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The Effect of the Minimum Effective Volume for Suprainguinal Fascia Iliaca Block in Fresh Cadavers

El Efecto del Volumen Efectivo Mínimo para el Bloqueo de la Fascia Ilíaca Suprainguinal en Cadáveres Frescos

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SUMMARY: The goal of ultrasound-guided suprainguinal fascia iliaca block (USG-SFIB) is anesthetic spread to three nerves, which are lateral femoral cutaneous nerve (LFCN), femoral nerve (FN), and obturator nerve (ON). The 90 % minimum effective volume (MEV90) for USG-SFIB is each result of studied showed the successful block and effect in various volume for block. So, Thus, the study purposes to demonstrate the efficiency of the effective volume (MEV90,62.5 ml) for USG-SFIB and confirm the staining of dye in connective tissue of nerve (nerve layer) that focused on the obturator nerve by histological examination in cadavers. The histological result showed the dye staining on the nerve layer of the ON in epineurium (100 %) and un-staining perineurium & endoneurium. Therefore, the minimal effective volume (MEV) is effective for USG-SFIB. Moreover, dye stain at the epineurium of stained obturator nerve only.

KEY WORDS: Fascia iliaca block; Anesthetic volume; Cadaveric study; Histological examination.

INTRODUCTION

Ultrasound-guided suprainguinal fascia iliaca block (USG-SFIB) was first described by Hebbard *et al*. (2011). The target nerves of this block are lateral femoral cutaneous nerve of thigh (LFCN), femoral nerve (FN), and obturator nerve (ON).

Anesthesiologists and emergency physicians usually perform the USG-SFIB to control pain from hip fracture and hip surgery. Chen *et al*. (2021) and Wang *et al*. (2021) showed that USG-SFIB fastened recovery after total hip arthroplasty and improved exercise tolerance and sleep quality in older patients with emergency hip fracture. A various volume of local anesthetic required for a successful block has been reported in previous literatures. Generally, anesthetic volume for the SFIB ranges from 20-40 ml. Vermeylen *et al*. (2018) suggested that the effective volume to block the LFCN, FN, and ON after the USG-SFIB was 40 ml. While Hebbard *et al*. (2011), Bullock *et al*. (2017) and Eastburn *et al*. (2017) demonstrated that 20, 30, and 40 ml of injectate covered only the LFCN and FN.

In clinical practice, the most commonly used volume of local anesthetic is 40 ml. After total hip arthroplasty, Desmet *et al*. (2017) demonstrated the USG-SFIB reduced pain scores and morphine requirement. Similarly, Gola *et al*. (2021) found that the USG-SFIB could reduce the opioid requirement, complication, and length of hospitalization in total hip replacement patients. For hip fractures in elderly patients, the USG-SFIB has a significant opioid-sparing effect and decreases the side effects of opioids (Bali & Ozmete, 2021).

Both LFCN and FN locate superficial to the iliopsoas muscle in the iliac fossa which is an area closed to the needle tip while USG-SFIB is performed. However, the ON locates medial to the psoas muscle and is quite far from the injection

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site. Therefore, high volume is required for a successful USG-SFIB. Gasanova *et al*. (2019) and Glomset *et al*. (2020) recommended 50-60 ml of local anesthetic for USG-SFIB. Recently, Kantakam *et al*. (2021) reported that the minimum effective volume (MEV) of dye to achieve the LFNC, FN, and ON blockade in 90 % of cases after USG-SFIB was 62.5 mL (95% CI: 60-65 mL). This study used methylene blue to imitate local anesthetic spread which was similar to several previous reports (Bullock *et al*., 2017; Vermeylen *et al*., 2018; Maikong *et al*., 2021). In this study, we aim to confirm that the MEV90 of USG-SFIB stains the obturator nerve by histological examination.

MATERIAL AND METHOD

A total of 13 fresh adult cadavers (24 sides), donated to the Department of Anatomy, Faculty of Medicine, Chiang Mai University, Thailand. The study protocol was approved by the Research Ethics Committee, Faculty of Medicine, Chiang Mai University, Thailand. (Research ID: ANA-2563-07179) The cadavers had pathology and previous surgery at the abdomen, hip, and inguinal regions were excluded from the study.

