Ultrasound transducer with dynamic visual aid improves out-of-plane vascular access

Ultrasound transducer with dynamic visual aid improves out-of-plane vascular access: a feasibility study

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Editor—Out-of-plane ultrasonography-guided vascular access procedures can be challenging. Reported first-pass success rates vary from 81%[1] in peripheral cannulation to 51–95% for arterial catheter placement.[2] Additionally, the complication rate increases with each subsequent attempt.[3,4] During out-of-plane needling, the target is placed approximately under the midline of the probe, and the required angle is based on a trigonometric interpretation by the operator. As transducer position, entry point, and needle angle are based on estimations, they are prone to error. The needle tip can be advanced beyond the imaging plane inadvertently, as the needle tip and shaft can appear similar by ultrasonography.[5] If unnoticed, this error can lead to posterior wall puncture (PWP) with subsequent failure of catheter placement.[6]

We hypothesised that providing visual clues could optimise the needle entry point and might consequently improve outcomes of out-of-plane procedures. To test this, we equipped a linear L12-4 ultrasound transducer with an organic light-emitting diode (OLED) strip and screen (Fig 1). The OLED strip was connected to an Xperius touchscreen ultrasound machine (B. Braun, Melsungen, Germany and Philips Medical Systems, Eindhoven, the Netherlands) through an Arduino Microcontroller (Arduino, Ivrea, Italy). After touching the target on the ultrasound (US) screen, the OLED strip showed the corresponding horizontal position of the target relative to the transducer. Furthermore, after entering the desired angle of approach, the required distance from the entry point to the transducer to enter the vessel precisely in plane was shown. This suggestion was accompanied by a visual representation of the angle.

We tested the device in a vascular phantom with a small vessel at ~5 mm depth and a large vessel at ~1.5 cm depth. Participants were either expert ultrasonographers (anaesthesiologists and intensivists, n=37) or ultrasound-naive users (anaesthetic nurses, n=32). Inexperienced users were allowed to perform practice punctures as desired. Participants performed the punctures individually to minimise bias. All participants performed one cannulation with the visual aid and one without the aid in each vessel. Participants were randomised to start with or without the device, and to start with the large or the small vessel. All attempts were performed at an angle of 45°. The study protocol was approved by the Medical Ethics Committee United (nWMO-2019.097).

The primary endpoint was first-pass success, defined as a correct intravascular placement of the needle tip in one puncture. A correction of the direction of the needle before the needle tip was visible on the US screen was allowed, so in that case a successful first-pass was counted with a withdrawal. Secondary endpoints were the total number of punctures, procedure time (defined as breaking of the skin until correct placement of the needle tip), needle withdrawals >5 mm, and operator satisfaction.

Primary and secondary endpoints were analysed using SPSS (version 27.0, SPSS Inc., Chicago, IL, USA) and included paired t-tests or Wilcoxon signed rank tests depending on data distribution. Proportions were compared using McNemar's test.

First-pass success was higher with the dynamic visual aid, with a success rate of 92% (64/69) for the large vessel compared with 78% (54/60) without the visual aid (95% confidence intervals 87.0–98.6 *vs* 68.1–88.4, P=0.021). When targeting the small vessel, the difference was even greater: with visual assistance 70% (48/69) of the punctures were successful *vs* 42% (29/69) without assistance (95% confidence intervals 59.4–81 *vs* 30.4–53.6, P<0.001).

Regarding the secondary endpoints, the number of punctures with the visual aid was lower for the small vessel but not for the large vessel. Fewer needle withdrawals were counted with the aid when targeting the large vessel (0.17 *vs* 0.55) and the small vessel (0.78 *vs* 1.93) (Supplementary Table S1). Operator satisfaction was higher with the aid, regardless of previous experience. Supplementary Tables S2 and S3 show the results for the inexperienced and experienced groups.

Our results suggest that a dynamic visual aid improves first-pass success for ultrasound-guided out-of-plane vascular access, probably by optimising the needle entry point. The effect of the visual aid was greatest among inexperienced users, but experienced users still benefited from the aid when targeting the small vessel.

Previous studies have shown that success rates can also be improved by other techniques, such as dynamic needle tip positioning, but those techniques require extensive practice.[5] Technological innovations such as magnetism[7] or specialised needle tips[8] have not consistently shown improvement in patient outcomes.[9] The OLED screen on the transducer facilitates correct needle tip placement without the need for specialised needles or expensive hardware, even when used by inexperienced users. Moreover, by increasing the chance

