Force and pressure measurements during simulated nerve block on the soft embalmed Thiel cadaver

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Introduction

Opportunities for regional anaesthesia training are limited, and a need arises for simulation training to fill the skills gap. The soft embalmed Thiel cadaver has many properties of the ideal simulator. We wish to use physical measurements from the cadaver in order to create a virtual, immersive simulator that all anaesthetists can use to train in regional anaesthesia.

The study was performed at the Centre for Anatomy and Human Identification, University of Dundee. Our model was the soft, embalmed Thiel cadaver, soaked in embalming solution in vats for 6 months. Needle tip force and injection pressure , physical measurements, were measured during the process of needle insertion into simulated cadaver. The simulated nerve block on the soft embalmed Thiel cadaver system was shown in Fig 1.

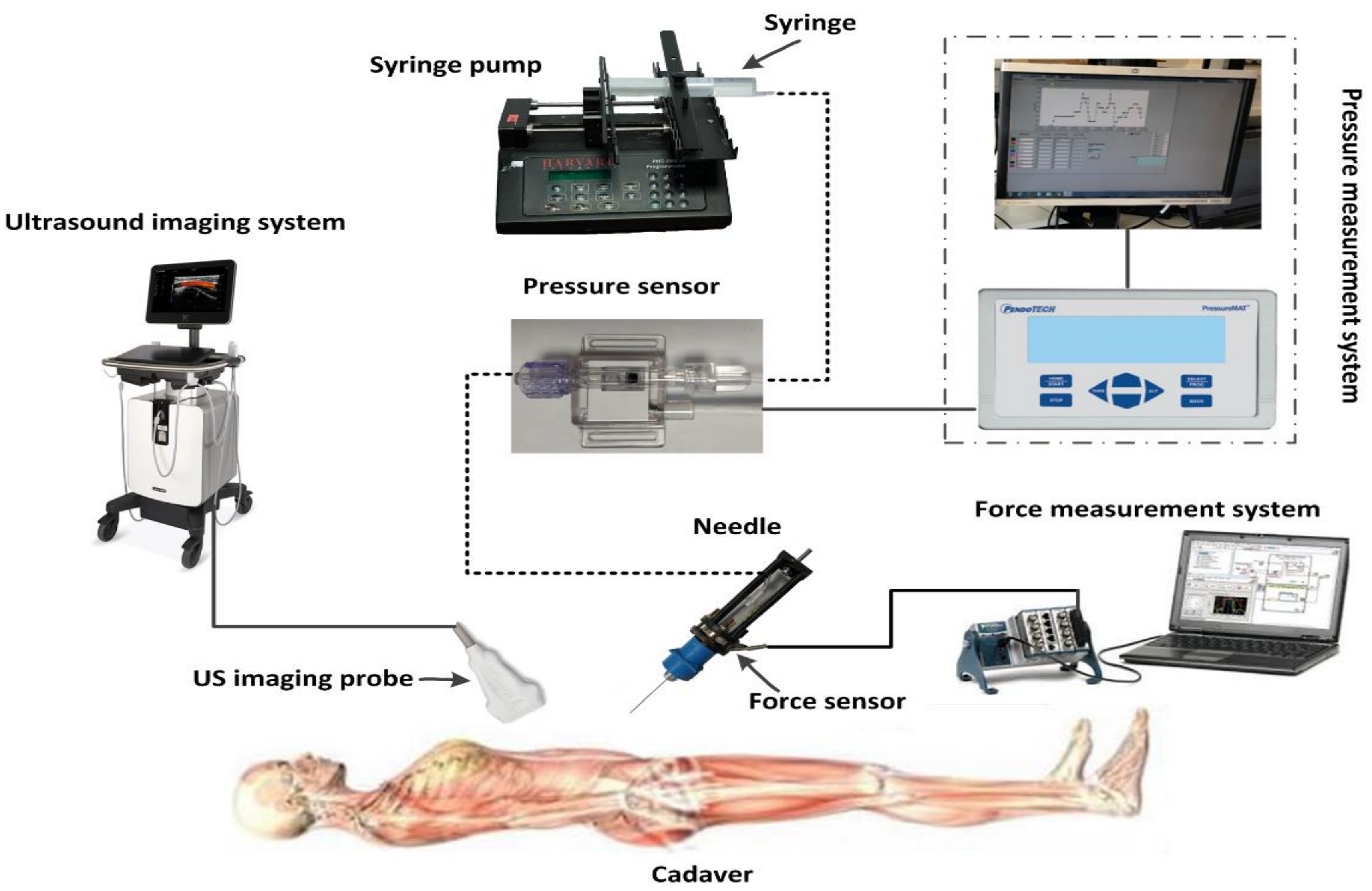

Fig.1 Schematic of simulated Cadaver system

Our primary objective was to measure the force of needle insertion through muscle and fascia onto the epineurium of nerves in the neck, axilla, forearm and popliteal fossa.
Our secondary objectives were to measure the:
(i) pressure generated during fluid injection at tissue interfaces over a range of injection speeds;
(ii) differences in force and pressure between and within cadavers.
(iii)differences between novices and experts.

Methods

In the pilot study we randomised 28 simulated nerve blocks to two operators, left and right sides of two cadavers and three fluid injection rates. Operators consisted of an expert regional anaesthetist and the other a PhD student. The student was trained to perform blocks on the Thiel cadavers by the chief investigator to a level of proficiency equivalent to the basic level of performance defined by the RCoA curriculum.

