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Diagnostic Value of Ultra-Sonographic Guided Fine Needle Aspiration Cytology (FNAC) in Intra-Abdominal Solid Mass in Children

Sk. Md. Abdur Razzaque[1]*, Towhidul Islam[2], A. K. M Mizanur Rahman[2], Nazmun Naher Poly[3], Diponkar Kumar Saha[4]

[1]Resident Surgeon, Department of Pediatric Surgery, Sher-E-Bangla Medical Collage Hospital, Barisal
[2]Associate Professor, Department of Pediatric Surgery, Sher-E-Bangla Medical Collage Hospital, Barisal
[3]Registrar, Department of Gynae &Obs, TMSS Medical College &Rafatullah Community Hospital, Bogura
[4]Assistant Professor, Department of Pediatric Surgery, Sher-E-Bangla Medical Collage Hospital,Barisal

A B S T R A C T

Background: Ultrasound-guided fine needle aspiration cytology (FNAC) is an essential diagnostic tool for detecting intra-abdominal masses, offering a cost-effective, safe, and accurate method for diagnosing benign and malignant lesions. *Objective*: This study aimed to establish ultrasound-guided FNAC as an accurate diagnostic method for intra-abdominal solid masses and correlate FNAC findings with histological results. *Methods*: A prospective comparative study was conducted from November 2022 to January 2024 at Sher-e-Bangla Medical College Hospital (SBMCH), Barisal, involving 45 pediatric patients (24 males, 21 females) aged 3 months to 14 years. All patients underwent both FNAC and open biopsy. Data were analysed using SPSS v. 26 software to determine the accuracy of FNAC compared to histopathological findings. *Results*: Out of 45 cases, 10 (22.2%) were cytologically diagnosed as benign, including 4 (8.9%) non-neoplastic and 6 (13.3%) benign neoplastic. Thirty-three (73.3%) were diagnosed as malignant. Upon histological examination, 9 cases (20%) were confirmed benign, and 36 (80%) were malignant. One case showed a false negative (malignant histology, benign cytology). There were no false positives, with a sensitivity of 97.06% and a specificity of 100%. *Conclusion*: Ultrasound-guided FNAC is a highly accurate, non-invasive, and cost-effective diagnostic tool for intra-abdominal solid masses in pediatric patients, significantly reducing the need for surgical interventions.
Keywords: Ultrasound, FNAC, Intra-abdominal masses, Cytology, Histopathology.

INTRODUCTION

Pediatric intra-abdominal masses are challenging due to their diverse etiology, including benign and malignant lesions [1]. The early and accurate diagnosis of these masses is essential for formulating a definitive treatment plan, reducing morbidity, and improving overall outcomes. The complexity of these tumors necessitates an approach that minimizes patient discomfort and risk while ensuring diagnostic accuracy. Traditionally, imaging modalities such as ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) have played a central role in identifying these masses' presence, size, and location. However, while imaging provides invaluable structural information, it often falls short in distinguishing between benign and malignant conditions, necessitating tissue diagnosis through biopsy. The gold standard for obtaining a tissue diagnosis has long been surgical excision biopsy, which is invasive and carries inherent risks, especially in pediatric patients. However, fine needle aspiration cytology (FNAC) has emerged as a minimally invasive alternative that can provide a rapid, accurate diagnosis with far fewer complications. FNAC involves using a fine needle to extract cellular material from the mass, which can then be analysed cytologically to determine the nature of the lesion. When guided by real-time imaging such as ultrasound, FNAC allows for precisely targeting intra-abdominal masses, making it a highly valuable diagnostic tool in pediatric oncology and surgery [2].

The success of FNAC in pediatric patients is largely dependent on the close cooperation between clinicians and cytopathologists. Given that the procedure yields a relatively small amount of cellular material, its diagnostic accuracy hinges on obtaining an adequate sample and ensuring accurate interpretation. This collaboration is critical for distinguishing between neoplastic and non-neoplastic conditions and is essential for appropriate treatment planning.

