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Proactive Clinical Auditing and Continuous Surgical Practice Monitoring in Reducing the Rate of Negative Appendectomy in Children

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ABSTRACT

Introduction:
Acute appendicitis is the most common intra-abdominal paediatric surgical emergency, with appendectomy being its standard treatment. In most centres, acute appendectomy is performed based on clinical diagnosis and hence has been associated with a negative appendectomy rate of 10-25%. Negative appendectomy has been associated with morbidity to the extent of 10-12% and mortality of 1%. We herein present our experience with proactive clinical auditing and a surgical monitoring approach in reducing the rate of negative appendectomy in children.

Materials and Methods:
We conducted a prospective clinical audit in a tertiary pediatric surgical center. All children with suspected acute abdominal pain and suspected appendicitis were treated on a standardized clinical pathway. The diagnostic workup included clinical scoring (Alvarado score), laboratory studies, and imaging (ultrasound and CT, as needed). All cases undergoing appendectomy were evaluated through histopathology. Negative appendectomy cases were reviewed weekly. Diagnostic and management algorithms were modified for subsequent cases.

Results:
Implementation of proactive auditing and continuous monitoring reduced the negative appendectomy rate to below 2%. This compares with the 10-25% rate reported in the literature. Multidisciplinary case discussions and real-time feedback helped identify diagnostic pitfalls. These efforts also refined clinical pathways.

Conclusion:
Proactive auditing and surgical monitoring appear effective in minimizing negative appendectomy rates. This approach improves compliance with diagnostic protocols, enhances surgical decision-making, and reduces morbidity associated with negative appendectomy.

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Introduction

Acute appendicitis remains the most common abdominal surgical emergency in the paediatric age group, with a reported incidence of 15.3 per 10,000 children, with peak incidence between 12 and 17 years of age (1,2).

The diagnosis of acute appendicitis is mostly based on clinical findings to calculate the appendicitis score and is often facilitated by radiological evaluation in the form of an abdominal ultrasound scan. Laparoscopic appendectomy remains the gold standard surgical approach (3). Despite advances in diagnostic imaging and scoring systems, accurate diagnosis of acute appendicitis in children remains challenging and often results in negative appendectomy, which has been reported in the literature in 10-25% of cases (4).

The negative appendectomy has been associated with complications like wound infection, adhesion-related small bowel obstruction, which has been reported in 10-12% of cases (5,6). To minimize associated complications, authors have proposed the use of structured clinical scoring systems (Alvarado or Paediatric Appendicitis Score), increased reliance on imaging modalities such as ultrasound and CT scans, and standardized diagnostic pathways (7-10). However, variability in clinical practice and differences in diagnostic thresholds continue to contribute to misdiagnosis.

Clinical audit remains a well-established tool for improving patient care in clinical practice, but proactive auditing in surgical practice is still not universally practiced. In surgical practice, audit tools are predominantly confined to retrospective case analyses. Consequently, by the time shortcomings in management are recognized and corrective strategies are introduced, a significant proportion of patients may already have been exposed to comparable complications.

Proactive auditing is systematic, quality improvement process in surgical practice which involves real-time assessment of cases, identification of potential pitfalls, and immediate corrective measures, whereas reactive auditing focuses on retrospective review of errors (11,12). Incorporating continuous monitoring with proactive auditing allows surgical teams to refine diagnostic approaches dynamically, thereby minimizing avoidable errors. This study aimed to evaluate the effectiveness of a structured proactive audit and continuous monitoring program in reducing the incidence of negative appendectomy in a paediatric surgical unit.

Materials and Methods

This prospective audit-based quality improvement initiative was conducted in the Department of Paediatric Surgery, Latifa and Al Jalila Children's Hospital, Dubai, between January 2018 and December 2024. All paediatric patients aged 0–18 years who presented to the emergency department with a clinical suspicion of appendicitis were included in this study.

Patients managed conservatively without surgical intervention were excluded. The diagnostic pathway was followed, which included a standardized clinical assessment in the form of history, physical examination, and laboratory investigations, which included total leukocyte count and C-reactive protein.

All patients underwent risk stratification by utilizing the Alvarado score. Ultrasound was used as the first-line imaging modality, while children with equivocal clinical findings in the presence of a high index of suspicion (Alvarado score ≥7) underwent contrast-enhanced computed tomography. Surgical management in the form of was laparoscopic appendectomy was performed in children with either a confirmed or highly probable diagnosis of appendicitis. The histopathology of all appendectomy specimens was reviewed, and cases showing no evidence of appendicitis, such as lymphoid hyperplasia, peri-appendicitis, carcinoid tumor, mural eosinophilia, or a normal appendix, were categorized as negative appendectomies.

