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PREDICTORS OF COMPLICATED APPENDICITIS AND THEIR IMPACT ON APPENDECTOMY OUTCOMES

Adil Mohammed Suleman [1], Janhavi Sirsat [2], Amrithraj Thiyagarajan [3], Vinod Kumar Singhal [4], Faris Dawood Alaswad [5], Hemant Sharma [6], Vidher V V Singhal [7]

[1]. Specialist, General Surgery, Prime Hospital, Dubai, UAE.

[2]. Register, Department of Surgery, Prime Hospital, Dubai, UAE.

[3]. Specialist, General Surgery, Prime Hospital, Dubai, UAE.

[4]. Specialist, General Surgery, Prime Hospital, Dubai, UAE

[5]. Consultant, General Surgery, Prime Hospital, Dubai, UAE

[6]. MD MS FACS, FEBS, Diplomate Multi-Organ Transplant & HPB Surgery (American Society of Transplant)

[7]. Postgraduate UCL, UK

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**Corresponding author*

Adil Mohammed Suleman

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Adil Mohammed Suleman, Specialist, General Surgery, Prime Hospital, Dubai, UAE
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Abstract

Background: Acute appendicitis is one of the most common emergency surgical conditions and may progress to complicated appendicitis, leading to increased operative difficulty, prolonged hospital stay, and postoperative morbidity.

Aim of the study: This study aimed to identify independent predictors of complicated appendicitis among patients undergoing appendectomy in a UK hospital and to evaluate its impact on operative and postoperative outcomes.

Methods: This prospective observational analytic study was conducted among 400 patients clinically diagnosed with acute appendicitis and treated by appendectomy in a UK hospital, from (start) to (end). Data were collected using a structured form that included sociodemographic characteristics, clinical features, laboratory parameters, imaging findings, operative findings, and 30-day postoperative outcomes. Patients were categorized into uncomplicated and complicated appendicitis groups based on operative and/or histopathological findings. Group comparisons were performed using appropriate statistical tests, and multivariable logistic regression was used to identify independent predictors of complicated appendicitis.

Results: Among 400 patients, the mean age was 32.8±13.9 years, with male predominance (236; 59.0%). Complicated appendicitis was found in 138 (34.5%) patients, most commonly perforated appendicitis (64; 16.0%). Complicated cases had significantly higher rates of pain duration >48 hours, fever, rebound tenderness or guarding, raised CRP, hyperbilirubinemia, appendicolith, and periappendiceal fluid collection. They also had longer operative time, prolonged hospital stays, and higher postoperative complications than uncomplicated cases. On multivariable analysis, periappendiceal fluid collection was the strongest independent predictor of complicated appendicitis (AOR 4.89), followed by pain duration >48 hours (AOR 4.31), raised CRP (AOR 3.37), hyperbilirubinemia (AOR 2.78), rebound tenderness or guarding (AOR 2.64), and appendicolith (AOR 2.32).

Conclusion: Complicated appendicitis was common and was associated with poorer appendectomy outcomes, including longer operative time, prolonged hospital stays, and higher postoperative morbidity. Pain duration >48 hours, raised CRP, hyperbilirubinemia, rebound tenderness or guarding, appendicolith, and periappendiceal fluid collection were key independent predictors.

Keywords: Acute appendicitis, Complicated appendicitis, Appendectomy outcomes, and Predictors.

Introduction:

Acute appendicitis remains one of the most common abdominal surgical emergencies worldwide and continues to impose a substantial clinical and service burden despite major advances in diagnostic imaging, perioperative care, and minimally invasive surgery [1,2]. It usually results from obstruction of the appendiceal lumen, followed by bacterial proliferation, inflammation, ischaemia, and, in some cases, progression to gangrene, perforation, abscess, phlegmon, or peritonitis. This distinction between uncomplicated and complicated appendicitis is clinically important because it influences the urgency of intervention, operative difficulty, antibiotic use, hospital stay, postoperative morbidity, and overall resource utilization [2,3].

The global burden of appendicitis remains high. In 2019, approximately 17.7 million new cases of appendicitis were estimated worldwide, with a global age-standardized incidence rate of about 229.9 per 100,000 population [3]. Although mortality has declined in many settings, disease burden remains considerable because appendicitis affects predominantly children, adolescents, and young adults, leading to emergency admissions, operative workload, and loss of productive life-years [3,4]. In the United Kingdom, appendicitis represents a major component of emergency general surgical practice. A large cohort study from NHS hospitals in the North of England reported more than 22,000 adult admissions for acute appendicitis over 15 years, accounting for 4.5% of acute surgical admissions, with increasing use of computed tomography and laparoscopic appendectomy over time [4]. These findings highlight the continuing regional relevance of appendicitis within UK emergency surgical services.