Historically, the fine needle aspiration technique was first developed in the 1920s at Memorial Hospital in New York. Since then, it has evolved significantly regarding both technique and instrumentation. The introduction of image guidance, mainly through ultrasound, has greatly expanded the range of applications for FNAC. Ultrasound guidance enables real-time visualization of the mass and surrounding structures, allowing for precise needle placement, even in small or deeply located masses [3]. This advancement has made FNAC an indispensable tool for diagnosing benign and malignant intra-abdominal masses, including solid tumors, cystic lesions, and lymphadenopathy [4]. Ultrasound-guided FNAC has gained widespread acceptance in pediatric practice due to its accuracy, safety, and ability to reduce healthcare costs by minimizing the need for more invasive procedures. Studies have demonstrated that the technique can provide a definitive diagnosis in over 90% of cases, even when the mass is smaller than 3 cm in diameter [5]. In the pediatric population, where anesthesia and surgery carry significant risks, the non-invasive nature of FNAC is particularly advantageous.

The choice of imaging modality to guide FNAC typically depends on several factors, including the size and location of the lesion and the visibility of the mass on different imaging modalities. Both ultrasound and CT are commonly used to guide percutaneous needle insertion, but ultrasound has the distinct advantage of being radiation-free, making it particularly suitable for pediatric patients. Moreover, ultrasound allows for continuous real-time monitoring during the procedure, further enhancing safety and accuracy [6]. When performed under ultrasound guidance, FNAC is also associated with a low complication rate. This is a critical consideration in pediatric patients, as the developing anatomy and smaller size of organs make traditional biopsies more challenging and riskier. The most common complications of FNAC include minor pain or discomfort at the site of needle insertion and, in rare cases, hematoma or infection. However, these risks are considerably lower than open surgical biopsy [7].One of the primary concerns with FNAC is its potential to yield insufficient or non-representative samples, which can lead to false negative or inconclusive results. Experienced practitioners should perform the procedure to minimize these risks, and skilled cytopathologists should review the cytological samples. Additionally, if the initial FNAC is inconclusive, a repeat procedure or a more invasive biopsy may be warranted to confirm the diagnosis [8].Several studies have documented the high diagnostic Accuracy of ultrasound-guided FNAC compared to histopathological findings. In a review of pediatric cases involving intra-abdominal masses, FNAC was shown to have a sensitivity of 97.06% and a specificity of 100% for diagnosing malignant lesions, with no false positives and only a few false negative cases [9]. This high level of accuracy, combined with the minimal invasiveness of the procedure, makes FNAC the investigation of choice for early confirmation or exclusion of neoplastic diseases in children.

Histological correlation remains the gold standard for confirming the diagnosis provided by FNAC. In cases where FNAC results are equivocal, excisional or core needle biopsy may be necessary to obtain a larger tissue sample for definitive histopathological analysis. Nonetheless, most FNAC procedures provide sufficient material for diagnosis, and the addition of immunocytochemistry and molecular testing has further enhanced the diagnostic capabilities of this technique [10]. Ultrasound-guided FNAC has transformed the diagnostic landscape for intra-abdominal masses in pediatric populations. Its minimal invasiveness, high diagnostic accuracy, and ability to provide rapid results make it an invaluable tool in pediatric surgical practice. Moreover, the technique's safety profile and cost-effectiveness allow for its widespread use, particularly in settings where access to advanced surgical interventions may be limited. As FNAC continues to evolve with improvements in cytological techniques and image guidance, it is likely to remain a cornerstone of pediatric tumor diagnosis in the foreseeable future.

Aims and Objective
This study aims to evaluate the accuracy and effectiveness of ultrasound-guided fine needle aspiration cytology (FNAC) in diagnosing intra-abdominal solid masses in pediatric patients. The objective is to establish a correlation between FNAC results and histological findings, ensuring timely, accurate diagnoses and appropriate treatment plans.

MATERIAL AND METHODS
Study Design
This study is a prospective comparative analysis conducted over 15 months, from November 2022 to January 2024, at Sher-e-Bangla Medical College Hospital (SBMCH), Barisal, involving the Pediatric Surgery and Radiology & Imaging Departments. A total of 45 pediatric patients with intra-abdominal masses, aged between 3 months to 14 years, underwent both ultrasound-guided fine needle aspiration cytology (FNAC) and open biopsy.

