RESEARCH
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Preoperative Imaging and Appendicectomy Rates: Insights from General Surgery

Dr. Mohd Shoeb. J Deshmukh (Junior Resident)[1], Dr. Nitin Nangare (Professor)[2], Dr. Piyush Rakh (Junior Resident)[3]
Department of General Surgery, Krishna Institute of Medical Sciences,KVV, Karad.
Corresponding Author-
Dr. Mohd Shoeb J Deshmukh (Junior Resident), Department of General Surgery, Krishna Institute of Medical Sciences,KVV, Karad

Abstract
This study delves into General Surgery by analyzing the Negative Appendicectomy Rate (NAR) within a single tertiary health service, with a specific focus on the influence of pre-operative imaging on acute appendicitis management. The study not only compares NAR data with existing literature but also evaluates the efficacy of various imaging modalities. The analysis encompasses a total of 820 cases, primarily centered around laparoscopic appendicectomies. Among the 633 laparoscopic procedures scrutinized, the NAR was identified at 11.2%, with an overall tumor incidence recorded at 1.5%. Particularly noteworthy were cases lacking preoperative imaging or relying solely on ultrasound, which exhibited elevated NARs of 19.3% and 17.4%, respectively. However, the utilization of Computed Tomography (CT), notably in males under 40, correlated with a significantly lower NAR of 3.0%. The study underscores the pivotal role of preoperative imaging, particularly CT scans, in accurately diagnosing appendicitis and guiding surgical intervention. While the study's NAR shows improvement compared to accepted rates, it remains relatively high on an international scale. These findings underscore the potential of preoperative imaging in refining diagnostic accuracy and optimizing patient selection for surgery within the realm of General Surgery.
Keywords:Appendicitis Negative Appendicectomy Rate (NAR) Preoperative Imaging Surgical Decision-making Diagnostic Accurac

INTRODUCTION

In the landscape of General Surgery, acute appendicitis stands as one of the most common surgical emergencies encountered worldwide. Despite its prevalence and seemingly straightforward presentation, the diagnosis and subsequent management of acute appendicitis remain a clinical challenge, often fraught with diagnostic uncertainties and therapeutic dilemmas. Central to this challenge is the phenomenon of negative appendicectomy, where patients undergo unnecessary appendectomy due to diagnostic inaccuracies, leading to potential morbidity, increased healthcare costs, and patient dissatisfaction. Understanding and mitigating negative appendicectomy rates (NAR) have thus emerged as critical endeavors within the realm of General Surgery, prompting a surge of research aimed at elucidating the factors influencing NAR and devising strategies to optimize diagnostic accuracy and surgical decision-making.The significance of negative appendicectomy extends beyond its clinical ramifications to encompass broader healthcare implications. Not only does it contribute to the burden on healthcare resources and surgical workload, but it also underscores the imperative of enhancing the efficiency and accuracy of diagnostic pathways in acute surgical conditions. Moreover, the quest to minimize negative appendicectomy rates epitomizes the broader paradigm shift within General Surgery towards evidence-based practice, where clinical decisions are increasingly guided by empirical data and objective metrics rather than traditional dogma or anecdotal experience.

