resource utilization. Together, these results suggest that within the context of operative management of pediatric appendicitis, outcomes and resource use are comparable across surgeon gender. In this multicenter cohort study of children undergoing appendectomy, surgeon gender and surgeon-patient gender concordance were not associated with postoperative adverse events or resource utilization.

To our knowledge, this is the first study to examine the association between surgeon gender or surgeon-patient gender concordance and clinical outcomes and resource utilization in children. Existing data are limited to the adult population and have

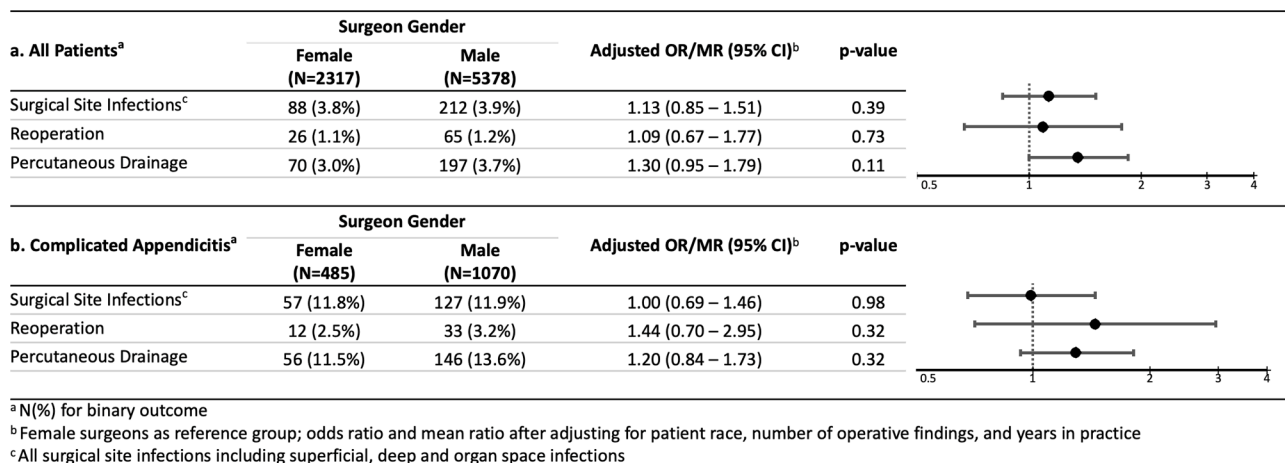


Fig. 1. Association of surgeon gender with adverse outcomes in A) all children undergoing appendectomy B) complicated appendicitis subgroup.

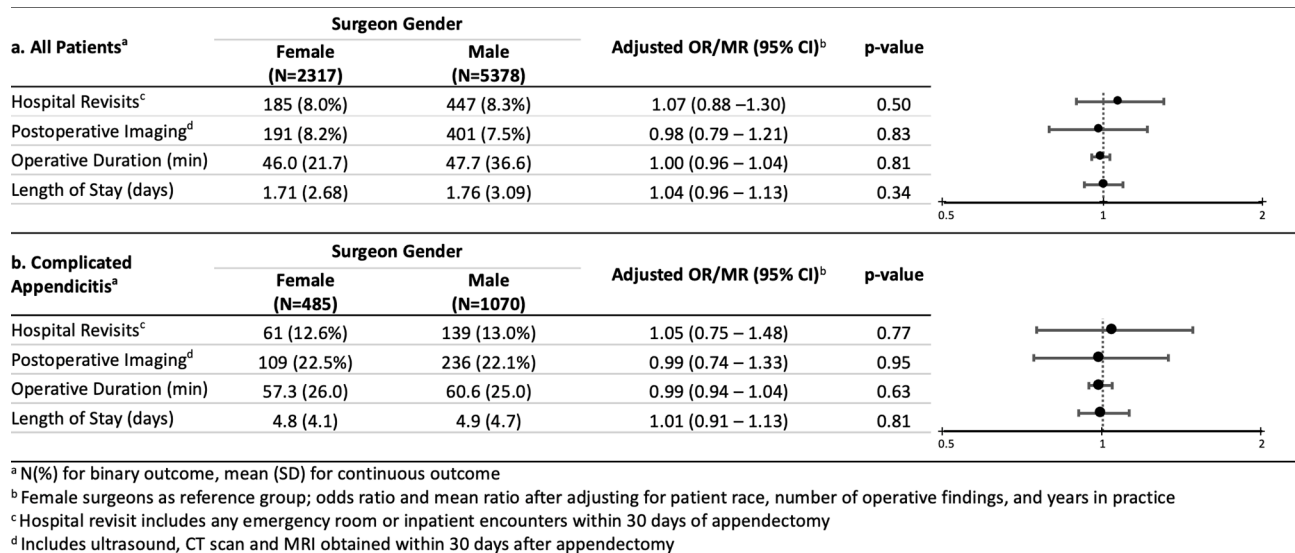


Fig. 2. Association of surgeon gender with resource use in A) all children undergoing appendectomy B) complicated appendicitis subgroup.

