

Abnormal pathology seen on appendectomy in patients with predominant right-sided pelvic pain

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Abstract

Introduction: Previous studies have linked chronic pelvic pain (CPP) to appendix pathologies. However, few studies have investigated appendix pathology specifically in the context of CPP that is right-side predominant (R-CPP). We hypothesized that women with R-CPP have higher rates of appendix pathology compared with women with CPP that is not right-side predominant (N-CPP).

Methods: We conducted a retrospective case–control study of 220 women who underwent diagnostic laparoscopy and planned or incidental appendectomy for CPP and suspected endometriosis between January 2015 and December 2018 at a tertiary care center in Saint Louis, MO.

Results: No significant difference in abnormal appendix pathology was found between women with R-CPP and women with N-CPP (30.9% vs 34.5%, $p=0.74$, odds ratio = 0.85, 95% CI: (0.44, 1.62)). Gross abnormalities of the appendix were documented in 40 of 220 patients (18.2%), with the most common abnormal gross findings being adhesions (8.2%), followed by abnormal lesions (7.3%).

Conclusion: In this study, the presence of abnormal pathology within the appendix did not correlate with R-CPP, indicating triage based on predominant pain location cannot help identify patients with underlying appendix pathology. However, consistent with previous studies, we identified a high rate of abnormal appendix pathology overall, supporting the practice of many surgeons to perform routine appendectomy in women with CPP.

Keywords

Appendectomy, endometriosis, dysmenorrhea, chronic pelvic pain

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Introduction

Chronic pelvic pain (CPP) is a complex condition defined as pain in the pelvic region lasting for more than 6 months.¹ It is associated with decreased quality of life, impaired functioning, and psychological distress. The etiology is poorly understood but is believed to be highly multifactorial. It can overlap with endometriosis, interstitial cystitis, and irritable bowel syndrome, among other pain conditions.^{2,3} Comorbidities such as fibromyalgia, anxiety, depression, and a history of sexual trauma are also common.² While CPP can stem from identifiable etiologies such as endometriosis, often no cause can be found, making management challenging.¹

Incidental appendectomy during laparoscopy for CPP frequently reveals abnormal pathology, such as endometriosis, appendicitis, fibrosis, and tumors. Wie et al.⁴ found that in women who underwent laparoscopy for ovarian endometriomas, 34.9% had appendix pathology, with the

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most common being endometriosis, accounting for 38% of the abnormal appendices. Ribeiro et al.⁵ revealed that almost 74% of women who underwent incidental appendectomy during laparoscopy for suspected deep endometriosis also had appendix pathology, with endometriosis also leading as the cause, accounting for 27.6% of the pathology. Even when the appendix appears grossly normal, McTavish et al.⁶ discovered that up to 42.4% can have abnormal histopathology. Despite these studies linking CPP and appendix pathology, few reports have assessed appendix pathology specifically in the setting of predominantly right-sided CPP (R-CPP). Such an investigation could shed insights into the pathogenesis of the condition and help develop guidelines for the use of appendectomy as an intervention for CPP.

Our objective for this study was to assess the rates of histologically confirmed pathology in the appendix of women with CPP, regardless of whether the appendices appeared grossly normal or not, and to determine if pathology rates differed based on the predominant location of the pain symptoms. We hypothesized that women reporting R-CPP would have more abnormal appendix pathologies compared with women whose CPP is not predominantly right-sided in nature (N-CPP). This includes increased rates of abnormal pathologies in appendices that appear grossly normal. We tested our hypothesis using a retrospective case–control study of 220 patients spanning four years, comparing gross and histological findings in the appendices of women undergoing laparoscopic surgery with planned or incidental appendectomy for CPP.

Methods

Patients

This study was approved by Saint Louis University Institutional Review Board under IRB #30000. A waiver of consent was granted by Saint Louis University Institutional Review Board under expedited review.

To identify patients, we created a query in Epic electronic medical records systemic (Madison, WI) used for patient documentation at our institution. We cross-referenced billing codes for appendectomy and patients operated upon by the senior study surgeon between 1 January 2015 and 31 December 2018. This produced an initial list of 239 patients who underwent planned or incidental appendectomy during laparoscopic surgery. Appendectomies were planned in cases with advanced endometriosis (especially Stage IV), colorectal involvement, or a history of repeated surgeries for endometriosis.

