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SHORT COMMUNICATION

Day zero ambulation under modified femoral nerve block after minimally invasive surgery for total knee arthroplasty: preliminary report

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Abstract Ambulation in the early postoperative period of total knee arthroplasty is crucial, in order to avoid complications and obtain preferable outcomes. Although a femoral nerve block can provide enough postoperative analgesia after total knee arthroplasty, falling, or other accidents due to motor paresis, are potentially adverse events in patients who have received a conventional femoral nerve block. We devised a modified femoral nerve block to spare voluntary knee extension ability, and clinically applied it to patients who received total knee arthroplasty under minimally invasive surgery. In our new-approach nerve blockade technique, the main targets of the sensory nerves are the saphenous nerves which branch out from the femoral nerve trunk. All the patients rated pain at bed rest between 0 and 3 on a numerical rating scale 3 h after the operation. In addition, the rectus femoris muscle was not affected at all, and the surgically invaded vastus medialis oblique muscle was completely anesthetized. Patients were able to not only actively raise their extremities with their knee in extension, but also to flex the knee in the air without pain or aggravation. On day 0, the patients were able to walk around, with the leg that had been operated upon not giving way. Our anesthetic approach can provide better pain relief than a conventional femoral nerve block, while the patients achieve ambulation on the day of the procedure, following minimally invasive knee surgery.

Keywords Total knee arthroplasty · Femoral nerve block · Early ambulation · Ultrasound-guided nerve block

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Early postoperative ambulation after knee surgery is important to obtain clinically preferable outcomes [1]. Whereas minimally invasive total knee arthroplasty (TKA) enables early ambulation and rehabilitation after surgery, conventional postoperative analgesia with regional blocks such as lumbar epidural analgesia and femoral nerve blocks may disturb weight-bearing ambulation in the early postoperative period. In addition, TKA belongs to the highest risk group of procedures for deep venous thrombosis (DVT), along with other various postoperative complications [2]. Therefore, ambulation in the early postoperative period after TKA is especially important. We preserve motor function for early weight-bearing ambulation after minimally invasive surgery (MIS)-TKA by the use of a modified femoral nerve block (mFNB), which does not block major knee extensors, unlike the standard femoral nerve block.

After approval was granted by the institutional ethics committee of Mie University (Mie, Japan), we enrolled 25 patients with osteoarthritis and rheumatoid arthritis who were to receive a primary unilateral cemented TKA (Columbus total knee system; Aesculap, 78532 Tuttlingen, Germany) under MIS (via a mid-vastus approach), performed using a navigation system (Orthopilot navigation system 4.2 Version; Aesculap). We obtained written informed consent for the procedure from each patient.

General anesthesia was induced with propofol 1 mg/kg, rocuronium (0.6 mg/kg), and remifentanil (0.5 μg/kg/min) and it was maintained with propofol target-controlled infusion (2.0–2.5 μg/ml) and remifentanil (0.15–0.2 μg/kg/min) within 50–60 on the bispectral index without additional rocuronium. The patients had an intraoperative air tourniquet at the pressure of 300 mmHg applied. Immediately after the surgery, a 38-mm broadband (13–6 MHz) linear array transducer (HFL38x; Sonosite, Bothell, WA, USA) coupled to a portable ultrasound machine (M-turbo®; Sonosite) was placed perpendicular to the neurovascular bundle in the apex of the femoral triangle where the sartorius muscle overlaps the superficial femoral artery, and the mFNB was conducted by an in-plane technique with a needle guidance system. An 18-G B|Braun contiplex® Tuohy needle (B|Braun Aesculap Japan, Tokyo, Japan), 10 cm in length, was set into the needle guide and attached to the transducer with its exclusive fixator (CIVCO Infiniti™ Needle Guidance System IA; USA).

As it is sometimes impossible to discern the femoral nerve from other structures at this level, contraction of the vastus medialis oblique (VMO) only should be a prerequisite at this time (Fig. 1). Muscle contraction of the VMO was detected by manual pulsation, using stimuli of 0.4–0.6 mA (B|Braun Stimuplex® HNS 12, Melsungen, Germany) [3, 4]. In total, 20 ml of 0.75 % ropivacaine was injected around the neural structure. During ropivacaine injection, the spot just proximal to the injection site was compressed by the thumb of the assistant so that local anesthetics did not flow proximalward.

Four of our patients were men and 21, women, with a mean (SD) age of 74 (6) years, height of 151 (8) cm, and weight of 62 (11) kg. The mean (SD) duration of surgery was 155 (30) min. All patients were able to raise their operated leg, straighten it, and actively flex and extend the knee immediately after emerging from general anesthesia. In the recovery room 3 h after the surgery, pain at rest was rated from 0 to 3 on a numerical rating scale (0 = no pain and 10 = worst pain imaginable). The patients were also able to stand on the operated extremity alone. Hence, without adjuvant analgesics, they were able to walk around independently, or with the slight assist of a walking frame,

