Retraction

JVA The Journal of Vascular Access

Retraction: "Brachial plexus block using only 1% lidocaine to reduce pain during the endovascular treatment of dysfunctional arteriovenous access"

The Journal of Vascular Access
2025, Vol. 26(5) 1788

DOI: 10.1177/11297298251365708
journals.sagepub.com/home/jva
Sage

At the request of Sage and the Journal Editors, the following article has been retracted:

Park S-J, Chung HH, Lee YH, et al. Brachial plexus block using only 1% lidocaine to reduce pain during the endovascular treatment of dysfunctional arteriovenous access. The Journal of Vascular Access. 2023;0(0). doi:10.1177/11297298231190418

The journal received communication from the Public IRB (Korea National Institute for Bioethics Policy), notifying them of the revocation and termination of the ethical approval for this study. The Public IRB representative stated this decision comes after a review of the study approval dates and noting that ethical approval was granted after the submission date to this journal.

The authors confirmed that the timelines of their ethical approval coincides with what the Public IRB states.

Due to the lack of appropriate ethical approval, this article has been retracted.

The authors did not respond when notified of this retraction.

Original research article

JVA The Journal of Vascular Access

The Journal of Vascular Access
2025, Vol. 26(5) NP1–NP7

DOI: 10.1177/11297298231190418
journals.sagepub.com/home/jva
Sage

RETRACTED: Brachial plexus block using only 1% lidocaine to reduce pain during the endovascular treatment of dysfunctional arteriovenous access

Sung-Joon Park[1], Hwan Hoon Chung[1], Yun Hak Lee[2], Hyoung Nam Lee[3], Youngjong Cho[4], Sangjoon Lee[5], Seung Hwa Lee[6] and Woo Young Yang[2]

Abstract

Background: Interventional endovascular treatments of dysfunctional arteriovenous (AV) access for hemodialysis can cause pain and discomfort to the patients. Ultrasound-guided brachial plexus block (BPB) is an alternative regional anesthesia method, but conventional BPB using ropivacaine or bupivacaine may cause long-lasting motor power loss, significantly reducing patient satisfaction. This study aimed to introduce BPB using only 1% lidocaine, which induces sensory loss while minimizing motor block, and evaluate the efficacy and safety of this procedure.

Methods: This retrospective study was conducted on 277 consecutive patients with dysfunctional AV access requiring percutaneous transluminal angioplasty (PTA). Of these, 174 patients underwent the BPB procedure using 1% lidocaine. Time data were recorded, and the motor strength grade (MRC scale, grade 0–5) was evaluated. Numeric rating pain score (NRPS, grade 0–10) was asked during every PTA, and overall NRPS and satisfaction scores (scale 1–3) were asked after the procedure was completed.

Results: Of the 174 patients who received BPB, the success rate was 100%, and there were no significant complications related to BPB. The MRC scale measured at the time when the complete sensory loss was achieved was 1.99 ± 0.63, and that at the point of sensory recovery when the block effect expired was 3.93 ± 0.62, indicating a good grade of motor strength. The average NRPS during PTA in the BPB group was significantly lower than that of the control group without BPB (1.04 ± 2.04vs 6.30 ± 2.71, $p < 0.001$). The overall satisfaction score was significantly higher in the BPB group than in the control group (2.79 ± 0.50vs 2.00 ± 0.81, $p < 0.001$).

Conclusions: BPB using only 1% lidocaine can induce a sensory block while minimizing the effect on motor function. It can be applied safely in an outpatient clinic setting with relatively higher satisfaction.