We then applied the following inclusion criteria: female gender, age range of 13–50 years old, symptoms of CPP, and appendectomy at the time of surgery. Symptoms of CPP included but were not limited to regular pain or cramping in the abdominal and pelvic area with or without

menses, pain with intercourse, or pain with urination or defecation. Exclusion criteria included absence of CPP symptoms, and previous laparoscopy by the same operating physician. Because of our interest in endometriosis of the appendix as a potential cause of R-CPP, this latter criterion was applied to avoid including patients who had previously achieved complete excision of endometriosis.⁷

After a retrospective review of preoperative notes, patients were assigned as cases (R-CPP: CPP reported by the patient during the initial history to be predominantly right-sided) or controls (N-CPP: CPP not reported to be predominantly right-sided, including left-sided, midline, or diffuse CPP).

Data collection

Standardized preoperative data have been collected during physician interviews and through patient questionnaires as part of an ongoing database at our institution for about 7 years, and includes information on symptomatology, quality of life as scored by the Endometriosis Health Profile Short Form (EHP5), and sexual functioning as scored by the Female Sexual Functioning Index (FSFI). For each patient, these documents combined with surgical and pathology reports were used to record the following: age at procedure; body mass index; race; parity; tobacco use; history of dysmenorrhea, dyschezia, and/or dyspareunia; hormonal interventions used; length of procedure; days of stay; estimated blood loss; complications; presence of endometriomas, obliterated cul-de-sac, and/or adhesions noted during laparoscopy; endometriosis score and stage; quality of life scores; gross appearance of appendices; and microscopic pathology of appendices.

Statistical analysis

Data were tabulated using REDCap (Vanderbilt, Nashville, TN), a web application for creating research surveys and databases, and analyzed using SPSS Statistics version 23.0 for Windows (IBM, Armonk, NY).

Of the continuous variables, only age was normally distributed. Age was therefore expressed both as mean \pm standard deviation (SD) and median and range, and it was analyzed with independent student t test. All other continuous variables (body mass index, parity, EHP5 score, FSFI score, length of procedure, and estimated blood loss) lacked normal distribution; therefore, they were represented as medians and ranges and compared using Mann–Whitney U test.

Categorical variables were expressed as numbers and percentages. Differences were assessed using chi-square test or Fisher's exact test depending on the sizes of the comparison cells. Odds ratios were calculated to assess the associations between the two pain groups, abnormal pathology in the appendix, and gross appearance of the appendix. A p value of < 0.05 was used to denote statistical significance.

