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Open reduction and internal fixation of ankle fracture using wide-awake local anaesthesia no tourniquet technique

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ABSTRACT

Introduction: Ankle fractures frequently occur and must be treated with open reduction for long-term stability. The existing anaesthesia methods include general anaesthesia, spinal and epidural anaesthesia, peripheral nerve block and local anaesthesia with IV sedation. However, each method has its inherent risks and potential costs, and the use of a tourniquet is inevitable. Therefore, the wide-awake local anaesthesia no tourniquet (WALANT) technique provides an alternative method for equivalent haemostasis and pain control without the use of a tourniquet.

Patients and methods: We prospectively enrolled 13 consecutive patients (9 males and 4 females) who presented ankle fractures and required ORIF from January 2017 to December 2017. The fracture types of the 13 patients included lateral malleolar fracture (three patients), bimalleolar fracture (two patients), bimalleolar equivalent fracture (three patients), medial malleolar fracture (two patients) and trimalleolar fracture (three patients; articular surface involvement <25%). We used a solution of 1% lidocaine mixed with 1:40,000 epinephrine for WALANT.

Results: All patients underwent surgery if they exhibited an initial numerical pain rating scale (NPRS) score of 0 without using a tourniquet. Only two patients required an additional 5 ml of local anaesthesia due to NPRS score elevation during the surgery; no dose exceeded the safe limit of 7 mg/kg. No local complications occurred, and no shifts to other anaesthesia methods were required due to the failure of WALANT.

Conclusions: WALANT simplified surgical preparations and provided a safe and reliable method for ankle fracture management. Because the use of a tourniquet was not required, reduced postsurgical pain was observed. Moreover, the use of local anaesthesia resulted in more satisfied patients and facilitated easier recovery.

Introduction

Ankle fractures occur commonly and must be treated with closed reduction at emergency departments to alleviate skin tension and painful sensations. Subsequently, ORIF is performed for maintenance of long-term stability, correction of alignment and prevention of early osteoarthritic changes. Surgical and postsurgical anaesthesia are administered in various forms. In the current literature, these methods include general anaesthesia, spinal and epidural anaesthesia, peripheral nerve block and local anaesthesia with IV sedation [1]. These techniques have their inherent risks and costs [2]. Alternative methods should be considered for patients with several comorbidities such as cardiovascular events and poor pulmonary function, which are unsuitable for general anaesthesia, spinal anaesthesia and IV sedation. Popliteal nerve block provides excellent surgical conditions with limited effects on cardiorespiratory function and lower rates of postsurgical nausea and vomiting [3]. However, neuropathic complications are notably high during the early postsurgical period [1]; moreover, this is a surgically demanding technique that cannot be performed in every local hospital.

Typically, a tourniquet is applied in cases of ankle fractures for preventing blood loss and creating a single, clear surgical field; this

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facilitates easy performance of ORIF. However, prolonged surgical times during the treatment of complex fractures or fixation requiring the use of more than one zone (e.g. bimalleolar or trimalleolar fractures) are instances that result in tourniquet-related thigh pain and postsurgical swelling. Therefore, although tourniquets ensure a smooth procedure, they add discomfort and possible complications. In addition, the discomfort from tourniquet pressure during surgery must be masked by general or spinal anaesthesia.

The wide-awake local anaesthesia no tourniquet (WALANT) technique was first described by Donald H. Lalonde for elective, minor wrist and hand surgeries, such as tendon ruptures and phalangeal and metacarpal fractures [4–6]. Recently, this technique was extended to bony procedures, such as distal radius fracture and basal joint arthritis [7,1–10]. Patient satisfaction is high with this technique because presurgical survey is not required and postsurgical recovery is rapid, enabling substantial saving of time and cost [11,12]. Without the use of a tourniquet, there are few complaints of postsurgical tourniquet pain and local swelling.

WALANT has rarely been applied for foot and ankle surgery, as evidenced in previous studies; it has had limited application in joint fusion, implant removal and tendon repair [13–15]. In our study, we applied WALANT for ORIF of ankle fracture; we recorded perisurgical data and quantitatively measured patient pain during the surgery using a numerical pain rating scale (NPRS).