yielded conflicting results. In a multicenter population-based matched cohort study of 104,630 patients, treatment by female surgeons was associated with a 12% lower odds of 30-day mortality compared with treatment by male surgeons, although no differences were observed in readmissions or complication rates [5]. Notably, this association was limited to elective procedures, with no significant gender-based differences in outcomes for emergent procedures. Similarly, a meta-analysis that included 8,915,504 surgical patients undergoing elective and emergent procedures reported a 5% lower odds of 30-day mortality among patients treated by female surgeons [18]. In contrast, a meta-analysis of 4,440,740 patients undergoing elective surgery found no association between surgeon gender and a composite 30-day outcome that included mortality, readmission and other complications [19]. Collectively, these results suggest that the observed

association between surgeon gender and outcomes may be context-dependent and potentially influenced by procedure urgency, case mix, and outcome definition across surgical settings. More broadly, these findings contribute to the growing body of literature evaluating surgeon-level characteristics and suggest that, within standardized pediatric surgical care, surgeon gender alone does not explain variation in postoperative outcomes or resource utilization. Importantly, these findings suggest that associations reported in adult surgical populations should not be assumed to apply across surgical specialties or patient populations without direct evaluation.

The absence of an association between surgeon gender and postoperative outcomes in the operative management of pediatric acute appendicitis may be explained by several contextual factors. Appendectomy in children is typically performed urgently, with

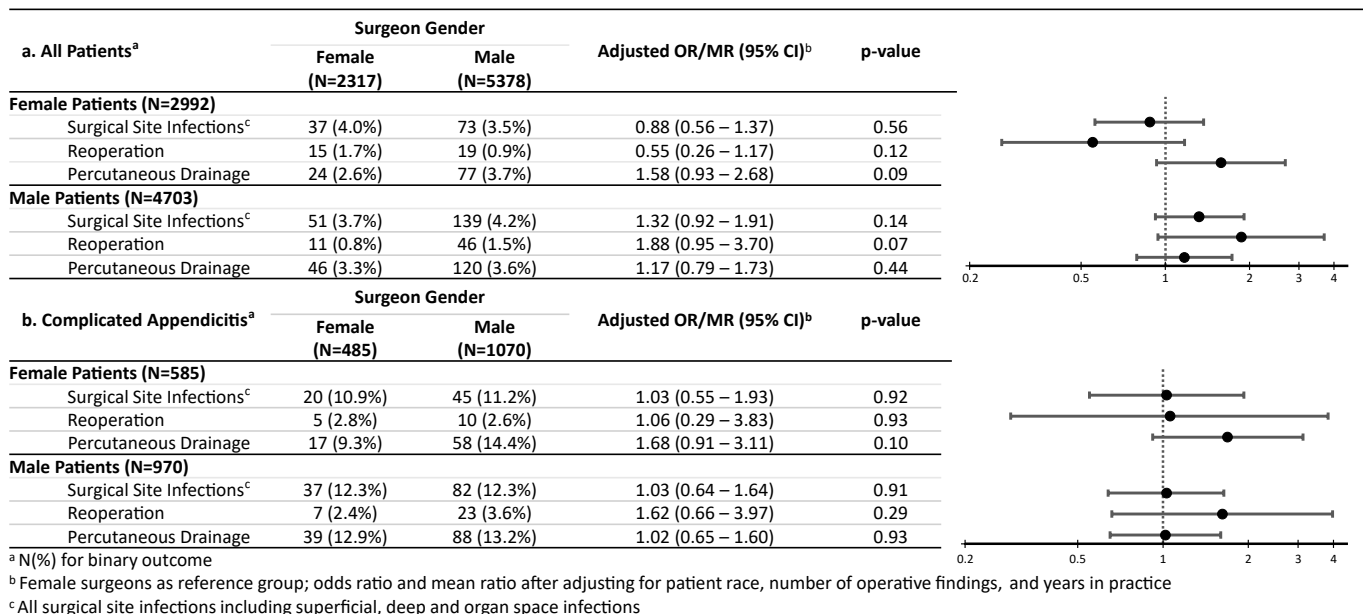


Fig. 3. Association of surgeon-patient gender concordance with adverse outcomes in A) all children undergoing appendectomy B) complicated appendicitis subgroup.

