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Research Article

Enhancing Detection of Early Bladder Cancer: The Role of Narrow-Band Imaging in Identifying Subtle Urothelial Lesions

Professor Syed Jaffry *[1], Tauqir Aslam Waraich[1], Dr Irfan Qadir afridi [1], Dr Asfandyar Khan[1], Dr Neel Kanwal [2]

1. *University Hospital Galway.*
2. *Blackrock health Galway.*

***Correspondence to**: Professor Syed Jaffry, University Hospital Galway.

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Abstract

Background: *Conventional white-light cystoscopy (WLC) may fail to detect subtle or flat bladder lesions such as carcinoma in situ (CIS).*

Objective: *To review the evidence on narrow-band imaging (NBI) cystoscopy, focusing on its sensitivity and diagnostic performance in detecting subtle bladder lesions.*

Methods: *Literature review of prospective trials and meta-analyses, supported by illustrative cystoscopic images obtained using both WLC and NBI.*

Results: *NBI enhances mucosal vascular contrast by exploiting specific haemoglobin absorption wavelengths (415 nm and 540 nm). Meta-analyses report pooled sensitivities up to 95.8 % for NBI versus 81.6 % for WLC, with a significant additional detection rate (ADR) of up to 18.6 % at the per-lesion level. Case illustration demonstrates the superiority of NBI in detecting a CIS lesion undetectable under WLC.*

Conclusions: *NBI markedly improves sensitivity for bladder cancer detection, particularly for flat or subtle lesions, and contributes to reduced recurrence after TURBT. Integration of NBI into routine diagnostic and surveillance cystoscopy is recommended for enhanced disease control.*

Keywords: *narrow-band imaging, bladder cancer, carcinoma in situ, cystoscopy, optical enhancement, sensitivity.*

