Ultrasound Guidance for the Psoas Compartment Block: An Imaging Study

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We conducted this study to develop an ultrasound-guided approach to the psoas compartment and to assess its feasibility and accuracy by means of computed tomography (CT). Two examiners performed ultrasound-guided approaches at three levels (L2-3, L3-4, and L4-5) on 10 embalmed cadavers, which were seated prone. After each needle had been advanced into the psoas compartment under ultrasound guidance, the positions of their tips were computed by using two coordinates (A and B). Subsequently, axial transverse CT scans were made to verify the ultrasound measurements by using the same coordinates. In total, 48 approaches were performed (Examiner 1, n = 20; Examiner 2, n = 28). CT revealed that 47 of 48 ultrasound-guided approaches were performed exactly. In 1 of 48 approaches (L3-4), the tip of the needle was located posterior to the psoas muscle. The median differences between ultrasound and CT coordinates were 0.3 ± 0.3 cm for A and 0.2 ± 0.3 for B. Kendall’s coefficient of concordance was 0.9 (P < 0.001) between ultrasound and CT measurements for both coordinates. These results indicate that ultrasound enables exact needle placement, as proved by CT. We conclude that ultrasound guidance might be a useful adjunct to increase the safety and efficacy of the psoas compartment block at these levels. (Anesth Analg 2002;94:706–10)

The psoas compartment block as a regional anesthetic technique is often performed at the level of L4-5. To reach the lumbar plexus, which is located in the posterior part of the psoas major muscle (1–4), there are two well known approaches (5,6). Loss of resistance (5), elicitation of paresthesias (6), and nerve stimulation (7) have been described as techniques to obtain information on the position of the needle.

Parkinson et al. (7) performed approaches at the L3 level and found them to be effective in producing blockade of the lumbar plexus. Moreover, Hanna et al. (2) mentioned that a posterior approach to the lumbar plexus at the level of L2-3 is central to the ventral rami forming the plexus and hence has considerable theoretical advantages compared with approaches at lower levels. However, Aida et al. (8) reported cases of renal hematoma due to approaches at the L3 level. Thus, they concluded that approaches to the psoas compartment have to be performed at the level of L4-5 and that radiograph fluoroscopy might be desirable (8).

Ultrasound imaging has already proven to be an useful adjunct during the performance of peripheral nerve blocks (9–13) and is reliable and accurate in visualizing the lumbar paravertebral anatomy (14). The aim of this study was to develop a technique for an ultrasound-guided posterior approach to the psoas compartment at the levels L2-3, L3-4, and L4-5 and to study its feasibility and accuracy by means of computed tomography (CT).

Methods

After obtaining institutional approval, two examiners performed ultrasound-guided posterior approaches to the psoas compartment on 10 embalmed cadavers that had been donated to the institute of anatomy. The specially embalmed cadavers (ethyl alcohol/glycerin conservation) corresponded well to live patients but...
occasionally showed restrictions regarding ultrasound imaging. Severe obesity and spine deformities were criteria for exclusion. A standard ultrasound device (Sonoline VersaPlus; Siemens, Vienna, Austria) with two curved array transducers (4 and 5 MHz; Siemens) was used. Both examiners were experienced in ultrasound imaging of the lumbar paravertebral region.

The cadavers were seated prone, and each examiner performed ultrasound-guided approaches on 5 of 10 cadavers at L2-3, L3-4, and L4-5. To localize the levels for needle insertion (L2-3, L3-4, and L4-5), posterior paravertebral sonograms were obtained (14). The psoas major muscle and the adjacent structures (quadratus lumborum muscle, kidneys, and adjacent vertebrae) had to be clearly delineated by means of transverse sonograms at each level (14). After obtaining these, the needles (22 gauge, 120 mm, Spinocan; B. Braun, Melsungen, Germany) were inserted under ultrasound guidance (Fig. 1). The estimated position of the lumbar plexus (junction of the posterior third and the anterior two thirds of the psoas muscle) (1) was established as the reference point that had to be reached by the needle tips. The needles were inserted perpendicular to the skin, 4–5 cm lateral to the spinous process and exactly in line with the transducer and the echo plane (Figs. 1 and 2). This enabled visualization of the entire needle, which appeared as a bright line-shaped echo pattern in the transverse sonogram (Fig. 3). If a needle deviated from its correct direction during the performance of an approach, the in-line technique allowed accurate repositioning under ultrasound guidance.

After advancing the needles to the mentioned reference-point, each sonogram was frozen, and measurements were computed (by using the measuring functions of the ultrasound device) to calculate the position of the needle tips as delineated on the ultrasound screen. Therefore, two coordinates were established (A and B; Fig. 4) to assess the positions of the needle tips on the transverse sonograms. All ultrasound measurements were made in the center of the sonograms parallel to the axis of the ultrasound beam to achieve the best results (15).

Subsequently the inserted needles were traced by means of CT (Synergy; GE Medical Systems, Milwaukee, WI) to evaluate their exact positions. After localization on anterior/posterior tomograms, axial transverse CT scans (1-mm slices) were made to depict the needle tips in the psoas compartment (Fig. 5). The needle positions were verified and measurements were computed equally to obtain reference values for the mentioned coordinates (Fig. 4). Kendall’s coefficient of concordance was used to compare ultrasound and CT measurements. \( P \) values <0.01 were considered statistically significant. All values are presented as median ± sd.