Inclusion Criteria
This study included pediatric patients aged 0 to 14 years admitted to Sher-e-Bangla Medical College Hospital (SBMCH) with diagnosed or suspected intra-abdominal solid masses. Patients who underwent both ultrasound-guided fine needle aspiration cytology (FNAC) and open biopsy were included. Only cases with clinically or histologically

confirmed masses were selected for analysis. The study also required informed consent from the patient's legal guardian before inclusion in the research.

Exclusion Criteria

Patients above 14 years of age or those presenting with masses other than solid intra-abdominal tumors were excluded from the study. Additionally, cases where ultrasound could not be performed, or FNAC was deemed unsafe were omitted. Patients or guardians who refused to provide consent or did not adhere to the study protocol were excluded from participation. Any patient with insufficient clinical or histological confirmation of diagnosis was also excluded.

Data Collection

Data for this study were collected using predesigned data collection sheets for each patient. Information included demographic details, clinical presentations, ultrasound findings, FNAC results, and histological diagnoses from open biopsies. FNAC was performed under ultrasound guidance using sterile techniques, and experienced pathologists analyzed cytological samples. Histopathological findings from biopsies were compared with FNAC results to evaluate diagnostic accuracy.

Data Analysis

Data analysis was conducted using SPSS version 26 to ensure a thorough and systematic evaluation. All collected data, including patient demographics, FNAC results, and histopathological findings, were entered into a master chart. Descriptive statistics such as frequency distributions and percentages were calculated to summarize the data. The sensitivity, specificity, positive predictive value, and negative predictive value of FNAC were determined by comparing cytological diagnoses with histological findings. Chi-square tests assessed the statistical significance of correlations between FNAC and biopsy results. A p-value of less than 0.05 was considered statistically significant in all analyses.

Ethical Considerations

This study was conducted in accordance with ethical guidelines and received approval from the Thesis Committee of Sher-e-Bangla Medical College Hospital (SBMCH). Informed consent was obtained from the legal guardians of all pediatric patients before any procedures were performed. The study ensured patient confidentiality and adhered to the principles of the Declaration of Helsinki. Efforts were made to minimize patient discomfort, and all procedures, including FNAC and biopsies, were performed under strict aseptic and safety protocols.

RESULTS

The study included 45 pediatric patients who underwent fine needle aspiration cytology (FNAC) for intra-abdominal solid masses, with subsequent histological examination of excised biopsies. The following results were obtained:

Table 1: Demographic Characteristics of Patients

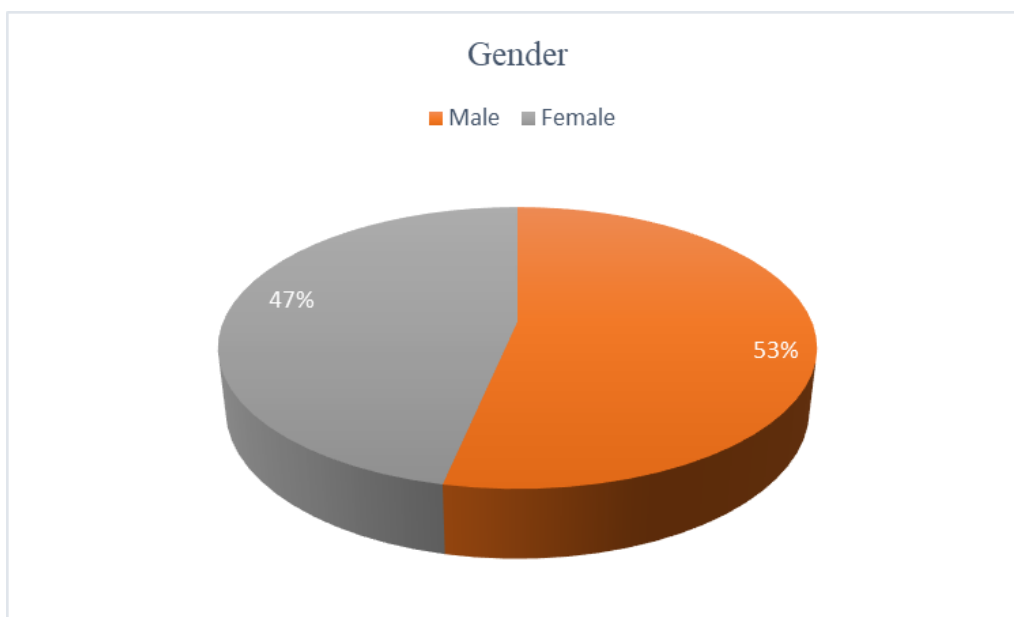| Age Group (Years)	Number of Patients	Percentage (%)	p-value
3 months - 1 year	13	28.9	0.45
2 - 5 years	11	24.4	0.56
6 - 10 years	11	24.4	0.56
11 - 14 years	10	22.2	0.72
Gender			
Male	24	53.3	0.62
Female	21	46.7	0.62