Block Performance. The USG-SFIB was conducted with a 6-13 MHz linear US probe (LOGIQ F8, GE Healthcare, Wisconsin, USA) by an experienced regional anesthesiologist. Each cadaver was positioned supine. The US probe was placed in the parasagittal plane on the junction between the lateral 1/3 and middle 1/3 of the imaginary line of the inguinal ligament. The sartorius, iliopsoas, and internal abdominal oblique muscles were indentified by moving the probe medially. A "bow-tie-sign" is formed by these muscles

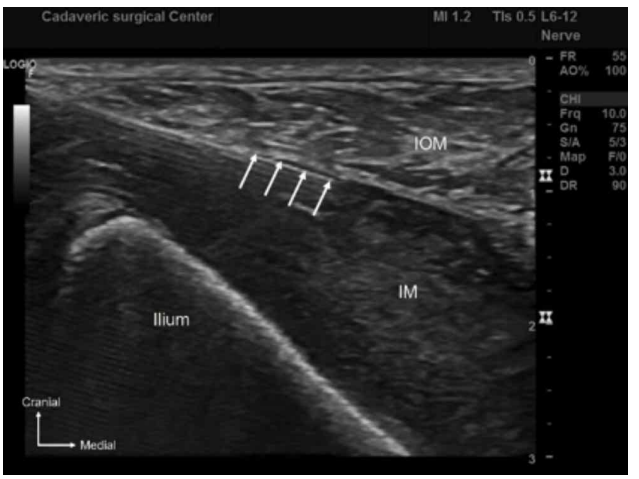

Fig. 1. Ultrasound image of suprainguinal fascia iliaca block. IOM: internal abdominal oblique muscle, IM: iliacus muscle, and white arrows: a needle underneath the fascia iliaca.

(Desmet *et al*., 2017). Blunt-tip needle (Stimuplex® A100, B Braun Medical AG, Melsungen, Germany) was inserted in the caudal to cephalad direction by in-plane technique. A volume of 62.5 ml of methylene blue and india ink (9:1) was injected deep to the fascia iliaca (Fig. 1).

Cadaveric Dissection. One hour after dye injection, all fresh cadavers were dissected. First, the skin was incised along the costal margin, midaxillary line, and inguinal ligament from the xiphoid process to the pubic tubercle on both sides. Next, the abdominal wall, as well as visceral organs such as stomach, intestines, and omentum were carefully removed. The psoas major muscle was retracted. Then, dye staining on the LFCN, FN, and ON was identified (Fig. 2).

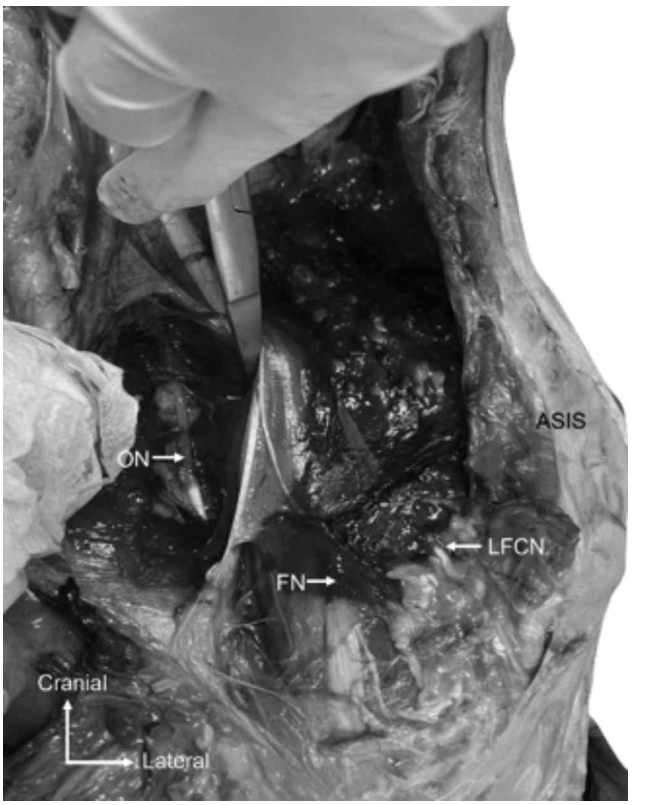

Fig. 2. Successful block. LFCN: lateral femoral cutaneous nerve, FN: femoral nerve, ON: Obturator nerve and ASIS: anterior superior iliac spine.

Histological examination. The ON overlying the sacral prominence was cut and prepared for light microscopy (Fig. 3). The ON tissues were fixed by immersion in 10 % formaldehyde solution for 1 week. Next, they were dehydrated in the alcohol and embedded in paraffin for histological analysis. Five μm-thick sections were stained with hematoxylin-eosin (H&E) to confirm the dye deposition in the connective tissue of ON, which consists of epineurium, perineurium, and endoneurium.