Early and accurate identification of complicated appendicitis is essential. Patients with complicated disease are more likely to require open or technically difficult surgery, longer operative time, drainage, prolonged hospitalization, and treatment for postoperative complications such as surgical site infection, intra-abdominal abscess, ileus, readmission, and rarely death [5,6]. The issue has become more clinically relevant as non-operative management is increasingly considered for selected patients with uncomplicated appendicitis, while complicated appendicitis usually requires more urgent and aggressive surgical or interventional management [6,7]. Therefore, differentiating uncomplicated from complicated appendicitis at presentation is now central to safe decision-making.

Several clinical, laboratory, and radiological factors have been associated with complicated appendicitis. Symptom duration, fever, guarding, leukocytosis, elevated C-reactive protein, hyperbilirubinemia, appendicolith, periappendiceal fat stranding, free fluid, abscess, and increased appendiceal diameter have been reported as useful predictors [8-12]. Recent scoring models combining clinical and imaging parameters have shown promising diagnostic performance, but many remain limited by retrospective design, heterogeneous definitions, variable access to computed tomography, and differences in population characteristics and healthcare pathways [8-11]. In addition, most available studies focus mainly on diagnostic discrimination, while fewer simultaneously examine how complicated appendicitis affects operative and short-term postoperative outcomes in a UK hospital setting.

This gap is important because UK emergency surgical practice requires locally applicable evidence to support risk stratification, imaging decisions, theatre prioritization, counseling, and postoperative planning. Identifying practical predictors using routinely available clinical, laboratory, and imaging findings may help clinicians recognize high-risk patients earlier and reduce avoidable morbidity. Therefore, this study aimed to identify independent predictors of complicated appendicitis among patients undergoing appendectomy in a UK hospital and to evaluate the impact of complicated appendicitis on operative and postoperative outcomes.

Methods

This hospital-based prospective observational analytic study was conducted in the Department of Surgery of [Name of Hospital] from [Month Year] to [Month Year]. A total of 400 patients clinically diagnosed with acute appendicitis and treated by appendectomy during the study period were enrolled by consecutive sampling. Patients of either sex and all age groups, with clinical, laboratory, radiological, operative, or histopathological evidence of acute appendicitis were included. Patients managed conservatively without appendectomy, those undergoing interval or incidental appendectomy, patients with incomplete records, and those who refused consent were excluded.

Data were collected using a pre-designed structured form covering sociodemographic characteristics, clinical presentation, comorbidities, laboratory parameters, and imaging findings. Laboratory variables included total leukocyte count, neutrophil percentage, C-reactive protein, and serum bilirubin, while imaging findings included appendicular diameter, appendicolith, periappendiceal fluid collection, abscess, mass, or phlegmon. The primary outcome was complicated appendicitis, defined as gangrenous or perforated appendix, appendicular abscess, mass, phlegmon, or peritonitis confirmed by operative findings and/or histopathology. Uncomplicated appendicitis was defined as an inflamed appendix without these features. Appendectomy was performed by open or laparoscopic technique according to clinical condition, operative feasibility, surgeon preference, and institutional protocol. Postoperative outcomes were assessed during hospital stay and up to 30 days after surgery, including hospital stay, surgical site infection, intra-abdominal abscess, ileus, wound dehiscence, reoperation, readmission, intensive care admission, and mortality.

Data were analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± standard deviation, and qualitative variables as frequency and percentage. Comparisons between uncomplicated and complicated groups were performed using chi-square test, Fisher's exact test, independent-samples t-test, or Mann-Whitney U test, as appropriate. Multivariable logistic regression was used to identify independent predictors of complicated appendicitis. Results were expressed as odds ratio, adjusted odds ratio, 95% confidence interval, and p-value. A p-value <0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Review Board of [Institution Name]. Written informed consent was obtained, and confidentiality was maintained throughout the study.

Results

Among 400 patients, the largest proportion was aged 19-30 years (148; 37.0%), followed by those aged 31-45 years (104; 26.0%). The mean age was 32.8±13.9 years, male patients were predominant (236; 59.0%), and most participants were from urban areas (245; 61.3%). More than half had a normal BMI (205; 51.3%), while most had no known comorbidity (303; 75.8%).