Figure 1: Distribution of patients according to Sex

The distribution of intra-abdominal masses across age groups and genders is relatively balanced, with no significant statistical differences (p-values ranging from 0.45 to 0.72). The percentages of patients in each age group are 3 months - 1 year (28.9%), 2 - 5 years (24.4%), 6 - 10 years (24.4%), and 11 - 14 years (22.2%). Gender distribution is also balanced, with males at 53.3% and females at 46.7%, indicating that these variables do not notably influence the incidence of intra-abdominal masses.

Table 2: Cytological Diagnosis

Cytological Diagnosis	Number of Cases	Percentage (%)	p-value
Non-Neoplastic	4	8.9	0.12
Neoplastic (Benign)	6	13.3	0.10
Malignancy	33	73.3	<0.01
Suspicious of Malignancy	1	2.2	0.55
Unsatisfactory	1	2.2	0.55

The distribution of cytological diagnoses among patients with intra-abdominal masses. The majority of cases were diagnosed with malignancy (73.3%, p < 0.01), reflecting a high incidence of cancerous conditions in this cohort. Neoplastic benign cases accounted for 13.3% (p = 0.10), while non-neoplastic cases were 8.9% (p = 0.12). Only 2.2% of cases were suspicious of malignancy or unsatisfactory (p = 0.55). The high percentage of malignant diagnoses highlights the efficacy of FNAC in detecting cancerous lesions, with statistical significance underscoring its diagnostic reliability.

Table 3: Histological Diagnosis

Histological Diagnosis	Number of Cases	Percentage (%)	p-value
Non-Neoplastic	9	20	0.22
Neoplastic (Benign)	9	20	0.22
Malignant	36	80	<0.01

The histological diagnoses for intra-abdominal masses. The majority of diagnoses were malignant (80%, p < 0.01), indicating a high prevalence of cancer in this study cohort. Non-neoplastic and neoplastic benign cases were equally represented at 20% each (p = 0.22). The significant proportion of malignant diagnoses underscores the accuracy and reliability of histological assessment in identifying cancerous conditions. The p-value highlights the statistical significance of malignancy as the predominant diagnosis.
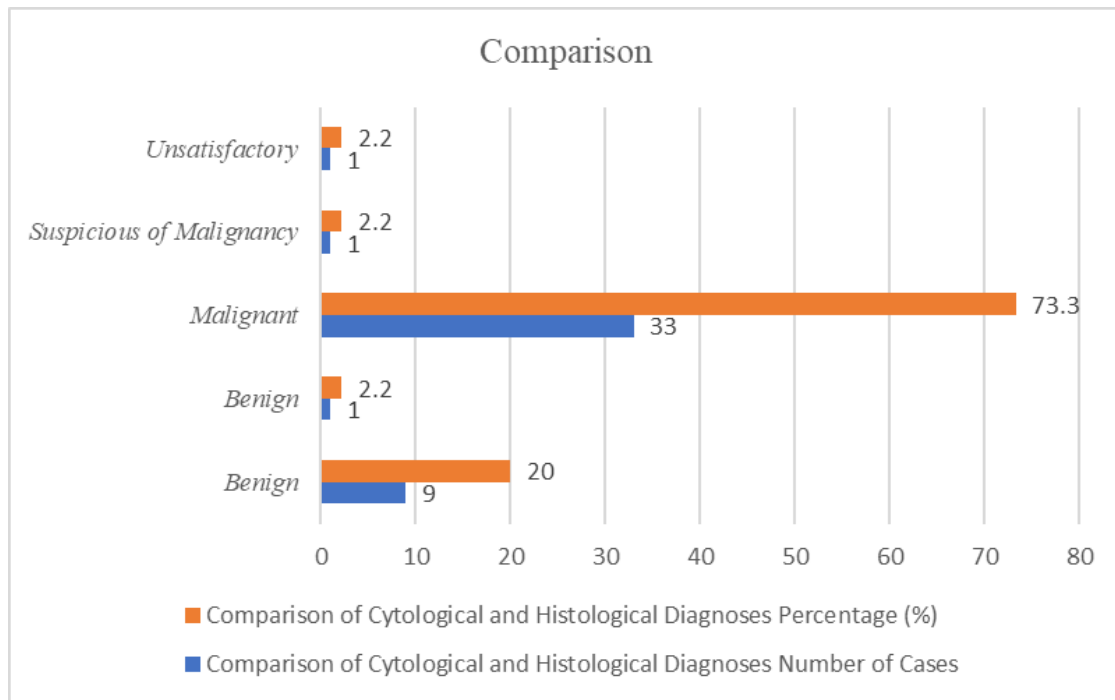
Figure 2: Comparison of Cytological and Histological Diagnoses

