

Editorial

The Stresses and Strains of Ultrasound-Guided Regional Anaesthesia

Lockwood H¹ and McLeod G^{2*}¹University of Dundee, Dundee, United Kingdom²Consultant and Honorary Reader in Anaesthesia, Ninewells Hospital & Medical School, Dundee, USA,

There can be no doubt that the addition of ultrasound to regional anaesthesia has enabled anaesthetists to directly visualise key anatomy and monitor local anaesthetic spread [1]. A recent meta-analysis of 42 studies has shown an increase in the proportion of patients receiving good quality nerve block without need for rescue analgesia to be 93% for ultrasound-guided regional anaesthesia (UGRA), compared to only 83% for peripheral nerve stimulation (PNS), risk ratio 1.09 (95% CI 1.05-1.13). The rate of conversion to general anaesthesia was found to be 4% lower for UGRA than PNS [2], emphasising the advantages of ultrasound, particularly in expert hands [3]. However, inadvertent intraneural injection and possible neurological impairment remains a significant clinical problem, with an observational study reporting an incidence of 1 in 6 UGRA patients and demonstrating no reduction in nerve damage using UGRA [4]. Although it is now recognised that nerve damage is secondary to inadvertent intra-fascicular injection, good clinical practice should still aim for extraneural injection at all times [4]. Reasons for intraneural injection may be in part due to user experience and patient characteristics but the technical limitations of B-Mode ultrasound must also be considered. The small differences in acoustic impedance (product of tissue density and acoustic wave velocity) between soft tissue structures and use of an 8-bit grayscale result in B-Mode images of limited contrast [5] which is perceived by the operator as anatomical ambiguity. Attempts to improve B-Mode image quality such as compound imaging, tissue harmonic imaging [6] and image optimization [7] have achieved increased contrast resolution [6], but clear delineation of intraneural and extraneural tissue remains suboptimal [8]. Furthermore, there is little literature on the quantitative assessment of image quality despite its significance in importance successful image interpretation [9]. Similarly qualitative measures such as brightness scores and grayscale histograms are rarely considered in the clinical environment; suggesting a general lack of awareness of the value of image quality assessment and perhaps even an acceptance of technically inadequate images. Ultrasonic quantification of basic tissue characteristics such as elasticity has been used for cancer detection in breast, thyroid and prostate due to the ability to

*Corresponding author

G A McLeod, Consultant and Honorary Reader in Anaesthesia, Ninewells Hospital & Medical School, Dundee, UK, E-mail: g.a.mcleod@dundee.ac.uk

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differentiate between “soft” normal tissue and “hard” carcinoma [10]: the imaging equivalent of clinical palpation [11]. Elasticity refers to the ability of a material to return to its resting form after application of force and is quantified as Young’s elastic modulus (ratio of stress, force per unit area, to strain) [11]. Elastography is the ultrasonic characterisation of tissue elasticity presented as a colour map elastogram and is subdivided into two forms: strain and shear wave. Strain elastography measures the response of tissue to application of force, whereas shear wave elastography provides a true quantitative, as opposed to indirect, measure of Young’s modulus (E) based on tissue density and shear wave velocity [11]. Shear wave elastography may be used in the practice of UGRA to delineate key anatomy in colour (Figure 1) and most importantly differentiate between intraneural and extraneural tissue [8]. We have shown that differences in tissue elasticity allow clear identification of anatomical structures in both Thiel embalmed human cadavers and living volunteers (E=11.1kPa for neural tissue compared to 2.8-4.2kPa for the anterior and medial scalene muscles) [8]. Moreover, shear wave elastography has been validated with B-Mode ultrasound by demonstration of

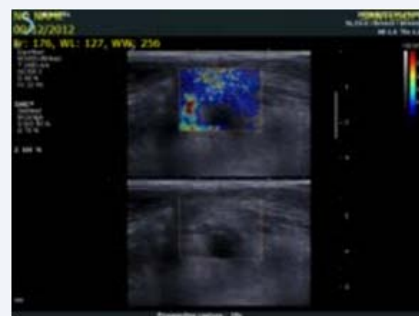


Figure 1 Infraclavicular nerve block. Shear wave elastography image (top) has been superimposed on the standard B-Mode image (bottom); the lateral cord can be clearly seen in red at the nine o'clock position (top). Also note coloured areas at six and seven o'clock (top) corresponding to the inferior cord. Note hypoechoic split between echogenic nervous tissue (bottom) reflected in upper image by absence of red colour. The square region of interest limits further delineation of the structure and thus our description.

bioequivalence of shear wave and B-Mode cross-sectional nerve areas.

Shear wave elastography provides a possible solution to the problem of nerve identification and should be further investigated as an adjunct to B-Mode ultrasound during UGRA procedures. Further research into the repeatability and reproducibility of Young's modulus using shear wave elastography and clinical measurement of intraneural and extraneural Young's moduli in UGRA patients will strengthen the evidence base for the use of shear wave in UGRA. Together with developments in UGRA teaching, it is hoped incorporation of future technologies such as elastography may reduce the stresses and strains of regional anaesthesia.

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