Variables	Frequency (n)	Percentage (%)
Age group (years)		
≤18	70	17.5
19-30	148	37
31-45	104	26
46-60	54	13.5
>60	24	6
Mean ± SD	32.8 ± 13.9	
Sex		
Male	236	59
Female	164	41
Residence		
Urban	245	61.3
Rural	155	38.8
BMI category		
Underweight	32	8
Normal weight	205	51.3
Overweight	126	31.5
Obese	37	9.3
Comorbidity status		
No known comorbidity	303	75.8
Diabetes mellitus	42	10.5
Hypertension	37	9.3
Both diabetes and hypertension	18	4.5

Table 1. Baseline characteristics of the study participants (N=400)

Right iliac fossa tenderness was the most frequent clinical sign, present in 389 (97.3%) patients. Other common presentations included migration of pain to the right iliac fossa (302; 75.5%); nausea or vomiting (268; 67.0%); anorexia (242; 60.5%); and fever (215; 53.8%). Pain duration of more than 48 hours was reported in 116 (29.0%) patients, while delayed hospital presentation was observed in 121 (30.3%) patients.

Variables	Frequency (n)	Percentage (%)
Pain duration >48 hours	116	29
Migration of pain to right iliac fossa	302	75.5
Fever	215	53.8
Nausea or vomiting	268	67
Anorexia	242	60.5
Right iliac fossa tenderness	389	97.3
Rebound tenderness or guarding	151	37.8
Palpable abdominal mass	40	10
Prior antibiotic use	88	22
Delayed hospital presentation	121	30.3

Table 2. Clinical presentation of the study participants (N=400)

The mean total leukocyte count was 13250±4280 cells/mm³, mean neutrophil percentage was 78.5±10.4%, mean CRP was 58.6±42.3 mg/L, and mean serum bilirubin was 1.16±0.62 mg/dL. Leukocytosis was found in 257 (64.3%) patients, neutrophilia in 243 (60.8%), and raised CRP in 224 (56.0%). On imaging, appendicular diameter >6 mm was the most common finding, 342 (85.5%), followed by periappendiceal fluid collection (96; 24.0%), and appendicolith (90; 22.5%).

Variables	Frequency (n)	Percentage (%)
	Mean ± SD	
Total leukocyte count (cells/mm³)	13250 ± 4280	
Neutrophil percentage (%)	78.5 ± 10.4	
C-reactive protein (mg/L)	58.6 ± 42.3	
Serum bilirubin (mg/dL)	1.16 ± 0.62	
Leukocytosis	257	64.3
Neutrophilia	243	60.8
Raised CRP	224	56
Hyperbilirubinemia	118	29.5
Appendicular diameter >6 mm	342	85.5
Appendicolith	90	22.5
Periappendiceal fluid collection	96	24
Abscess or mass on imaging	46	11.5

Table 3. Laboratory and imaging findings of the study participants (N=400)