Keywords

AV fistula, dialysis access, interventional radiology, brachial plexus block, lidocaine, anesthesia, motor strength grade, numeric rating pain score, percutaneous transluminal angioplasty

Date received: 6 March 2023; accepted: 11 July 2023

[1]Department of Radiology, Korea University College of Medicine, Korea University Ansan Hospital, Ansan, Gyeonggi-do, Republic of Korea
[2]Vascular and Pain Clinic, Seoul Sun Orthopedic Surgery Hospital, Seoul, Republic of Korea
[3]Department of Radiology, Soonchunhyang University College of Medicine, Cheonan Hospital, Cheonan, Republic of Korea
[4]Department of Radiology, University of Ulsan College of Medicine, Gangneung Asan Hospital, Gangneung, Gangwon, Republic of Korea
[5]Vascular Center, The Eutteum Orthopedic Surgery Hospital, Paju, Republic of Korea
[6]Department of Radiology, Andong Hospital, Andong, Republic of Korea

Corresponding author:
Hwan Hoon Chung, Department of Radiology, Korea University College of Medicine, Korea University Ansan Hospital, 123 Jeokguem-ro, Danwon-Gu, Ansan, Gyeonggi-do 15355, Republic of Korea.
Email: Chungmic@korea.ac.kr

Introduction

The prevalence of end-stage renal disease (ESRD) continues to increase worldwide.[1–3] The most common form of renal replacement therapy is hemodialysis,[4] and the creation of arteriovenous (AV) access for hemodialysis is widely performed across the world. Nevertheless, the 3-year patency of these AV accesses is less than half,[5] and the interventional endovascular treatments to restore or maintain AV access patency are effective for stenosis-associated lesions and are gradually replacing surgical revisions.[6]

However, the pain caused by the dilation of blood vessels during interventional endovascular treatment for AV access may be a great burden on the patient and reduce the patient's compliance with the procedure.[7] Various methods such as local anesthesia or systemic anesthetic agents have been used to alleviate this pain. However, most ESRD patients have multiple comorbidities, and they are more susceptible to the adverse effects of systemic anesthesia, such as respiratory distress or sudden cardiopulmonary arrest.[8–10]

Ultrasound-guided brachial plexus block (BPB) has emerged as an alternate regional anesthesia method, and this anesthesia technique has been used for upper extremity surgeries of the hand and wrist.[11] Several studies reported the application of this anesthesia technique to interventional endovascular treatment for dysfunctional AV access.[12–14] However, BPB using ropivacaine or bupivacaine has the limitation that the patient's motor power loss lasts for more than 10 h due to the long block duration. This is a factor that significantly lowers the patient's satisfaction with the procedure. In this study, we introduce BPB using only lidocaine, which induces sensory loss while minimizing motor block, and retrospective research on procedures that apply it.

Material and methods

This retrospective study was approved by the institutional review boards of all collaborating institutions, and written informed consent was waived (IRB registration No. Institution A (Korea University Ansan Hospital): 2023AS0105, Institution B (Seoul Sun Orthopedic Surgery Hospital): 2023-0652-001). Written informed consent for interventional procedures was obtained from all patients.

Study design and participants

Two hospital databases were queried from December 2020 to December 2022, and 277 consecutive patients were identified who were referred to interventional radiology clinics for dysfunctional AV accesses requiring percutaneous transluminal angioplasty (PTA) in the endovascular treatment progress. AV access was defined as hemodialysis vascular access for renal replacement treatment, including arteriovenous fistulas (AVFs) and arteriovenous grafts (AVGs).

Table 1. Patient characteristics between groups.

Parameters	BPB group	Control group	*p* Value
	(*n* = 174)	(*n* = 103)	
Age	66.70 ± 12.52	67.18 ± 12.70	0.758
Sex			
Female	98 (56.3%)	54 (52.4%)	0.103
Male	76 (43.7%)	49 (47.6%)	
Type of AV access			
AVF	93 (53.4%)	44 (42.7%)	0.166
Forearm	51	24	
Upper arm	42	20	
AVG	81 (46.6%)	59 (57.3%)	
Forearm	43	23	
Upper arm	38	36	

BPB: brachial plexus block; AV: arteriovenous; AVF: arteriovenous fistula; AVG: arteriovenous graft.