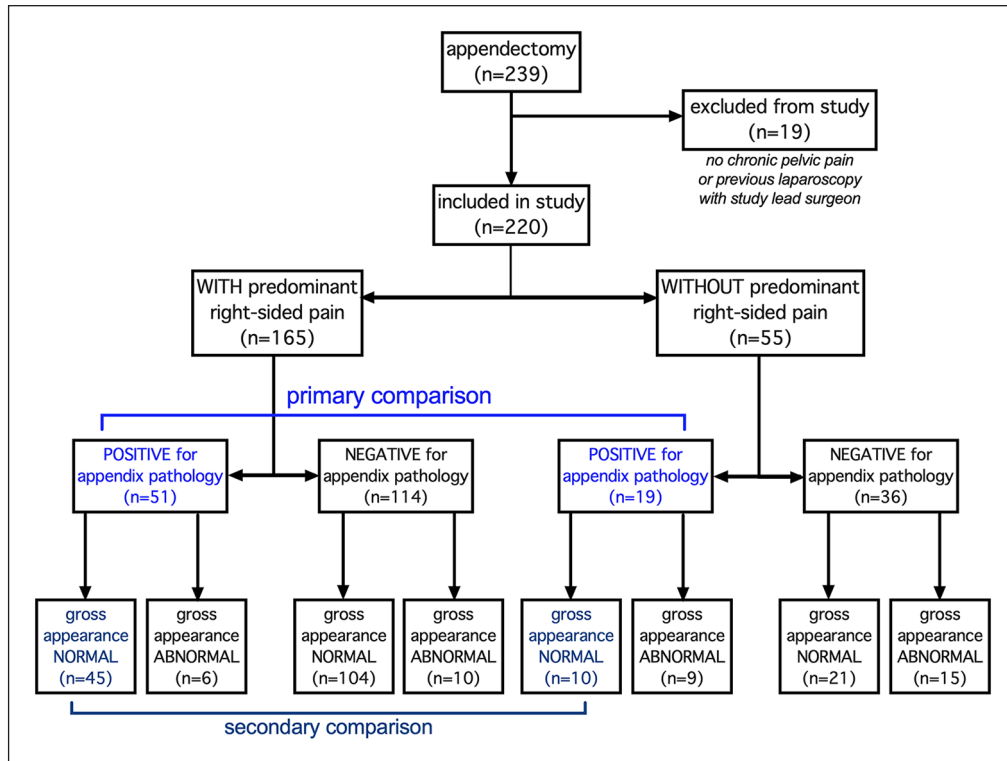


Figure 1. Patient selection and study design. A total of 239 patients undergoing elective appendectomy between 2015 and 2018 were identified. Eighteen were excluded for having had previous laparoscopy with the same surgeon and one was excluded for absence of chronic pelvic pain symptoms. Of the remaining 220 patients, 165 were classified as cases for reporting predominantly right-sided pain, and 55 were classified as controls for reporting pain that was not predominantly right-sided. The main comparisons of interest were the presence of abnormal appendix pathology in cases versus controls (primary), and the presence of abnormal pathology in appendices that appear grossly normal in cases versus controls (secondary).

Results

Demographics and symptomatology

A total of 239 women were identified who underwent planned or incidental appendectomy. Nineteen of these women were excluded due to lack of having CPP, or if they were having a repeat surgery with the same operating surgeon. We included a total of 220 patients in the study after application of inclusion and exclusion criteria (Figure 1). All surgeries were performed by the same surgeon.

R-CPP was reported by 75% of the study population (Table 1). The median age of all 220 patients was 31 years, and 85% percent was Caucasian. BMI varied greatly, with a median of 24.9 and a range of 17.3–51.7. About 40% self-identified as current or former smokers. Median parity was 0, with a range of 0–7. The vast majority of patients studied endorsed pain symptoms, including dysmenorrhea (95.4%), dyschezia (75.2%), and dyspareunia (82.6%). About 95.4% had used at least 1 form of hormonal suppression, the most common being oral contraceptive pills followed by leuprolide.

Quality of life data scored using EHP5 and FSFI questionnaires prior to surgery were available for roughly half

of all patients (Table 1). The median EHP5 score was 65 with a range of 0–100; higher scores indicate lower quality of life. The median FSFI score was 19.5 with a range of 2.0–34.8; an FSFI total score of ≤ 26 indicates risk for sexual dysfunction.

Overall, cases and controls did not vary significantly in demographic characteristics, obstetrical history, hormonal suppression history, or quality of life scores (Table 2). However, a significantly greater proportion of cases reported dysmenorrhea compared with controls (98.2% vs 87.3%, $p < 0.01$).

Appendix pathology and surgical data

Gross abnormalities of the appendix were documented in 40 of 220 patients (18.2%), with the most common abnormal gross findings being adhesions (8.2%), followed by abnormal lesions (7.3%) (Table 3). Histological abnormalities of the appendix occurred in 70 of 220 patients (31.8%), with the most common abnormalities being fibrous obliteration (13.6%), followed by endometriosis (10.5%). About 78.6% of the study population had evidence of endometriosis confirmed by histological analysis

Table 1. Demographic characteristics, symptomatology and pain data, and quality of life scores for entire study population of 220 women.

