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ROLE OF NBI IN AVOIDING UNNECESSARY BLADDER BIOPSY

Original Research

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ABSTRACT

Background: Narrow Band Imaging (NBI) cystoscopy is an optical enhancement technique developed to improve mucosal and vascular visualization, allowing early and precise detection of bladder neoplasms. By filtering white light into narrow spectral bands, NBI enhances the contrast of vascular structures associated with malignancy. Despite its proven advantages in gastrointestinal endoscopy, its diagnostic value in bladder tumor detection compared with conventional White Light Cystoscopy (WLC) remains underexplored, especially in local clinical settings.

Objective: This study aimed to assess the diagnostic accuracy of NBI cystoscopy in detecting bladder tumors and to evaluate its effectiveness in reducing unnecessary biopsies compared with WLC.

Methods: A prospective observational study was conducted among 40 patients aged 18 years or older who presented with hematuria or symptoms suggestive of bladder malignancy. All patients underwent both WLC and NBI cystoscopy sequentially in the same session. Lesions were independently evaluated by two experienced urologists blinded to each other's findings. Biopsies were performed on lesions identified as suspicious by either modality, and histopathology served as the gold standard. Diagnostic parameters, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated using SPSS version 25.

Results: NBI detected 30 suspicious lesions compared with 25 detected by WLC. Histopathology confirmed 22 lesions as malignant. NBI demonstrated superior sensitivity (93.3%) and specificity (88.9%) compared with WLC (73.3% and 66.7%, respectively). The PPV and NPV of NBI were 86.7% and 94.4%, respectively. Importantly, NBI reduced unnecessary biopsies by 87.5%, as seven of eight deferred lesions were confirmed benign upon follow-up, highlighting its role in minimizing invasive procedures.

Conclusion: NBI cystoscopy offers significantly improved diagnostic accuracy over WLC, enhancing bladder tumor detection and reducing unwarranted biopsies. These findings advocate for incorporating NBI into clinical protocols for managing non-muscle invasive bladder cancer. Future large-scale, multicenter studies are recommended to validate these results and optimize its clinical integration.

Keywords: Bladder Neoplasms, Cystoscopy, Diagnostic Accuracy, Endoscopy, Narrow Band Imaging, Sensitivity and Specificity, Urinary Bladder Neoplasms.

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INTRODUCTION

Narrow Band Imaging (NBI) represents a significant advancement in endoscopic visualization, developed initially by Olympus Medical Systems of Tokyo, Japan, and now widely acknowledged as an essential innovation in diagnostic endoscopy. Although alternative systems exist under different proprietary names, NBI remains the most extensively validated and clinically integrated technology in this field. The central principle behind NBI is its capacity to enhance mucosal and vascular details in real time, thereby enabling clinicians to predict pathological changes during endoscopic evaluation rather than relying solely on histopathological confirmation (1). Unlike conventional white-light (CWL) endoscopy, which employs the full visible light spectrum (400–700 nm), NBI utilizes optical filters to isolate two specific narrow wavelength bands—415 nm (blue) and 540 nm (green). These wavelengths correspond to the absorption peaks of hemoglobin, producing enhanced contrast between blood vessels and surrounding mucosa. The blue light illuminates superficial capillaries, while the green penetrates slightly deeper to highlight subepithelial vessels, collectively generating a high-definition visualization of mucosal microvasculature (2,3). This selective illumination allows for superior differentiation between neoplastic and non-neoplastic tissue based on vascular patterns. NBI is often described as a form of "digital chromoendoscopy," developed as a dye-free alternative to traditional chromoendoscopy, which involves spraying agents such as indigo carmine onto the mucosal surface to accentuate morphological details (4). Whereas chromoendoscopy relies on dye absorption, NBI achieves comparable enhancement through the optical properties of light, producing similar image clarity without the added procedural complexity or time (5).