Five interventional radiologists (S-J.P, H.H.C, Y.H.L, S.H.L, W.Y.Y) with at least 5 years of experience in endovascular procedures performed all the procedures. All patients undergoing the procedure were monitored for electrocardiogram, blood pressure, and oxygen saturation throughout the procedure. Two interventional radiologists (Y.H.L, W.Y.Y) performed the procedure using BPB, and the rest performed it without BPB. The interventional endovascular treatment for AV access whether or not including BPB was not performed for the following patients: (1) patients with underlying respiratory diseases such as COPD or asthma, or (2) patients with abnormal coagulation parameters (PT INR $>$ 2.0, or platelet count $<$50,000/mL). In the following cases, reliable pain scale data could not be collected, and due to the retrospective nature of the study, they were not included: (1) patients who have difficulty in communicating or have significantly poor compliance to evaluate the pain scale, or (2) patients with a history of neurological deficit in the arm on the side of the procedure. Of the total 277 patients, 174 (62.8%) underwent the procedure after receiving BPB. Patient demographics are listed in Table 1. In the control group without BPB, only local anesthesia for puncture was administered. No additional systemic sedatives or analgesics were used for all patients in both groups.

Brachial plexus block procedure

The 174 patients who underwent BPB followed the procedure below. When the patient arrived at the intervention room, they were laid in the supine position, and the supraclavicular area was exposed. Patients were explained about BPB, informed in advance about possible intravascular

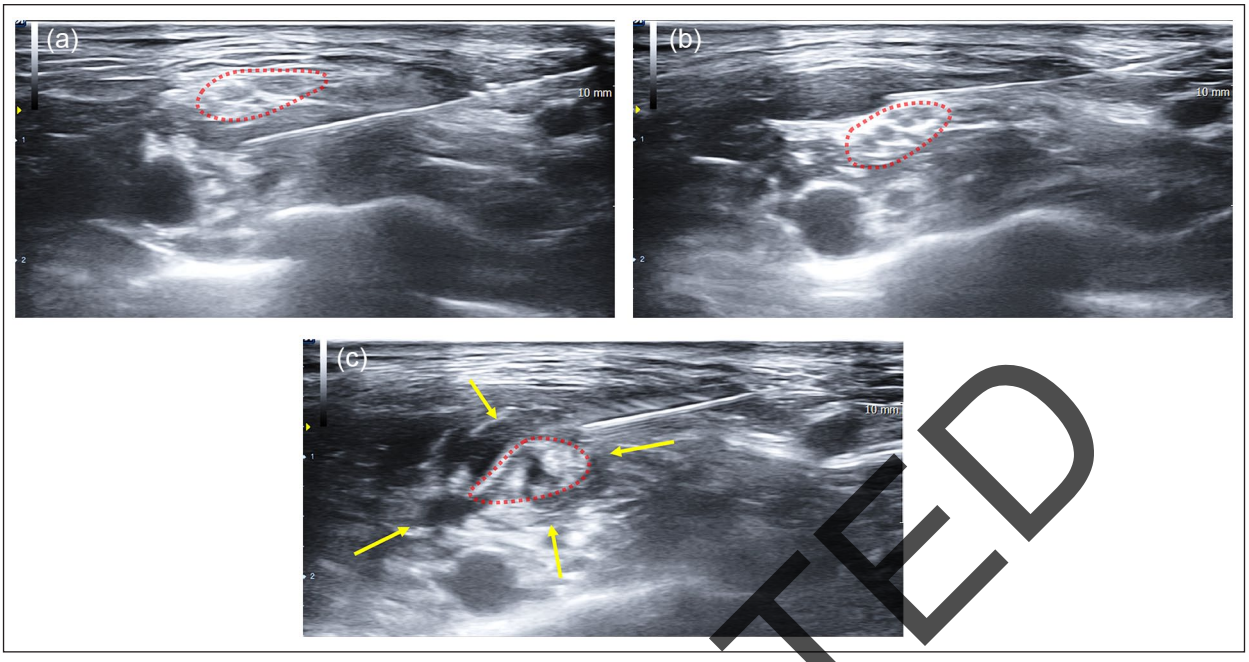

Figure 1. 1% Lidocaine injection around the brachial plexus 1% lidocaine was first injected into the inferior part of the brachial plexus ((a), dotted line) and then into the superior part (b), and the sheath of the brachial plexus was surrounded with lidocaine to look like an anechoic halo sign ((c), arrows).

