Erectile dysfunction (ED) is defined as the consistent inability to achieve and maintain an erection sufficient to permit satisfactory sexual performance or intercourse. The vast majority of cases of ED are primarily of organic and vascular etiology, although psychological factors also play a role in many cases. Affecting an estimated 2 million Canadians and becoming increasingly common with age, ED has been shown to compromise overall quality of life and is associated with depression, anxiety, and loss of self-esteem. To date, the diagnosis of ED is typically made on history and physical exam. In recent years however, increased understanding of the hemodynamics involved in vasculogenic ED has led to the development of a number of different diagnostic tests. These include penile brachial index, intracavernous pharmacologic testing, penile tumescence monitoring, color duplex ultrasonography, cavernosography and pharmacologic cavernosometry, penile scintigraphy, and selective pudendal arteriography. While each yields information of some diagnostic value, there is yet to be a single test or “gold standard” for diagnosis of ED. Much of this could be due to the fact that many of the current tests are complex, expensive, invasive, and often inaccurate. Given these limitations, and especially in light of advancing efficacious oral therapies readily available, some specialists argue that these tests should be reserved for special cases of ED where a diagnosis is important or surgery is required. However, an opposing view is that a minimally invasive and cost-effective test may still be of value in completing the appropriate management of a patient with suspected vasculogenic ED.

This study was undertaken to examine near-infrared spectroscopy (NIRS) as an approach to study penile blood flow and thereby explore a potential novel diagnostic tool for assessing vasculogenic ED. NIRS has emerged as a new technology within recent years for monitoring blood flow non-invasively and safely. The technology uses photons of light in the near infrared spectrum to assess concentration changes of oxygenated and deoxygenated hemoglobin in tissues. It can provide information concerning both oxygen saturation and relative blood volume changes within the organ of interest. Although NIRS has been widely used to assess muscle and cerebral blood flow, its use in the assessment of penile blood flow has been limited. We examined the use of NIRS to detect penile blood flow and to determine if increases in oxygenated hemoglobin (O$_2$Hb) concentrations correlate with erections.

**METHODS**

Two groups of men were examined. Group 1 consisted of 10 young men with no erectile difficulties, mean age 19 years (range 18-22). These men allowed us to determine the technical aspects of NIRS monitoring on the penis (i.e. optical sensor placement and how to secure the sensor) and the feasibility of assessing penile blood flow with visual sexual stimulation (VSS). Group 2 consisted of 12 men with prostate cancer undergoing a bilateral nerve sparing radical prostatectomy (RP). Mean age of the patients was 55 years (range 44-66). These men underwent NIRS with VSS preoperatively and at 3 months postoperatively with and without 20 mg of vardenafil. Each completed a validated psychometrically validated questionnaire IIEF (International Index of Erectile Function) pre and postoperatively. During NIRS testing each man was asked to assess if an erection occurred during the VSS.

**RESULTS**

With Group 1 we were able to create a re-usable NIRS optical sensor probe which was taped to the penis. In 7/10 of the men an erection occurred with VSS and with NIRS testing. O$_2$Hb concentration increased in all 7 men (Figure 1). In Group 2 the mean IIEF preoperative score was 25 (range 5-30) and the postoperative score was 11.1 (range 1-26). With NIRS testing preoperatively without vardenafil, 8/12 men felt they had some erection with VSS, and in 7/8 of these men there was an increase in O$_2$Hb concentration. In the one in which NIRS was unsuccessful the erection was minimal. In this same group, 9/12 men with NIRS testing showed increases in O$_2$Hb concentration with VSS, 2 of which felt they had no erection (Figure 2). When vardenafil was given preoperatively with NIRS testing, 12/12 men felt they had some erection and 10/12 of these men had an increase in O$_2$Hb concentration. Postoperatively without vardenafil on NIRS testing 2/12 men felt they had some erection and 7/12 men were found to have increases in O$_2$Hb concentration including the 2 men that had some erection. When vardenafil was
added postoperatively 7/12 men felt they had some erection and 7/12 men had increases in \(O_2\text{Hb}\) concentrations on NIRS testing (5 patients with an erection and 2 without). There was a rapid rise in \(O_2\text{Hb}\) concentration in men with excellent erections.

**DISCUSSION**

To date, management of a patient with suspected ED is often centred on a goal-oriented approach\(^7,8\). Treatment selection is based on patient preferences following a thorough discussion with a treating physician regarding therapeutic options with minimal diagnostic testing. Reasons for this empirical approach probably stem from the relatively safe and highly effective medications currently available for ED\(^9\). Despite this, studies completed on outcome analyses of the goal-directed approach, often indicate low patient satisfaction rates\(^10,11,12\). In part, this could be due to the fact that without a thorough understanding of the etiology and pathophysiology of a given patients ED, commonly preferred therapies may be ineffective. Perhaps a diagnosis-based, (pathogenesis-specific) treatment approach to patients with suspected ED may yield better outcomes\(^12\).

In this preliminary study, we demonstrated that NIRS can be used to assess penile blood flow with sexual stimulation. Accordingly, we performed a series of penile NIRS studies on both healthy subjects, and on patients presenting with various degrees of ED. Upon analysis, a rise in \(O_2\text{Hb}\) concentration on NIRS was found to correlate very well to patient perceived erections. The results from this early investigation suggest that it may be clinically useful for the practicing urologist. The appeal of this modality is further supported by its perceived advantages: low equipment cost, transportability, operator non-dependence, simple operation, and safety.

Despite these indications for a diagnostic role of a penile NIRS device, the critical measure of the clinical utility of any new technology rests on its ability to direct appropriate therapeutic management. Given our limited sample size, our study was unable to examine whether penile NIRS can accurately discern blood flow profile differences between vasculogenic and non-vasculogenic ED. Looking ahead, further studies are needed to establish diagnostic ranges that identify psychogenic/neurogenic (non-vasculogenic), mild vasculogenic, and severe vasculogenic causes of ED. As well, more studies are needed to correlate NIRS testing with Doppler studies\(^13\).

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**REFERENCES**