Characteristic		
Age (years)	30.8 ± 6.5 31 (18–48)	
Race		
Caucasian	187	85.0
African American	20	9.1
Asian	4	1.8
Hispanic	5	2.3
Other	4	1.8
Body mass index (kg/m ²)	24.9 (17.3–51.7)	
Tobacco use		
Never smoker	132	60.0
Former smoker	42	19.1
Current smoker	46	20.9
Parity	0 (0–7)	
Dysmenorrhea	209	95.4
Dyschezia	164	75.2
Dyspareunia	171	82.6
Hormonal suppression history		
Intrauterine device	39	17.7
Oral contraceptive pill	194	88.2
Implant	10	4.5
Leuprolide	72	32.7
Injection	61	27.7
Patch	4	1.8
Ring	16	7.3
Never used	10	4.5
Location of chronic pelvic pain		
Predominantly right-sided (R-CPP)	165	75.0
Not predominantly right-sided (N-CPP)	55	25.0
Endometriosis Health Profile Short Form Score (EHP5)	65 (0–100)	
Female Sexual Functioning Index Score (FSFI)	19.5 (2.0–34.8)	

The study population was predominantly Caucasian (85%) and nulliparous. Age ranged from 18 to 48 and BMI ranged from 17.3 to 51.7. The vast majority of women reported the pain symptoms of dysmenorrhea, dyschezia, and dyspareunia and a history of hormonal suppression use. Data are presented as means ± standard deviations, medians and ranges, or n, %. Body mass index and dysmenorrhea were unknown for one woman, dyschezia was unknown for two women, dyspareunia was unknown for 13 women, EHP5 score was unknown for 112 women, FSFI score was unknown for 123 women.

of tissue samples taken during surgery (Table 3). Most women had an endometriosis stage of 1 or 2 (85.7%), which was determined by clinical observation and reported in the operative note. Few complications occurred (4/220) and included a vaginal cuff abscess and a colonic serosal injury among cases, and a partial ureteral transection and a rectal enterotomy among controls.

Gross appearance of the appendix was more likely to be abnormal in women with N-CPP (controls) than in women

with R-CPP (cases) (43.6% vs 9.7%, $p < 0.001$). Significant individual differences within the category were present, including abnormal contour (10.9% vs 1.2%, $p < 0.01$), adhesions (18.2% vs 4.8%, $p < 0.01$), and abnormal lesions (18.2% vs 3.6%, $p < 0.001$) of the appendix (Table 4). An obliterated cul-de-sac (16.4% vs 4.2%, $p < 0.01$) and adhesions found (45.5% vs 25.5%, $p < 0.01$) also occurred more frequently in controls. More control patients had an advanced stage of endometriosis (stage 4) as well (20.4% vs 7.4%, $p < 0.05$).

Cases and controls did not significantly differ in the presence of abnormal appendix pathology found on histology (30.9% vs 34.5%, $p = 0.74$, odds ratio = 0.85, 95% CI: (0.44, 1.62)) (Table 5). There was no significant association between abnormal pathology found in the appendix and pain location/gross appearance of the appendix combinations when all four such combinations were considered simultaneously ($p = 0.86$) or when pairwise comparisons were considered (Table 5).

Discussion

CPP affects up to 24% of women^{8,9} and is a very common complaint seen in primary care practices.¹⁰ Treatment is difficult due to the multifactorial etiology and poorly understood mechanisms. Elective appendectomy is sometimes performed as an empiric treatment for CPP, particularly in the context of endometriosis,^{11,12} and can be an appropriate treatment option depending on age and history.¹² Although the morbidity associated with elective appendectomy is low, the cost–benefit ratio is unclear, and no specific guidelines exist for its use.¹³

To our knowledge, only one previous study has investigated appendix pathology specifically in the context of R-CPP. AlSalilli and Vilos previously found pathology in 48% of abnormal appearing appendices among a small cohort of women with R-CPP.¹⁴ The investigation of only abnormal appearing appendices may underestimate the true burden of disease and is a limitation of this study. Our study expands upon this work by evaluating the presence of pathology in both normal and abnormal appearing appendices among women with R-CPP.

Interestingly, in the present study, the prevalence of appendix pathology on histology did not vary between R-CPP and N-CPP, despite differences in pain location, gross appearance of the appendix, and endometriosis disease stage. These results are consistent with a previous study finding no overall correlation between endometriosis lesion location and pain location.¹⁵ Despite this, the data still identify an overall high rate of histologically confirmed pathology (30.9% of cases and 34.5% of controls). Regardless of where the patient had CPP, the presence of pathology was 30.6% in macroscopically normal appearing appendices and 37.5% in appendices with

Table 2. Demographic characteristics, symptomatology and pain data, and quality of life scores for cases versus controls.