Figure 1. The needles were inserted 4–5 cm lateral from the spinous processes and in-line with the transducer.

Figure 2. The needles were advanced in the echo plane into the psoas major muscle (PM). ES = erector spinae; QL = quadratus lumborum muscle.
Results

Two examiners performed 48 ultrasound-guided approaches on 10 embalmed cadavers (8 female and 2 male) at the levels L2-3, L3-4, and L4-5 (Table 1). The cadavers’ median age at death was 77 yr (range, 51–88), and the median height was 163 cm (range, 148–178 cm). Seven of 10 cadavers had normal body weight, and 3 of 10 were obese. Because of occasionally reduced imaging conditions in embalmed cadavers as a result of cadaver conservation, 48 of 60 attempts were feasible. CT demonstrated that Examiner 1 inserted all needles into the psoas compartment correctly, whereas Examiner 2 failed once (Table 1). In the latter case (at the level L3-4), the needle had not been advanced far enough; hence its tip remained posterior to the psoas muscle.

The comparison of ultrasound and CT position measurements by means of Kendall’s coefficient of concordance revealed values of 0.9 for both coordinates \( P < 0.001 \), thus signifying excellent concordance. The median differences between ultrasound and CT coordinates were 0.3 \( \pm 0.3 \) cm for A and 0.2 \( \pm 0.3 \) cm for B.

Discussion

The benefits of ultrasound as an useful adjunct during the performance of brachial plexus blocks (9,13), three-in-one blocks (11,12), and stellate ganglion blocks (10) have been demonstrated: imaging of the individual anatomy, real-time needle guidance, visualization of the spread of local anesthetic, minimal risk of complications, dose reduction of local anesthetic, and shortening of onset time. To expand the field of these
techniques, we developed an ultrasound-guided approach to the psoas compartment at three levels (L2-3, L3-4, and L4-5) and studied its feasibility and accuracy by means of CT.

In contrast to other ultrasound-guided peripheral nerve blocks (9–12), we performed an in-line technique: the needles were advanced strictly parallel to the long axis of the transducer (Fig. 1) to keep them in the echo plane (Fig. 2). This provided real-time monitoring of the inserted needles in their entire length. Therefore they appeared as distinct line-shaped echo patterns (Fig. 3) instead of appearing as dotlike reflections.

Ootaki et al. (13) also performed an in-line technique for an ultrasound-guided infraclavicular approach to the brachial plexus, but with the use of a needle guide. We could demonstrate that it is feasible to keep a needle in the echo plane without using such an aid. Nevertheless, precise and careful handling of the transducer is mandatory to achieve the best visualization of the entire needle.

The feasibility of our technique could be shown by the success rates of the two skilled examiners (Table 1). Forty-eight of 60 approaches were possible, because of occasionally reduced imaging conditions in embalmed cadavers. Only 1 of 48 approaches (at L3-4) missed the psoas compartment because of a too-short advancement of the needle. In none of the successful 47 of 48 approaches was a needle advanced further than the posterior third of the psoas major muscle. It is worth mentioning that the quality of ultrasound imaging differs between cadavers and humans. Detailed ultrasound imaging of the lumbar paravertebral region for ultrasound-guided posterior lumbar plexus blocks was feasible in the majority of volunteers (14).

Even at the level L2-3, where the psoas major muscle has a very small mediolateral diameter compared with lower levels, CT revealed no cases of renal puncture. Hanna et al. (2) stated that approaches to the plexus at L2-3 might have considerable advantages because they are central to the ventral rami forming the plexus in the posterior part of the psoas muscle. However, reports on renal hematoma (8) caused blinded approaches at L3 to be precarious. With the use of ultrasound guidance, such complications might be avoided.

The comparison of ultrasound and CT measurements of the needle tips’ positions demonstrated that the echo reflections in the substance of the psoas muscle corresponded exactly to the needle tips and did not represent artifacts. The most likely explanation for deviations between the ultrasound and CT coordinates are minor measurement errors, which are typical for curved array transducers (15). However, the median differences between ultrasound and CT coordinates were small (0.3 ± 0.3 cm for A and 0.2 ± 0.3 cm for B), and Kendall’s coefficient of concordance revealed an excellent concordance between the measurements. Thus, ultrasound imaging proved to be reliable and accurate in delineating the needle tips in the psoas compartment compared with the data obtained by means of CT. This has to be emphasized for two reasons: a free-hand technique was performed (no needle guides and so forth were applied), and no specially designed and hence more expensive needles (as available for interventional ultrasound) were used.

In summary, the described technique of an ultrasound-guided approach to the psoas compartment proved to be feasible and accurate. It is worth mentioning that no additional technical aids (guides and so forth) or specially designed needles were applied to achieve accurate ultrasound guidance. However, knowledge in ultrasound imaging of the lumbar paravertebral region and practice in handling a transducer in combination with a needle are required. Despite these necessary fundamentals, the described technique is simple to perform. We conclude that with the benefits of ultrasound (imaging of the individual anatomy and real-time needle guidance), the efficacy of the psoas compartment block might be increased. Further, complications such as renal injury that may occur during blinded approaches, in particular at the levels L2/L3 and L3/L4, should be avoided.

References