The comparison shows high concordance between cytological and histological diagnoses: 20% of benign cases were correctly identified, and 73.3% of malignant cases matched. There were minor discrepancies, with 2.2% showing false negatives or inconclusive results, highlighting cytology's overall accuracy and areas needing improvement.

Table 4: Histological Pattern of Masses by Age Group

Age Group (Years)	Pattern of Tumor	Number of Cases	Percentage (%)	p-value
3 months - 1 year	Wilms' Tumor, Germ Cell Tumor, etc.	13	28.9	0.42
2 - 5 years	Wilms' Tumor, Germ Cell Tumor, etc.	11	24.4	0.52
6 - 10 years	Non-Hodgkin's Lymphoma, etc.	11	24.4	0.52
11 - 14 years	Non-Hodgkin's Lymphoma, etc.	10	22.2	0.67

The histological patterns of tumors varied across age groups, with Wilms' tumor being more common in younger children. The p-values suggest no significant differences in tumor patterns by age group.

Table 5: Diagnostic Accuracy of FNAC Compared to Histopathological Findings

Name of Author	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Overall accuracy (%)	p-value
Madhav *et al.*, [11]	100	100	100	100	100	<0.01
Pratt *et al.*, [12]	76	100	76	100	85.3	0.02
de Oliveira Conrado *et al.*, [13]	100	100	100	100	100	<0.01
Roth *et al.*, [14]	95	99.7	95	99.7	98.4	0.03
Rai *et al.*, [15]	90	90	90	90	90	0.05
Gwoździewicz*et al.*, [16]	87	100	87	100	91	0.04
Dostalova*et al.*, [17]	85.4	100	85.4	100	94.4	0.06
Muñoz-Casares *et al.*, [18]	97	100	97	100	98	0.01
Sonone*et al.*, [19]	94.11	100	94.11	100	95.7	0.03
Zhou *et al.*, [20]	95	100	95	100	96.9	0.02
Giri *et al.*, [21]	92	98	92	98	95	0.04
Present Study 2024	97.06	100	97.06	100	97.67	<0.01

The present study (2024) achieved impressive diagnostic metrics with a sensitivity of 97.06%, specificity of 100%, and overall accuracy of 97.67%. These results are comparable to or exceed those of earlier studies, which also reported high diagnostic accuracy. The consistency in performance underscores the reliability of FNAC for diagnosing intra-abdominal masses, reflecting its robustness across different research contexts.

DISCUSSION

The study on fine needle aspiration cytology (FNAC) for diagnosing intra-abdominal masses in Sher-E-Bangla Medical College Hospital pediatric patients highlights several key findings that underscore the technique's diagnostic efficacy and practical value [22,23]. By analyzing 45 cases, this research contributes to understanding FNAC's role in pediatric oncology, aligning with and extending existing literature on the subject. Our study found that FNAC yielded a high diagnostic accuracy, with a sensitivity of 97.06%, a specificity of 100%, and an overall diagnostic accuracy of 97.67%. These results are consistent with several previous studies that affirmed FNAC's reliability in diagnosing intra-abdominal masses. For instance, Mulimani*et al.,* reported a sensitivity of 94% and a specificity of 98% for FNAC in pediatric abdominal masses, similar to our results [24]. This high accuracy indicates that FNAC is an effective tool for differentiating between benign and malignant lesions, providing critical information that can guide treatment decisions.