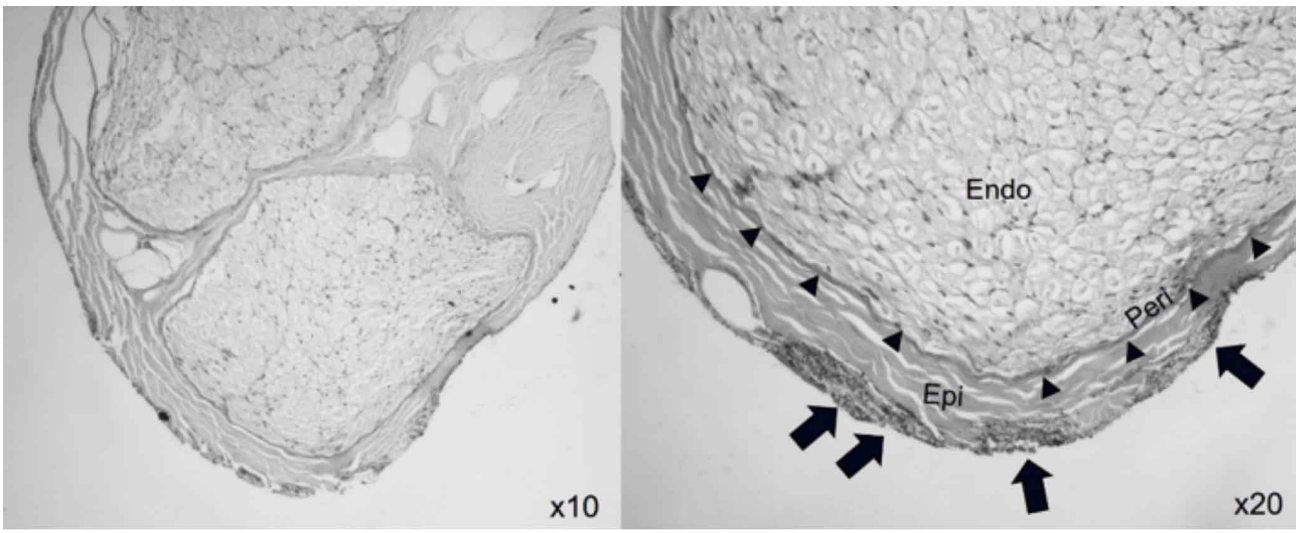

Fig. 3. Dye staining by histological examination (hematoxylin and eosin stain, H&E). Endo: endoneurium, Peri: perineurium (head arrows), Epi: epineurium, and black arrows: methylene blue + india ink staining.

RESULTS

A mean age among the twelve cadavers ranges from 60-80 years old. The effective volume (62.5 ml) was injected in a total of 24 lower limbs. The result showed that 62.5 ml of dye stained all LFCN and FN, and 91.67 % of ON as shown in Table I. The histological result showed dye stained on only the epineurium of the ON (100 %). None of them was dyed in the perineurium and endoneurium layers as shown in Table II.

Table I The efficiency of the minimal effective volume (MEV) for USG-SFIB

Nerve	Stained (n,%)	Un-stained (n,%)
LFCN	24, (100)	0, (0)
FN	24, (100)	0, (0)
ON	22, (91.67)	2, (8.33)
Successful block (%)	91.67	

Table II. The dye staining of connective tissue of obturator nerve.

Dye staining connective tissue of obturator nerve		
ON layer	Stained (n,%)	Un-stained (n,%)
Epineurium	22, (100)	0, (0)
Perineurium	0, (0)	22, (100)
Endoneurium	0, (0)	22, (100)

DISCUSSION

This study validated the MEV90 for USG-SFIB and demonstrated that 62.5 ml of dye provided 91.67 % success rate (Table I) which was comparable to Kantakam *et al*. (2021). Additionally, our study focused on the dye staining on the ON to confirm that MEV90 reached which nerve layers by histological examination. We found that only the epineurium of the ON was stained with dye.

The connective tissue of the peripheral nerve is surrounded by epineurium, perineurium, and endoneurium. The three layers of connective tissue are present along the length of the nerve, and become thinner at the branches (Reina *et al*., 2013). The ON is one of main peripheral nerve that supplies the lower limbs. Our result shown that methylene blue and india ink was localized outside the epineurium (Fig 3.). The epineurium is the external layer that composed mainly of collogen fibers with no fat tissue (Reina *et al*., 2011). The ON tissue section in our study were cut at the sacral prominence which was a common location where the ON was stained with dye after USG-SFIB. We found that the epineurium of ON was thin and had no fat layer.

The ON block is crucial in determining the USG-SFIB's success. The ON locates deep to the medial margin of the psoas major muscle, passes into the lesser pelvic and exits through the obturator foramen to the medial thigh (Meier & Büttner, 2016). Because of a large distance between the ON and the location of needle injection. SFIB requires a high volume of anesthetic to reach the ON. A caution of using a high volume of a local anesthetic to provide effective analgesia must be considered when it is applied in patients.

