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Original Article

Superficial Venous Dilatation Induced by Ultrasound-Guided Axillary Nerve Block in Vascular Access Surgery

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Objectives: We aim to assess the effect and significance of ultrasound-guided axillary nerve block on the diameter of basilic vein in vascular access surgery.
Methods: 78 consecutive patients who underwent vascular access surgery with ultrasound-guided axillary nerve block were studied retrospectively. Diameter of basilic vein at the elbow level before and after the nerve block were measured and the dilatation rate was also calculated to assess the effect of nerve block on venous diameter.
Results: Basilic vein diameter increased from 3.0±1.1 mm before the block to 4.1±1.2 mm after the block ($p<0.001$). Mean dilatation rate was 143±34%. The dilatation rate was inversely correlated with venous diameter before the block ($p<0.001$).
Conclusion: Ultrasound-guided axillary nerve block induces significant basilic venous dilatation and that make the anastomotic procedure involving basilic vein possible, or much easier. This anesthetic technique was considered to be an effective option in vascular access surgery. (This is a translation of Jpn J Vasc Surg 2017; 26: 235–239.)

Keywords: vascular access surgery, ultrasound-guided regional block, superficial vein

Introduction

Patients undergoing vascular access surgery are typically given local or general anesthesia; however, in recent years, ultrasound-guided nerve block has been employed safely with a high success rate, thus gaining popularity for use in abdominal and limb surgery.[1] In particular, a nerve block in the axillary fossa is considered effective for vascular access surgery with the operative field centered in the upper limb, especially in the forearm. We started performing ultrasound-guided axillary nerve block (US-ANB) in October 2009, and reported its safety and effectiveness.[2] Although we observed a venous dilatation effect of US-ANB in our experience of >7 years (914 patients), we did not quantitatively examine this effect. In the present report, we describe the rate of venous dilatation based on the diameter of the brachial basilic vein following US-ANB and report the significance in vascular access surgery.

Subjects and Methods

Among 428 patients who underwent vascular access surgery from July 2016 to April 2017, we included 78 patients who underwent US-ANB. The indication for US-ANB included all inpatient vascular access surgeries; at our hospital, surgical thrombectomy and percutaneous transluminal angioplasty that are completed with a single skin incision are performed on an outpatient basis and were thus excluded. Patient characteristics are shown in **Table 1**. US-ANB was performed after measuring the diameter of the brachial basilic vein on ultrasound with the patient in the supine position, and the point of measurement was at the venous junction above the elbow. We used a mixture of 10 mL of 1% xylocaine, 10 mL of physiological saline, and 10 mL of 0.75% anapeine, for a total of 30 mL, as the anesthetic agent for US-ANB, and for the ultrasound-guided block (22G 10 cm blunt needle: Hakko), approximately 6 mL each of the anesthetic agent was injected around the musculocutaneous nerve, median nerve, ulnar nerve, radial nerve, and subcutaneously into the axilla (**Fig. 1**). After injection, we applied manual pressure to the same site for 5 min, attempting to spread the anesthetic agent proximally.[1] After confirming the anesthetic effect, we measured the diameter of the basilic vein

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at the same point of the medial forearm measured prior to anesthesia and calculated the dilatation rate [post axillary nerve block (ANB)/pre ANB venous diameter, in percent]. Furthermore, the number (proportion) of patients with diameter <2.5 mm (our criterial diameter for venous anastomosis in arteriovenous grafting) was compared pre and post US-ANB. We administered intravenous anesthetic (Precedex) following venous diameter measurement after US-ANB. All patients received venous anesthesia. Furthermore, additional local anesthetic (0.5% xylocaine) was infiltrated as required when patients complained of pain during surgery. Change in pre and post US-ANB basilic vein diameter (pre ANB and post ANB diameter) was examined using paired t test, the correlation between the dilatation rate and other continuous variables [body mass index (BMI), pre and post US-ANB venous diameter, age, and dialysis period] were evaluated using Pearson correlation coefficient, and other ordinal variables (sex and presence or absence of comorbidity) were evaluated using Spearman rank correlation coefficient. A p value of <0.05 was considered statistically significant. All statistical analyses were performed using EZR software.[3)]

