● Imaging Article

A Description of the Spread of Injectate After Psoas Compartment Block Using Magnetic Resonance Imaging

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Background and Objectives: Magnetic resonance imaging (MRI) provides for excellent visualization of spread of solution after peripheral nerve block. The aim of this observational study was to utilize MRI to describe the distribution of injectate (gadopentetate dimeglumine) administered for continuous psoas compartment block (PCB) performed by use of two approaches (Capdevila and modified Winnie) and to describe the spread of injectate to the lumbar plexus.

Methods: Four volunteers were enrolled in a prospective crossover study. Each volunteer underwent PCB with catheter placement performed by use of Capdevila's approach followed 1 week later by PCB, with catheter placement performed by use of a modified Winnie approach. MRI of injectate distribution was performed after each PCB.

Results: The catheter was unable to be inserted in 1 volunteer undergoing Winnie's approach; therefore, 7 sets of MR images were analyzed. In 6 of 7 cases (4 Capdevila and 2 Winnie) spread was primarily within the psoas muscle. Contrast surrounded the L2-3 lumbar branch of the femoral nerve at L4 and cleaved the fascial plane within the psoas muscle and spread cephalad to reach the lumbar nerve roots. In 1 case (Winnie approach) contrast spread between the psoas and quadratus lumborum muscles. Contrast surrounded the femoral and obturator nerves where they lie outside the psoas muscle at L5.

Conclusion: The most common pattern of injectate spread seen on MRI with both approaches to PCB was spread within the body of the psoas muscle around the lumbar branches (L2-4), with cephalad spread to the lumbar nerve roots. One catheter resulted in injectate between the psoas and quadratus lumborum muscles. *Reg Anesth Pain Med 2005;30:567-571.*

Key Words: Injectate, Lumbar plexus, Magnetic resonance imaging, Psoas compartment block.

The anatomy of the lumbar plexus is intimately related with the psoas major muscle.[1] The second, third, and fourth lumbar nerve roots form the femoral, lateral femoral cutaneous (LFC), and obturator nerves, respectively.[2] The femoral and LFC nerves, and, more variably, the obturator nerve, run in a fascial plane within the psoas muscle before leaving the muscle at various levels.[1,3] Physical spread of solution after posterior lumbar plexus or psoas compartment block (PCB) is, therefore, most likely to occur within the psoas muscle.[4]

Few studies have investigated the physical distribution of injectate after PCB. The distribution of dye injected by use of a "single shot" loss-of-resistance technique for PCB has been described in cadaveric specimens for both an L3 approach[5] and Chayen's approach.[6] A number of other approaches to the lumbar plexus exist, including those of Winnie et al. and of Capdevila et al.[7] The original description by Winnie et al.[8] has been modified such that femoral-nerve stimulation rather than paresthesia is sought.[9] We have successfully further modified their technique on the basis of their rec-

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ommendation of "a slight mesiad" needle orientation by standardizing medial needle redirection to 15°.[10] Capdevila et al.[4] recently described a further alternative approach for PCB, which modifies Winnie's surface anatomical landmarks. The distribution of injectate after Capdevila's continuous PCB (CPCB) approach in adults has been demonstrated by use of radiographic imaging[4,11] and correlated with the extent of block.[4] The only literature on solution spread after PCB by use of Winnie's approach was a radiographic description of contrast spread in a pediatric patient.[9]

Magnetic resonance imaging (MRI) provides excellent anatomical visualization and has been utilized to successfully study the spread of injectate after various peripheral nerve blocks.[12] The aim of this observational study was to utilize MRI to describe the distribution of injectate from CPCB performed by use of two approaches (Capdevila and modified Winnie) and to describe the spread of injectate to the lumbar plexus.

Methods

After institutional review board ethical approval had been granted and written informed consent had been obtained, 4 volunteers were enrolled in this prospective crossover study. Each volunteer underwent continuous psoas compartment block (CPCB) on two occasions, performed once by use of the Capdevila approach and once by use of the modified Winnie approach. The same operator (SM) performed all blocks. MRI of contrast-containing injectate was performed after each PCB. Exclusion criteria were claustrophobia; previous back, abdominal, or lower-limb surgery; weight less than 50 kg or more than 90 kg; or allergy to contrast.