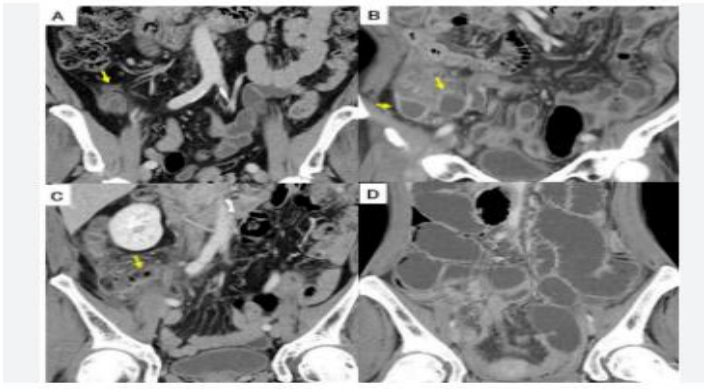

Fig.1 : Presence of Periappendiceal fluid

Against this backdrop, this study embarks on a comprehensive exploration of negative appendicectomy rates within the context of a single tertiary health service, offering valuable insights into the intricacies of acute appendicitis management and the role of preoperative imaging in optimizing surgical outcomes. By delving into the nuances of NAR and interrogating the impact of imaging modalities on diagnostic accuracy, this research endeavors to advance our understanding of acute appendicitis while paving the way for more refined and evidence-based approaches to its management.The rationale underlying the focus on negative appendicectomy rates stems from the recognition of its multifaceted implications and the persistent challenges it poses to both clinicians and patients. Despite decades of clinical experience and technological advancements, the accurate diagnosis of appendicitis remains elusive in a significant proportion of cases, leading to a considerable proportion of unnecessary surgeries and attendant complications. Moreover, the repercussions of negative appendicectomy extend beyond the immediate perioperative period, encompassing long-term sequelae such as psychological distress, surgical site infections, and prolonged hospital stays, all of which exact a toll on patients' well-being and healthcare resources.Historically, the evaluation of suspected appendicitis has relied heavily on clinical assessment supplemented by laboratory investigations and radiological imaging.

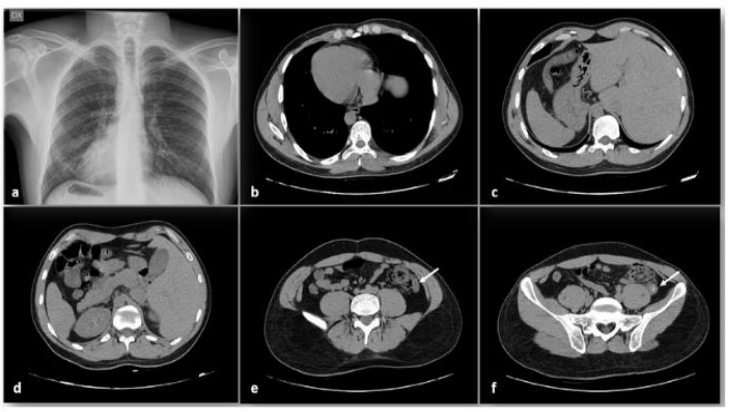

Fig. 2: Radiological imaging with the infection

However, the optimal diagnostic approach remains a subject of debate, with variations in practice patterns reflecting differences in institutional protocols, clinician experience, and resource availability. While some advocate for a conservative "watchful waiting" approach, others advocate for a more aggressive stance, favoring early surgical intervention to mitigate the risk of perforation and its attendant complications. Amidst these divergent viewpoints, the imperative of minimizing negative appendicectomy rates emerges as a unifying goal, driving efforts to refine diagnostic algorithms and leverage technological innovations to enhance diagnostic accuracy and surgical decision-making.Against this backdrop, the role of preoperative imaging assumes paramount importance, offering a non-invasive means of corroborating clinical suspicions and guiding surgical planning. Various imaging modalities, including ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI), have been employed in the evaluation of acute appendicitis, each with its unique strengths and limitations. While ultrasound is widely accessible and devoid of ionizing radiation, its operator-dependent nature and limited sensitivity in obese patients have prompted skepticism regarding its reliability as a standalone diagnostic tool. Conversely, CT imaging, with its superior spatial resolution and ability to visualize peri-appendiceal inflammation, has gained favor among clinicians for its diagnostic accuracy and ability to identify alternative diagnoses. However, concerns regarding radiation exposure, particularly in pediatric populations, have tempered enthusiasm for its routine use, necessitating a judicious risk-benefit analysis in clinical decision-making.Amidst these considerations, the quest to optimize preoperative imaging strategies and minimize negative appendicectomy rates assumes heightened significance, underscoring the need for empirical evidence to inform clinical practice and mitigate diagnostic uncertainties. By elucidating the impact of imaging modalities on NAR and identifying factors associated with diagnostic accuracy, this study endeavors to advance our understanding of acute appendicitis while facilitating informed decision-making and enhancing patient outcomes.

Research Gap:

Despite considerable advances in diagnostic imaging and surgical techniques, the management of acute appendicitis continues to pose challenges, with negative appendicectomy rates (NAR) representing a persistent concern. Existing literature has provided valuable insights into the factors influencing NAR, including the role of preoperative imaging modalities such as ultrasound and computed tomography (CT). However, significant variations in practice patterns and conflicting evidence regarding the optimal diagnostic approach underscore the need for further research to elucidate the determinants of NAR and inform evidence-based clinical practice. Moreover, while several studies have investigated the impact of preoperative imaging on NAR, few have examined this relationship within the context of a single tertiary health service, thereby limiting the generalizability of findings and necessitating tailored interventions to address institutional challenges and resource constraints. Thus, there exists a notable research gap in understanding the intricacies of NAR and optimizing diagnostic strategies to enhance patient outcomes in acute appendicitis management.