injection symptoms such as tinnitus, circumoral numbness, and lightheadedness, and asked to report symptoms immediately when they occurred. BPB was performed under aseptic conditions and ultrasound guidance. A linear 8–17 MHz transducer (E-CUBE 15; Alpinion) was placed transversely on the supraclavicular fossa to identify the supraclavicular brachial plexus and guide the 26-gauge block needle while injecting the 1% lidocaine for BPB. The time at which the injection needle pierced the skin for the first time was recorded as the BPB start time. The brachial plexus, which appears as a low echoic cluster located anterior to the first rib and inferior to the subclavian artery, was searched first. The 1% lidocaine solution was first injected into the inferior part of the brachial plexus and then into the superior part, and the sheath of the brachial plexus was surrounded with lidocaine to look like an anechoic halo sign (Figure 1). The total amount of 1% lidocaine injected and the BPB completion time was recorded when it was ascertained that the BPB injection was sufficient.

The success of BPB was defined in this study as a complete absence of sensation during a light touch test that was performed by the examiner at intervals of about 5 min. At the time when the sensory loss was achieved, the motor function was also evaluated. It was assessed by the examiner and graded according to the Medical Research Council (MRC) scale for muscle strength on a grade of 0–5, with grade 5 indicating active movement against gravity with full resistance (normal), grade 4 indicating active movement against gravity with some resistance (good), grade 3 indicating active movement against gravity but not resistance (fair), grade 2 indicating active movement only with gravity eliminated (poor), grade 1 indicating flicker or trace of contraction seen, and grade 0 indicating no observed muscle contraction.[15]

Data collection and image acquisition

Two of the authors (S-J.P, Y.H.L) collected medical record information about the type of AV access (AVF or AVG), complications during the procedure, where the PTA was performed, and which balloon catheter (diameter, length, product name) was used during PTA for all cases. Before the procedure, each patient was informed about procedure-related pain evaluation by numeric rating pain score (NRPS, grade 0–10) in advance, and NRPS was routinely asked and recorded whenever PTA was performed for each stenoses target.

Before performing PTA, fistulography was performed to select the location of the target and measure its diameter. After performing PTA for each target, follow-up fistulography was performed to evaluate luminal gain and complications such as rupture or pseudoaneurysm formation.

After the procedure was completed, the medical staff asked each patient about the step that was the most painful in the overall procedure, and its NRPS. The satisfaction score was on a scale of 1–3; with 1 being not satisfied, 2 indicating partially satisfied, and 3 being satisfied. The efficacy of the BPB, evaluated using the NRPS and satisfaction score was the primary endpoint of this study. The

Table 2. Result of supraclavicular brachial plexus block.

Parameters	Average (mean ± SD)	Minimum	Maximum
BPB procedure time (min)	6.4 ± 2.2	3	15
Time to complete sensory loss (min)	11.3 ± 3.8	5	33
Duration of sensory loss (min)	52.5 ± 23.9	15	165
MRS scale: motor strength grade			
At the time of complete sensory loss	1.99 ± 0.63	0	4
At the time of sensory recovery	3.93 ± 0.62	3	5

BPB: brachial plexus block, MRS: Medical Research Council.

time of complete sensory recovery was recorded, and MRC scale at this time was re-evaluated.

Complications were evaluated in accordance with the Society of Interventional Radiology (SIR) Classification System for Complications by Outcome.[16]

Statistical analysis

The Statistical Package for the Social Sciences (version 25.0; IBM Corporation, Armonk, NY, USA) was used for all statistical analyses, and p values <0.05 were considered statistically significant. A Student's *t*-test was used for continuous data, and a chi-squared test was used to compare categorical data. Simple regression analyses were performed between the NRPS and independent variables (type of AV access, number of previous PTA, PTA target vessel diameter, PTA balloon catheter diameter, and injected solution amount).