After standard monitoring (pulse oximetry, blood pressure, and ECG) was applied, volunteers were placed in the left lateral position, and, after skin marking and injection of 10 mL of 1% lidocaine subcutaneously, a right-sided PCB was performed, as previously described by Capdevila and colleagues.[4] Contiplex D (B Braun Medical, Melsungen, Germany) 110-mm needle was inserted at the junction of the lateral third and medial two thirds of a line between the spinal process of L4 and a line parallel to the spinal column through the posterior superior iliac spine (PSIS). The spinous process of L4 was estimated to be approximately 1 cm cephalad to the upper edge of the iliac crests (intercristal line). A nerve-stimulator technique (Stimuplex HNS 11; B Braun Medical) with a starting output of 1.5 mA and 2 Hz was used to advance the needle perpendicular to the skin until contact with the transverse process of L4 was made. The needle was then pulled back and advanced under the transverse process until quadriceps twitches were elicited at 0.5 mA. Normal saline, 5 mL, was injected to expand the space, and the skin depth was noted. The needle was then removed from the cannula, and the catheter was inserted 5 cm beyond skin depth and secured.

The scanner was an Opart™ (Toshiba America Medical Systems, San Francisco, CA) MRI machine (0.35 Tesla). T1-weighted imaging was performed in the axial (5-mm slices from S1 to T11), coronal (5-mm slices from S2 to T10), and sagittal (5-mm slices from S2 to T8) planes to determine normal anatomy before solution injection. The contrast solution administered was gadopentetate dimeglumine (Magnevist; Schering AG, Germany) in 1:250 dilution with normal saline. This contrast solution provides optimal MR imaging of injectate spread after peripheral nerve blocks.[12] Fifteen percent of the (total) 0.4 mL/kg solution was injected through the catheter, and T1-weighted axial imaging (5-mm slices from S1 to T11) was performed to determine catheter position. The remainder of the solution was then administered over 3 minutes. T1-weighted imaging was then performed in the same planes as the "precontrast" scan. Total scanning time for the contrast magnetic-resonance sequences was approximately 30 minutes. The open configuration of the Opart™ MRI scanner ensured that the volunteer remained in the same position by providing easy access to the catheter port.

Volunteers returned 1 week later and underwent PCB performed on the opposite side (left) as described by Winnie and colleagues.[8] Nerve stimulation was used as before but with a different skin site for needle insertion. The Contiplex D needle was inserted at the point where a line through the PSIS parallel to the spinous processes intersected with the intercristal line. The needle was advanced in a 15° medial direction until quadriceps twitches were elicited at 0.5 mA. Catheter insertion was as previously described. The sequence of MRI and solution administration was as described for PCB performed by use of Capdevila's technique.

The magnetic resonance images were reviewed, and the findings reported by one of the authors (DK). To determine the distribution of contrast, the images were compared with the noncontrast images. The position of the catheter was determined as either within or outside the psoas muscle on the basis of the initial spread of the test dose of contrast. The overall distribution of contrast was recorded as within or outside the psoas muscle relative to surrounding structures. The maximum extent of spread was also noted.

Results

All 4 volunteers recruited were males with ASA classification I. Mean age was 35.5 years (range: 29 to 43 years). Mean weight was 72 kg (range: 55 to 80 kg). The mean volume of injectate was 28.5 mL (range: 22 to 32 mL).

Catheter placement after PCB was successful in all volunteers, except volunteer 3 who was undergoing a modified Winnie approach. In this case, insertion of the catheter was not possible, and subsequent MRI of contrast spread via the indwelling cannula revealed dislodgement of the cannula and contrast in the erector spinae muscles only. Therefore, only 7 sets of images were available for examination.

Imaging showed no evidence of subarachnoid, epidural, or bilateral paravertebral spread of contrast. The catheter position as determined by the initial test dose of contrast was identified within the psoas muscle in 6 sets of images and outside in 1 set (volunteer 4, Winnie approach). Distribution of contrast was similar in 6 of the 7 sets of images (4 Capdevila approaches and 2 Winnie approaches). The axial views demonstrate "cleavage" of the fascial plane within the psoas muscle, where the femoral nerve can be identified as hypodense (dark) relative to the hyperdense (white) signal of the contrast solution below the transverse process of L4 (Fig 1). Above L4, the axial views demonstrate contrast surrounding the L2-3 branches contained within the fascial plane. For each set of images, a "psoas stripe" can be seen on the coronal views, with spread of contrast to the L1-4 nerve roots by expansion of the intrapsoas fascia and cephalad spread of contrast media (Fig 2). Most of the contrast (in these 6 sets of images) remained in the psoas muscle sheath, but some extension of contrast outside the psoas sheath also occurred in all but 2 cases (both Capdevila approaches). Contrast was seen between the psoas and quadratus lumborum muscles in volunteer 1 (Winnie) and volunteer 3 (Capdevila). Contrast was seen between the psoas muscle and perirenal fat in volunteer 1 (Capdevila) and volunteer 2 (Winnie).