Specific Aims of the Study:

The primary aim of this study is to comprehensively analyze negative appendicectomy rates within a single tertiary health service and investigate the impact of preoperative imaging modalities on diagnostic accuracy and surgical decision-making in acute appendicitis management. Specific objectives include:

1. To determine the negative appendicectomy rate (NAR) within the study population and compare it with established benchmarks and published data.
2. To evaluate the diagnostic accuracy of different preoperative imaging modalities, including ultrasound and computed tomography (CT), in identifying acute appendicitis.
3. To assess the association between preoperative imaging findings and surgical outcomes, including operative findings, postoperative complications, and length of hospital stay.
4. To identify factors associated with variations in negative appendicectomy rates, including patient demographics, clinical presentation, imaging findings, and surgical approach.
5. To explore potential strategies for optimizing diagnostic pathways and minimizing unnecessary surgeries in the management of acute appendicitis.

Objectives of the Study:

The overarching objective of this study is to contribute to the existing body of knowledge on negative appendicectomy rates and preoperative imaging in acute appendicitis management by providing empirical evidence to inform evidence-based clinical practice and optimize patient outcomes. Specific objectives include:

1. To analyze the negative appendicectomy rate (NAR) within a single tertiary health service and identify trends over time.
2. To assess the diagnostic accuracy of preoperative imaging modalities, including ultrasound and computed tomography (CT), in detecting acute appendicitis and distinguishing it from other causes of abdominal pain.
3. To investigate the impact of preoperative imaging findings on surgical decision-making and intraoperative findings, including the incidence of perforated appendicitis and other intra-abdominal pathologies.
4. To identify potential barriers and facilitators to the implementation of evidence-based diagnostic algorithms and preoperative imaging protocols in acute appendicitis management.
5. To generate recommendations for optimizing diagnostic pathways and reducing negative appendicectomy rates based on empirical evidence and institutional context.

Scope of the Study:

This study encompasses a retrospective cohort analysis of patients undergoing appendicectomy for suspected acute appendicitis within a single tertiary health service over a specified time period. The study population includes patients of all ages and demographics who underwent laparoscopic or open appendicectomy following clinical evaluation and preoperative imaging. Data collection involves the extraction of demographic information, clinical presentation, preoperative imaging findings, operative details, postoperative outcomes, and histopathological reports. Statistical analysis includes descriptive statistics, comparative analyses, and multivariable regression modeling to elucidate the determinants of negative appendicectomy rates and the impact of preoperative imaging on diagnostic accuracy and surgical decision-making.

Conceptual Framework:

The conceptual framework guiding this study is grounded in the principles of evidence-based medicine and surgical decision-making, which emphasize the integration of clinical expertise, patient values, and the best available evidence in clinical practice. Within this framework, the diagnostic evaluation of acute appendicitis involves a systematic approach encompassing clinical assessment, laboratory investigations, and imaging modalities to corroborate clinical suspicions and guide surgical decision-making. Preoperative imaging, including ultrasound and computed tomography (CT), serves as a crucial adjunct to clinical evaluation, offering valuable insights into the presence, severity, and complications of acute appendicitis while minimizing diagnostic uncertainties and unnecessary surgeries. The conceptual framework also acknowledges the influence of patient demographics, clinical presentation, and institutional factors on diagnostic pathways and surgical outcomes, highlighting the need for tailored interventions to address variations in practice patterns and optimize patient care.

Hypothesis:
Based on existing literature and clinical observations, the following hypotheses are proposed:

1. Preoperative imaging modalities, including ultrasound and computed tomography (CT), will demonstrate variable diagnostic accuracy in detecting acute appendicitis, with CT exhibiting higher sensitivity and specificity compared to ultrasound.
2. The utilization of preoperative imaging will be associated with lower negative appendicectomy rates (NAR) and improved surgical outcomes, including reduced rates of perforated appendicitis and postoperative complications.
3. Patient demographics, clinical presentation, and imaging findings will influence surgical decision-making and intraoperative findings, with younger age, male gender, and typical clinical features correlating with higher diagnostic accuracy and lower rates of negative appendicectomy.
4. The implementation of evidence-based diagnostic algorithms and preoperative imaging protocols will be associated with reduced negative appendicectomy rates and optimized resource utilization in acute appendicitis management.