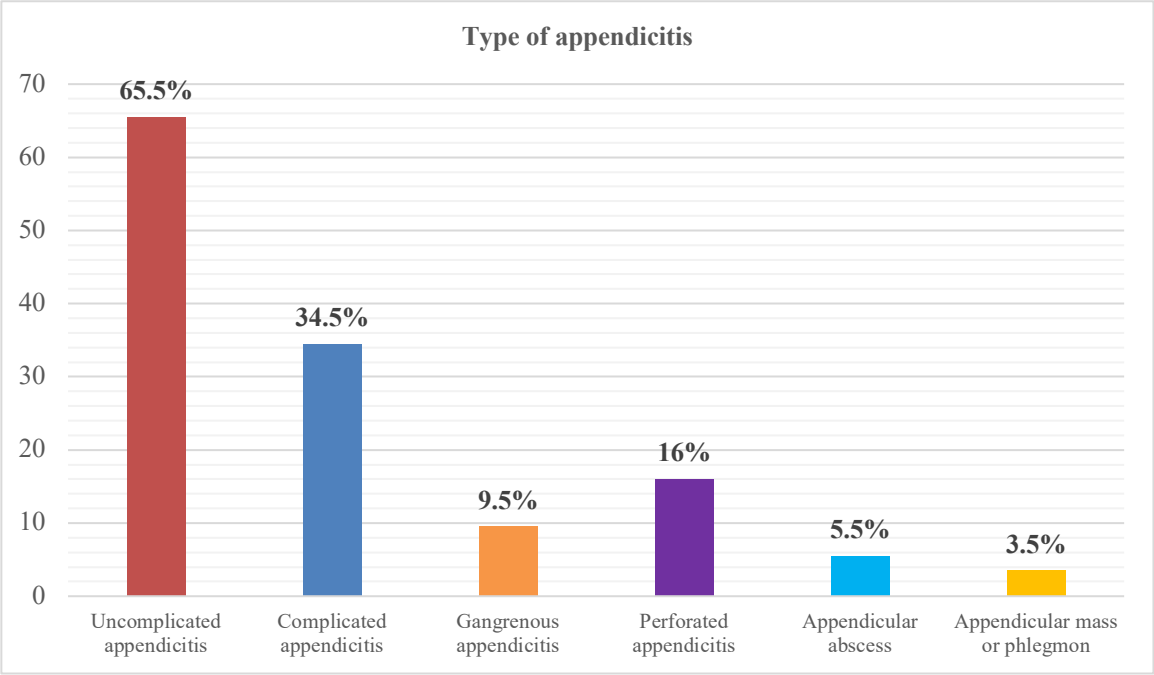

Figure 1. Distribution of uncomplicated and complicated appendicitis (N=400)

Out of 400 patients, 262 (65.5%) had uncomplicated appendicitis, while 138 (34.5%) had complicated appendicitis. Among complicated cases, perforated appendicitis was the most common, observed in 64 (16.0%) patients, followed by gangrenous appendicitis (38; 9.5%); appendicular abscess (22; 5.5%); and appendicular mass or phlegmon (14; 3.5%).

Complicated appendicitis was significantly more common among patients aged >40 years (36.2% versus 21.0%), males (65.9% versus 55.3%), and rural residents (47.8% versus 34.0%). Strong clinical and laboratory predictors included pain duration >48 hours (56.5% versus 14.5%), fever (71.0% versus 44.7%), rebound tenderness or guarding (63.0% versus 24.4%), raised CRP (83.3% versus 41.6%), hyperbilirubinemia (55.1% versus 16.0%), and periappendiceal fluid collection (52.2% versus 9.2%). All these differences were statistically significant.

Variables	Uncomplicated appendicitis (n=262)	Complicated appendicitis (n=138)	p-value
Age >40 years	55 (21.0)	50 (36.2)	<0.001
Male sex	145 (55.3)	91 (65.9)	0.04
Rural residence	89 (34.0)	66 (47.8)	0.007
Pain duration >48 hours	38 (14.5)	78 (56.5)	<0.001
Fever	117 (44.7)	98 (71.0)	<0.001
Rebound tenderness or guarding	64 (24.4)	87 (63.0)	<0.001
Palpable abdominal mass	9 (3.4)	31 (22.5)	<0.001
Leukocytosis	143 (54.6)	114 (82.6)	<0.001
Raised CRP	109 (41.6)	115 (83.3)	<0.001
Hyperbilirubinemia	42 (16.0)	76 (55.1)	<0.001
Appendicolith	36 (13.7)	54 (39.1)	<0.001
Periappendiceal fluid collection	24 (9.2)	72 (52.2)	<0.001

Table 4. Comparison of predictors between uncomplicated and complicated appendicitis

Patients with complicated appendicitis had poorer operative and postoperative outcomes than those with uncomplicated appendicitis. Open appendectomy was more frequent in complicated cases (67.4% versus 44.7%), whereas laparoscopic appendectomy was less frequent (32.6% versus 55.3%). Complicated cases had a longer mean operative time (72.4±21.6 versus 49.6±14.8 minutes) and a longer mean hospital stay (5.8±2.4 versus 2.6±1.1 days). Postoperative complications were also higher, including surgical site infection (27.5% versus 5.3%), intra-abdominal abscess (10.9% versus 0.8%), postoperative ileus (14.5% versus 1.9%), readmission (11.6% versus 1.9%), and overall postoperative complications (37.7% versus 9.5%).

