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Clinical Investigation

CLINICAL INVESTIGATION

Ultrasound-guided adductor canal block: a cadaveric study investigating the effect of a thigh tourniquet

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Abstract

Background: Placement of local anaesthetic within the adductor canal using ultrasonography is an alternative to femoral nerve blocks for postoperative pain relief after knee joint replacement surgery. However, the effect of an inflated thigh tourniquet on the distribution of local anaesthetic within the adductor canal is unknown. The aim of this cadaveric study was to compare the distribution of radio-opaque dye within the adductor canal in the presence or absence of an inflated thigh tourniquet.

Methods: Bilateral ultrasound-guided adductor canal blocks were performed on the thawed lower limbs of five fresh frozen human cadavers. The left and right lower cadaver limbs were randomised to receive or not receive a thigh tourniquet inflated to 300 mm Hg for 1 h. X-rays with iohexol radio-opaque dye were obtained in four views, and fiducial markers inserted as reference points. Virtual editing technology was used to recreate outlines representing the distribution of the radio-opaque dye and superimpose these on anatomical images.

Results: Radio-opaque dye was distributed on the medial aspect of the thighs with entire and well circumscribed margins. The majority of the radio-opaque dye was confined within the adductor canal. Superior-inferior dye distribution was 315.2 mm [95% confidence intervals (CI) 288.7–341.7] and 263.9 mm (95% CI 238.9–288.9) in the presence and absence of an inflated thigh tourniquet, respectively (diff 95% CI −80.46 to −22.22, P=0.0081). Image analysis using the recreated radio-opaque outlines suggested that the most proximal point of the radio-opaque dye was 99.6 mm (95% CI 82.52–116.7) or 116.6 mm (95% CI 61.77–171.4) below the inguinal ligament in the presence and absence of an inflated thigh tourniquet, respectively (diff 95% CI −38.51 to 72.43, P=0.456).

Conclusions: Application and inflation of thigh tourniquets significantly increased the combined superior–inferior dye distribution within the adductor canal of cadaveric limbs. There was insufficient evidence to suggest significant proximal spread of 25 ml of local anaesthetic to involve the motor branches of the femoral nerve. In some patients, the local anaesthetic may reach the popliteal fossa in close approximation to the sciatic nerve.

Keywords: adductor canal; arthroplasty; knee; radio-opaque dye; regional anaesthesia

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Editor's key points

- Improved understanding of local anaesthetic spread in regional anaesthesia may be gained from cadaveric studies.
- How thigh tourniquets, for lower limb surgery, impact on local anaesthetic spread is poorly understood.
- Superior–inferior spread of injectate in ultrasound-guided adductor canal blocks was studied in cadavers using imaging analysis technology.
- Both superior and inferior spread of injectate was increased by use of a thigh tourniquet.
- Effects on improved block efficacy, or increased motor block warrant further clinical study.

The adductor canal is a pyramidal conduit in the thigh bounded by the sartorius, adductor magnus, and vastus medialis muscles.[1] It extends from the apex of the femoral triangle to the adductor hiatus approximately 140 mm above the knee.[1] The neural contents of the adductor canal include the saphenous nerve, a branch to the vastus medialis muscle, and a posterior branch of the obturator nerve.[2] The adductor canal block (ACB) was first described in 1993 and is increasingly used to provide postoperative analgesia after knee joint surgery.[3] ACBs offer significant potential advantages over traditional femoral nerve blocks including the avoidance of motor blockade of the quadriceps muscle, thus permitting early ambulation.[4,5] A number of studies have investigated the distribution of local anaesthetic after ACBs in the absence of a thigh tourniquet which is usually applied before knee joint surgery in order to limit perioperative blood loss.[6] Two recent studies have investigated the distribution of radio-opaque dye after ACB, but have not considered the effect of the thigh tourniquet. One study focussed on the distribution of the radio-opaque dye to the popliteal fossa after a single shot ACB, while another investigated the distribution of radio-opaque dye after continuous infusion.[7,8] Compression bandages have been reported to influence the flow of local anaesthetic.[9] The primary outcome of this study was the superior–inferior distribution of radio-opaque dye after single shot ultrasound-guided ACB in the presence and absence of an inflated thigh tourniquet. The secondary goal of this study was to describe the anatomical spread of the radio-opaque dye.