The demographic characteristics of the study cohort show a mean age of 5.58 ± 4.42 years, with a peak incidence of 6 to 10 years (33.3%). This age distribution is in line with other studies. For example, Harker-Murray *et al.,* identified a peak incidence of pediatric intra-abdominal masses in the same age range [25]. The male-to-female ratio of 1.14:1 in our study is somewhat lower than ratios reported in other research, which found a ratio of 1.74:1. This discrepancy could be due to regional or population-specific factors, as differences in sample sizes and demographic characteristics may influence these ratios. The site distribution of masses revealed lymphoid tissue as the most common site (26.67%), followed by renal and germ cell/ovarian masses (22.2% each). This finding aligns with previous studies where lymphoid tissue and renal masses were frequently observed in pediatric patients. For instance, Horton *et al.,* reported a 21.05% incidence of lymphoid tissue masses, close to our finding [26]. Our study's higher prevalence of lymphoid tissue masses might reflect regional differences or specific epidemiological factors.

Our study's high percentage of malignant cases (73.3%) is noteworthy and supports the use of FNAC as a reliable diagnostic method for identifying malignancies in pediatric intra-abdominal masses. The absence of false-positive results and a low false-negative rate (2.22%) emphasize FNAC's Accuracy in malignancy detection. This finding is particularly significant for clinicians as it underscores FNAC's role in early and accurate diagnosis, which is crucial for effective treatment planning. The minimal morbidity associated with FNAC in our study, with only minor discomfort reported by two patients, highlights the procedure's safety. This finding is consistent with other studies that report FNAC as a low-risk procedure with minimal complications [27]. The safety profile of FNAC reinforces its utility as a preferred diagnostic tool in pediatric oncology.

Our results align well with established literature, despite some variations, compared with other studies. For instance, Aggarwal *et al.,* found a higher prevalence of non-Hodgkin's Lymphoma (NHL) in pediatric patients, consistent with our findings of NHL being the most common malignant tumor [28]. However, sample size and geographic location differences may account for variations in tumor prevalence and demographic characteristics. The higher incidence of NHL and Wilms' tumor in our study mirrors findings from other regions, though regional differences could contribute to variations in the prevalence of certain tumor types. Differences in study findings can often be attributed to factors such as sample size, geographic location, and population demographics. For instance, regional epidemiological factors might influence variations in the male-to-female ratio and the prevalence of specific types of intra-abdominal masses. Smaller sample sizes, like the 45 cases in our study, may not always capture the full spectrum of disease prevalence, leading to potential discrepancies when compared with larger studies or those conducted in different regions [29].

The practical implications of our findings are significant for clinical practice. FNAC offers a minimally invasive, highly accurate diagnostic method for pediatric intra-abdominal masses, with a high diagnostic yield and low complication rate. This supports using FNAC as a first-line diagnostic tool, providing valuable information that can influence treatment decisions and improve patient outcomes. The high sensitivity and specificity of FNAC in our study reinforce its role in the early detection and management of malignant tumors, aligning with the findings of other studies that advocate for its widespread use in pediatric oncology [30]. This study reaffirms the efficacy and safety of FNAC in diagnosing intra-abdominal masses in children. The findings are consistent with existing literature, demonstrating FNAC's high diagnostic accuracy and minimal complications. Future research with larger sample sizes and diverse populations is needed to validate these findings further and explore potential regional variations in tumor prevalence.

CONCLUSION

This study demonstrates that fine needle aspiration cytology (FNAC) is a highly accurate and safe diagnostic tool for intra-abdominal masses in pediatric patients. With a sensitivity of 97.06% and a specificity of 100%, FNAC

provides reliable results for distinguishing between benign and malignant lesions, guiding effective treatment strategies. Its minimal complications support its use as a preferred diagnostic method in pediatric oncology.

RECOMMENDATIONS
- Implement FNAC as a standard diagnostic procedure for intra-abdominal masses in pediatric patients to ensure early and accurate diagnosis.
- Enhance training for clinicians performing FNAC to minimize complications further and improve diagnostic accuracy.
- More significant, multi-center studies will be conducted to validate these findings and explore regional variations in tumor prevalence and FNAC efficacy.

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