Outcomes	Uncomplicated appendicitis (n=262)	Complicated appendicitis (n=138)	p-value
Open appendectomy	117 (44.7)	93 (67.4)	<0.001
Laparoscopic appendectomy	145 (55.3)	45 (32.6)	<0.001
Operative time ≥60 minutes	62 (23.7)	97 (70.3)	<0.001
Drain placement	31 (11.8)	94 (68.1)	<0.001
Hospital stay >3 days	48 (18.3)	106 (76.8)	<0.001
Surgical site infection	14 (5.3)	38 (27.5)	<0.001
Intra-abdominal abscess	2 (0.8)	15 (10.9)	<0.001
Postoperative ileus	5 (1.9)	20 (14.5)	<0.001
Reoperation	1 (0.4)	8 (5.8)	0.001
Readmission within 30 days	5 (1.9)	16 (11.6)	<0.001
Mortality	0 (0.0)	2 (1.4)	0.118
Overall postoperative complication	25 (9.5)	52 (37.7)	<0.001

Table 5. Impact of complicated appendicitis on appendectomy outcomes

Multivariable logistic regression showed that periappendiceal fluid collection was the strongest independent predictor of complicated appendicitis (AOR 4.89, 95% CI: 2.64-9.05, p<0.001), followed by pain duration >48 hours (AOR 4.31, 95% CI: 2.43-7.65, p<0.001), raised CRP (AOR 3.37, 95% CI: 1.84-6.16, p<0.001), hyperbilirubinemia (AOR 2.78, 95% CI: 1.59-4.86, p<0.001), rebound tenderness or guarding (AOR 2.64, 95% CI: 1.54-4.52, p<0.001), and appendicolith (AOR 2.32, 95% CI: 1.28-4.20, p=0.006). Male sex and rural residence were not independent predictors after adjustment.

Variables	Crude OR	Adjusted OR	95% CI	p-value
Age >40 years	2.14	1.68	1.01-2.79	0.045
Male sex	1.56	1.29	0.77-2.15	0.328
Rural residence	1.78	1.42	0.86-2.34	0.171
Pain duration >48 hours	7.66	4.31	2.43-7.65	<0.001
Fever	3.04	1.76	1.02-3.05	0.043
Rebound tenderness or guarding	5.28	2.64	1.54-4.52	<0.001
Leukocytosis	3.95	2.05	1.11-3.77	0.022
Raised CRP	7.02	3.37	1.84-6.16	<0.001
Hyperbilirubinemia	6.42	2.78	1.59-4.86	<0.001
Appendicolith	4.04	2.32	1.28-4.20	0.006
Periappendiceal fluid collection	10.82	4.89	2.64-9.05	<0.001

Table 6. Multivariable logistic regression analysis of predictors of complicated appendicitis

Discussion

The present prospective observational study showed that complicated appendicitis remains a frequent and clinically important condition in emergency surgical practice. Among 400 patients, 138 (34.5%) had complicated appendicitis, while 262 (65.5%) had uncomplicated disease. Perforated appendicitis was the most common complicated form, observed in 64 (16.0%) patients, followed by gangrenous appendicitis in 38 (9.5%), appendicular abscess in 22 (5.5%), and appendicular mass or phlegmon in 14 (3.5%). This proportion is comparable to that in the SAS 2.0 validation study, in which complicated appendicitis accounted for nearly one-third of cases [13]. Similar rates have also been reported in large observational studies and guideline-based reviews, although reported frequencies vary with patient selection, disease definition, imaging availability, and delay to presentation [2,5]. A UK-based cohort from the North of England also confirmed that acute appendicitis remains a major emergency surgical burden, with variation in investigation, operative approach, and outcomes across hospitals [4].

Delayed presentation emerged as one of the strongest predictors of complicated appendicitis. Pain duration >48 hours was significantly more common among complicated cases than uncomplicated cases (56.5% versus 14.5%) and remained independently associated with complicated disease (AOR 4.31, 95% CI 2.43–7.65, p<0.001). This finding is consistent with previous studies [14-18], where they reported that prolonged symptom duration increases the risk of gangrene, perforation, abscess, and localized peritonitis. The biological explanation is clear: persistent luminal obstruction, bacterial proliferation, elevated intraluminal pressure, vascular compromise, and transmural necrosis may progress to perforation if treatment is delayed.

Clinical signs were also strongly related to disease severity. Rebound tenderness or guarding was found in 63.0% of complicated cases compared with 24.4% of uncomplicated cases and remained an independent predictor (AOR 2.64, 95% CI 1.54–4.52, p<0.001). Fever also independently predicted complicated appendicitis (AOR 1.76, 95% CI 1.02–3.05, p=0.043). These findings agree with previous studies showing that peritoneal irritation and systemic inflammatory response are more frequent in advanced appendiceal inflammation [15-17]. However, clinical findings alone may not be sufficient because early complicated appendicitis can present atypically, especially among elderly patients, immunocompromised patients, and those who have already received antibiotics.