Table 1 Patients' characteristics

Patients characteristics	
Sex	Male 38 Female 40
Age	75±11
BMI	22±4.4
HD duration (years)	6.8±9.1 years
Cause of HD	n (%)
Diabetic nephropathy	34 (43)
Chronic glomerulo nephritis	18 (23)
Hypertensive nephropathy	12 (15)
Others	14 (18)
Comorbidity	
Diabetes mellitus	42 (54)
Hypertension	60 (77)
Hyperlipidemia	14 (18)
Ischemic heart disease	16 (21)
Chronic heart failure	14 (18)
Cerebrovascular disease	14 (18)
Type of operation	
Loop AVG (forearm)	7 (9)
Loop AVG (upper arm)	2 (3)
Loop AVG (upper-forearm)	43 (55)
AVF creation (wrist)	7 (9)
AVF creation (elbow)	3 (4)
Graft interposition (forearm)	6 (8)
Jump graft (upper arm)	5 (6)
Others	5 (6)

Results

Surgery (skin incision) was initiated at 22±4 min (mean±standard deviation) after anesthesia completion. No complications or side effects, such as local anesthetic toxicity or intravascular injection, were observed. Pre US-ANB, basilic vein diameter was 3.0±1.1 mm, which significantly dilated to 4.1±1.2 mm post US-ANB ($p<0.001$) with a dilatation rate of 143%±34% (**Fig. 2**). Upon examining numerical values and factors correlating with the dilatation rate, we observed a weak inverse correlation between BMI and the dilatation rate (correlation coefficient, −0.255) and a strong inverse cor-

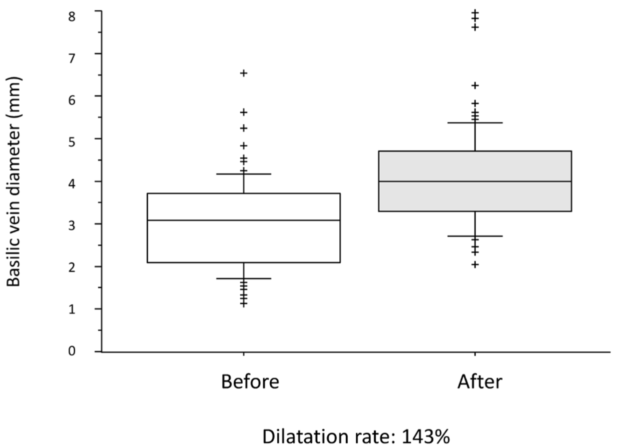

Fig. 2 Changes of basilic vein diameter (mm) before and after US-ANB. Mean dilatation rate was 43%.

Fig. 1 **a**, **b**: The position of a patient and an anesthetist in US-ANB. **c**: A screen of US picturing axillar nerves. AA: axillary artery; AV: axillary vein; M: median nerve; U: ulnar nerve; R: radial nerve; MC: musclocutaneous nerve.

Table 2 Correlation between dilatation rate and other variables

Variables	Correlation coefficient	p value
Sex	−0.0524	0.648
Age	0.143	0.212
BMI	−0.255	0.024*
HD duration (days)	0.138	0.271
Diabetes mellitus	−0.117	0.309
Hypertension	0.00811	0.944
Hyperlipidemia	−0.185	0.105
Ischemic heart disease	−0.0649	0.572
Chronic heart failure	−0.000742	0.995
Cerebrovascular disease	−0.13	0.257
Pre ANB diameter	−0.609	3.29e-09**
Post ANB diameter	−0.093	0.418

