Chapter 23

Narrow band imaging (NBI®): What is it and why to use it when examining the vocal folds?

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Abstract

Narrow band imaging (NBI®) refers to an optical imaging technique used in endoscopy, where special filter is electronically activated to split the white light into blue (415 nm) and green (540 nm) wavelengths to enhance the details of mucosa that contains hemoglobin. Because the peak light absorption of hemoglobin occurs at these wavelengths, superficial blood vessels will appear very dark and deeper and will be seen as cyan in color. This illumination leads to an increase in the recognition of mucosal lesions that that are fed by blood vessels, such as carcinoma and papillomatosis. However, other conditions that cause hyper-vascularization such as chronic laryngitis or vocal phono-trauma are also thought to respond differentially to NBI®, and hence NBI® illumination may lead to improved diagnoses. Alternative methods to improve visualization of the mucosa in endoscopy include chromoendoscopy, confocal microscopy, and optical coherence tomography—subjects of many other chapters in this publication.

Keywords: white light, narrow band imaging (NBI®), light wave-lengths, diagnosis, hemoglobin, vocal folds, cancer, papillomatosis, phonotrauma, angiogenesis, new technology, Olympus, HD TV

Introduction

Optical visualization of the vocal folds (VF) requires illumination of the glottis with some type of a light source. The first ever visualization of the glottis under illumination employed the sunrays, later on a candle light was used to illuminate the glottis observed via a strobe disk, and with time very sophisticated light sources were introduced. No matter the light source, i.e. xenon or LED (light emitting diode), the light delivered is essentially in a form of what is commonly seen as a white light.

Light, depending on its nature, has specific characteristics usually defined as having specific wavelengths. The primary properties of the visible light include intensity, frequency, directionality, polarization and speed. When the light with a single frequency is directed at an object, this object might attract specific light frequencies (i.e. green or blue light) while absorbing all other frequencies of a visible light. This exchange depends on the frequency of the light and the structure of the object being illuminated. This process is illustrated in Figure 1, representing the wavelength for the conventional white light expressed by a RBG (Red-Blue-Green) model. The main purpose of the RGB color model is to sense, to represent, and to display images in electronic systems, as in the one produced discussed here.
Figure 1. The graph above shows the conventional red, blue and green (RGB) wavelengths from which the conventional white light is composed. Also, shown are the penetration characteristics of the short and long wavelength of this light. Reprinted with permission from Olympus.

**NBI® concept**

The NBI® is a technique developed in Japan for Olympus [1], and it is based on the principle of a selective light (RGB) absorption by an object. This principle is illustrated in Figure 2.

Figure 2. This figure shows how the NBI® works and what gains in visualization are obtained in relation to tissue illumination with the conventional white light. (Reprinted with permission from Olympus).

When NBI® is applied to an optical imaging technique used in endoscopy, a special filter is electronically activated to split the white light into specific blue (415 nm, short) and green (540 nm, long) wavelengths. These wavelengths enhance the details of mucosa that contains hemoglobin. Because the peak light absorption of hemoglobin occurs at these specific wavelengths, superficial blood vessels will appear very dark and deeper ones will be seen as cyan in color. See Figure 2.

The longer 540 nm wavelengths are the green waves and these penetrate deeper compared to the shorter 415 nm (blue) light. The longer waves are absorbed by hemo-
globin contained in the blood vessels (even veins), which are located deeper than capillary vessels found in the surface layer of the laryngeal mucosa. This wavelength is particularly useful for detecting tumors, which are often highly vascularized and where blood supply is in a form of neo-angiogenesis. These blood vessels appear in cyan color in the NBI® illuminated image.

Shorter wavelengths (415nm) penetrate only the superficial layers of the laryngeal mucosa, hence these are absorbed by capillary vessels that are found in the superficial layer of the laryngeal mucosa. These appear dark brown in the NBI® image. This color distinction is illustrated in Figures 3, 4 & 5.

Figure 3. Identification of capillaries and deeper veins due to NBI® illumination. The RVF shows no neo-angiogenic blood vessels while the LVF shows intraepithelial papillary capillary loops (IPCL). Such appearance is suspicious for carcinoma shown here in the NBI® image or for papilloma (shown in Figure 5).

Figure 4. An advantage of NBI® over a white light illumination of the VF, in this case representing bamboo VF (white transverse tissue), showing absence of neo-angiogenic blood vessels and clearly demonstrating lack of disruption of capillaries. Images courtesy of Ekaterina V. Osipenko, Head of Division of Phoniatrics, Moscow, Russia.
Figure 5. Images of VF illuminated with white light (left) and NBI® (right), clearly showing diagnostic advantage with NBI® illumination in a case representing papilloma. Images courtesy of Sebastian Dippold, Germany, www.klinik.uni-mainz.de/kommunikationsstoerungen/uebersicht.html.

Since NBI® entered medical applications, NBI® has been applied to investigate many types of mucosa, with the idea of enhancing diagnosis of the tissue, specifically when applied to early cancer detection. However, it is only recently that NBI® is being applied to study the laryngeal mucosa, as the larynx and hypopharynx is good site for NBI® applications. It is because, these areas contain thin, non-keratinized, stratified squamous epithelium, and such environment is ideal for visualization of the subtle angiogenic and neo-angiogenic changes referred to as intraepithelial papillary capillary loops (IPCL). For more on these diagnostic traits we refer the reader to the available literature [2].

NBI® is also valid for benign processes such as recurrent respiratory papillomatosis of the VF [3-4]. We have recently also discussed NBI® applications to non-malignant mucosal changes [5].

Conclusions

Abnormal vascular patterns observed in the laryngeal mucosa are subjects to the most recent studies using NBI® technology. The emerging literature demonstrates NBI® usefulness in studying different aspects and phases of laryngeal lesions containing hemoglobin. The accuracy of interpreting NBI® imaging has recently been shown to be enhanced by using HD display monitors [6]. Besides NIB usefulness in the diagnosis, recent NBI® applications include intraoperative evaluation of microsurgical margins [7] and in a post-treatment follow-up [8-11]. Particularly intriguing is the capacity of NBI® to properly distinguish post-actinic changes from persistent/recurrent disease. We expect more advances in NBI® applications to the larynx, hypo-pharynx, oral cavity and nasal passages and naso-pharynx as the NBI® technology and its applications develop further.
References

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