A different distribution of contrast was seen in volunteer 4 (Winnie approach), as shown in Figure 3. Contrast spread mainly outside the psoas muscle, between the psoas and quadratus lumborum muscles and the perirenal fat. Contrast was seen surrounding the femoral and obturator nerves, where they run between the psoas and quadratus lumborum muscles at the level of the fifth lumbar vertebra (Fig 4).

The maximum superior extent of contrast spread where the "psoas stripe" was noted was the L1-L2 disc space in 4 series (3 Capdevila and 1 Winnie) and the L2 vertebral body in the other 2 series (1 Capdevila and 1 Winnie). No cases of spread beyond where the iliacus and psoas muscles fuse were seen. In volunteer 4 (Winnie approach), contrast extended

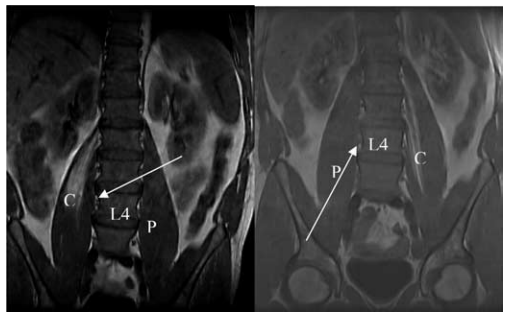

Fig 2. Coronal view of contrast (C) spread—the "psoas stripe"—in the right psoas muscle after Capdevila's approach in volunteer 1 and left psoas after Winnie's approach in same volunteer. The fourth lumbar nerve root (arrows) is the dark (hypodense) area seen. L4 = fourth lumbar vertebra. P = psoas muscle.

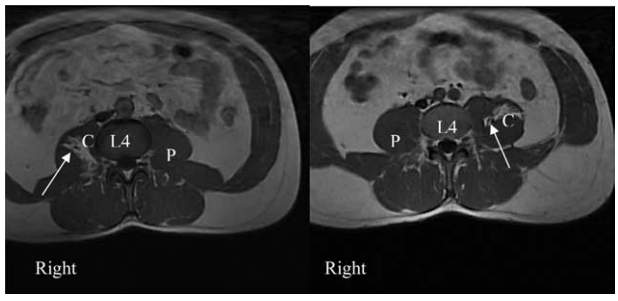

Fig 1. Contrast (C) spread in the right psoas muscle after Capdevila's approach in volunteer 2 and left psoas after Winnie's approach in same volunteer. The femoral nerve (arrow) is the dark (hypodense) area within the contrast. L4 = fourth lumbar vertebra. P = psoas muscle.

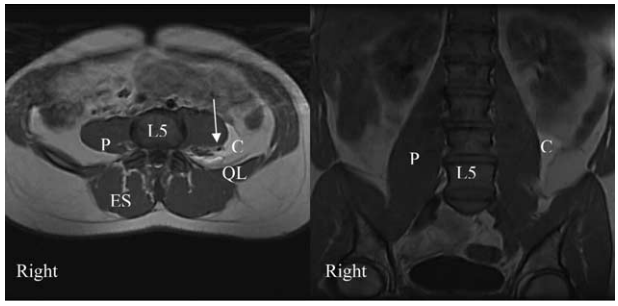

Fig 3. Contrast (C) spreading from the left psoas muscle to the space between the psoas and quadratus lumborum (axial view) and perirenal fat (coronal view) after Winnie's approach in volunteer 4. Arrow indicates femoral nerve. L5 = fifth lumbar vertebra. P = psoas muscle. QL = quadratus lumborum muscle. ES = erector spinae muscle.