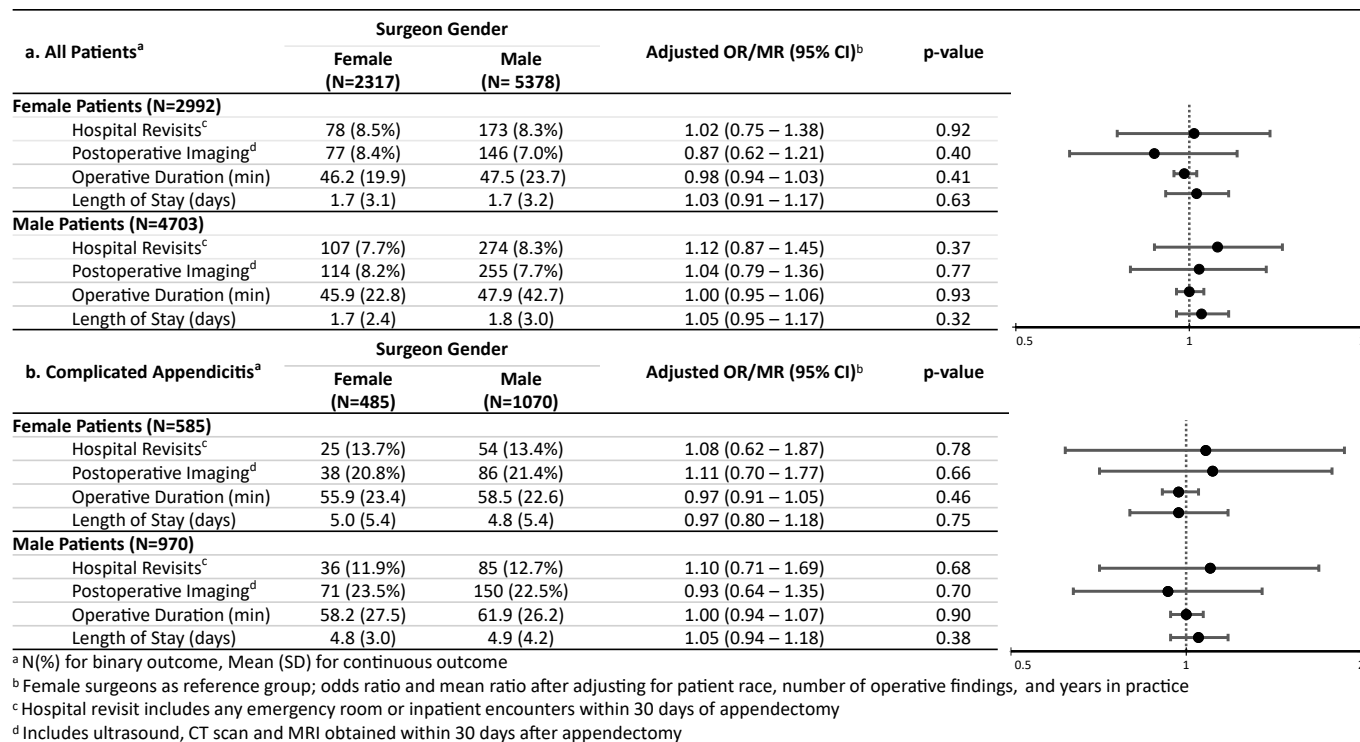


Fig. 4. Association of surgeon-patient gender concordance with resource use in A) all children undergoing appendectomy B) complicated appendicitis subgroup.

surgeon assignment largely determined by call schedules rather than patient preference. As a result, opportunities for preoperative interaction are limited, potentially attenuating the influence of gender-related differences that may exist in communication or decision-making that have been described in other clinical scenarios [3,4,20]. While uncomplicated appendicitis is often managed using standardized clinical pathways, substantial heterogeneity exists in operative and perioperative decision making for complicated disease [2]. Nevertheless, given the urgent nature of presentation, limited perioperative interaction, and high degree of protocolization in many centers, system-level practices may outweigh individual surgeon characteristics in this setting.

