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Comparison of success rates, learning curves, and inter-subject performance variability of robot-assisted and manual ultrasound-guided nerve block needle guidance in simulation

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Editor's key points

- A novel robot assistance nerve block system has been recently developed and tested in patients.
- This study investigated the role of this system in training in ultrasound-guided nerve blocks.
- The robot system reduced inter-subject variability, with faster learning of needle placement than manual techniques.
- This new approach to regional anaesthesia training may increase learning rates; it needs further evaluation.

Background. This study focuses on a recently developed robotic nerve block system and its impact on learning regional anaesthesia skills. We compared success rates, learning curves, performance times, and inter-subject performance variability of robot-assisted *vs* manual ultrasound (US)-guided nerve block needle guidance. The hypothesis of this study is that robot assistance will result in faster skill acquisition than manual needle guidance.

Methods. Five co-authors with different experience with nerve blocks and the robotic system performed both manual and robot-assisted, US-guided nerve blocks on two different nerves of a nerve phantom. Ten trials were performed for each of the four procedures. Time taken to move from a shared starting position till the needle was inserted into the target nerve was defined as the performance time. A successful block was defined as the insertion of the needle into the target nerve. Average performance times were compared using analysis of variance. $P<0.05$ was considered significant. Data presented as mean (standard deviation).

Results. All blocks were successful. There were significant differences in performance times between co-authors to perform the manual blocks, either superficial ($P=0.001$) or profound ($P=0.0001$); no statistical difference between co-authors was noted for the robot-assisted blocks. Linear regression indicated that the average decrease in time between consecutive trials for robot-assisted blocks of 1.8 (1.6) s was significantly ($P=0.007$) greater than the decrease for manual blocks of 0.3 (0.3) s.

Conclusions. Robot assistance of nerve blocks allows for faster learning of needle guidance over manual positioning and reduces inter-subject performance variability.

Keywords: learning curves; medical robotics; regional anaesthesia; robot assistance; robotic anaesthesia; simulation

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Robot assistance has been present in surgery for more than a decade, with robots such as the Da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) being commonly used today by surgeons in the fields of gynaecology and urology. The mechanical robots that provide this robot assistance have been shown to provide an increased precision of movements, improve patient outcome,[1 2] and reduce perioperative morbidity.[3]

Studies have demonstrated that surgical, robot-assistance skills are relatively easy to acquire by novices.[4 5] In fact, a study by Brinkman and colleagues[5] in 2013 showed that more than half of the novices achieved expert-level proficiency with a robot assistance system after only 10 operations. Additionally, robot-assisted surgery has been found to help achieve shorter learning curves and better accuracy than manual or laparoscopic surgery.[6 7] A prospective study of robotic *vs* laparoscopic surgery in 2006 concluded that not only does robot assistance in surgery lower the learning curve for both standard tasks and actual operations, but also that prior surgical knowledge (for open or laparoscopic procedures) is not necessary to learn how to perform robotic procedures.[8]

While all of these studies focus on robot assistance in surgery, little research has been done on robot assistance in anaesthesia. This lack of research into robot assistance for