Patients and methods

The patients in our study were consecutively enrolled by one surgeon (C.Y.C.). We enrolled a total of 25 consecutive adult patients with acute traumatic injuries related to ankle fractures from January 2017 to December 2017. We excluded patients with trimalleolar fractures who required posterior malleolar fixation, medial malleolar fracture with proximal fibula fracture (Maisonneuve fracture) and open fracture considering the involvement of an extended area in the trauma zone and expectation of a poor anaesthetic effect. Totally, seven patients were excluded due to special fracture patterns. We informed the remaining 18 patients about WALANT; we explained the pros and cons of the technique and observed their personality and attitude. Accordingly, we excluded two patients who appeared easily nervous, anxious, worried and depressed and three patients who met the criteria but refused to undergo WALANT. Finally, 13 patients (9 males and 4 females, mean age: 59.8 years) with ankle fractures who required subsequent ORIF were enrolled in this study. The fracture types among these 13 patients included lateral malleolar fracture (three patients), bimalleolar fracture (two patients), bimalleolar equivalent fracture (three patients), medial malleolar fracture (two patients) and trimalleolar fracture (three patients; articular surface involvement <25%). Comorbidities such as cardiovascular disease, pulmonary dysfunction and coronary artery disease were not considered the contraindications for WALANT. Consent to undergo surgery was obtained from the enrolled patients or their families. Table 1 presents the demographic data, fracture pattern, perisurgical variables and quantitative measurements using NPRS prior to and during the surgery.

Anaesthetic technique

At our institution, the local anaesthetic solution comprises 20 ml of 2% lidocaine and 1 ml of epinephrine (1:1000). We mixed these with normal saline to yield a 40 ml solution (1% lidocaine mixed with 1:40,000 epinephrine), and the solution was used for later injection. We first performed haematoma block by injecting 3–5 ml of 1% local anaesthesia at the unimalleolar or bimalleolar fracture site (Fig. 1). Subsequently, 5–10 ml of local anaesthesia was subcutaneously injected along 1 or 2 incision lines, with 1 cm of a subcutaneous local anaesthetic (visually or palpably) proximal and distal to the site of the planned incision (Fig. 2). Subcutaneous injections were performed with 27 G needles to alleviate injection site discomfort. We allowed an 18-min delay until anaesthesia and haemostasis stabilised. Adequacy of anaesthesia was assessed by palpating the fracture before creating skin incision such that the NPRS score was 0. We used the following technique for reducing patient discomfort during local injection. First, we followed the 'blow slow before you go' injection technique wherein the solution is slowly injected before the needle progresses into the tissue such that the nerve endings are blocked before the needle reaches deeper into the tissue. Second, we created sensory noise by proximally pinching at the injection site. Lastly, 0.5 ml of solution

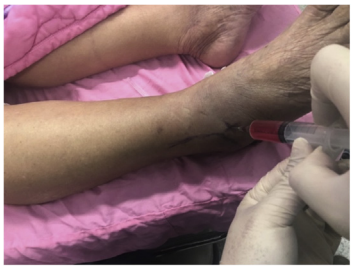

Fig. 1. Haematoma block with 3–5 ml of 1% local anaesthesia into unimalleolar or bimalleolar fracture site.

Table 1
Demographic data, fracture pattern, perisurgical variables and quantitative measurements of all patients.