Results

For the 174 patients in the BPB group, all the BPB procedures were successful—all patients succeeded in reaching sensory loss through supraclavicular BPB performed using 1% lidocaine. The BPB results are listed in Table 2. The average time required for the block procedure was 6.4 ± 2.2 min (3–15 min), and the average time required for sensory loss from initiation of BPB was 11.3 ± 3.8 min (5–33 min). The average duration of sensory loss was 52.5 ± 23.9 min (15–165 min). The average dose of 1% lidocaine required to achieve sufficient BPB was 20.4 ± 5.4 mL. There were no minor or major complications.

The most important aspect of this study was determining how much the anesthesia affected the motor function while achieving sufficient sensory loss to perform supraclavicular BPB. The MRC scale measured at the time when the complete sensory loss was achieved was 1.99 ± 0.63. The MRC scale measured at the point of sensory recovery when the block effect expired was 3.93 ± 0.62, indicating a good grade of motor strength.

The NRPS was surveyed by the examiner every time PTA was performed during the procedure (Table 3). PTA was performed on a total of 490 targets, of which 290 procedures were performed under BPB and 200 were in the control group. The average NRPS in the BPB group was 1.04 ± 2.04, and that in the control group was 6.30 ± 2.71, which was a statistically significant difference. The average NRPS divided by AV access type and location also showed a statistically significant difference in both types. When a subgroup analysis was conducted to determine whether the effect of BPB varies depending on the location of AV access, the values were 1.53 ± 2.65 for cases where the AV access was located in the forearm, and 2.07 ± 2.99 for those where it was located in the upper arm. This did not show a statistically significant difference ($p = 0.075$).

Table 3. Comparison of NRPS between BPB and control groups at each PTA targets.

Parameters	BPB group ($n = 290$)	Control group ($n = 200$)	*p* Value
Average NRPS	1.04 ± 2.04	6.30 ± 2.71	<0.001
Average NRPS by AV Access Type			
AVF	1.03 ± 1.95	7.14 ± 2.18	<0.001
Forearm	1.18 ± 2.08	7.60 ± 0.89	<0.001
Upper arm	0.88 ± 1.81	6.89 ± 2.67	<0.001
AVG	1.06 ± 2.14	5.97 ± 2.84	<0.001
Forearm	1.16 ± 2.29	7.33 ± 1.16	<0.001
Upper arm	0.96 ± 1.97	5.67 ± 2.76	<0.001

NRPS: Numeric Rating Pain Scores; BPB: brachial plexus block; PTA: percutaneous transluminal angioplasty; AV: arteriovenous; AVF: arteriovenous fistula; AVG: arteriovenous graft.

Overall NRPS of the patients surveyed after the procedure was 1.33 ± 2.22 on average in the BPB group and 6.39 ± 2.15 in the control group, showing significantly higher pain scores in the control group. The overall satisfaction score was 2.79 ± 0.50 points on average in the BPB group and 2.00 ± 0.81 points in the control group, showing significantly higher satisfaction in the BPB group (Table 4).

The results from the simple regression analyses between the NRPS (dependent variable) and various PTA-related variables are listed in Table 5. There were statistically significant correlations between NRPS and the ratio of the

Table 4. Comparison of overall NRPS and satisfaction scores between BPB and control groups.

Parameters	BPB group ($n = 174$)	Control group ($n = 103$)	p Value
Overall NRPS	1.33 ± 2.22	6.39 ± 2.15	<0.001
Overall Participant Satisfaction Scores	2.79 ± 0.50	2.00 ± 0.81	<0.001

NRPS: Numeric Rating Pain Scores; BPB: brachial plexus block.

initial diameter of the PTA target vessel to the diameter of the balloon catheter in the BPB group.