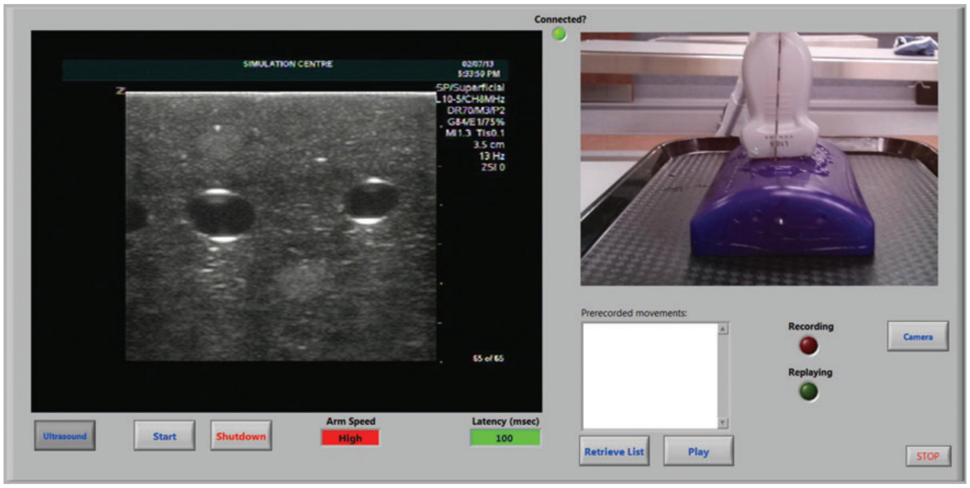

Fig 1 The cockpit of the Magellan robotic nerve block system featuring the US video feed on the left and needle insertion area on the right. If reading the PDF online, click on the image to view the video.

anaesthesia is due to an absence of any such systems designed specifically for this field. As several studies have indicated a lowering of the learning curve for robotic *vs* manual surgery, a similar trend could be expected for robot-assisted anaesthetic procedures. Having recently developed the first robot-assisted nerve block system (Magellan robotic nerve block system)[9] and tested it in patients,[10] we set out to compare the success and learning rates, performance times, and inter-subject performance variability of ultrasound (US)-guided, robot-assisted *vs* US-guided, manual nerve block needle guidance in simulation on a nerve block phantom. The hypothesis of this study is that robot assistance will result in faster nerve block needle guidance skill acquisition than traditional, manual nerve blocks.

Methods

The Magellan robotic nerve block system used in this study is composed of a Tuohy standard nerve block needle mounted on a robotic arm (JACO robotic arm, Kinova Rehab, Montreal, QC, Canada) that is controlled via a software control centre and joystick. The graphical user interface for the system (the Magellan cockpit) features a view of the US video feed and a camera view of the needle insertion area (visible in Fig. 1).

In this study, five co-authors (J.M., C.P., N.T., M.W., C.Z.) each performed four different US-guided nerve block needle placement procedures on two different nerves of an US nerve phantom (Blue Phantom Select Series Peripheral Nerve Block Ultrasound Training Model, Blue Phantom, Redmond, WA, USA) (Fig. 2). This phantom features a superficial nerve at a depth of 1 cm and a profound nerve at a depth of 2.5 cm. It is made of a material that provides for realistic US image characteristics of human peripheral nerves and blood vessels. Half of the procedures were manual, while the other half were robot-assisted. Each procedure was repeated for 10 trials by each user and all procedures involved an 'out-of-plane' nerve block where the needle is inserted perpendicular to the US beam.

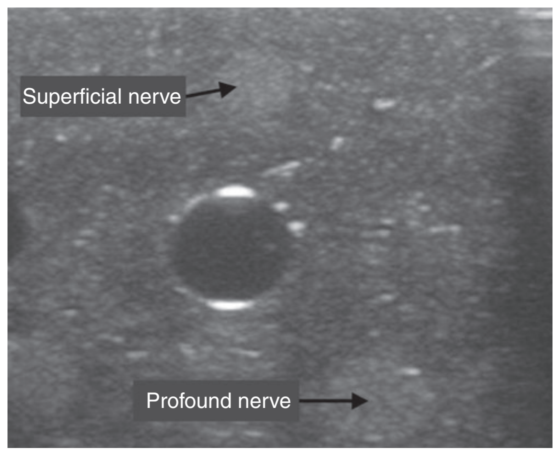

Fig 2 The US view of the phantom detailing the two target nerves used in this study.

The four procedures performed were a manual, US-guided nerve block needle placement of the superficial nerve; a manual, US-guided nerve block needle placement of the profound nerve; a robot-assisted, US-guided nerve block needle placement of the superficial nerve; and a robot-assisted, US-guided nerve block needle placement of the profound nerve. Refer to Figure 2 for the identification of the superficial and profound nerves.

Each of the five co-authors had different experience in performing nerve blocks. One author (C.Z.) was an anaesthesiologist with less than a year of experience in regional anaesthesia; the other four co-authors were one anaesthesia resident (N.T.), a PhD candidate with a background in engineering (M.W.), and two undergraduate engineering students (J.M., C.P.) without experience in performing nerve blocks. Experience