Case	Gender	Age	Fracture type	Weber classification	Syndesmosis injection	NPRS before operation	Highest NPRS during operation	Bleeding (ml)	Surgery time (minutes)
1	M	21	BI	B	Y	0	0	5	120
2	F	43	TRI	B	Y	0	0	15	110
3	M	76	LAT	A	N	0	0	10	65
4	M	45	LAT	B	Y	0	0	15	80
5	M	62	TRI	B	Y	0	0	10	130
6	F	70	BIE	B	Y	0	2	5	45
7	M	83	BIE	B	Y	0	0	5	55
8	M	66	TRI	B	Y	0	0	20	70
9	F	54	MED	N	N	0	0	5	60
10	F	34	LAT	A	N	0	0	5	40
11	M	70	MED	N	N	0	0	10	50
12	M	66	BIE	B	Y	0	3	10	55
13	M	88	BI	B	Y	0	0	5	90

Abbreviations: BI: bimalleolar fracture; BIE: bimalleolar equivalent fracture; TRI: trimalleolar fracture; LAT: lateral malleolar fracture; MED: medial malleolar fracture; NPRS: Numeric Pain Rating Scale.

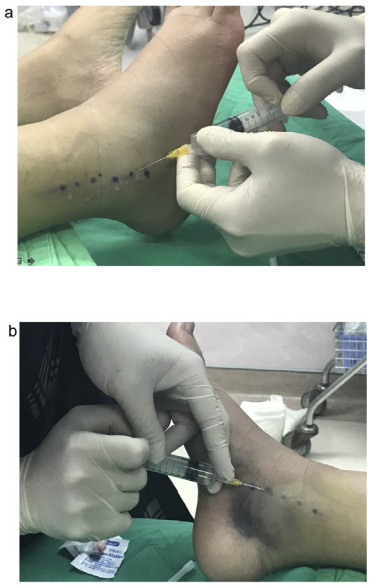

Fig. 2. A volume of 5–10 ml via subcutaneous injection in (A) lateral malleolar and (B) medial malleolar. The distance of each injection point is 1 cm from the proximal and distal incision ends.

was first injected in the subcutaneous layer for pain control; after a patient reported no pain, we administered the remaining 0.5 ml of injection solution [16].

Surgical procedure

ORIF was performed in the standard manner. Notably, an additional 5–10 ml of 1% lidocaine mixed with 1:40,000 epinephrine was injected into the syndesmosis space from the anterior aspect of the fibula if a syndesmotic screw was required later (Fig. 3). During the surgery, the operator could verbally communicate with the patients regarding postsurgical care and methods to avoid complications; the patients could also provide feedback regarding pain or traction. The patients' vital signs and NPRS score were recorded every 10 min during the surgery. If NPRS score elevation was noted during the surgery, an additional 3–5 ml of local anaesthesia was injected into the surgical field, without exceeding the safe limit of 7 mg/kg for lidocaine with epinephrine [16]. The patients could feel pulling and movement at the fracture site, which was normal. They could follow the operator's instructions about performing dorsiflexion and plantar flexion to check stability.

Postsurgical care

A short leg splint was applied to protect the repaired fracture, and the fracture dressing comprised gauze without the use of elastic bandages. Vital signs, skin colour and toe temperature were monitored for 1 day. The patients were typically discharged after 1 day if their follow-up assessment showed a normal status. Weekly outpatient follow-ups were postsurgically performed.

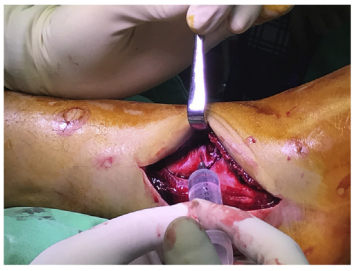

Fig. 3. Additional 5–10 ml of solution was injected into the syndesmosis space from the anterior aspect of the fibula if a syndesmotic screw was required later.

Results

In our study, nine patients (69%) who required a syndesmosis screw received an additional syndesmosis injection. All patients underwent surgery with an initial NPRS score of 0 without the use of a tourniquet; the mean bleeding volume was 9.23 ± 4.94 ml. The surgery time ranged from 40 to 120 min. Notably, only two patients required 5 ml of additional local anaesthesia due to NPRS score elevation during the surgery; none exceeded the safe limit of 7 mg/kg for lidocaine with epinephrine. No local complications of artery or nerve penetration, terminal toe cyanosis, ischaemic skin or wound problems were noted; moreover, no systemic reactions such as arrhythmia, epinephrine rush or vasovagal syncope were noted. No patients were shifted to other anaesthesia methods due to the failure of WALANT.