All cases were prospectively entered into a surgical audit database, and patients with negative appendectomy were systematically reviewed in weekly morbidity and mortality meetings where management pitfalls were analyzed through collaborative discussions among surgeons and radiologists.

The clinical pathways were modified in real time and disseminated across the surgical

team for their implementation in subsequent cases. The primary outcome measure was the negative appendectomy rate, defined as the proportion of total appendectomies with normal histopathology, while secondary outcomes included postoperative morbidity, length of hospital stay, and compliance with diagnostic protocols.

Results

A total of 652 appendectomy cases with a mean age of 11.2 ± 3.7 years were analysed between 2018 and 2024, with a relatively stable overall case volume ranging from approximately 95 to 135 cases per year (Table 1).

Table 1: No of cases of Appendectomy

Year	No of cases	Pathology		Rate of Negative Appendectomy (%)
		Positive	Negative	
2018	116	104	12	10
2019	126	118	10	8
2021	92	87	5	5.5
2022	112	110	2	1.7
2023	119	118	1	0.8
2024	121	119	2	1.6

In 2018 and 2019, negative appendectomies accounted for approximately 10% and 8% of cases, respectively. Following the implementation of structured diagnostic pathways and real-time audit feedback, the NAR declined further to 5.5% in 2021 (5/92), 1.7% in 2022 (2/112), and reached a nadir of 0.8% in 2023 (1/119). A slight increase was observed in 2024, with 2 of 121 cases negative (1.6%). (Figure 1).

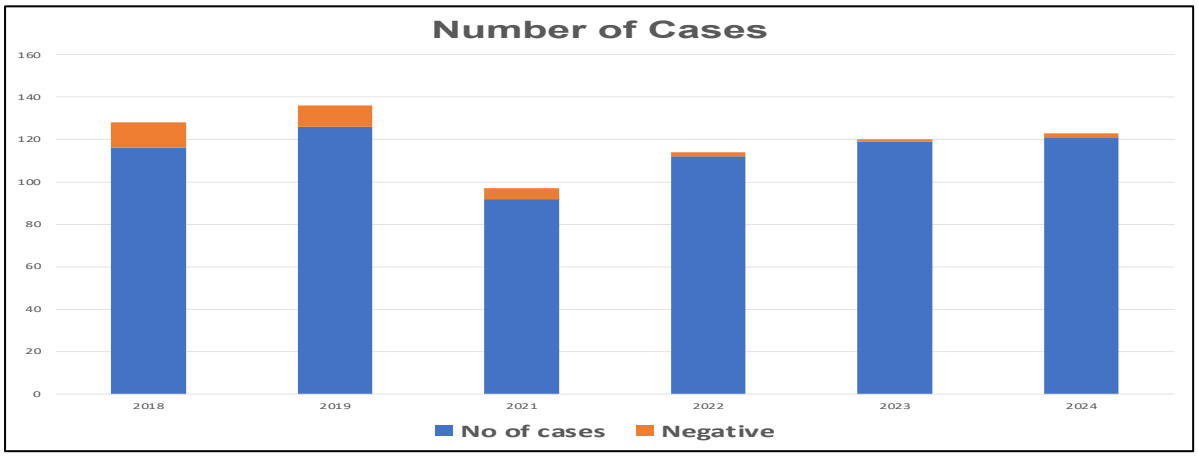

Figure 1: No of cases of Negative Appendectomy

Histopathological analysis of negative appendectomy specimens revealed several non-specific or non-diagnostic findings. These included acute intraluminal inflammation without transmural involvement, acute mucosal (catarrhal) inflammation, peri appendicitis, and increased mural eosinophilic infiltration. These patterns were generally associated with minimal or no gross pathological changes. In particular, peri appendicitis and catarrhal inflammation were considered

likely secondary to extra-appendiceal processes or self-limiting conditions, while eosinophilic infiltration was of uncertain significance. The downward trend in negative appendectomy rates over the 7-year period corresponds with an apparent improvement in preoperative diagnostic accuracy, reflecting more judicious use of clinical scoring systems and availability of advanced imaging, which facilitated more accurate operative decision making (Table 3).

