Invited lecture/Reflection

Narrow-Band Imaging – Clinical Application in Otorhinolaryngology

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Abstract:

Narrow-Band Imaging (NBI) is an optical endoscopic technique using optic filters to select two wavebands from a white light source and revealing mucosal and submucosal vascular patterns. NBI endoscopy is implemented to detect various lesions of the nasal and oral cavity, oropharynx and hypopharynx, and larynx; for finding bleeding vessel in recurrent epistaxis, for more precise tissue biopsy, in the diagnostics of synchronous cancers, for tumours of unknown origin, in defining surgical margins, inflammation and for follow-up of oncologic patients. According to lesion area in otorhinolaryngology, three classifications are known for observation of suspicious lesions: the "IPCL classification" for oral mucosa, the Ni's classification, and the classification recommended by the European Laryngological Society, for vocal cords. The correct recognition of vascular patterns by physician is strongly influenced by the learning curve of the clinician. In line with limits of NBI, a tissue biopsy remains the gold standard for definitive proof of malignancy. However, NBI endoscopy is especially useful tool for early detection of malignant and precursor lesions when the lesions are invisible during classical otorhinolaryngological examination.

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1. Introduction

Narrow-Band Imaging (NBI) as one of biological enodoscopies was developed in Japan in 1999 and was initially used for observing vascular patterns of intestinal mucosa. Later, it was implemented in various fields of medicine, including otorhinolaryngology (Gono, 2015). NBI is an optical image enhancement technology that enhances the visibility of vessels in the surface of the (sub)mucosa. The article presents the NBI endoscopic technique, its characteristics, its use in clinical practice, characteristics of the vascular patterns and its limits .

2. Narrow-Band Imaging characteristics and equipment

NBI is an endoscopic diagnostic method where the examined mucosa is illuminated with only two narrow bands of blue and green light spectra through optical filters instead of the entire spectrum of white light, ranging from 400 to 700 nm. A different wavelength is visually perceived as a different color. Hemoglobin in the vessels contains chromophores and absorbs blue and green light. The peak of blue light has a wavelength of 415 nm and shows us the superficial capillaries in the mucous membrane, while the green light with the peak of 540 nm reveals the submucosal vessels.
NBI takes advantages of selected light spectrum and some physics behind it. Firstly, the longer the wavelength, the deeper the light penetrates into the tissue (Ni et al., 2015). Secondly, since the energy of the blue and green spectrum is lower than the energy of white light, the light penetrates less deep than normal light, so we can observe only the surface of the mucous membranes, i.e., NBI is not appropriate method for observing deeper tissues. Thirdly, when the depth penetration is shorter, there is also less light scattering that sharpens the image. Finally, unlike the rest of the surrounding tissues, blue and green light is well absorbed by (sub)mucosa and consequently the contrast is improved (Šifrer, 2017a; Piazza et al., 2008; Piazza et al., 2010).
For NBI examination we need a light source and NBI filter placed between the xenon light source and a red-green-blue filter. Moreover, a rigid or flexible endoscope is needed, connected to a standard definition television (SDTV) camera or a high definition television (HDTV) camera or even an ultra high definition camera (ultra high definition, ultra HDTV), which uses 4K technology for the highest resolution needed. A light source and a monitor for observing vascular patterns are also indispensable accessories (Šifrer, 2017a; Lukes et al., 2013; Piazza et al., 2008).

3. Narrow-Band Imaging in clinical practice

NBI endoscopy is based on recognition of vascular patterns during formation of new blood vessels in neovascularization (as a phisiological process) or during neoangiogenesis (as a vessel growth proccess in malignant lesions) (Piazza et al., 2010).
NBI in otorhinolaryngology might be used for detecting pathological lesions in the oral and nasal cavity, oropharynx and lower hypopharynx and larynx (Lukes et al., 2013). In the nasal cavity, NBI can be appropriate for finding the bleeding vessel in the recurrent epistaxis (Šifrer et al., 2013). Furthermore, NBI is used for screening and early diagnostics of superficial mucosal cancer and pre-cancerous lesions; to distinguish malignant and benign lesions; for precise detection of the spread of mucosal lesions; for preoperative decision-making; for searching for the cancers of unknown origin; for intraoperative assistance and for follow-up of all oncologic patients after primary oncologic and/or surgical therapy. It improves visualization of the cancer pre- and intraoperatively; in revealing synchronous cancers due to the cancerization field; in the diagnosis of tumors of unknown origin; in the diagnosis of leukoplakias, erythroplakias and oral ulcers; in determination of safety surgical margins during the intervention and in inflammation (Srivastava, 2019; Šifrer, 2017a; Šifrer et al., 2017b; Piazza et al., 2010). Some authors also use NBI as an aid in more accurate intraoperative tissue biopsy (Piazza et al., 2010).