*p<0.05 **p<0.01

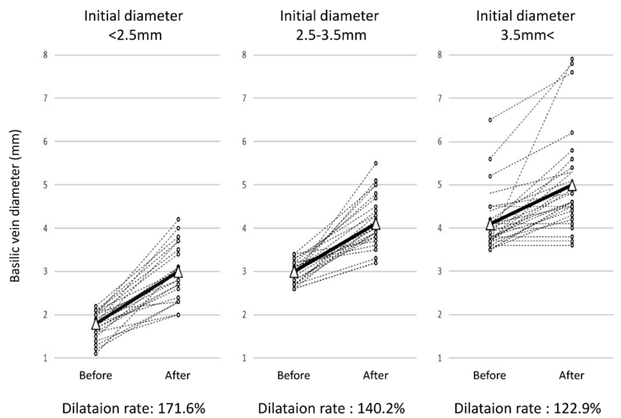

Fig. 3 Changes of basilic vein diameter (mm) in three subgroups classified by initial vein diameter (mm).

relation between pre US-ANB basilic diameter (pre ANB diameter) and the dilatation rate (correlation coefficient, −0.609) (**Table 2**). Subgroup analysis classified by initial vein diameter showed that the smaller the pre US-ANB diameter (initial diameter), the greater was the dilatation rate (**Fig. 3**). For arteriovenous grafting, we stipulate that the criterial venous size should be >2.5 mm. Overall, 54 patients (69%) met this criterion pre US-ANB, which increased to 72 patients (92%) post US-ANB ($p<0.001$). In fact, among 52 patients who underwent arteriovenous grafting, 48 (92%) had a basilic vein feasible for anastomosis with an artificial graft. In the remaining 4 patients, anastomosis was performed in the deep veins of the upper arm. Last but not least, we observed postoperative venous spasms in 5 patients (6.4%).

Discussion

Anesthesia for vascular access surgery is mostly performed by local anesthesia, and intraoperative patient pain is often significant. In particular, for vascular access surgery in which the extent of dissection and operative field are large (such as in arteriovenous grafting and infected graft removal), it is often difficult to obtain the sufficient analgesic effect for a dose of local anesthetic, thus requiring multiple additional injections and causing unbearable pain for the patient. On the other hand, many patients with end-stage renal disease have comorbidities, such as arteriosclerotic disease, in whom the risk of general anesthesia cannot be ignored and in whom there is concern for postoperative complications and deterioration in activities of daily living.[4] Therefore, in October 2010, our department started US-ANB in all inpatients undergoing vascular access surgery with reported safety and effectiveness.[2] Compared to other brachial plexus nerve blocks (supraclavicular or subclavian), ANB carries minimal risk of causing pneumothorax and is the safest approach to perform if the surgeon has experience doing ultrasound-guided puncture. Combining venous anesthesia with ANB, we believe it would be a very effective anesthesia with practically the same sedation and analgegic effect as general anesthesia, and the analgesic effect lasts for several hours after operation.

It is thought that the vasodilatation effect of a nerve block arises by blocking the sympathetic nerve, the effect of which lasts for approximately 5 h. The venous dilatation and increased blood flow effect also last for approximately 5 h, contrasting with sympathicotonia following emergence from general anesthesia.[5] Similarly, in a study comparing local anesthesia, radial artery and arteriovenous fistula (AVF) blood flow were found to be significantly increased[6] after creating an AVF. Furthermore, the venous dilatation effect was increased on using a tourniquet (additional 19%–42% dilatation),[7] and dilatation appeared more remarkable in the superficial compared to the deep veins (dilatation of 31% in the basilic vein and 24% in the radial vein compared to 8.7% in the cephalic vein). Further, this venous dilatation effect improved the AVF creation rate from 89% to 93% and the site of AVF creation was changed from the proximal to more distal in 14% of cases following the nerve block.[8] The present study is the first to identify a greater dilatation effect with smaller venous diameter prior to US-ANB. In other words, US-ANB considerably dilates the superficial veins in which anastomosis has been deemed impossible or difficult with conventional methods. Furthermore, US-ANB allows the vein for anastomosis to be identified preoperatively and facilitates the anastomosis procedure itself, which is highly significant in vascular access surgery. However, although improved patency and initial success rate can be expected due to vasodilatation and the increased blood flow effect, in our experience, there is no difference in patency of arteriovenous grafting between local anesthesia and