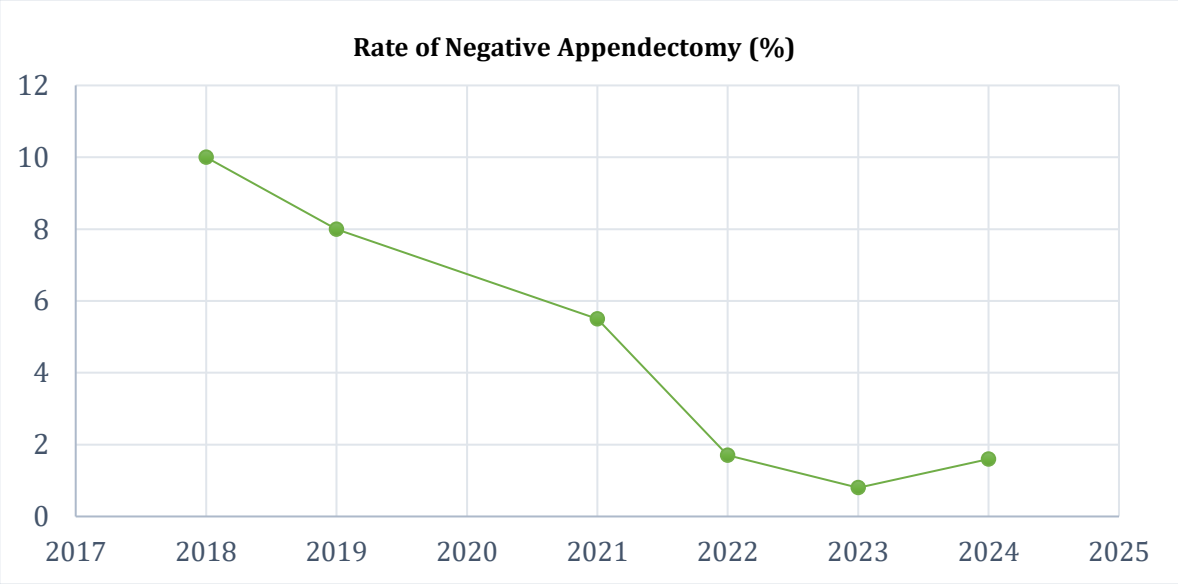

Figure 2: Rate of Negative Appendectomy

This trend highlights the impact of proactive auditing and continuous refinement of diagnostic protocols in achieving and sustaining a negative appendectomy rate consistently below the internationally accepted benchmark of 2% in recent years. The graph illustrates the correlation between abdominal CT scan usage and the rate of negative appendectomies over the years 2018 to 2024. It shows that as the percentage of CT scans increased, particularly in 2019, 2022, and 2024, the incidence of negative appendectomies decreased consistently, reaching the lowest point in 2023. Notably, in 2021, when CT scan utilization dropped to zero, the rate of negative appendectomies was still moderate, but as CT use rose again in subsequent years, negative appendectomies further declined. This trend suggests that greater reliance on CT scans plays a significant role in reducing unnecessary appendectomies by improving diagnostic accuracy.

The overall postoperative morbidity rate among cases undergoing negative appendectomy was 7.2%, with surgical site infections being the most frequent complication (3.5%), followed by intra-abdominal abscesses (1.1%) and postoperative bowel obstruction (0.6%). Importantly, no mortality was recorded during the study period. The mean hospital stay was 2.8 ± 1.1 days, reflecting generally favorable postoperative outcomes.

Discussion

Negative appendectomy has been a concern in pediatric surgery for a long time. It leads to issues that go beyond immediate postoperative problems. Reported complications, which remain both physical and emotional challenges in the pediatric age group, include wound infections, intra-abdominal collections, postoperative ileus, and bowel obstruction from adhesions with a cumulative morbidity rate of 10 to 12% (5,6). Negative appendectomy also extends hospital stays and raises healthcare costs, apart from taking away limited surgical resources from patients who need them. Thus, reducing the negative appendectomy rate is not just a statistical goal, but it also directly improves patient safety and healthcare efficiency.