4. Vessel pattern presentation

During NBI endoscopy we can detect possible tumor lesions that are smaller than 5 mm or even invisible during classical ENT examination (with white light observing) (Lukes et al., 2013; Piazza et al.; 2010; Muto et al.; 2005).

The tip of the endoscope is firstly placed far from the mucous membrane under observation. Under the NBI filter, healthy capillaries in the mucosa are stained brown, and healthy veins in the submucosal area are stained blue (Srivastava et al., 2019). Then the mucous membrane is slowly approached. In the case of suspicious oncological lesion, a well demarcated brown area is observed first. It follows the description of dimensions and the structures contained in it. Further, the endoscope is gradually brought closer to the lesion, thereby the image becomes apparently larger and the examination becomes more accurate. After the magnification, the previously observed sharply demarcated brown lesion becomes the image of thick brown spots which may be scattered over the area of the suspicious epithelium and represent pathologically changed intraepithelial papillary capillary loops (IPCL) (Sano et al., 2016; Watanabe et al.; 2009). During neoangiogenesis, IPCLs can be transformed by expanding in diameter, branching, making elongations, meandering, etc (Lukes et al., 2013). Regarding anatomical site, there are many classifications for describing the vascular patterns: the IPCL classification for oral mucosa, the Ni's classification for vocal cords and the classification recommended by the European Laryngological Society, for vocal cords. However, as opposed to normal vocal cord vessel patterns, healthy oral mucosa is presented as regularly scattered thin brown dots (if they are in a perpendicular position in relation to the surface of mucosa), or as waved lines (if they are in the parallel position in relation to the surface of mucosa). IPCL elongated, meandering IPCL or IPCL in the form of the tangled lines represent malignant alteration of the oral mucosa. Healthy vocal cord vessels under NBI endoscopy are seen as tiny parallel vessels. But when vessels are presented like dilated, "worm shaped" or brown dots, this might be a sign of malignancy of vocal cords (Bitenc Zore and Šifrer , 2022; Šifrer et al., 2018; Šifrer et al., 2020). According to pathological vascular samples discovered as part of NBI endoscopy, this indicates further action - tissue biopsy, imaging diagnostics and regular check-ups of the current condition. NBI endoscopy serves as an aid in the detection of early (pre)malignant lesions. Tissue biopsy for histopathological examinations still remains the gold standard for confirming malignancy (Šifrer, 2017a; Piazza et al., 2011).

5. Limitation of Narrow-Band Imaging

The success of correct identification of vascular patterns with NBI endoscopy in benign and malignant mucosal lesions is dependent on the number of treated patients and thus the steep learning curve is typical (Srivastava, 2019; Piazza et al., 2010). During NBI examination, saliva and bleeding may severely limit the procedure. The latter leads to vascular patterns being completely obscure. Moreover, a strong pharyngeal reflex prevents the examiner to come in contact or at least close enough to mucosa of interest (Srivastava, 2019). With the NBI method, microvascular patterns can be misinterpreted, leading to a higher number of false-negative and false-positive results. We can successfully identify vascular patterns, especially of squamous cell carcinoma. False-negative cases often include patients with submucosal, non-squamous cell tumors (e.g. sarcomas, non-Hodgkin's lymphoma, neuroendocrine tumors,...) and hyperkeratoses, where whitish plaques obscure vascular patterns. False-positive cases are common in patients after radiotherapy, ulcers and infections (e.g. in granulomatous tuberculosis, histoplasmosis), in the oral cavity due to the complexity of the epithelium in various places and in patients with numerous scars after surgical procedures (Chabrillac et al., 2021; Gale et al., 2017; Odell et al., 2021; Vilaseca et al., 2017; Valls-Mateus et al., 2018).

6. Conclusion

NBI is a useful, fast and patient-safe endoscopic diagnostic method which can be used to identify many pathologies of the head and neck based on distribution of vascular patterns of the mucosa. However, tissue biopsy still remains the gold standard for confirming malignant lesions. A key advantage of NBI endoscopy is early identification of cancer-suspicious lesions based on the distribution of vascular patterns that would be missed using just white light endoscopy.

Conflicts of Interest: The authors declare no conflict of interest.

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