Characterising, Understanding, and Treating Balance Impairment in Parkinson's Disease

Research

Impaired balance greatly diminishes quality of life for patients with Parkinson's disease (PD). It causes symptoms such as falls, a sense of unsteadiness when walking and difficulty transitioning between positions such as sitting to standing. Yet, balance impairment in PD is largely unresponsive to current treatments. To develop effective treatments, we need to objectively measure and understand the underlying causes of balance impairment in PD and identify therapeutic targets.

A potential method to measure and characterise balance impairment in PD is to track postural sway. Postural sway is the constant movement in centre of mass which occurs even during quiet stance. This can be captured using 'posturography', which involves standing on a pressure sensitive plate to track variations in centre of pressure. Maintenance of upright stance requires a constant and active process of leg muscle modulation to counteract torque from gravity. However, it was unknown how the brain controls these small movements to regulate postural sway.

An experimental treatment for balance impairment in PD is to implant and modulate a small brain region called the Pedunculopontine nucleus (PPN) with deep brain stimulation (DBS; a brain 'pacemaker'). Neurologist Peter Silburn and Neurosurgeon Terry Coyne in Brisbane, Australia, have been leaders in implanting and investigating this novel therapy. It was hoped, but never proven, that PPN DBS could improve balance in PD. The potential of any therapy to improve balance in PD would be important information, even if only to reveal a viable therapeutic mechanism.

We therefore performed an experimental study, performing posturography on patients with PD with balance impairment, whilst off and on PPN DBS and comparing results to healthy controls. Novel analysis methods using mathematical modelling were applied to measure balance impairment, to characterise how the brain controls postural sway, and to seek a treatment effect of PPN DBS.

This work is published in the journal 'Brain': Perera T et al, 2018 Oct 1;141(10):3009-3022

Outcome

Our analysis, supported by the Brain Foundation, detected the involvement of two types of brain systems controlling balance; intermittent and continuous. Intermittent control was indicated by the appearance of abrupt redirections of sway (switching behaviour). Continuous control was indicated by the data conforming to a 'Proportional Integral Derivative' model (akin to adaptive cruise control in cars). Both these control systems were abnormal in the patients with PD compared to healthy subjects, and improved towards normal with PPN DBS.

These findings are important, as they demonstrate a novel way to measure and characterise balance impairment in PD. They clarify how the brain controls postural sway and how that control breaks down in PD. Crucially, we found that some of the balance impairment was amenable to reversal, in this study with PPN DBS. Whilst PPN DBS is an invasive treatment that is unsuitable for many patients, these findings highlight a therapeutic mechanism that could be exploited by other treatments. Indeed, our group is now developing a less invasive device to try and emulate this treatment effect.

RESEARCH TEAM:

Chief Investigator:

Associate Professor Wesley Thevathasan FRACP DPhil.Oxf

Lions International Neurobionics Fellow,
The Bionics Institute, Melbourne, Australia
Consultant Neurologist, Melbourne University Hospitals (RMH, Austin, St Vincent's, RCH)
Principal Fellow, Department of Medicine, University of Melbourne

Co-investigator:

Dr Thushara Perera PhD

Research Fellow (Biomedical Engineer)
The Bionics Institute, Melbourne Australia
Department of Medical Bionics, University of Melbourne