Characteristic	R-CPP (cases) ^a		N-CPP (controls) ^b		p-value
	(N=165)		(N=55)		
Age (years)	30.7 ± 6.6		31.1 ± 6.3		0.69
	31 (26, 36)		30 (27, 35)		0.69
Race					
Caucasian	141	85.5	46	83.6	
African American	13	7.9	7	12.7	0.42
Other	11	6.7	2	3.6	
Body mass index (kg/m ²)	24.9 (21.7, 30.0)		25.0 (21.3, 32.0)		0.83
Tobacco use					
Never smoker	95	57.6	37	67.3	
Former smoker	36	21.8	6	10.9	0.20
Current smoker	34	20.6	12	21.8	
Parity	0 (0, 1)		0 (0, 1)		0.86
Dysmenorrhea	161	98.2	48	87.3	<0.01
Dyschezia	124	75.6	40	74.1	0.96
Dyspareunia	130	83.9	41	78.8	0.54
Hormonal suppression history					
Intrauterine device	28	17.0	11	20.0	0.76
Oral contraceptive pill	147	89.1	47	85.5	0.63
Implant	7	4.2	3	5.5	0.71
Leuprolide	50	30.3	22	40.0	0.25
Injection	46	27.9	15	27.3	1.00
Patch	4	2.4	0	0.0	0.57
Ring	13	7.9	3	5.5	0.77
Never used	8	4.8	2	3.6	1.00
EHP5 Score	65 (50, 75)		55 (45, 70)		0.25
FSFI Score	18.8 (14.0, 25.8)		20.6 (11.1, 27.9)		0.77

R-CPP: predominantly right-sided chronic pelvic pain; N-CPP: not predominantly right-sided chronic pelvic pain; EHP5: Endometriosis Health Profile Short Form; FSFI: Female Sexual Functioning Index.

Dysmenorrhea was reported at a significantly higher rate in cases compared with controls. Otherwise, cases and controls did not significantly differ in demographic characteristics, symptomatology and pain data, or quality of life scores. Data are presented as means ± standard deviations, medians and interquartile ranges, or n, %.

^aBody mass index, dysmenorrhea, and dyschezia were unknown for one woman; dyspareunia was unknown for 10 women; EHP5 score was unknown for 89 women; FSFI score was unknown for 96 women.

^bDyschezia was unknown for one woman, dyspareunia was unknown for three women, EHP5 score was unknown for 23 women, FSFI score was unknown for 27 women.

gross abnormalities. These high rates are consistent with other studies, and if anything may represent underestimates, as previously published reports have found abnormalities in 50%–81% of appendices from women with CPP or endometriosis.^{14,15}

Grossly abnormal appearing appendices were significantly more common in control patients (43.6% vs 9.7% among cases). This can be explained by more advanced stages of endometriosis among the control group (26% of controls with Stage 3 or 4, compared with 10.5% of cases). The advanced stages among controls would result in increased adhesions within the pelvis and lesions present on the appendix, the two most common reasons for gross abnormal appearance. In addition, the appendix was removed in controls due to advanced endometriosis

disease or abnormal appearance, while in cases, the appendix was removed based on preoperative right-sided pain, regardless of appearance. In future work, comparing patients undergoing systematic planned appendectomy during laparoscopy for CPP regardless of pain location will permit better controlled comparisons.

Although this initial study did not find a relationship between R-CPP and abnormal appendix pathology, additional work is necessary to adequately investigate this possible link. Small sample sizes may have contributed to the lack of significance in this study, as 149 of 220 (67.7%) of the patients fell into a single study group (R-CPP with a normal gross appearance of the appendix). Future studies should strive to enroll a larger study population. In addition, a significant percentage of patients

Table 3. Appendix pathology and surgical data for entire study population of 220 women.