Nerves were scanned using an Ultrasonix tablet, (Ultrasonix, Vancouver, Canada) with a 20MHz ultrasound probe. Nerves consisted of the C5 and C6 nerve roots, axillary median nerve, axillary ulnar nerve, forearm median and ulnar nerves and the popliteal tibial nerve. A 21g B.Braun stimuplex needle was inserted in the plane of the ultrasound transducer through fascia and muscle onto epineurium. The epineurium was distended using sufficient force to slightly invert the nerve wall and simulate needle nerve contact in patients. Once the needle was opposed to epineurium, we randomly administered a 0.5ml bolus of Thiel embalming solution through an infusion pump (Harvard Apparatus) at 1ml/min, 6ml/min and 12ml/min in order to match the rates used in an anaesthetised pig study we recently conducted. During nerve block, we collected real-time force and pressure data on dedicated computers .

Results

Force, during needle insertion, differentiated between epineurium and sub epineural tissue, [geometric ratio 1.66 (95%CI: 0.97 - 2.84), P < 0.001], and between novice and expert operators [geometric ratio 1.47(95%CI: 1.21 - 1.74), P = 0.003]. Pressure at a flow rate of 12ml.min-1 was greater than at a flow rate of 6 ml.min-1 [geometric ratio 0.80 (95%CI:0.58 - 1.02), P = 0.002]. Pressure generated in cadaver 1 was less than in cadaver 5, geometric ratio 0.75 (95%CI: 0.24 -1.26), P = 0.02.
Examples of temporal patterns of force and pressure are shown in Fig 2A shows a typical response to fascial penetration and contact with epineurium. Force rises then falls when the needle is retracted from the epineurium. Pressure increases in response to fluid injection. Fig 2B shows epineurium contact and nerve penetration characterized by a small plateau.