Discussion

As the number of ESRD patients increases worldwide, AV access creation also tends to increase, and accordingly, the demand for endovascular treatment to maintain AV access patency is bound to increase. The pain accompanying the dysfunctional AV access procedure is a significant burden for the patients. As mentioned above, most end-stage renal failure patients have complex comorbidities and are more susceptible to the side effects of general anesthesia, such as dyspnea or sudden cardiopulmonary arrest, which makes it inconvenient to use these systemic anesthetics in an outpatient clinic setting. Therefore, there have been recent studies to apply BPB to solve this problem.[12–14,17]

Bupivacaine or ropivacaine is the preferred long-acting local anesthetic for peripheral nerve block and is also used in many BPB studies. These agents exhibit significant advantages in postoperative pain management, as even the most commonly used concentration of 0.5% can reduce opioid consumption while prolonging the duration of anesthesia. As a result, they are widely employed as local anesthetics.[18] Safa et al. compared the analgesic effect (duration and quality) between 0.5% Bupivacaine with 1:200,000 Epinephrine (BE), 1% Ropivacaine (R1), and 0.5% Ropivacaine (R2) in ultrasound-guided interscalene BPB, and similar results were obtained at equal concentration. The results indicated efficacy and proved that there is no concentration-dependent difference in duration. The mean duration of the motor block reported in that study was 17.6 ± 7.7, 18.5 ± 9.7, and 14.9 ± 5.7 h for BE, R1, and R2, respectively, confirming that motor block was maintained for a considerably long time.[19] Fredrickson et al., who performed an interscalene block using ropivacaine, reported that using a higher primary ropivacaine bolus dose further deteriorates motor function (grip strength) and lowers patient satisfaction.[20] They believed that motor block was strongly related to patient dissatisfaction while performing brachial plexus block in the minor wrist and hand surgery and compared cases of long-acting block and short-acting blocks. However, they concluded that reducing the duration of BPB did not improve patient satisfaction.[21] They mentioned that the biggest factor for the dissatisfaction felt by patients was related to motor paralysis, the so-called "dead arm" sensation, that persisted after the block.

The 1% lidocaine used for BPB in this study is a short-acting anesthetic and does not completely block motor functions. This is valuable since it can minimize the discomfort felt by the patient and increase satisfaction. The BPB in this study using only 1% lidocaine preserved the MRC scale at around 2 points at the time of complete sensory loss and around 4 points at the time of sensory recovery.

Other previously reported studies using only lidocaine showed similar results to our study. Chiba et al. used only 1.8% lidocaine to block the radial nerve and musculocutaneous nerve selectively, and transient motor paralysis was absent in most cases or appeared in the form of partial paralysis, but all recovered completely within 60 min and were able to be discharged after 90 min.[13] Hull et al. also performed supraclavicular BPB in 21 cases using 1% and 2% lidocaine and reported a BPB duration of 5.1 min and a sensory block duration of 77.9 min.[17]

When the NRPS of the BPB group in this study were reviewed, it showed that patients reported more severe pain when the initial vessel diameter was smaller. Regression analysis of the ratio of initial vessel diameter and balloon nominal pressure diameter with NRPS also showed a negative correlation (Regression coefficient $= -2.289$, $R^2 = 0.030$, p-Value $= 0.003$). No statistically significant relationship was observed for the control group, which is presumed to be due to the lower pain discrimination ability as compared to the sensory block in the BPB group. In other words, for patients who received BPB, their NRPS baseline would be significantly lower compared to the control group when experiencing the same pain stimulus. Therefore, it was hypothesized that under these conditions, when balloon PTA was performed, the severity of pain was more pronounced differentiation: BPB might allow for a clearer distinction between different levels of pain intensity.

This study has several limitations. Firstly, this study is retrospective-based design, which may lead to several biases such as information or selection bias. Secondly, whether BPB was performed or not varied by the operator—only certain operators performed BPB, and the rest performed the procedure under conventional local anesthesia. This could act as a bias because it was difficult to fundamentally block the possibility of differences in pain caused by unspecified differences in treatment methods according to specific operators. More randomized, prospective studies will be needed to provide more reliable results. Lastly, while this study has demonstrated that it is possible to induce adequate sensory loss in BPB without the use of ropivacaine or bupivacaine, it did not make a direct comparison to ascertain whether avoiding the use of these drugs leads to improvements in

Table 5. The results of simple regression analyses between NRPS and PTA-related variables.