US-ANB.[9] Similarly, in a 2017 meta-analysis, although improved patency of AVF was observed, the initial success rate and morbidity were comparable to those in the local anesthesia group.[10] With regard to the vascular spasms, the frequency and severity of spasm are alleged to be lower with US-ANB than with local anesthesia[11]; however, at our institution, we experienced several cases of venous spasm after opening vascular clamps, indicating that spasms cannot be inhibited completely by nerve block. At present, we believe that the advantages of the venous dilatation effect following nerve block are limited to the point that it helps identify the optimal vein to anastomosis on-table and facilitates venous anastomosis itself.

Among our 78 patients, none experienced complications or side effects of US-ANB. Local anesthetic toxicity, which is always a concern, is often observed when a large dose of the local anesthetic is injected into the muscles, and we believe this can be prevented by using ultrasound guidance and reducing the concentration of the local anesthetic (<1%). Furthermore, vascular injury can be prevented by using a nerve block needle (blunt needle), and no patient experienced vascular injury at our institution. Regarding analgesic effects, the success rate of nerve block is improved by injecting the anesthetic agent under ultrasound guidance individually into the target areas surrounding the musculocutaneous nerve, median nerve, radial nerve, and ulnar nerve. Besides, in the medial upper arm for which an axillary block is typically considered ineffective, analgesic effect can be obtained by extensive subcutaneous injection (3–4 mL) into the axilla under ultrasound guidance (blocking the intercostobrachial nerve), and by using this technique (US-ANB), the analgesic effect can be achieved throughout the entire upper limb except lateral region of upper arm. In a previous study that we conducted (performing surgery under US-ANB alone without combined venous anesthesia), additional local anesthesia was required in approximately 20% of patients, and approximately 80% of these patients needed additional local anesthesia in the medial region of upper arm. In other words, previously mentioned disadvantages of axillary nerve block, including insufficient anesthetic effect, incidental vascular/nerve injury, and side effects of local anesthetic, are mostly due to blind puncture of the needle, and almost all of these are eliminated by using ultrasound-guided puncture and injection of local anesthetic. An only shortcoming of US-ANB is ensuing motor paralysis of the upper limbs. For several hours after administration, a state of so-called "dead arm" persists; hence, to ensure the safety of patients, the indication of US-ANB at present is limited to vascular access surgery performed for inpatients. Even in inpatients, the slightest fall could lead to a serious accident, and therefore, caution should be exercised, such as having the patient wear an arm sling.

Conclusion

The superior analgesic efficacy of US-ANB helps alleviate pain during operation and facilitates venous anastomosis as a result of venous dilatation induced by the sympathetic nerve blocking effect. Furthermore, the venous dilatation effect appeared to be more remarkable in smaller veins of <2.5 mm diameter, thereby enabling satisfactory anastomosis in superficial veins that have been unsuitable for anastomosis before. Although improved patency in arteriovenous grafting and spasm prevention have not been demonstrated so far, considering the safety, effectiveness, and advantages, we believe that US-ANB is an effective anesthetic option for vascular access surgery.

Disclosure Statement

There are no conflicts of interest to declare for the present study.

Additional Remarks

This original article was primarily published in the Japanese Journal of Vascular Surgery Vol. 26 (2017) No. 5; however, sign errors were detected after the publication. The erratum was published in Vol. 27 (2018) No. 5 of the same journal. This secondary publication reflects these corrections.

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