Methods

University Research Ethics Approval (Application No. 200150035) was obtained. The cadavers used were pre-consented for research, imaging, and photography according to the Human Tissue (Scotland) Act 2006. Ten fresh frozen, unembalmed and intact lower limbs were used from five cadaver subjects (four males and one female) of similar age [mean 77.2 yr (range 72–85)] and height [175 cm (range 166–181)] which had been fresh frozen for up to a year at −20°C. No subjects had any known abnormalities or previous surgery on their lower limbs, except one, who had had a total hip replacement. However, this surgery had been performed at a site distant and in a different compartment to the compartment being studied.

The cadavers were thawed to room temperature (22°C). Two experienced anaesthetic consultants, who were blinded to the randomisation process, performed ACBs on each limb in sequence. The adductor canal was identified by ultrasonography (Fig. 1). Using a 5–10 MHz linear array transducer (Sonosite, Bothell, WA, USA), the superficial femoral artery was followed caudad until it lay directly beneath the sartorius muscle distal to the femoral triangle and proximal to the adductor hiatus (Fig. 1). The usual anaesthetic agent, levobupivacaine 0.25%, was replaced with 25 ml of radio-opaque dye (Omnipaque 300, GE Healthcare, Chicago, Illinois, USA) and injected through a 21G, 100 mm long Stimuplex needle (Braun, Melsungen, Germany). The injection site on the skin was recorded using a black marker pen. The distance between the anterior superior iliac spine and the injection point was measured. In each cadaver, the limb receiving the inflated thigh tourniquet was determined by coin flip. Each tourniquet cuff (Single Port, Single Bladder; Zimmer Biomet, UK Ltd, Swindon, UK) was applied immediately after the ACB to reflect clinical practice and positioned as proximal as possible on the thigh. This position also corresponded to 10 mm above the injection point in each of the selected limbs. The tourniquets were given additional support with Cellona padding and an Esmarch bandage to prevent slippage, as in normal clinical practice. Tourniquets were inflated immediately after placement of the ACB using an electronic tourniquet system (Anetic Aid, Leeds, UK) to 300 mmHg and applied for 1 h.[10] During the period of inflation, all limbs underwent knee flexion and extension at 5 min intervals by an experienced orthopaedic surgeon in an attempt to replicate normal movements of the limb during total knee replacement surgery. Thereafter, the cadavers were stored flat in a freezer at −20°C for 1 week until the radiological analysis could be undertaken. Fiducial markers comprised of 1 mm diameter metal ball bearings (Grade 100 hardened 52100 chrome steel; Simply Bearings Ltd, Leigh, UK) were drilled into the frozen musculature of each thigh; one overlying the injection point and at four other random positions, medial, lateral, proximal, and distal to the injection point. The injection point marker acted as a reference point for measurement of the radiographic distribution of the radio-opaque dye. X-rays of each thigh were performed in four different planes (anteroposterior, lateral, medial oblique, and lateral oblique) using an Atomscope HF300 (Full Bridge Inverter System, Atomscope, dlc imaging, Hoppers Crossing, Victoria, Australia) portable X-ray machine. Magnification was estimated using a British 5 pence coin (18 mm diameter) placed on the thigh at the level of the knee facing each radiographic plane.[11] The radiographs were stored as 'Digital Imaging and Communications in Medicine' (DICOM) files. Two

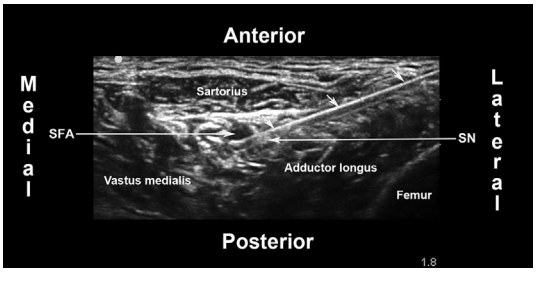

Fig 1. Ultrasound-guided adductor canal block in a cadaveric subject. Left limb of Subject 2 – Tourniquet. SFA: Superficial Femoral Artery; SN: Saphenous Nerve. The unlabelled arrows indicate the block needle.