Laboratory markers provided additional predictive value. Raised CRP was present in 83.3% of complicated cases compared with 41.6% of uncomplicated cases and remained independently associated with complicated appendicitis (AOR 3.37, 95% CI 1.84–6.16, p<0.001). Leukocytosis was also independently predictive (AOR 2.05, 95% CI 1.11–3.77, p=0.022). These findings are consistent with previous studies [12,16,20,21] which identified CRP, leukocyte count, and other inflammatory markers as useful indicators of complicated appendicitis. Hyperbilirubinemia was also significantly more frequent in complicated cases than in uncomplicated cases (55.1% versus 16.0%) and remained independently predictive (AOR 2.78, 95% CI 1.59–4.86, p<0.001). This supports previous studies suggesting that raised bilirubin may result from bacterial translocation, endotoxaemia, portal bacteraemia, or sepsis-related cholestasis in gangrenous or perforated appendicitis [19,22].

Radiological findings were among the strongest predictors. Periappendiceal fluid collection was observed in 52.2% of complicated cases compared with 9.2% of uncomplicated cases and was the strongest independent predictor in the model (AOR 4.89, 95% CI 2.64–9.05, p<0.001). Appendicolith was also more common in complicated cases (39.1% versus 13.7%) and remained independently significant (AOR 2.32, 95% CI 1.28–4.20, p=0.006). These findings are consistent with CT-based scoring studies [8,9,13,14], in which periappendiceal fluid, appendicolith, abscess, phlegmon, and surrounding inflammatory changes were important indicators of complicated disease.

Complicated appendicitis had a clear adverse effect on appendectomy outcomes. Open appendectomy was more common in complicated cases than in uncomplicated cases (67.4% versus 44.7%), while laparoscopic appendectomy was less frequent (32.6% versus 55.3%). Complicated cases also had longer operative time (72.4±21.6 versus 49.6±14.8 minutes) and longer hospital stay (5.8±2.4 versus 2.6±1.1 days). Overall postoperative complication rates were markedly higher in complicated cases (37.7% versus 9.5%). Surgical site infection (27.5% versus 5.3%), intra-abdominal abscess (10.9% versus 0.8%), postoperative ileus (14.5% versus 1.9%), reoperation (5.8% versus 0.4%), and 30-day readmission (11.6% versus 1.9%) were also increased. These findings are consistent with previous studies showing that perforation, abscess, contamination, and longer operative time increase postoperative morbidity [23-26]. Mortality was higher in complicated cases (1.4% versus 0.0%), although not statistically significant, probably due to the small number of deaths.

The findings have important clinical implications for UK emergency surgical care. Patients presenting with pain duration >48 hours, fever, rebound tenderness or guarding, leukocytosis, raised CRP, hyperbilirubinemia, appendicolith, or periappendiceal fluid collection should be regarded as high-risk for complicated appendicitis. Early senior surgical review, timely imaging, broad-spectrum antibiotics, theatre prioritization, and closer postoperative monitoring may reduce morbidity. These findings also support careful exclusion of complicated disease before considering conservative or antibiotic-first treatment for presumed uncomplicated appendicitis.

Limitation of the study: This study was limited by its single-center design, which may restrict generalisability to all UK hospital settings. Some findings may have been influenced by surgeon preference, institutional protocols, and variation in imaging use. The 30-day follow-up period may not capture late postoperative complications.

Conclusion

This study concluded that complicated appendicitis was common among patients undergoing appendectomy in a UK hospital setting and was associated with significantly poorer operative and postoperative outcomes. Pain duration >48 hours, raised CRP, hyperbilirubinemia, rebound tenderness or guarding, appendicolith, and periappendiceal fluid collection were important independent predictors of complicated appendicitis. Patients with complicated appendicitis had longer operative time, prolonged hospital stay, and higher rates of postoperative complications, including surgical site infection, intra-abdominal abscess, ileus, reoperation, and readmission. Early recognition of these predictors may support timely surgical decision-making and improve appendectomy outcomes.

Recommendations

Patients with suspected acute appendicitis should be promptly assessed for high-risk features such as prolonged pain duration, raised inflammatory markers, hyperbilirubinemia, appendicolith, and periappendiceal fluid collection. High-risk patients should receive early senior surgical review, timely imaging, appropriate antibiotics, and prompt operative planning. Further multicentre UK studies are recommended to validate these predictors and develop a practical risk-scoring tool.

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