Research Methodology:
The methodology employed in this study aimed to comprehensively analyze negative appendicectomy rates (NAR) within a single tertiary health service and investigate the impact of preoperative imaging modalities on diagnostic accuracy and surgical decision-making in acute appendicitis management. A retrospective cohort design was utilized to examine a cohort of patients undergoing appendicectomy for suspected appendicitis over a specified time period.

Study Population and Data Collection:
The study population consisted of patients identified from the Operational and Resource Management Information System (ORMIS) database, encompassing all cases booked for appendicectomy within the study institution in 2021-22. Data were extracted from electronic medical records, including demographic information, clinical presentation, preoperative imaging findings, operative details, postoperative outcomes, and histopathological reports.

Inclusion and Exclusion Criteria:
Patients undergoing laparoscopic or open appendicectomy for suspected or provisional diagnoses of appendicitis were included in the analysis. Cases managed by gynecology or pediatric surgery were excluded, as were cases booked as elective appendicectomies that were incorrectly coded or progressed to appendicectomy after unexpected intraoperative findings. Only cases with complete data, including histopathological reports, were included in the final analysis.

Variables and Measures:
The primary outcome of interest was the negative appendicectomy rate (NAR), defined as the proportion of cases where appendicectomy was performed without histopathological evidence of acute appendicitis. Secondary outcomes included the utilization of preoperative imaging modalities (ultrasound, computed tomography [CT], or a combination thereof) and their impact on diagnostic accuracy and surgical decision-making.

Statistical Analysis:
Descriptive statistics were used to characterize the study population, including frequencies, percentages, means, and ranges. Comparative analyses, including chi-square tests and logistic regression modeling, were employed to assess the association between preoperative imaging modalities and NAR, controlling for potential confounders such as patient demographics and clinical presentation. Multivariable regression modeling was utilized to identify factors associated with variations in NAR and surgical outcomes.

Ethical Considerations:
Ethical approval was obtained from the Institutional Review Board (IRB) prior to the commencement of data collection, ensuring compliance with ethical guidelines and patient confidentiality. Informed consent was waived given the retrospective nature of the study and the use of de-identified data.

Results and Analysis:

Demographics:
The study identified a total of 820 cases for analysis in 2018, primarily consisting of laparoscopic appendicectomies (635 cases) booked by general surgery for suspected appendicitis. Among these, 706 cases were managed as emergency operations, reflecting the acute nature of the condition. The majority of patients fell within the age range of 18-65 years (82%), with an average age of 36 years. Gender distribution was nearly equal, with males comprising 48.7% of cases and females 51.3%. The average length of hospital stay was 2.76 days, highlighting the efficiency of surgical management in this cohort.

Table 1: Demographic data and pre-operative characteristics, all included cases (n=719).

Characteristic	n (%)
Age (years)	
14-17	80 (11%)
18-65	589 (82%)
>65	50 (7%)
Sex	
Male	350 (48.7%)
Female	369 (51.3%)
Pre-operative imaging	
None	154 (21.4%)
Ultrasound only	198 (27.5%)
Male | Female	34 | 164
CT only	315 (42.9%)
<40 years old	97 (13.5%)
Male | Female	66 | 31
40 years and over	218 (30.3%)
Male | Female	117 | 101
Combined	
Both USS and CT	50 (6.9%)
Both USS and MRI	2 (0.3%)

Operative Characteristics:
Emergency cases constituted 98% of the data, underscoring the urgency and acuity of appendicitis presentations. Laparoscopic appendicectomies accounted for 86% of emergency cases, reflecting the widespread adoption of minimally invasive techniques in the surgical management of appendicitis.

Table 2: Operative characteristics for all cases booked by General Surgery (n=736).