Discussion

In recent decades, WALANT has been widely accepted for wrist and hand surgeries such as tendon repair and transfer, skin grafting, carpal ligament release and finger fracture [17–20]. Achieving successful local anaesthesia of the distal radius bone is challenging due to the remarkably rich and heterogeneous sensory innervation of the periosteum [21]. Through subperiosteal injection [10] or haematoma block [8], the application of WALANT has been extended to distal radius fracture and basal joint arthritis in the past 2 years. Acute physiological derangements precipitated by anaesthesia and surgery may cause older patients with extensive chronic medical illnesses to decompensate. Moreover, the use of a tourniquet for haemostatic effect may cause postsurgical tourniquet pain, and its prolonged use may stimulate nerve injury [22]. With WALANT, the haemostatic effect is limited to the surgical field and injection site; thus, no tourniquet pain or nerve injury has been reported. Therefore, WALANT could reduce the length and cost of hospitalisation in addition to simplifying surgical preparation [20]. Despite these advantages, WALANT has limited use in hand and wrist surgeries and has rarely been used for ankle and foot surgeries.

For ORIF of ankle fractures, various methods of surgical analgesia exist, including general anaesthesia, spinal anaesthesia, popliteal nerve block and local anaesthesia with IV sedation. Popliteal fossa nerve block has gained widespread use owing to its reduced risks related to those of other forms of anaesthesia. Compared with spinal anaesthesia, popliteal block selectively affects the surgical side and improves earlier postsurgical mobilisation without the risk of dural injury and resultant postsurgical headache [23]. Popliteal nerve block also has limited adverse effects on cardiorespiratory function, postsurgical nausea and vomiting compared with general anaesthesia [3]. Previous studies have suggested that popliteal nerve block exhibits minimal risk. Borgeat et al. conducted a study of 1001 patients and reported the rates of different complications, including paresthaesia (0.5%), blood aspiration (0.4%) and painful sensation during anaesthesia (0.8%). Their study indicated that popliteal block is sufficiently safe, with a few mild complications [24]. However, Anderson et al. conducted a retrospective analysis of 1014 patients who had undergone popliteal nerve block for foot and ankle surgeries, and 52 of these patients (5%) developed postsurgical neuropathic symptoms as a result of popliteal block [1]. This report implied that the likelihood of neuropathic complications following popliteal block was notably higher than had described in previous reports.

Additionally, popliteal block requires experienced ultrasound guidance with substantial technical and instrumental demands. Some local hospitals lack sufficiently skilled experts or appropriate instrumentation. However, WALANT provides an alternative method in such a situation.

Studies have demonstrated the use of WALANT in extensor hallucis longus repair [15] and forefoot surgery [14]. To the best of our knowledge, this study represents the first analysis of the application of WALANT to ankle fractures. We applied the technique in cases of lateral malleolar fracture, bimalleolar equivalent or bimalleolar fracture and trimalleolar fracture without the need of posterior malleolar fixation. Cases involving the requirement of posterior fixation were excluded due to the possibility of an inadequate anaesthetic effect. Intra-fracture site haematoma block has been widely used for performing closed reduction of ankle fractures at emergency departments [25] without the requirement of monitoring a patient's medication dosing and airway; this contrasts with the standard requirements during procedural sedation. In the present study, we combined haematoma block before subcutaneous injection with WALANT to achieve an effective anaesthetic outcome. There are concerns that the use of lidocaine in haematoma block is harmful for joint cartilage. In an in vitro study, a large volume of intra-articular lidocaine injection (30–60 ml) exhibited dose- and time-dependent cytotoxic effects on chondrocytes. Chondrotoxicity with 2% lidocaine was greater than that observed with 1% lidocaine [26]. However, the long-term negative effects of lidocaine on human cartilage have not been demonstrated; notably, single intra-articular injection of lidocaine did not influence the viability, morphology or cultivation potential of chondrocytes from articular cartilage biopsy specimens [27]. In our study, the maximal dose of haematoma block with 1% lidocaine was less than 10 ml, which appears relatively safe; moreover, intra-articular involvement was not present in some of the fractures.