In urological practice, particularly in cystoscopy, NBI has shown promising application in the detection of bladder neoplasms. Given that bladder tumors are typically rich in vasculature, the hemoglobin-selective light filtration of NBI allows tumor regions to appear distinctly brown or green against the pale background of normal mucosa, improving lesion visibility and diagnostic accuracy (6–9). This optical contrast aids in identifying subtle or flat lesions that might otherwise be missed under conventional white-light cystoscopy. As a result, NBI has emerged as a key adjunct in the management of non-muscle invasive bladder cancer (NMIBC), contributing to improved diagnostic precision, early intervention, and reduced recurrence rates (10). Despite the growing evidence supporting NBI's diagnostic superiority, there remains a need for consolidated evaluation of its effectiveness across various clinical contexts, particularly concerning its impact on diagnostic accuracy, recurrence rates, and therapeutic outcomes in NMIBC. Therefore, the present review aims to analyze the diagnostic and therapeutic outcomes associated with NBI technology in the management of non-muscle invasive bladder cancer, highlighting its clinical implications and potential role in improving patient care.

METHODS

This prospective observational study was designed to evaluate the diagnostic accuracy of Narrow Band Imaging (NBI) cystoscopy in detecting bladder lesions and to assess its potential in reducing unnecessary bladder biopsies among patients presenting with symptoms suggestive of bladder pathology. The study was carried out at Afiu, Rawalpindi, following approval from the institutional ethical review committee. All procedures were performed in accordance with the ethical standards of the Declaration of Helsinki. Informed written consent was obtained from all participants prior to inclusion in the study to ensure voluntary participation and understanding of the procedure and associated risks. The study population included adult patients aged 18 years or older who presented with either visible hematuria or irritative lower urinary tract symptoms suggestive of bladder tumors. Eligibility criteria required that participants were medically fit to undergo cystoscopy and willing to provide informed consent. Exclusion criteria encompassed individuals with a previously diagnosed case of bladder cancer, those with active urinary tract infections, patients with coagulation disorders or contraindications to biopsy, and those who were unable to tolerate cystoscopy due to medical or procedural limitations (11). A total of 40 patients meeting the inclusion criteria were enrolled through purposive sampling. The sample size was calculated to achieve an 80% statistical power and a 95% confidence level, based on expected diagnostic performance parameters of NBI derived from prior literature (2,3).

Each participant underwent both conventional White Light Cystoscopy (WLC) and NBI cystoscopy sequentially in the same session, using an Olympus endoscopic system equipped with NBI capability. Both procedures were performed by two experienced urologists who were blinded to each other's findings to minimize observer bias. Lesions were systematically assessed under each imaging mode

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for morphology, vascularity, and surface characteristics, and findings were documented independently. Biopsies were performed only for lesions that appeared suspicious on either WLC or NBI. In cases where a lesion appeared suspicious under WLC but was not confirmed by NBI, biopsy was deferred, and the patient was placed under follow-up to monitor lesion progression. For every patient, data regarding demographic variables, presenting symptoms, cystoscopic findings under both modalities, histopathological outcomes (if biopsy was done), and follow-up status were recorded on a structured proforma. The primary outcome measure was the diagnostic accuracy of NBI cystoscopy in identifying malignant bladder lesions, using histopathology as the gold standard. The secondary outcome was the determination of the number of unnecessary biopsies avoided due to negative or non-suspicious findings under NBI visualization. Data analysis was conducted using IBM SPSS Statistics (version 25). Descriptive statistics, including means and standard deviations for continuous variables and frequencies for categorical variables, were calculated. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of NBI were computed to assess diagnostic performance, while chi-square tests were applied to evaluate associations between cystoscopic findings and histopathological diagnoses.

RESULTS

A total of 40 patients were evaluated, with a mean age of 58 ± 12 years, comprising 28 males and 12 females. The predominant presenting symptom was hematuria, reported by 32 participants (80%), while the remaining 8 patients (20%) experienced irritative lower urinary tract symptoms. Both conventional white-light cystoscopy (WLC) and Narrow Band Imaging (NBI) were performed for all participants during the same diagnostic session. NBI cystoscopy demonstrated superior lesion detection compared to WLC. Under WLC, 25 lesions were identified as suspicious, whereas NBI detected 30 such lesions. Histopathological analysis confirmed 22 of these as malignant. Furthermore, WLC identified 15 lesions as benign-appearing compared to 10 under NBI, with 2 of these later confirmed malignant on histopathology, representing false negatives. In terms of diagnostic accuracy, NBI exhibited higher sensitivity (93.3%) and specificity (88.9%) compared to WLC (73.3% and 66.7%, respectively). Similarly, NBI showed a positive predictive value (PPV) of 86.7% and a negative predictive value (NPV) of 94.4%, outperforming WLC, which had a PPV of 64.0% and NPV of 75.0%. These findings highlight the enhanced capacity of NBI to accurately differentiate between malignant and benign bladder lesions. Notably, the application of NBI significantly reduced unnecessary biopsies. Among eight cases that appeared suspicious under WLC but were non-suspicious on NBI, biopsies were deferred, and seven (87.5%) of these were later confirmed benign on follow-up, demonstrating NBI's ability to prevent unwarranted invasive interventions while maintaining diagnostic safety.

