355

Clarkson B[1], Huppert T[1], Beluk N[1], Tadic S[1], Resnick N[1], Schaefer W[1]
1. *University of Pittsburgh*

BRAIN RESPONSE TO PELVIC FLOOR MUSCLE SQUEEZES: USING FUNCTIONAL NEAR INFRARED SPECTROSCOPY WITH URODYNAMICS

Hypothesis / aims of study

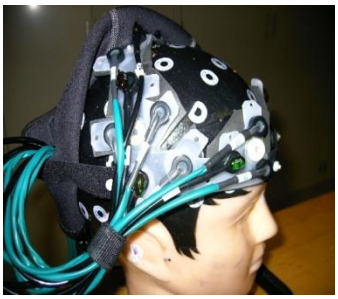
The brain's role in bladder control is an important area of research. PET and functional MRI have been used to identify some key centres and mechanisms governing lower urinary tract function (1), however, their restrictive brain scanning environments limit the bladder testing that can be done simultaneously, and the signal to noise ratio is insufficient to evaluate an individual, especially in real time. Near infrared spectroscopy (NIRS) has the potential to measure brain activity in a urodynamic laboratory during a range of bladder tests (2), without the physical restrictions of a traditional MRI/PET scanner such as movement, position and complexity of task. It may also permit studies of individuals. Because NIRS can measure up to 1cm into the cortex, it also may be an ideal way to measure the motor areas associated with sphincter control, and the prefrontal cortex associated with executive control of voiding.

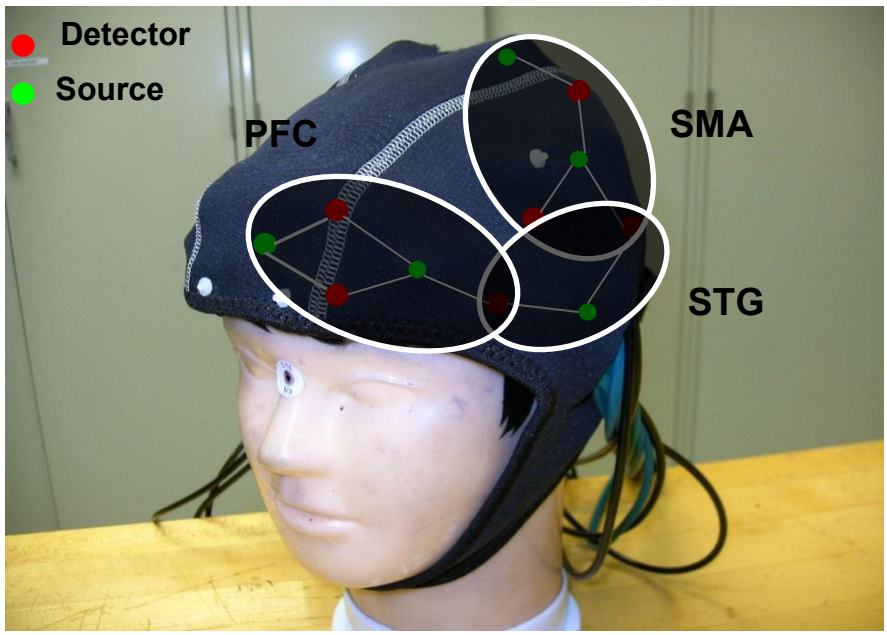
The aim of the study was to investigate brain activity during basic stages of a urodynamic test, including bladder filling, voiding and pelvic floor muscle squeezes. Here we report on the feasibility of using NIRS to measure brain activity during pelvic floor muscle squeezes.

Study design, materials and methods

Nineteen urge incontinent and eight continent women over 60 years of age were recruited to have urodynamic studies (UDS) with simultaneous measurement of brain activity using NIRS. Targeted areas included the supplementary motor area (SMA), superior temporal gyrus (STG) and prefrontal cortex (PFC) (fig 1). Sources and detectors of light (690 and 830nm) were aligned at a distance of 3cm apart in such a way as to record change in concentration of oxy- deoxy- and total haemoglobin (Hb) concentration over the PFC (three measurements), STG (2 measurements) and SMA (4). Measurements were made continuously during UDS which included two sets of five pelvic floor muscle contractions (5 second duration) with 20 second rest period and three filling/voiding cycles.