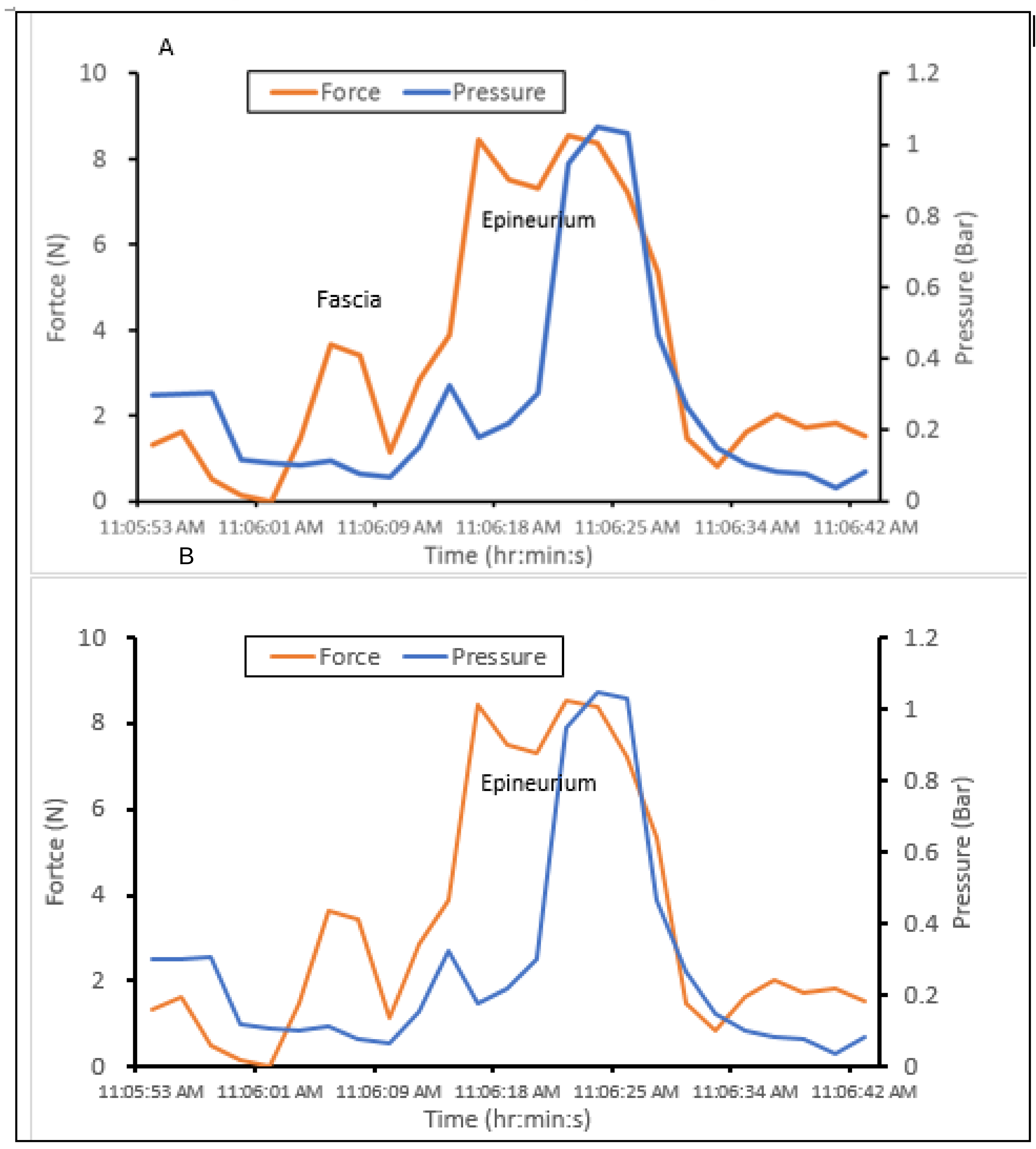

Fig.2 Two Examples of temporal patterns of force and pressure

Conclusions

We have showed that the soft embalmed Thiel cadaver is a valid life-like simulator of regional anaesthesia. Haptic feedback identified tissue boundaries and showed a two-fold difference between novice and experts. Pressure responses secondary to fluid injection showed characteristic increases with infusion flow rate and varied between cadavers.

Discussion

Our findings raise the possibility of using force as a surrogate marker of perineural and sub-epineural needle tip placement. the potential benefits and weaknesses of force and pressure measurement can be observed on our graphs. Continuous measurement of force allows instant detection of epineural contact, loss of resistance, and no requirement for fluid injection.

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