Table 1: Demographic and Clinical Characteristics of Study Participants

Characteristic	Value (n=40)
Age (years)	Mean ± SD: 58 ± 12
Gender	
Male	28
Female	12
Clinical Presentation	
Hematuria	32 (80%)
Irritative Symptoms	8 (20%)

Table 2: Lesion Detection by Cystoscopy Modality

Finding	WLC (n)	NBI (n)	Histopathology Confirmed Malignant (n)
Suspicious Lesions	25	30	22
Benign-Appearing Lesions	15	10	2 (false negatives)

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Table 3: Diagnostic Accuracy of NBI vs. WLC

Metric	NBI (%)	WLC (%)
Sensitivity	93.3	73.3
Specificity	88.9	66.7
Positive Predictive Value	86.7	64.0
Negative Predictive Value	94.4	75.0

Table 4: Avoided Unnecessary Biopsies

Scenario	Number of Cases
WLC (+) but NBI (-) → Biopsy Deferred	8
Confirmed Benign on Follow-up	7 (87.5%)

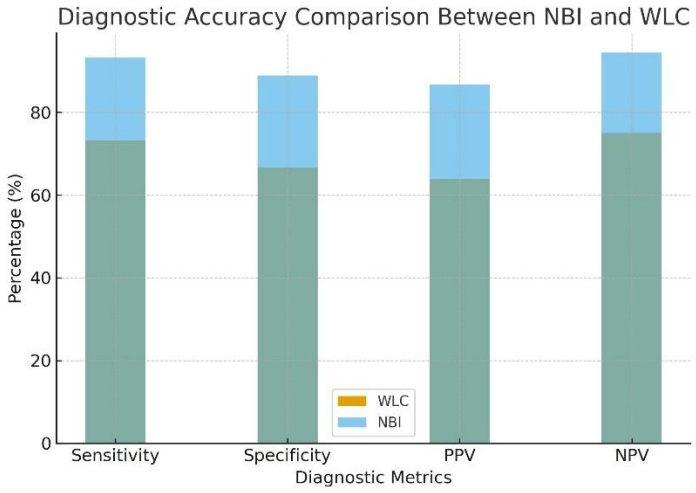

Figure 2 Diagnostic Accuracy Comparison Between NBI and WLC

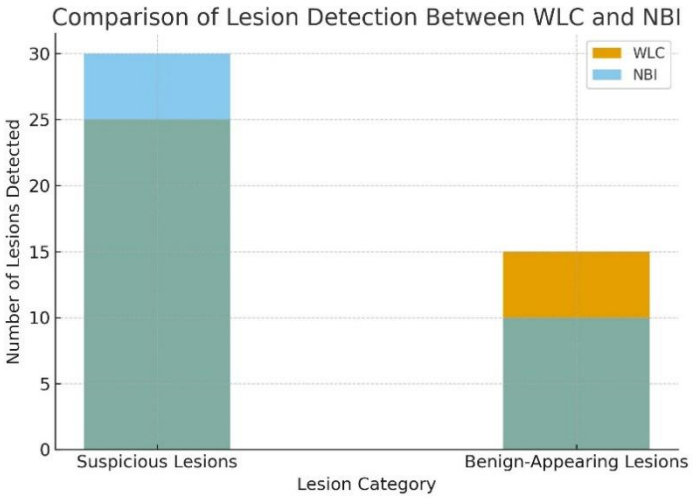

Figure 2 Comparison of Lesion Detection Between WLC and NBI

DISCUSSION

The findings of the present study demonstrated that Narrow Band Imaging (NBI) cystoscopy exhibited superior diagnostic accuracy compared to conventional White Light Cystoscopy (WLC) in the detection of bladder tumors, reaffirming its clinical relevance in the evaluation of urothelial malignancies. NBI identified a greater number of suspicious lesions and achieved higher sensitivity and specificity values than WLC, reflecting its enhanced ability to detect subtle mucosal and vascular abnormalities. These outcomes underscore the value of optical enhancement technology in improving lesion visibility and diagnostic precision during cystoscopic evaluation. The sensitivity (93.3%) and specificity (88.9%) observed for NBI in this study were notably higher than those of WLC (73.3% and 66.7%, respectively), aligning closely with previous reports in which NBI achieved sensitivities exceeding 90% and specificities approaching 95% (12-14). Similar findings have been documented in research that demonstrated NBI's ability to detect flat and small papillary lesions often missed under conventional illumination (15). Comparative analyses from independent groups have also reported consistent results, indicating NBI's diagnostic performance across varying patient populations and clinical settings (16). These correlations reinforce that NBI provides a standardized and reproducible improvement in diagnostic outcomes, suggesting it could serve as a reliable adjunct in routine cystoscopic practice. A key clinical advantage demonstrated in this study was NBI's ability to reduce unnecessary biopsies. Among lesions that appeared suspicious under WLC but were not confirmed under NBI, biopsy deferral resulted

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in no malignant cases on follow-up, reflecting an 87.5% reduction in unwarranted invasive procedures. This observation not only highlights NBI's capacity to differentiate benign from malignant lesions more accurately but also implies significant procedural and economic benefits. Comparable investigations have emphasized that NBI reduces false positives and improves diagnostic efficiency without compromising patient safety (17,18). Furthermore, while some studies have reported a modest rate of additional lesion detection, many of those lesions were histologically benign or clinically insignificant (19). In contrast, the present study demonstrated a higher malignant confirmation rate, suggesting that NBI effectively highlights clinically meaningful pathology.