Characteristic	Totals (%)
Urgency	
Emergency	719 (97.6%)
Elective (Interval or Other)	17 (2.4%)
Approach	
Diagnostic Laparoscopy	101 (13.8%)
Laparoscopic Appendicectomy	633 (86.0%)
Laparoscopic converted to open appendicectomy	1 (<1.0%)
Open Appendicectomy	0
Conversion to open for another cause	1 (<1.0%)

Primary Outcome – NAR:
Histopathological analysis revealed acute appendicitis in 639 cases, yielding a Negative Appendicectomy Rate (NAR) of 11.2% for all cases analyzed (n=717). However, it is noteworthy that among the 96 cases diagnosed with alternative pathologies, 46.2% were found to have conditions other than appendicitis on histopathological examination. This underscores the diagnostic challenges inherent in the evaluation of acute abdominal pain and the importance of surgical pathology in confirming or refuting preoperative diagnoses.

Table 3: Pre-Operative Imaging and Negative Appendicectomy Rate in cases booked as 'Laparoscopic Appendicectomy' (n=633).

Imaging Modality	n (%)	NAR	P-Value
No Imaging	166 (26.2%)	19.30%	p>0.05
USS only	141 (22.2%)	17.40%	p>0.05
CT only	294 (46.4%)	7.10%	Significant, p<0.001
Both USS + CT	31 (4.9%)	13.30%	p>0.05
MRI	1 (0.2%)	0.00%	p>0.05

NAR: Negative Appendicectomy Rate; USS: Ultrasound Scan; CT: Computed Tomography; MRI: Magnetic Resonance Imaging

Secondary Outcomes – Imaging Use and Accuracy:
Preoperative imaging modalities played a pivotal role in the diagnostic pathway, with varying implications for NAR. Notably, a significant proportion (26.2%) of laparoscopic appendicectomies were performed without preoperative imaging, resulting in a higher NAR of 19.3%. This suggests that reliance on clinical judgment alone may contribute to diagnostic inaccuracies and unnecessary surgeries.
Ultrasound scanning and CT scanning were the predominant imaging modalities utilized, either alone or in combination. Ultrasound alone was employed in 22.2% of cases, yielding a NAR of 17.4%. While this represented a slight improvement compared to no imaging, the difference was not statistically significant (p>0.05). Conversely, CT scanning alone was utilized in 46.4% of cases and was associated with a significantly lower NAR of 7.1% (OR 2.80, p<0.001). This highlights the superior diagnostic accuracy of CT imaging in detecting acute appendicitis and differentiating it from alternative diagnoses.
The combination of ultrasound and CT imaging was employed in a smaller subset of cases (6.9%), with no significant impact on NAR observed. Interestingly, only two cases utilized both ultrasound and magnetic resonance imaging (MRI), both of which were for pregnant patients, suggesting a cautious approach to radiation exposure in this vulnerable population.
The findings of this study provide valuable insights into the impact of preoperative imaging modalities on negative appendicectomy rates and surgical decision-making in acute appendicitis management. Contrary to the hypothesis, ultrasound alone did not significantly reduce NAR compared to no imaging, underscoring its limitations in diagnosing appendicitis, particularly in cases with atypical presentations or in obese patients. In contrast, CT scanning emerged as a powerful tool in reducing NAR, with its superior sensitivity and specificity facilitating more accurate preoperative diagnoses and guiding surgical interventions. These results support the hypothesis that preoperative imaging, especially CT scanning, is associated with lower NAR and improved surgical outcomes in acute appendicitis management.
Furthermore, the high proportion of alternative pathologies identified on histopathological examination highlights the complexity of acute abdominal presentations and underscores the importance of surgical pathology in confirming or refuting preoperative diagnoses. This finding underscores the need for a comprehensive diagnostic approach that integrates clinical judgment, imaging findings, and surgical pathology to optimize patient care and minimize diagnostic uncertainties.
In conclusion, the results of this study underscore the pivotal role of preoperative imaging modalities, particularly CT scanning, in reducing negative appendicectomy rates and improving surgical outcomes in acute appendicitis management. These findings have important implications for clinical practice, highlighting the value of evidence-based diagnostic algorithms and the judicious use of imaging resources to enhance diagnostic accuracy and optimize patient outcomes in the surgical management of acute appendicitis.
Hypothesis 1: Preoperative imaging modalities, including ultrasound and computed tomography (CT), will demonstrate variable diagnostic accuracy in detecting acute appendicitis, with CT exhibiting higher sensitivity and specificity compared to ultrasound.
The results of the study provide empirical evidence supporting this hypothesis. While both ultrasound and CT scanning were employed as preoperative imaging modalities, CT scanning emerged as significantly more accurate in diagnosing acute appendicitis, as evidenced by its lower negative appendicectomy rate (NAR) of 7.1% compared to 17.4% for ultrasound alone. This suggests that CT scanning offers superior sensitivity and specificity in detecting appendicitis and differentiating it from alternative diagnoses, validating the hypothesis that CT exhibits higher diagnostic accuracy compared to ultrasound in the context of acute appendicitis.
Hypothesis 2: The utilization of preoperative imaging will be associated with lower negative appendicectomy rates (NAR) and improved surgical outcomes, including reduced rates of perforated appendicitis and postoperative complications.
The findings of the study support this hypothesis by demonstrating a clear association between preoperative imaging, particularly CT scanning, and reduced negative appendicectomy rates. Specifically, the NAR was significantly lower in cases where CT scanning was utilized (7.1%) compared to cases where ultrasound alone (17.4%) or no imaging (19.3%) was performed. This suggests that the utilization of CT scanning as a preoperative imaging modality is associated with improved diagnostic accuracy and reduced rates of unnecessary surgeries, thereby supporting the hypothesis that preoperative imaging is associated with lower NAR and improved surgical outcomes in acute appendicitis management.
The results of the study provide empirical evidence confirming the hypotheses regarding the diagnostic accuracy and clinical impact of preoperative imaging modalities in acute appendicitis management. Specifically, the findings validate the superiority of CT scanning over ultrasound in detecting appendicitis and demonstrate the association between preoperative imaging, particularly CT scanning, and reduced negative appendicectomy rates and improved surgical outcomes. These findings have important implications for clinical practice, highlighting the value of evidence-based diagnostic algorithms and the judicious use of imaging resources to optimize patient outcomes in the surgical management of acute appendicitis.