Change in concentration of haemoglobin in each brain area was calculated from the reduction in intensity of the transmitted light using a modified Beer-Lambert law. A generalised linear model (GLM) was used to calculate the block average of each task at a threshold statistical significance of $p<0.001$. This allowed diagrammatic representation of statistically significant increase or reduction in brain activity as the summation of activity during all pelvic floor squeezes. The change in HbO (oxy-haemoglobin) between each source-detector pair was displayed with the timing of tasks such as pelvic floor squeezes allowing squeeze-related activity to be identified in the SMA (as expected for motor activity, 3).





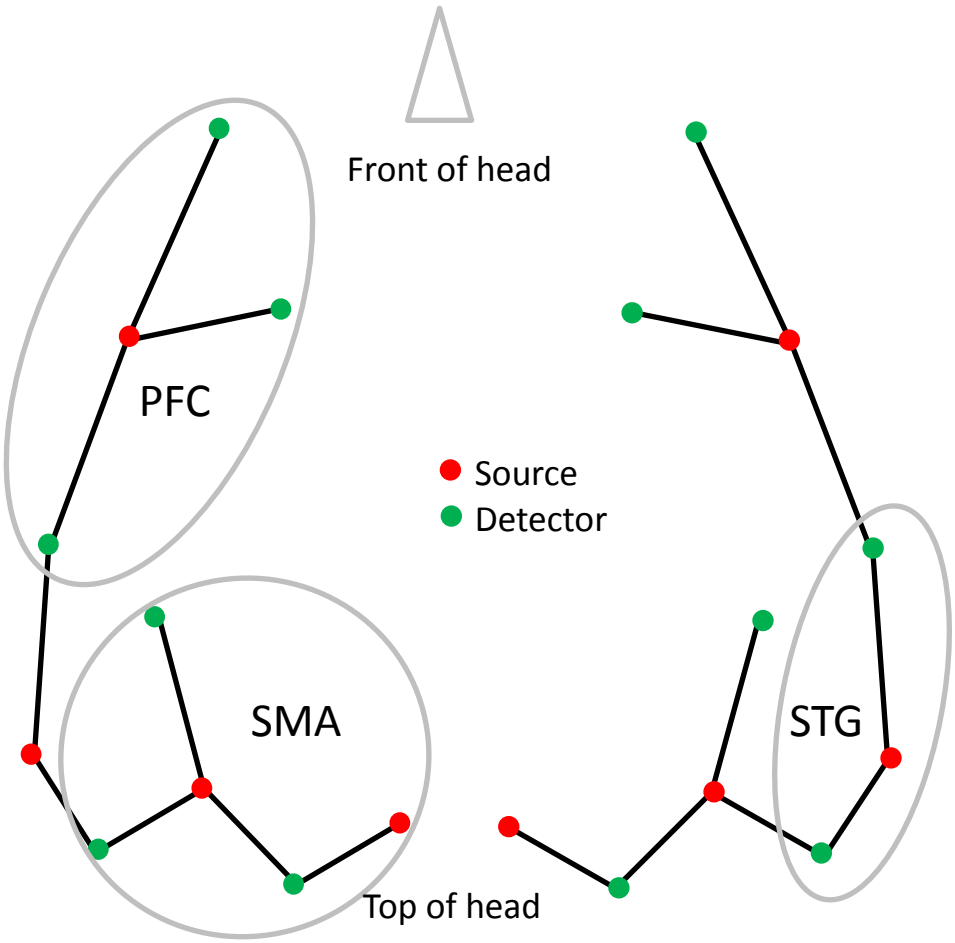


Fig 1, (left) probe on dummy head; (center) secured by scuba cap; (right) probe geometry and covered brain areas.
Since this application of NIRS is still under development, empirical study was deemed most appropriate in this pilot study. HbO measurements from each source detector pair in the SMA were visually inspected to assess association with timing of squeezes. Since an advantage of NIRS is its real time capability, visual assessment is important. Activity was confirmed if there were 4-5 peaks (or troughs) in the same frequency as the squeezes, within 10 seconds of the onset of the squeeze, for both sets of 5 squeezes.

