RCoA Research, Education & Travel Grants 2017

Award: Ernest Leach Research Fund

Applicant: Prof Graeme McLeod

Project Title: *Is intraneural injection associated with nerve ischaemia? A quantitative analysis of nerve blood flow and oxygenation using micro-ultrasound and photo-acoustics in an anaesthetised pig model*

Project Description:

Nerve damage still occurs after regional anaesthesia. One in 10[1] patients have symptoms up to one month and 1 in 2,500 patients suffer debilitating nerve damage[2]. Damage is attributed to the site of injection[3], needle trauma[4, 5] and needle tip pressures >20psi on injection of local anaesthetic[6].

Local anaesthetic injection remains controversial. Animal studies show nerve inflammation[6-8], haematoma[9] and deterioration in electrophysiology[10]. In two clinical studies[11, 12] injection between fascicles was not associated with clinical nerve damage. Evidence of safety has relied on histology images[13] and there is a need to supplant this with real-time imaging.

Our first microultrasound study[4] used a single element 40MHz transducer. In dissected cadaver nerves, fascicles were difficult to enter and rotated in response to needle insertion. We repeated this study in anaesthetised pigs in April 2017 at Sunnybrook hospital, Toronto, where my ex colleague Dr C Demore now has tenure as a bioengineer researcher. In 5 pigs, we replicated extraneural nerve block, forceful needle nerve contact, interfascicular and intrafascicular injection. Injection of only 0.5ml to 3ml volumes at rates compatible with clinical practice ($<0.2 ml.s^{-1}$) repeatedly led to traumatic epineural rupture. Histology is awaited.

Needle tip pressure > 20 psi is associated with inflammation and cell death. I am translating benchtop needle pressure studies[14] to soft cadaver tissue using combinations of flow rate and needle gauge. Results will inform the choice of flow rates between 0.05 and $0.3 ml.s^{-1}$ in the proposed study.

The primary objective is to correlate real-time needle tip pressure with nerve blood flow and oxygen saturation using photo-acoustic imaging during conduct of regional anaesthesia in the axillary nerves of anaesthetised pigs. Nerve blood flow and oxygenation is quantified using a photo-acoustics attachment on the Visual Sonics ultrasound transducer. Pulsed light is emitted and absorbed by chromophores causing heat and tissue expansion and generation of acoustic waves. Data is processed and superimposed onto B-Mode images.

Pigs will be ventilated, hydrated and temperature maintained by a vetinary assistant. Axillae will be surgically dissected and a small muscle ridge placed between the

40MHz transducer and nerve. A standard 21g regional block needle will be inserted under microultrasound control. Pressure will be generated via a calibrated syringe pump driven at five flow rates compatible with a range of low to high generated pressures during regional block. Needle pressures will be measured at epineural and perineural tissues boundaries and during fluid injection of 0.5 mL at extraneural, extrafascicular and intrafascicular sites. Continuous ultrasound video, needle tip pressure, blood flow and nerve SpO2 will be acquired during needle insertion and injection. Experiments will be repeated 3 times. Thus a total of 75 experiments will be conducted on 10 axillary nerves of 5 pigs.

This research study is novel and first to quantify nerve blood flow and oxygenation in an animal. The facility is well established. The research will provide first real-time modelling of ischaemia/reperfusion in regional anaesthesia. The Visual Sonics system was invented in this department, and is the only laboratory in the world that can undertake this.

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