The incorrect belief that the use of epinephrine is dangerous for fingers and toes due to the risks of necrosis and cyanosis began in the 1950s. However, this belief arose from the use of procaine (novocaine [28]), which was used until lidocaine was introduced in 1948. Procaine initially has a pH of 3.6; however, when it is stored for a long time, the pH decreases to 1. Such acidity may cause finger and toe necrosis; however, this effect is not associated with the use of epinephrine [16,29]. Therefore, epinephrine injection is safe for use in fingers and toes because it does not induce necrosis. Previous studies regarding WALANT reported the use of 1:100,000 epinephrine and 1% lidocaine. Maximal cutaneous vasoconstriction occurred for more than 25.9 min [10,30]. We modified this protocol to 1:40,000 epinephrine and 1% lidocaine to shorten the waiting time to 18 min for the onset of the anaesthetic effect [8]. The epinephrine vasoconstrictor effect can reportedly be reversed using phentolamine; however, this is rarely necessary in clinical practice because there have been no clinical cases of finger necrosis, even when high doses of epinephrine (1:1000) were accidently injected [31,32]. In our study, no patient required phentolamine for the reversal of vasoconstrictor effect, and no complication of necrosis or cyanosis was noted. Therefore, our solution of 1:40,000 epinephrine can be considered safe.

Other relative side effects of WALANT mentioned in previous studies include vasovagal reaction in response to needle penetration [16] as well as epinephrine rush (e.g. agitation and tremor), which was reversible in patients with mild symptoms. However, we created sensory noise by pinching proximally at the injection site and using the 'blow slow before you go' injection technique. We hypothesise that the risk of vasovagal reaction was lowered by this effort to reduce penetration discomfort. The possibility of epinephrine-induced cardiac ischaemia has rarely been reported, even with high-dose epinephrine (1:1000) [33]. In this study, no obvious adverse effects or intolerable discomfort was observed during the anaesthesia procedure following careful explanation to the patients prior to the surgery. There has been considerable concern regarding blood loss when using WALANT during surgeries without tourniquet use. Huang et al. reported the average blood loss in distal radius fractures to be 18.9 ml without tourniquet use. However, the amount of blood loss in the conventional tourniquet group may be significantly higher than that in the WALANT group because of the blood oozing that occurs following tourniquet release [8].

There are some specific advantages of WALANT for ORIF in ankle fractures. The patients could remain completely alert, which enabled the operator to test the stability of the ankle after fixation under physiological forces; notably, the patients could actively perform dorsiflexion and plantar flexion. Despite these advantages, operators should evaluate each patient prior to the surgery; patients with psychological disorders and anxious personalities are contraindicated for undergoing WALANT. For those who are not amenable to use of the awake procedure, general or spinal anaesthesia should be considered.

This study has several limitations including its small sample size and lack of a control group of patients treated with general anaesthesia, spinal anaesthesia or popliteal block. Additionally, we chose patients with selected fracture patterns such as lateral malleolar, bimalleolar, bimalleolar equivalent and trimalleolar fractures without the need for posterior fixation. Open, Maisonneuve and trimalleolar fractures with posterior fixation were not assessed in this study. Lastly, patients with conditions including dementia, psychological disease and intolerance of injection pain and behaviours including easily nervous, anxious, worried and depressed who were considered to experience difficulty in following orders during the surgery were not included in this study.

Conclusions

WALANT simplifies surgical preparation and provides a safe and reliable approach for the management of ankle fractures. Unlike other types of anaesthesia, WALANT does not require a highly demanding nerve block technique; moreover, it does not require advanced spinal or general anaesthesia, which carry cardiopulmonary risk. Without the use of a tourniquet in this procedure, postsurgical tourniquet pain is generally reduced; thus, patient satisfaction is increased and the use of local anaesthesia with reduction of pain facilitates easy recovery.

Conflict of interest

The authors declared no conflict of interest in this study.

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