Characteristic		
Gross appearance of appendix		
Normal	180	81.8
Abnormal	40	18.2
Abnormal contour	8	3.6
Adhesions	18	8.2
Lesions (blisters, red spot, blue spot)	16	7.3
Vascular changes	2	0.9
Erythema	3	1.4
Unspecified	2	0.9
Endometriosis found on pathology anywhere	173	78.6
Endometriomas	24	10.9
Obliterated cul-de-sac	16	7.3
Adhesions	67	30.5
Abnormal micro pathology found in appendix		
None	150	68.2
Any	70	31.8
Endometriosis	23	10.5
Endosalpingiosis	1	0.5
Fecalith	13	5.9
Focal appendicitis	7	3.2
Fibrous obliteration	30	13.6
Tumor	1	0.5
Lymphoid hyperplasia	3	1.4
Length of appendectomy surgical procedure (min)	117 (34–381)	
Estimated blood loss (mL)	20 (5–600)	
Length of hospital stay (days)		
0	155	70.5
1	63	28.6
2	2	0.9
Endometriosis stage ^a		
1	91	41.9
2	95	43.8
3	8	3.7
4	23	10.6
Intra/post-operative complications	4	1.8

The percentage of appendices that appeared normal upon gross inspection was 81.8% and decreased to 68.2% upon histological analysis. The most common gross abnormalities included adhesions and lesions, while the most common microscopic abnormalities included fibrous obliteration and endometriosis. Data are presented as medians and ranges or n, %. Length of appendectomy surgical procedure was unknown for one woman, intra/post-operative complications were unknown for two women.

^aEndometriosis stage was based on what was observed clinically and reported in the operative note regardless if endometriosis was later confirmed by pathology. Three women had no clinical evidence of endometriosis as recorded in the operative note.

did not complete quality of life questionnaires, and symptom data were missing for some. This limited our analyses of these parameters. Another interesting question that remains is whether symptoms and quality of life are differentially impacted by appendectomy in patients with R-CPP versus N-CPP. Previous studies have found improvement of chronic pain symptoms following appendectomy.^{14,16–18} In future investigations, patients will be evaluated at various timepoints post-appendectomy to assess whether symptomatic improvement occurs, and if

this is improvement correlated with pain location prior to surgery. Such patient-centered outcomes may be a more useful measurement for investigating whether appendectomy can be an effective intervention for the management of CPP.

In summary, according to our results, triage based on the predominant location of CPP is not helpful in identifying patients with underlying appendix pathology. However, routine appendectomy may be reasonable for any woman with CPP given high rates of abnormal appendix pathology,

Table 4. Appendix pathology and surgical data for cases versus controls.

Characteristic	R-CPP (cases) ^a		N-CPP (controls) ^b		p-value
	(N= 165)		(N=55)		
Gross appearance of appendix					
Normal	149	90.3	31	56.4	<0.001
Abnormal	16	9.7	24	43.6	
Abnormal contour	2	1.2	6	10.9	<0.01
Adhesions	8	4.8	10	18.2	<0.01
Lesions (blisters, red spot, blue spot)	6	3.6	10	18.2	<0.001
Vascular changes	0	0.0	2	3.6	0.06
Erythema	2	1.2	1	1.8	1.00
Unspecified	0	0.0	2	3.6	0.06
Endometriosis found on pathology anywhere	129	78.2	44	80.0	0.92
Endometriomas	15	9.1	9	16.4	0.21
Obliterated cul-de-sac	7	4.2	9	16.4	<0.01
Adhesions	42	25.5	25	45.5	<0.01
Abnormal micro pathology found in appendix					
None	114	69.1	36	65.5	0.74
Any	51	30.9	19	34.5	
Endometriosis	15	9.1	8	14.5	0.37
Endosalpingiosis	1	0.6	0	0.0	1.00
Fecalith	10	6.1	3	5.5	1.00
Focal appendicitis	5	3.0	2	3.6	1.00
Fibrous obliteration	23	13.9	7	12.7	1.00
Tumor	1	0.6	0	0.0	1.00
Lymphoid hyperplasia	3	1.8	0	0.0	0.58
Length of surgical procedure (min)	117.0 (86.5, 161.5)		114.0 (86.5, 162.8)		0.78
Estimated blood loss (mL)	20 (5, 50)		10 (5, 50)		0.29
Length of hospital stay (days)					
0	115	69.7	40	72.7	
1	49	29.7	14	25.5	0.61
2	1	0.6	1	1.8	
Endometriosis stage ^c					
1	72	44.2	19	35.2	
2	74	45.4	21	38.9	<0.05
3	5	3.1	3	5.6	
4	12	7.4	11	20.4	
Intra/post-operative complications ^d	2	1.2	2	3.6	0.27

R-CPP: predominantly right-sided chronic pelvic pain; N-CPP: not predominantly right-sided chronic pelvic pain.