Parameters	Group							
	BPB group ($n = 290$)				Control group ($n = 200$)			
	Regression coefficient	r	R^2	p-Value	Regression coefficient	R	R^2	p-Value
Type of AV Access	0.035	0.009	0.000	0.884	− 1.171	0.196	0.039	0.172
Number of previous PTA	0.110	0.031	0.001	0.602	0.135	0.031	0.001	0.832
Initial diameter of the PTA target vessel	− 0.291	0.170	0.029	0.004	0.061	0.022	0.000	0.881
Balloon catheter diameter using PTA (at nominal pressure)	0.030	0.020	0.000	0.730	− 0.146	0.053	0.003	0.713
The ratio of the initial diameter of the PTA target vessel to the diameter of the balloon catheter	− 2.289	0.173	0.030	0.003	1.129	0.060	0.004	0.677
Injection solution amount	0.012	0.033	0.001	0.573	-	-	-	-

NRPS: Numeric Rating Pain Scores; PTA: percutaneous transluminal angioplasty; BPB: brachial plexus block; AV: arteriovenous; AVF: arteriovenous fistula.

patient dissatisfaction, such as the "dead-arm" sensation. It may be necessary to consider a further study design that can verify improvements in patient satisfaction in this regard.

In hand or wrist surgery, the motor block of not only the forearm and upper arm but also of the hand and fingers are essential. However, in AV access endovascular treatment, the patient's cooperation alone, if available, is sufficient, and a motor block may not be necessary. The block that restricts motor function lowers the patient's satisfaction. In conclusion, supraclavicular BPB using only 1% lidocaine can induce a sensory block while minimizing the effect on motor function so that it can support endovascular treatment for AV access in ESRD patients relatively safely in an outpatient clinic setting with relatively higher satisfaction.

Author contributions

Conceptualization: S-J. Park, Y.H. Lee. Data Curation: S-J.Park, H.H. Chung, Y.H. Lee, S.H. Lee, W.Y. Yang. Investigation: S-J. Park, Y.H. Lee. Methodology: S-J. Park. Supervision: H.H. Chung, H.N. Lee, Y. Cho, S. Lee. Software: S-J. Park. Writing—original draft: S-J. Park. Writing—review & editing: Y.H. Lee, H.H. Chung, H.N. Lee, Y. Cho, S. Lee.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethics approval

Ethical approval was waived by the local Ethics Committee of participating institutions in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

ORCID iDs

Sung-Joon Park https://orcid.org/0000-0002-1187-7671
Hwan Hoon Chung https://orcid.org/0000-0002-6213-4376
Hyoung Nam Lee https://orcid.org/0000-0002-2135-9384
Youngjong Cho https://orcid.org/0000-0003-2881-9221

References

1. Crews DC, Bello AK and Saadi G. 2019 World Kidney Day Editorial - burden, access, and disparities in kidney disease. *J Bras Nefrol* 2019; 41(1): 1–9.
2. Jin DC. Analysis of mortality risk from Korean hemodialysis registry data 2017. *Kidney Res Clin Pract* 2019; 38(2): 169–175.
3. Saran R, Robinson B, Abbott KC, et al. US renal data system 2016 annual data report: epidemiology of kidney disease in the United States. *Am J Kidney Dis* 2017; 69(3 Suppl 1): A7–A8.
4. Campos I, Arellano J, Gomez V, et al. Renal replacement therapy preferences survey: is allo-hemodialysis an acceptable option for patient caregivers and health care professionals? *Blood Purif* 2020; 49(1–2): 197–201.
5. Arhuidese IJ, Orandi BJ, Nejim B, et al. Utilization, patency, and complications associated with vascular access for hemodialysis in the United States. *J Vasc Surg* 2018; 68(4): 1166–1174.
6. Beathard GA, Lok CE, Glickman MH, et al. Definitions and end points for interventional studies for arteriovenous dialysis access. *Clin J Am Soc Nephrol* 2018; 13(3): 501–512.
7. Muromiya Y, Nagai K, Yokota N, et al. Factors associated with pain during vascular access intervention therapy. *J Vasc Access* 2015; 16(10_suppl): S43–S45.
8. Brakoniecki K, Tam S, Chung P, et al. Mortality in patients with end-stage renal disease and the risk of returning to the operating room after common general surgery procedures. *Am J Surg* 2017; 213(2): 395–398.