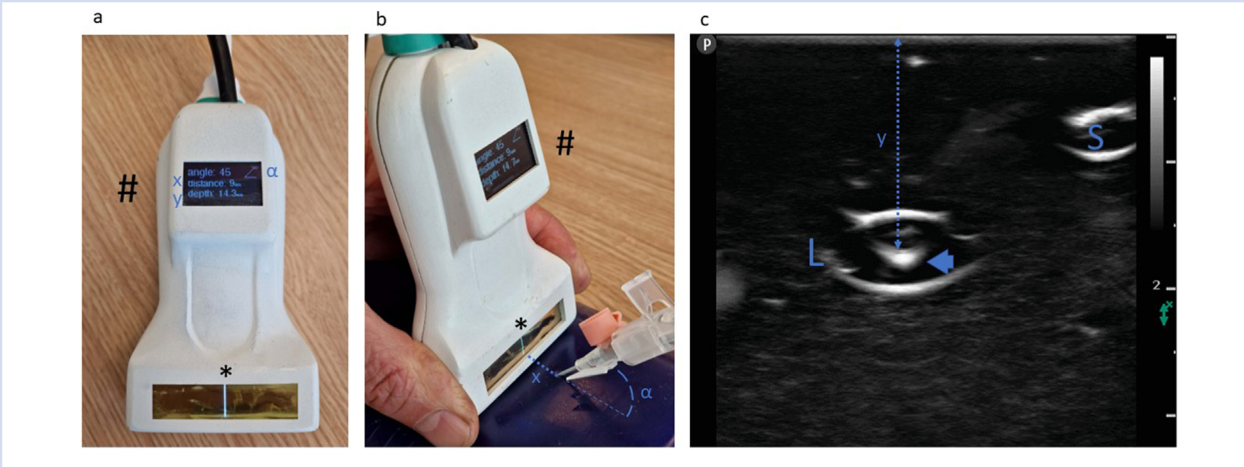

Fig 1. Organic light-emitting diode (OLED)-enhanced probe. (a) The OLED display (#) showing the angle of approach (α) and visual representation of that angle, the suggested distance of the needle entry point to the probe (x), and the depth of the selected target (y). The strip (*) shows the horizontal position of the target relative to the probe. (b) OLED-enhanced probe in action. Optimisation of the needle entry point with suggestions for the horizontal position (*), distance to the probe (x), and angle of approach (α). (c) Ultrasound touch screen with selected large vessel (L) at depth y, with intraluminal needle tip (arrowhead). The small vessel target is also visible in the upper right corner (S).

that the needle tip enters the vessel exactly below the transducer, the risk of posterior wall puncture is possibly reduced. Since the use of the visual aid benefitted both inexperienced and experienced users and both groups reported greater satisfaction, the present study suggests that the aid can improve workflow and facilitate obtaining competency in ultrasound-guided peripheral vascular access.

A phantom study has its limitations. However, we show proof-of-principle that providing visual clues can improve out-of-plane ultrasound-guided procedures. Although we did not evaluate catheter placement, we did evaluate needle tip placement, which is the major determinant for failed catheter placement.[5] A disadvantage of the aid was that unintentional movements of the probe were not followed by a subsequent correction of the marker. This would have required not only a real-time tracked probe, but also extensive software programming to establish communication between the tracked probe, the ultrasound machine, and the OLED marker, which was not within the scope of our resources.

In summary, use of the visual aid led to significant improvement in first-pass success in out-of-plane procedures. Clinical studies should follow to determine whether vascular access accuracy can be improved or the incidence of posterior wall puncture reduced by integrating visual aids in ultrasonography, possibly in combination with a real-time tracked probe or 3D imaging.

Authors' contributions

Conceptualised and designed the study: RAB, HHMK, HJS
Developed the OLED enhanced probe: RAB, HHMK, TH, EK, MdW
Collected data: YH
Performed statistical analyses and drafted the manuscript: HJS
Revised the manuscript for important intellectual content: RAB, HHMK, TH, EK, MdW, YH
All authors take full responsibility for data integrity.

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Declarations of interest

RAB and HHMK have acted as clinical consultants for Philips Medical Research (Eindhoven, the Netherlands) since January 2016. All other authors declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2022.05.037.

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A novel anterior approach for ultrasound-guided lumbar plexus combined with sacral plexus blocks with one-point puncture. Comment on *Br J Anaesth* 2022; 128: 297-299

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Editor - Gong and colleagues describe a novel ultrasound-guided anterior approach for combined lumbar and sacral plexuses block with one-point puncture in supine position.[1] However, we have a different opinion with respect to the proposed mechanism and site of injection.

Firstly, except for the transducer orientation, the technique described by the authors is similar to the technique described for suprainguinal fascia iliaca compartment block (S-FICB).[2,3] The S-FICB is a fascial plane block that targets branches of the lumbar plexus, rather than the true plexus or its nerve roots. As the site of injection chosen by the authors is close to the site of injection described for S-FICB, it is difficult to explain how this novel technique is aiming at the level of the lumbar plexus rather than the individual nerves.

Secondly, use of a peripheral nerve stimulator for confirming the location of the needle tip within the vicinity of the plexus to elicit a typical motor response of either the lumbar or sacral plexus would have strengthened authors' claim of blocking the plexus. A true ultrasound-guided plexus block would have required a lower volume of the local anaesthetic solution than the volume injected by the authors, which is sufficiently large to produce successful plane block by diffusion.

Thirdly, the authors have depicted the normal sonoanatomy of the proposed dual plexuses block in figure 1 of their manuscript, showing individual nerve branches of both the lumbar and sacral plexuses rather than the cluster of plexuses that they were targeting. The normal anatomy of the lumbar plexus described in standard textbooks shows that the lumbar plexus lies within the body of the psoas major muscle and its branches emerge as they traverse it.[4] At the level of the body of the iliopsoas muscle one finds the individual branches of both the lumbar and sacral plexuses rather than the true plexus.

All this prompts us to believe that the technique described by the authors is another plane block targeting the individual nerve branches of either the lumbar or sacral plexus, and the site of injection chosen by the authors is too distal to block either the true lumbar or the sacral plexus.

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Declaration of interest

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