Results

During pelvic floor muscle squeezes, temporally correlated activity in at least one channel over the SMA (expected area for motor activity, see figure 2) was observed in only 10 out of 19 incontinent subjects and in 2 of 7 control subjects. Table 1 shows percentage of channels showing squeeze response (one incontinent and two controls had all four channels excluded due to noise).

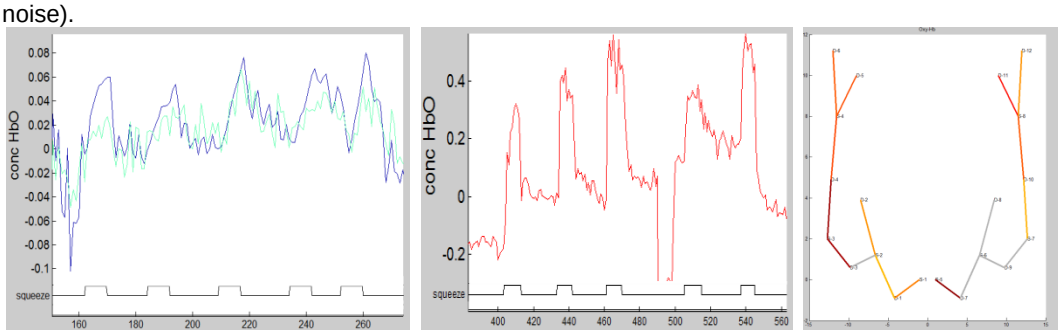


Fig 2, during squeeze (left) concentration of oxy-Hb in two sites in left SMA (subject 1); (middle) right SMA (subject 2); (right) map of significant increase in activity (red/orange shows p<0.001) in each NIRS measurement of subject 2 during block average of all squeezes.

	Incontinent	Control
Number of channels	152	56
Number of subjects	19	5
% too noisy	32	43
% no response	45	45
% squeeze response	20	9

Table 1: Percent of channels overlying the SMA region that show squeeze activity

In all subjects with SMA activity, there was measurable urethral pressure increase. In five subjects there was no temporally correlated SMA activity, but urethral pressure increase was measurable. Block averaged data over all 10 squeezes per subject showed that 12 out of 19 subjects had increased activity in the SMA (at least one channel) during squeeze ($p<0.001$).

Interpretation of results

A response to pelvic floor squeeze in the SMA was detected by NIRS in many participants (Fig 2), but it was only present in half who completed the task successfully. Almost half of the channels did not show any visible squeeze response; usually squeeze response was not present consistently over 4 SMA channels per subject. The very low number of total channels showing a response (Table 1) suggests that although the signal is significant in some subjects, it may be lost in others due to noise, movement artefact or interference during the task, and in some cases be completely absent.

Concluding message

The aim of this analysis was to assess NIRS' consistency across subjects, in order to begin to identify how NIRS could be used to assess physiology and/or pathology. Although this method shows promise in that a response to motor tasks can clearly be seen in the brain, the consistency of the measurement between channels (and the absence of a signal in a large proportion of channels) suggest that the method and experimental technique need further development and are not yet ready for use as a research tool.

References

1. Griffiths, D. and S. D. Tadic (2008). "Bladder control, urgency, and urge incontinence: evidence from functional brain imaging." Neurourology & Urodynamics 27(6): 466-474.
2. Sakakibara, R., K. Tsunoyama, et al. (2010). "Real-time measurement of oxyhemoglobin concentration changes in the frontal micturition area: An fNIRS study." Neurourology and Urodynamics 29(5): 757-764.
3. Zhang, H., A. Reitz, et al. (2005). "An fMRI study of the role of suprapontine brain structures in the voluntary voiding control induced by pelvic floor contraction." Neuroimage 24(1): 174-180.

Disclosures

Funding: NIH R03 AG038583-01 **Clinical Trial:** No **Subjects:** HUMAN **Ethics Committee:** University of Pittsburgh IRB **Helsinki:** Yes **Informed Consent:** Yes