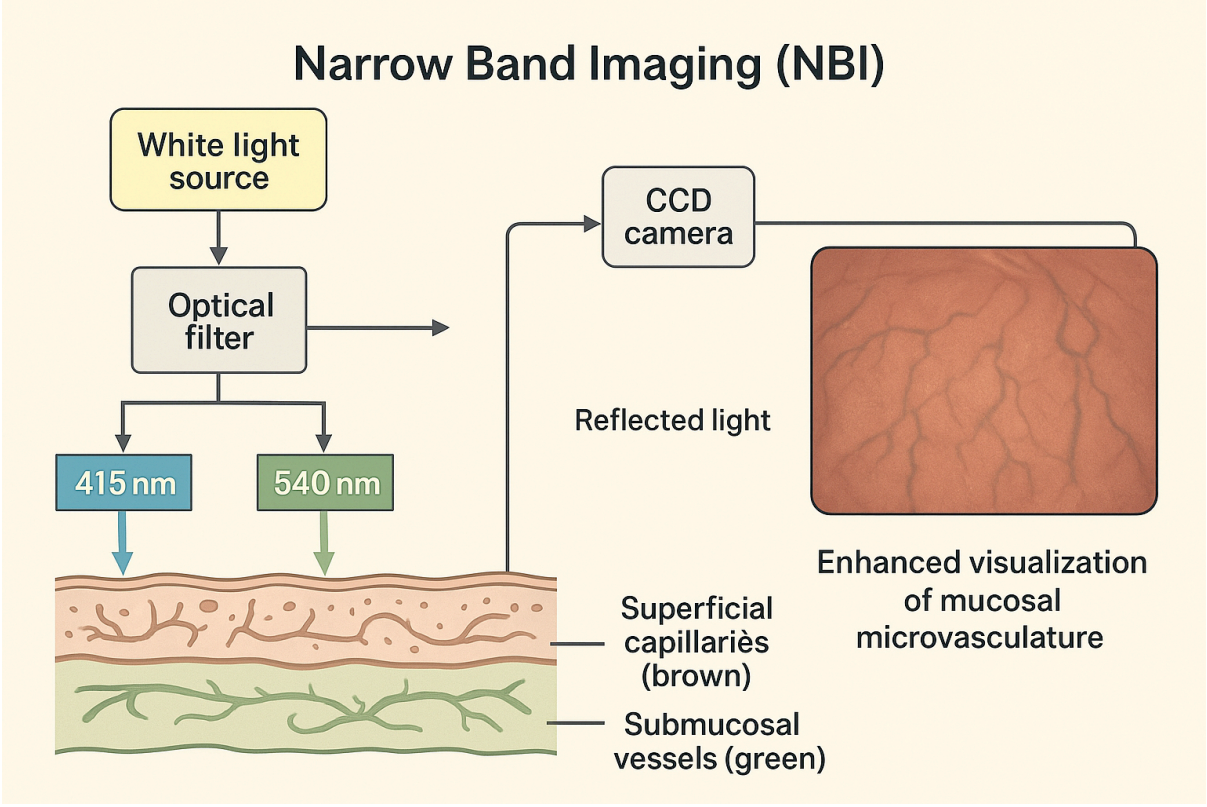
Introduction

Non-muscle-invasive bladder cancer (NMIBC) constitutes the majority of bladder cancer cases and is characterised by a high recurrence rate. Conventional white-light cystoscopy (WLC) remains the gold standard for diagnosis and transurethral resection of bladder tumour (TURBT), yet it often fails to visualise small papillary or flat lesions, such as CIS, which may appear macroscopically normal. These limitations have spurred the development of optical enhancement techniques, including photodynamic diagnosis (PDD) and narrow-band imaging (NBI). Unlike PDD, NBI does not require instillation of an exogenous agent and can be activated instantly during cystoscopy, making it both practical and cost-effective.

Principles of Narrow-Band Imaging

NBI uses filtered light at two narrow wavelength bands—approximately 415 nm (blue) and 540 nm (green)—that correspond to haemoglobin absorption peaks. Blue light penetrates superficial mucosa and highlights capillaries, while green light penetrates deeper and accentuates subepithelial vessels. The resulting image enhances mucosal vascular patterns, improving visual contrast between neoplastic and normal tissue. Neoplastic areas, due to increased angiogenesis, appear reddish-brown, whereas normal mucosa appears greenish.

This optical enhancement enables earlier detection of malignant lesions and more precise tumour mapping without the need for photosensitising agents.



Representative Case: Detection of a Subtle Carcinoma in Situ

Methods:

Diagnostic cystoscopy was performed for a patient with positive urinary cytology and normal findings on initial WLC. Both conventional and NBI modes were sequentially used with an Olympus high-definition cystoscope equipped with integrated NBI optics. The same mucosal area was imaged under identical conditions.

Findings:

- **Figure 1A (WLC):** The mucosa shows faint erythema but no discrete lesion.
- **Figure 1B (NBI):** The same region exhibits a distinct, irregular vascular pattern and reddish discoloration consistent with neoplastic vascularity.

Subsequent biopsy confirmed carcinoma in situ.