9. Nadolski G, Praestgaard A, Shlansky-Goldberg RD, et al. Medical emergencies and cardiopulmonary arrests in interventional radiology. *J Vasc Interv Radiol* 2013; 24(12): 1779–1785.
10. Wang AYM, Lam CWK, Chan IHS, et al. Sudden cardiac death in end-stage renal disease patients: a 5-year prospective analysis. *Hypertens Dallas Tex 1979* 2010; 56(2): 210–216.
11. Marhofer P, Harrop-Griffiths W, Willschke H, et al. Fifteen years of ultrasound guidance in regional anaesthesia: part 2-recent developments in block techniques. *Br J Anaesth* 2010; 104(6): 673–683.
12. Gedikoglu M, Andic C, Evren Eker H, et al. Ultrasound-guided supraclavicular brachial plexus block for analgesia during endovascular treatment of dysfunctional hemodialysis fistulas. *J Vasc Interv Radiol* 2014; 25(9): 1427–1432.
13. Chiba E, Hamamoto K, Nagashima M, et al. Efficacy of ultrasound-guided axillary brachial plexus block for analgesia during percutaneous transluminal angioplasty for dialysis access. *Cardiovasc Intervent Radiol* 2016; 39(10): 1407–1412.
14. Heo S, Won JH, Kim J, et al. Efficacy and safety of ultrasound-guided supraclavicular brachial plexus block during angioplasty of dysfunctional arteriovenous access: a prospective, randomized single-center clinical trial. *J Vasc Interv Radiol* 2020; 31(2): 236–241.
15. Naqvi U and Sherman AL. *Muscle strength grading*. In: StatPearls [Internet]. Treasure Island, FL: StatPearls Publishing, http://www.ncbi.nlm.nih.gov/books/NBK436008/ (2022, accessed 12 January 2023).
16. Sacks D, McClenny TE, Cardella JF, et al. Society of interventional radiology clinical practice guidelines. *J Vasc Interv Radiol* 2003; 14(9): S199–S202.
17. Hull J, Heath J and Bishop W. Supraclavicular brachial plexus block for arteriovenous hemodialysis access procedures. *J Vasc Interv Radiol* 2016; 27(5): 749–752.
18. Bowens C Jr and Sripada R. Regional blockade of the shoulder: approaches and outcomes. *Anesthesiol Res Pract* 2012; 2012: 971963.
19. Safa B, Flynn B, McHardy PG, et al. Comparison of the analgesic duration of 0.5% bupivacaine with 1:200,000 epinephrine versus 0.5% ropivacaine versus 1% ropivacaine for low-volume ultrasound-guided interscalene brachial plexus block: a randomized controlled trial. *Anesth Analg* 2021; 132(4): 1129–1137.
20. Fredrickson MJ, Smith KR and Wong AC. Importance of volume and concentration for ropivacaine interscalene block in preventing recovery room pain and minimizing motor block after shoulder surgery. *Anesthesiology* 2010; 112(6): 1374–1381.
21. Fredrickson MJ, Wolstencroft PJ, Chinchanwala S, et al. Does motor block related to long-acting brachial plexus block cause patient dissatisfaction after minor wrist and hand surgery? A randomized observer-blinded trial. *Br J Anaesth* 2012; 109(5): 809–815.