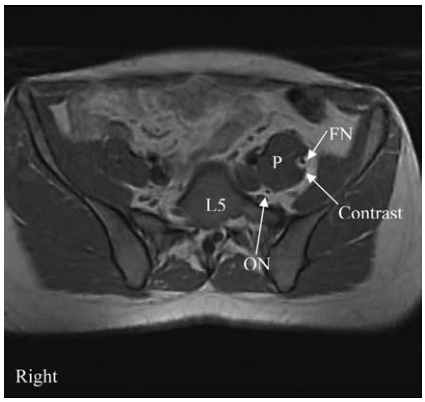

Fig 4. Axial view of the fifth lumbar vertebra (L5). Contrast (white) can be seen around femoral nerve (FN) and obturator nerve (ON), which are dark (hypodense). P = psoas muscle.

superiorly as far as the L2-L3 disc space lateral to the psoas and inferiorly to the transverse process of L4 lateral to the psoas muscle. Medial spread in all cases was to the lumbar paravertebral space.

Discussion

We have used MRI to investigate distribution of contrast after CPCB performed by application of two different approaches (Capdevila and modified Winnie) in healthy human volunteers. Our study size was limited as a result of difficulties in volunteer recruitment and the technical and safety aspects of MRI.[13] These results should, therefore, be viewed as preliminary pending further, larger imaging studies and clinical correlation.

The anatomical nature of this study means that we can only postulate as to the extent of lumbar plexus block because the lack of a local anesthetic agent prevents any direct clinical correlation. These MRI findings demonstrate only the physical route(s) by which solution spreads to the plexus after CPCB, one of many factors necessary for local anesthetic action at a nerve.[12]

The lumbar plexus lies within the psoas muscle in a fascial plane that separates the muscle into anterior and posterior parts.[2,3] The lumbar nerve roots (L1-4) enter the psoas muscle and form lumbar nerve branches and the terminal nerves.[1,2] The L1 and L1-2 nerve roots give rise to the iliohypogastric/ilioinguinal nerves and genitofemoral nerve, respectively.[3]

The LFC nerve formed from the L2 or L2-3 nerve roots runs in the fascial plane with the femoral nerve until it leaves the psoas at the L4 or L5 level.[1,3] The femoral nerve arises within the psoas muscle from the posterior divisions of the L2-3 and L4 lumbar branches, usually below the transverse process of L4, and emerges posterolateral to the muscle at a level that ranges from L4 to S1.[2,14] The anterior divisions of these branches become the obturator nerve, which lies medial to the femoral and LFC nerves and is often (50% to 60% of cases) found separated from these nerves by a muscular fold and, therefore, outside the fascial plane.[1,3] The nerve then emerges from the medial psoas muscle border at the level of L5-S1.[2,3]

The MRI findings of contrast distribution after CPCB performed via Capdevila's approach were similar in all 4 volunteers. Contrast spread within the psoas muscle along the fascial plane and surrounded the femoral nerve and L2-3 branches. Contrast also spread to the lumbar nerve roots via this fascial plane. MRI demonstrates that after CPCB, injectate reaches the femoral and LFC nerves directly within the psoas muscle but also reaches the lumbar nerve roots. Block of the lumbar plexus can, therefore, be postulated to occur both at the L2-3 and L4 nerve roots and, more peripherally, at the lumbar branches. These findings may explain a rate of 85% to 90% obturator nerve block found with PCB,[4,10] despite anatomical findings that the obturator nerve is often outside the fascia plane. [1,3] The distribution of contrast on MRI in these images is similar to findings of Hanna et al.[5] These authors used a loss-of-resistance technique to inject 10 mL of dye into 6 cadavers 3 to 5 cm lateral to the L2-3 interspace. In all cases, dye was contained within the psoas muscle and covered the L1-4 lumbar nerve roots.[5]

Distribution of contrast was less consistent after CPCB performed via the modified Winnie approach. In 2 volunteers, the distribution was similar to that of Capdevila's approach. Despite these similar findings, the study size precludes comment on whether MRI provides an explanation for the clinical findings of similar lumbar plexus block with both approaches.[10] The failure of catheter insertion in 1 subject and a different pattern of spread in volunteer 4 make further assessment of spread after this approach difficult. In volunteer 4, spread occurred between the psoas and quadratus lumborum muscles, with contrast surrounding the femoral and obturator nerves outside the psoas (Fig 4). This case, however, may not be representative of solution spread after Winnie's approach for PCB. Therefore, determination of whether the original description by Winnie et al.[8] of PCB that occurred via the "interfascial space between the quadratus lumborum and psoas major muscles" is accurate requires further imaging studies with clinical correlation to confirm.

In conclusion, the most common pattern of injectate spread seen on MRI with both approaches to PCB was spread in the fascial plane within the body

of the psoas muscle around the lumbar branches (L2-3 and L4), with cephalad spread to the lumbar nerve roots.

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