Prior studies in adults have reported differences in resource utilization and healthcare costs across physician and surgeon gender [8,9,21]. In a multicenter population-based cohort study of 1,165,711 patients, treatment by female surgeons had 9% lower total health care costs compared to male surgeons, driven by lower inpatient and post-discharge resource use [9]. In a multicenter retrospective study of 150,509 patients that underwent cholecystectomy, female surgeons had longer operative duration but lower complication rates and shorter hospital stays [22]. Collectively, these findings suggest that gender-associated differences in resource utilization in adult surgery may be influenced by variations in perioperative decision-making and postoperative management. In contrast, the present analysis did not demonstrate differences in postoperative imaging use, hospital revisits, operative duration or length of stay by surgeon gender. Overall, these findings suggest that surgeon gender may have a limited impact on postoperative practice patterns for procedures that have become more standardized such as pediatric appendectomy.

With respect to surgeon-patient gender concordance, prior adult studies have suggested potential benefits of concordant care, including lower mortality, fewer postoperative complications and reduced resource utilization [6,7,23]. Although mechanisms underlying these associations remain uncertain, differences in

communication style, trust and perceived comfort have been proposed as contributing factors [3,20,24]. In this study, however, gender concordance was not associated with clinical outcomes or resource utilization. This finding may reflect the nature of pediatric surgical encounters, in which caregivers play a central role in communication and decision-making. Consequently, interpersonal dynamics between surgeons and patients that influence outcomes in adults may be different from those present in pediatric settings.

The results of this study must be considered in the context of its limitations. Although standardized definitions were used, the retrospective design introduces a risk of exposure and outcome misclassification. Misclassification of surgeon gender is a general limitation of gender-based outcomes research, as gender identity may not be accurately captured through readily available sources [25]. To mitigate this concern, surgeon gender in the present study was determined through manual review of pronouns used in official institutional materials, avoiding reliance on administrative identifiers. To our knowledge, this is the first study to use pronouns as a proxy for surgeon gender. However, misclassification remains possible, as surgeons may not publicly disclose their gender identity through pronouns they use in the workplace. Another limitation is the inconsistent distinction between sex and gender in the literature. The studies referenced in this discussion include both surgeon sex- and surgeon gender-based analyses, and these constructs are frequently conflated. This lack of conceptual clarity limits direct comparison across studies and complicates interpretation of whether observed differences are due to gendered interpersonal dynamics, biological sex, administrative classification, or their proxies. Future studies and databases should explicitly and consistently distinguish sex and gender to improve measurement, comparability, and interpretation. Residual confounding may be present, as postoperative outcomes may reflect unmeasured differences in team-based care, such as trainee involvement, advanced practice provider participation, and

nursing care. In addition, although the overall cohort was large for a pediatric surgical study, it was not powered to exclude small differences in outcomes, particularly in subgroup analyses. Therefore, the absence of statistically significant association should not be interpreted as evidence of equivalence. However, the differences in point estimates between genders for all outcomes were exceedingly small, arguing against the presence of any clinically meaningful differences if they exist. This study was also limited by outcomes available in the dataset. Important patient- and family-centered domains, such as pain management, communication quality, and caregiver satisfaction were not captured. These unmeasured outcomes may be particularly relevant when evaluating the potential influence of surgeon gender, as gender-related differences in care may be more evident in communication style and relational aspects than surgical complications alone. Future studies should investigate these outcomes in pediatric surgical settings where longitudinal follow-up is common, such as fetal counseling, cancer surgery, and chronic surgical conditions. Finally, the results of this study were derived from a research consortium of NSQIP-Pediatric hospitals and may not be generalizable to other healthcare settings.

5. Conclusion

Despite the limitations noted, this multicenter study found no association between surgeon gender or surgeon-patient gender concordance and adverse events in children undergoing appendectomy for acute appendicitis. Resource utilization was also comparable, suggesting that the fiscal implications of care delivery within and outside the operating room are similar across surgeon genders. These findings, however, may not be generalizable to other clinical contexts. It remains possible that surgeon gender or gender concordance could influence outcomes in non-emergent or elective pediatric procedures, or in the management of chronic conditions requiring operative intervention, where longitudinal surgeon-patient relationships and more nuanced, preference-sensitive decision-making play a greater role.

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Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Shawn Rangel reports financial support was provided by Boston Children's Hospital Department of Surgery. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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