Controls had a significantly higher rate of appendices that appeared grossly abnormal than cases. Controls also were significantly more likely to have obliterated cul-de-sacs and adhesions noted during laparoscopy. The presence of microscopic abnormalities in the appendix did not significantly differ between cases and controls. Data are presented as medians and interquartile ranges or n, %.

^aIntra/post-operative complications were unknown for two women.

^bLength of surgical procedure was unknown for one woman.

^cEndometriosis stage was based on what was observed clinically and reported in the operative note regardless if endometriosis was later confirmed by pathology. Two women with R-CPP and one woman with N-CPP had no clinical evidence of endometriosis as recorded in the operative note.

^dComplications among cases included a vaginal cuff abscess requiring readmission and drainage, and a colonic serosal injury. Complications among controls included a partial transection of the right ureter at the level of the uterosacral ligament, and an accidental rectal enterotomy.

as the appendix is a nonessential organ that poses the risk of future disease such as infection or malignancy. The estimated lifetime risk of appendicitis in women is 6.7%,¹⁹ and these risks may be even higher in patients with CPP. These

risks, coupled with the high rates of pathology found in our study, support the already existent practice of many surgeons to perform routine appendectomy in laparoscopy for CPP.

Table 5. Appendix abnormal pathology by pain location and appendix gross appearance for 220 women.

Abnormal micro pathology found in appendix ^a	R-CPP (cases) (N = 165)		N-CPP (controls) (N = 55)		p-value
Any	51	30.9	19	34.5	0.74
None	114	69.1	36	65.5	
Total	165	100.0	55	100.0	

Abnormal micro pathology found in appendix ^a	R-CPP (N = 165)				N-CPP (N = 55)				p-value ^c
	Gross appearance of appendix				Gross appearance of appendix				
	Abnormal ^b		Normal		Abnormal ^b		Normal		
Any	6	37.5	45	30.2	9	37.5	10	32.3	0.86
None	10	62.5	104	69.8	15	62.5	21	67.7	
Total	16	100.0	149	100.0	24	100.0	31	100.0	

R-CPP: predominantly right-sided chronic pelvic pain; N-CPP: not predominantly right-sided chronic pelvic pain.

$$\begin{aligned} \text{Odds Ratio} &= \frac{\text{odds of abnormal pathology in women with predominantly right-sided chronic pelvic pain}}{\text{odds of abnormal pathology in women with not predominantly right-sided chronic pelvic pain}} \\ &= \frac{51/114}{19/36} = \frac{51 \times 36}{114 \times 19} = 0.85, 95\% \text{ CI: } (0.44, 1.62) \end{aligned}$$

Cases and controls did not significantly differ in the presence of abnormal microscopic pathology found on histological examination of the appendix (OR: 0.85, 95% CI: (0.44, 1.62)). There was no significant association between abnormal pathology found in the appendix and pain location/gross appearance of the appendix combinations when all four such combinations were considered simultaneously ($p=0.86$) or when pairwise comparisons were considered. Data are presented as n, %.

^aAbnormal micro pathology found in appendix may have included any of the following: endometriosis, endosalpingiosis, fecalith, focal appendicitis, fibrous obliteration, tumor, and lymphoid hyperplasia.

^bAbnormal gross appearance of appendix may have included any of the following: abnormal contour, adhesions, lesions, vascular changes, erythema, and unspecified.

^cThe p-value reflects an overall comparison across all four pain location/gross appearance of appendix combinations simultaneously. No pairwise comparisons were significant.

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Author contributions

P.P.Y. conceived the study. All authors contributed to the study design. C.W.C. and K.E.S. collected data and drafted the manuscript. J.A.G. performed statistical analysis. All authors participated in data interpretation. All authors participated in manuscript revision and approved the final version.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethical approval for this study was obtained from Saint Louis University Institutional Review Board under IRB #30000.

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Informed consent to publish

Informed consent was not sought for the present study because of the retrospective nature of the study, the pre-existence of all data used in the study, the lack of intervention, and the minimal harm posed to patients. A waiver of consent was granted by Saint Louis University Institutional Review Board under expedited review.

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