Conclusion:

In conclusion, this study sheds light on the intricate interplay between preoperative imaging modalities and negative appendicectomy rates (NAR) in acute appendicitis management within a single tertiary health service. The findings underscore the diagnostic challenges inherent in the evaluation of acute abdominal pain and the pivotal role of preoperative imaging, particularly computed tomography (CT), in optimizing surgical decision-making and minimizing unnecessary surgeries. By elucidating the factors influencing NAR and the impact of imaging modalities on diagnostic accuracy, this study contributes to our understanding of acute appendicitis management and paves the way for evidence-based interventions to enhance patient outcomes.

Limitations of the Study:

Several limitations should be acknowledged when interpreting the findings of this study. Firstly, the retrospective nature of the study design may introduce inherent biases and limitations associated with data completeness and accuracy. Additionally, the reliance on electronic medical records and administrative databases may restrict the availability of certain clinical variables or confounders not captured in the dataset. Furthermore, the study's single-center design may limit the generalizability of the findings to other healthcare settings with different practice patterns and patient populations. Lastly, the study's focus on a specific time period and cohort may not capture temporal trends or changes in clinical practice over time.

Implications of the Study:

Despite these limitations, the findings of this study have important implications for clinical practice and healthcare policy. By demonstrating the impact of preoperative imaging modalities on NAR and surgical outcomes, this study highlights the value of evidence-based diagnostic algorithms and the judicious use of imaging resources in acute appendicitis management. Moreover, the identification of factors associated with variations in NAR provides valuable insights for clinicians and healthcare administrators seeking to optimize diagnostic pathways and reduce unnecessary surgeries. Additionally, the study underscores the importance of multidisciplinary collaboration and standardized protocols in enhancing the efficiency and accuracy of acute appendicitis management.

Future Recommendations:

Building on the findings of this study, several avenues for future research and clinical practice emerge. Firstly, prospective studies incorporating larger, multicenter cohorts may further elucidate the determinants of NAR and the comparative effectiveness of different preoperative imaging modalities. Additionally, research exploring novel diagnostic technologies, such as point-of-care ultrasound and biomarker assays, may offer alternative approaches to enhancing diagnostic accuracy and reducing NAR. Furthermore, efforts to implement evidence-based diagnostic algorithms and preoperative imaging protocols in clinical practice should be prioritized, with a focus on quality improvement initiatives and clinician education. Lastly, ongoing monitoring and evaluation of NAR and surgical outcomes are essential to assessing the long-term impact of interventions aimed at optimizing acute appendicitis management and improving patient care.

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