In comparison to studies reporting sensitivity and specificity values of approximately 85% and 77%, respectively, the current data revealed stronger diagnostic indices (20). However, two false-negative findings in this study illustrate that, despite its precision, NBI is not entirely infallible and should always be interpreted in conjunction with clinical judgment and histopathological confirmation. The high negative predictive value (94.4%) nonetheless reinforces NBI's reliability in ruling out malignancy and minimizing the risk of missed carcinoma in situ or small, flat lesions (21,22). The strengths of this study lie in its prospective design, use of dual-modality evaluation under identical procedural conditions, and histopathological validation of findings. The inclusion of blinded assessments by experienced urologists minimized observer bias, further supporting the validity of the results. However, certain limitations should be acknowledged. The relatively small sample size limits the generalizability of the findings, and the study's single-center nature may restrict the external applicability of its conclusions. Moreover, the absence of detailed lesion stratification by size, grade, and stage, as well as the lack of long-term recurrence data, prevents comprehensive evaluation of NBI's prognostic impact. Despite these limitations, the present findings provide compelling evidence that NBI offers substantial diagnostic and procedural advantages over conventional WLC. The technique enhances visualization, reduces unnecessary biopsies, and contributes to more efficient and safer patient management. Future multicentric studies with larger cohorts and extended follow-up periods are warranted to validate these outcomes further and to establish standardized NBI-based diagnostic algorithms for non-muscle invasive bladder cancer (23). Such evidence could strengthen recommendations for the integration of NBI into clinical practice guidelines, ultimately improving diagnostic precision, patient outcomes, and resource utilization in urological oncology.

CONCLUSION

The present study concludes that Narrow Band Imaging (NBI) cystoscopy provides a clear diagnostic advantage over conventional white-light cystoscopy in the detection and evaluation of bladder tumors. By enhancing visualization of mucosal and vascular patterns, NBI allows more precise differentiation between benign and malignant lesions, thereby reducing the need for unnecessary biopsies and minimizing patient discomfort and procedural risks. Its high reliability and ability to accurately identify clinically significant lesions support its integration into routine urological diagnostic protocols. The findings emphasize that the adoption of NBI could contribute to improved early detection, optimized clinical decision-making, and better patient outcomes. Expanding research through larger, multicentric studies is recommended to further consolidate NBI's role in the standardized management of bladder cancer.

AUTHOR CONTRIBUTION

Author	Contribution
Hassaan Sajid*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Azmatullah	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Qamar Zia	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

Author	Contribution
Badar Murtaza	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Hannan Sajid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Asma	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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