Local anesthetic systemic anesthetic toxicity (LAST)

and nausea/vomiting are the main complications that occur in patients. Allegri *et al*. (2016) employed the maximal volume (75 ml) of anesthetic and found that ten out of 14 patients had LAST symptoms. Also, some studies of using high volume (40-60 ml) for FICB found complications in the patient (Glomset *et al*., 2020; Ridderikhof *et al*., 2020). Thus, anesthesiologists should carefully weigh the risks and benefits of using the peripheral nerve block technique requiring a high anesthetic volume.

Recently, an alternative to SFIB has been introduced. It is pericapsular nerve group (PENG) block. The benefit of the PENG block over the SFIB is motor sparing effect and lower local anesthetic volume used. The target nerves of PENG block are the articular branches of FN and ON to the hip joint including the accessory of the obturator nerve (AON). The articular branches is located between the anterior inferior iliac spine (AIIS) and ilio-pubic eminence (IPE) 20 ml of local anesthetic for the PENG block effectively lessened the pain of the hip joint (Girón-Arango *et al*., 2018). Jadon *et al*. (2021) studied about comparison between PENG and USG-SFIB in hip surgery patients. They found the PENG that is effective of reducing pain more than USG-FICB. Moreover, After hip arthroplasty, the combination of USG-SFIB with the selective obturator nerve block effectively reduced postoperative opioid consumption and pain scores (Lee *et al*., 2020). The efficiency of the SFIB with ON block, on the other hand, is still debatable. In some previous studies, the ON block did not reduce pain after hip arthroplasty (Nielsen *et al*., 2019). At present, Zheng *et al*. (2021) improved the USG-SFIB technique of analgesic for total hip arthroplasty. It called modified USG-SFIB that developed the needle insertion approach. They used cranial to caudal approach and the point of needle located above the psoas muscle. Their result showed the block of FN, ON and sciatic nerve (SN), especially for ON.

This study has some limitations. First, In the clinical setting, the concentration of medications and procedure of blocking is required with the volume of local anesthetics. (Helayel *et al*., 2006) Second, the spreading of dye in cadaver differs from living humans. Passive movement in living subjects affected the cephalad diffusion of dye (Vermeylen *et al*. 2021). Then, the articular branches of innervation of hip joint is required to consider, especially the AON. Finally, our studies focused on the spreading of dye in nerve layer to confirm the nerve staining (H&E staining technique) by light microscopy only. Further studies specifically demonstrating the specific technique to confirm and improve the dye staining namely using immunohistochemical techniques.

In summary, the minimum effective volume (MEV) of dye spread to all three target nerves of the SFIB. However, potential complications following high anesthetic volume are existing concerns. Thus, anesthesiologists carefully evaluate the risks and benefits of using a high anesthetic volume. Further efficacy studies on alternatives of SFIB should be investigated.

Therefore, the minimal effective volume (MEV) is effective for suprainguinal fascia iliaca block. Moreover, dye stain at the epineurium of stained obturator nerve only.

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KANTAKAM, P.; MAIKONG, N.; LEURCHARUSMEE, P.; SINTHUBUA, A. & MAHAKKANUKRAUH, P. El efecto del volumen efectivo mínimo para el bloqueo de la fascia ilíaca suprainguinal en cadáveres frescos. *Int. J. Morphol., 40(3)*:627-631, 2022.

RESUMEN: El objetivo del bloqueo de la fascia ilíaca suprainguinal guiado por ecografía (USG-SFIB) es la propagación anestésica a tres nervios, cutáneo femoral lateral, femoral y obturador. El volumen efectivo mínimo del 90 % (MEV90) para USG-SFIB en cada uno de los resultados mostró el bloqueo exitoso y el efecto en varios volúmenes por bloqueo. Por lo tanto, el estudio tuvo como objetivo demostrar la eficiencia del volumen efectivo (MEV90,62.5 ml) para USG-SFIB y confirmar la tinción de tinte en el tejido conectivo del nervio, el cual se centró en el nervio obturador a través del examen histológico en cadáveres. El resultado histológico mostró tinción de colorante en el epineuro (100 %) del nervio obturador, sin embargo no hubo tinción del perineuro y endoneuro. Por lo tanto, el volumen efectivo mínimo (MEV) es efectivo para USG-SFIB.

PALABRAS CLAVE: Bloqueo de fascia ilíaca; Volumen anestésico; Estudio cadavérico; Examen histológico.

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