Figure 1

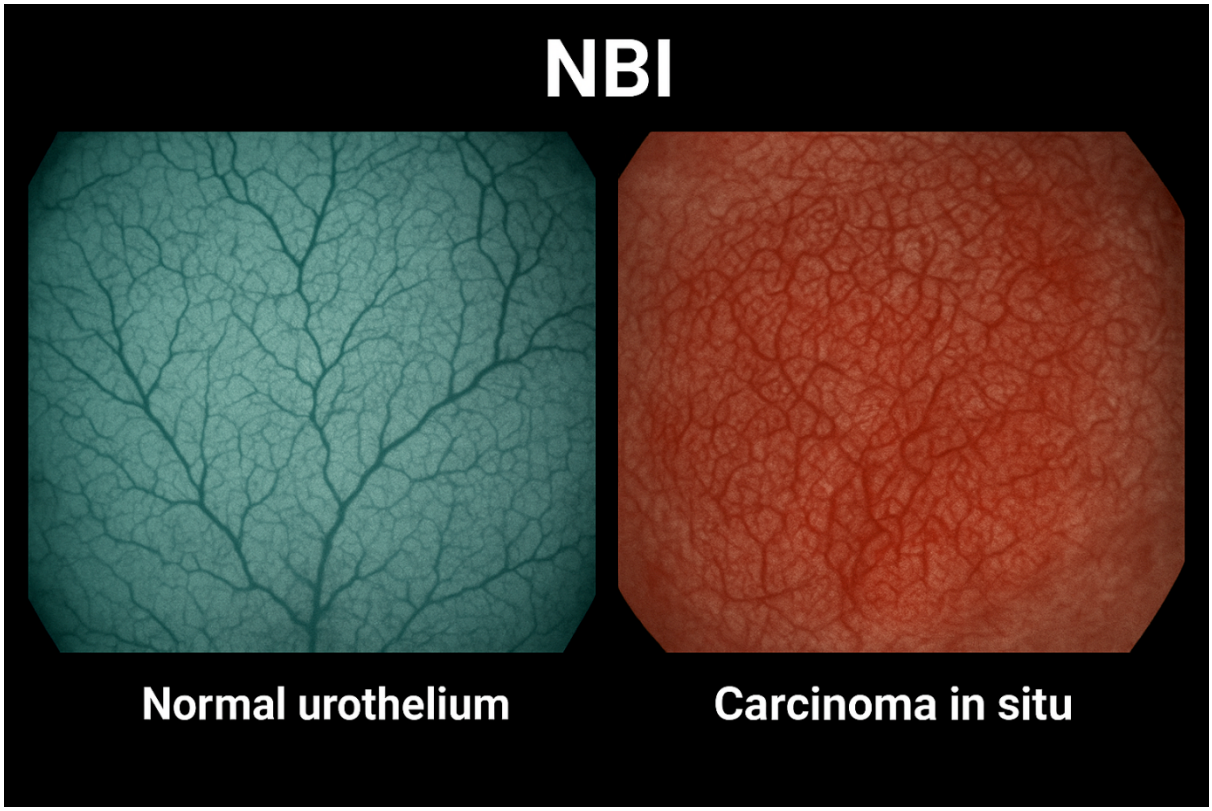
Figure 2

Figure 1. Detection of subtle carcinoma in situ using NBI cystoscopy

(A) White-light cystoscopy: faint mucosal erythema with minimal contrast from surrounding urothelium.

(B) NBI cystoscopy of the same area reveals a well-demarcated region of abnormal vascularity, illustrating NBI's superior sensitivity for detecting subtle or flat bladder lesions.

(Images courtesy of the authors; used with patient consent.



Diagnostic Performance and Sensitivity

Several meta-analyses confirm that NBI substantially improves diagnostic sensitivity compared with WLC.

- A pooled analysis of eight studies (n = 1,022) reported sensitivity of 94.3 % for NBI vs 84.8 % for WLC on a per-patient basis, and 92.7 % for CIS detection [1].
- Xiong et al. analysed 25 studies (17 full texts, 8 abstracts) and found a per-patient ADR of 9.9 % and per-lesion ADR of 18.6 %. Pooled sensitivity reached 95.8 % for NBI versus 81.6 % for WLC [2].
- Giulianelli et al. demonstrated that NBI increased lesion detection by 30 %, especially for lesions < 3 cm and unifocal or recurrent tumours [4].

The presented images (Figure 1) exemplify these results: under NBI, vascular irregularities and subtle mucosal alterations become readily apparent, enabling biopsy confirmation of CIS.

Clinical Implications

Improved detection directly impacts clinical outcomes. Incomplete tumour resection and missed lesions contribute to high NMIBC recurrence rates.

- Xiong et al. reported significantly reduced recurrence with NBI-assisted TURBT (RR 0.43 at 3 months; RR 0.81 at 12 months) [2].

- The CROES trial showed recurrence at 12 months of 5.6 % in the NBI group vs 27.3 % in the WLC group [5].

Enhanced identification of satellite lesions and improved margin delineation during TURBT likely explain these findings. NBI is particularly valuable for patients with high-risk NMIBC, recurrent disease, or positive cytology with inconclusive WLC.

Limitations

While NBI enhances sensitivity, specificity may be reduced due to inflammatory or vascular mimics. Reported specificity varies between 55 % and 70 % [9]. NBI does not provide information on tumour grade or invasion depth and should be combined with histopathology. Standardised training, interpretation criteria, and long-term outcome data remain necessary for optimal implementation.

Conclusion

Narrow-band imaging provides a significant advance in cystoscopic visualization of bladder cancer. By enhancing mucosal vascular contrast, NBI improves sensitivity for detecting flat, subtle, and multifocal lesions. The illustrated case demonstrates how lesions invisible under white light can be clearly identified with NBI, supporting biopsy and accurate diagnosis. Incorporating NBI into diagnostic and surveillance protocols can enhance lesion detection, resection completeness, and potentially reduce recurrence rates, making it a valuable adjunct in contemporary NMIBC management.

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