Traditional quality control methods in surgical practice are reactive and analysed after retrospective auditing, thus resulting in

the identification of errors after they have already caused harm (11,12). In contrast, proactive auditing focuses on prevention, real-time feedback, and forward-thinking correction (Figure1). By systematically reviewing clinical pathways right after a surgical procedure like appendectomy, the diagnostic issues like relying too much on unclear ultrasound results or giving too much weight to clinical suspicion in unusual cases, can be identified prospectively. This also facilitates academic discussion so that they were actively included in updated diagnostic guidelines for later patients. This ongoing learning cycle shows the principles of high-reliability organizations. These groups focus on preventing errors, working together across disciplines, and improving step by step. Similar proactive strategies in other surgical areas, like trauma care and perioperative safety checklists, have shown clear benefits in lowering bad outcomes (13-15). Our study showed that active auditing and ongoing monitoring of pediatric appendicitis cases significantly lowered the rate of negative appendectomy to less than 2%. This finding is especially important when we compare it to historical rates of 10 to 25% reported among pediatric populations worldwide (4,6,8). The strength of our approach comes from using imaging and scoring systems and from integrating real-time audit and feedback into regular surgical decision-making.

While imaging and scoring systems like the Alvarado and Pediatric Appendicitis Scores are important diagnostic tools, their sensitivity and specificity are not absolute (8,9). Ultrasound is non-invasive and does not use radiation, but it relies on the operator and may lead to inconclusive results, especially in obese children or those with unusual appendix positions (5). CT scans offer better diagnostic accuracy but expose children to ionizing radiation, which raises concerns about long-term cancer risk (9,13). A review of literature suggests that even with advanced imaging, misdiagnoses still happen. Proactive auditing provides an extra layer of safety by reviewing cases of diagnostic uncertainty together. The ongoing changes to clinical pathways, such as adding second-opinion radiology reviews with next-day ultrasound scans, facilitate diagnostic accuracy and even limit the use of CT scan in cases with a high index of suspicion, thus further reducing unnecessary appendectomies.

One of the less obvious but important results of proactive auditing is its effect on team culture and surgical education. As experienced in the present study, regular discussions about cases bring together different specialties, promote open communication, lower hierarchical barriers, and encourage junior staff to evaluate their clinical reasoning. By discussing diagnostic errors without assigning blame, the audit process creates a culture of safety and ongoing improvement. This supports the World Health Organization's framework for patient safety, which focuses on learning from systems instead of pointing fingers at individuals (16).

Healthcare economics plays a crucial role in pediatric surgery. A negative appendectomy leads to direct costs for the operation and hospital stay, along with indirect costs from parents missing work and children missing school. At busy centers, even a slight decrease in unnecessary appendectomies can result in substantial savings by providing OR time and bed occupancy apart from availed hospital resources, physician and nursing man-hours. Hence, several strategies have been suggested to lower negative appendectomy rates. These include routine MRI for unclear cases (17), point-of-care biomarkers like procalcitonin and serum amyloid A (18), and treating selected patients with antibiotics instead of surgery (10). While these methods are promising, they also bring up concerns about cost, accessibility, and the risk of recurrence. Our proactive audit model works alongside these strategies, providing a way to integrate new diagnostic and treatment methods safely. Although proactive auditing takes staff time but is cost-effective over time, as it lowers surgical complications and improves resource use.

Despite the positive results, several limitations should be recognized in the present study. This was a single-center study done in a specialized pediatric facility, which may affect its applicability to other settings. The success of proactive auditing depends a lot on the institutional culture, the

availability of various expertise, and the commitment to ongoing review; these factors can differ between centers. Also, while we showed a decrease in negative appendectomy rates, we did not look at long-term outcomes like adhesion-related illness or effects on quality of life. Furthermore, the audit did not formally assess differences in imaging interpretation among different observers, which is a known cause of diagnostic mistakes.

Future research should focus on collaborations across multiple centers to confirm how proactive auditing applies in different healthcare settings. Using artificial intelligence in radiology and decision-support systems may further improve diagnostic accuracy when paired with structured auditing frameworks (16-19). Long-term studies are needed to evaluate the benefits of lower negative appendectomy rates on complications related to adhesions, fertility outcomes in women, and overall cost savings. Lastly, including proactive audit principles in surgical training programs may help ensure this practice remains sustainable and widespread (19).

Conclusion

Proactive auditing and continuous monitoring are effective tools for improving pediatric surgical care. Our experience with the present structured approach lowered the negative appendectomy rate to less than 2%. This shows that real-time auditing, teamwork across different specialties, and updating protocols regularly are important strategies to reduce diagnostic errors and surgical complications. An insight among the surgical community will help in a widespread implementation of proactive auditing for routine surgical procedures, thus helping surgeons identifying pitfalls in patient management in real time with the aim to optimize outcomes.

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