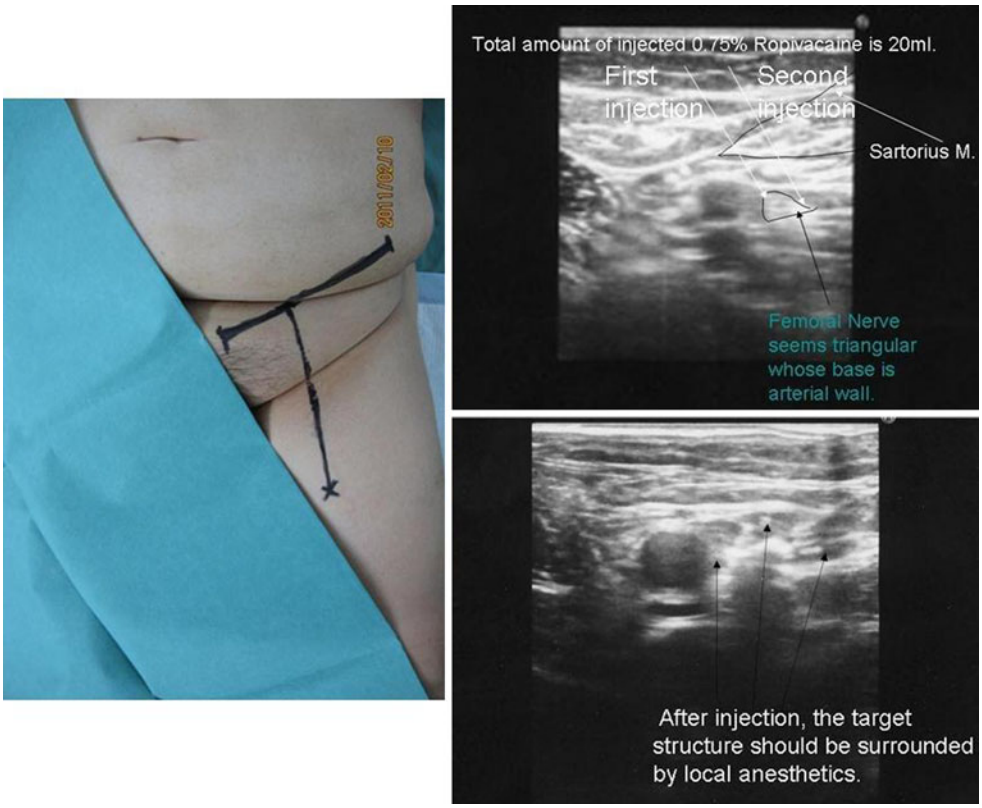

Fig. 1 In this very obese female, the femoral crease where a conventional femoral block is preferably performed is far away from the inguinal band, which is an important anatomical landmark. The '*X*' mark is where the block is performed. The *oblique line* to the inguinal crease is the one drawn between the pubic tubercle and the anterior superior iliac spine. The *line almost vertical* to the crease is in line with the femoral nerve trunk. The femoral nerve seems triangular, with its base being the arterial wall. *White arrows* indicate the injection site. First, local anesthetic was injected between the artery and the base of the triangular structure. Second, the remaining anesthetic was injected around the apex of the structure. After the injection, the target structure should be surrounded by local anesthetic and the femoral nerve fibers should appear bloated and dispersed. *M* muscle

and without knee braces. During ambulation, the patients displayed respiratory and hemodynamic stability, and did not complain of severe pain. Ambulation did not increase drainage bleeding.

There are some reports that early postoperative ambulation in TKA patients prevents locomotive complications and the formation of DVT [5, 6]. Therefore, retaining the practical motor function of the lower extremities immediately after surgery through proper anesthetic management is crucial.

MIS in TKA encourages early rehabilitation. However, conventional regional anesthetic techniques result in motor paralysis, which will sometimes lead to the knee giving way, or the patient falling immediately after surgery [7]. Hence, our anesthetic management is of significance for this surgery.

One of the important clinical assessments used for a decision on when to start weight-bearing ambulation is whether or not the patient can elevate the operated leg with no extension lag [8]. Among the quadriceps muscles, the rectus femoris is the muscle which contributes the most to knee extension. The motor branch of the rectus femoris branches out about 2 fingerwidths below the inguinal ligament from the femoral nerve trunk. It is not anesthetized in our method, due to there being "no patellar motor response" to stimuli [9]. The main targets of our nerve blockade technique are the motor branches of the VMO and the saphenous nerve. The motor branches of the VMO diverge distal to the other motor branches. Then, with continuous electrical stimuli at this point, the VMO contracts alone; namely, this is "a medial motor response" to stimuli. In the mini mid-vastus approach, the distal part of the muscle belly of the VMO is split in line with the fibers. Therefore, blocking the motor branches of the VMO alleviates ascending myogenic pain from the surgically invaded VMO, especially in knee flexion, whether this is voluntary or involuntary. Blocking the saphenous nerves also alleviates the pain of operatively invaded skin and soft tissues. Unlike the standard femoral nerve block, with our technique, abdominal subcutaneous fat does not interfere with the procedure during the process. Compared with the standard femoral nerve block, however, our mFNB was inferior in revision TKA, as the revision procedure usually requires extended proximal skin incision or surgical invasion to the rectus femoris tendon.

In the present study, we performed the mFNB procedure after the surgery to facilitate immediate rehabilitation by alleviating postoperative pain. For the future, we are considering the use of preoperative tubing for the mFNB procedure, although there are some obstacles to overcome, such as the unveiled anatomy of the adductor canal, and the non-rigid connective tissue of the thigh, which makes catheter placement unstable and unpredictable.

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