Effectiveness and Safety of Ultrasound Guided Lower Extremity Nerve Blockade in Infragenicular Bypass Grafting for High Risk Patients With Chronic Limb Threatening Ischaemia

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> **WHAT THIS PAPER ADDS**
> Ultrasound guided lower extremity nerve blockade (UGNB) is an effective anaesthetic technique for infragenicular bypass surgery in high risk patients with chronic limb threatening ischaemia. UGNB has advantages for intra- and post-operative patient management, especially with regard to haemodynamic stability during the operation, an early recovery, including resumption of clear liquid and solid food diet after surgery, and a lower incidence of post-operative delirium. UGNB in infragenicular bypass surgery could be a useful method for high risk and elderly patients to prevent peri-operative complications.

Objectives: Surgical revascularisation to accomplish limb salvage remains preferable in some patients with chronic limb threatening ischaemia (CLTI). The aim of this study was to evaluate the effectiveness and safety of ultrasound guided lower extremity nerve blockade (UGNB) in infragenicular bypass surgery (IGBS).

Methods: This was a single centre, retrospective clinical study. Fifty-nine patients with CLTI (67 limbs) who underwent IGBS under UGNB (femoral and sciatic nerve blockade) at Asahikawa Medical University between January 2012 and December 2017 were compared with patients with CLTI (137 limbs) who underwent IGBS under general anaesthesia (GA) over the same period. Propensity score matching based on pre-operative comorbidities was used to minimise background differences of the two groups.

Results: Fifty-six pairs of CLTIs were matched and analysed (55% dialysis dependent). Procedure duration was similar between the two groups, but intraoperative catecholamine index and intravenous fluid volume were lower with UGNB compared with GA (2.9 ± 4.6 vs. 5.9 ± 6.5; $p < .01$ and 1831 ± 990 vs. 2335 ± 931 mL; $p < .01$, respectively). The mean arterial blood pressure during induction of anaesthesia was significantly decreased with GA. Post-operatively, the time period to resume a clear liquid and solid food diet was significantly shorter with UGNB ($P<0.01$ for both outcome measures). Intravenous fluid volume was significanlty lower, while cardiac complications and delirium, based on the NEECHAM confusion scale, occurred significantly less often with UGNB than GA. These significant differences show advantages of UGNB compared to GA. No mortality or major amputations were observed in either group. Early graft thrombosis was observed in five limbs (8.9%) with UGNB and in four limbs with GA (7.1%) ($p = .73$).

Conclusions: UGNB has advantages for intra- and post-operative management and could be a useful method to prevent peri-operative complications for high risk patients with CLTI. To ensure the effectiveness of UGNB for IGBS for future indications, a randomised study is required.

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INTRODUCTION

More than 40% of patients with chronic limb threatening ischaemia (CLTI) are over 80 years of age according to Medicare data.[1,2] In older patients with serious comorbidities, such as diabetes mellitus (DM), heart failure (HF), ischaemic heart disease (IHD), and end stage renal disease (ESRD), the stress of anaesthesia is a considerable risk during ongoing management. Although previous

randomised trials of patients undergoing lower extremity revascularisation have demonstrated that there is no significant difference in outcome according to the type of anaesthesia,[3,4] these results offer little guidance because of the small number of included patients.

Long recovery times, HF, respiratory failure, and heart complications after surgery under general anaesthesia (GA) have been observed in high risk patients with DM, chronic kidney disease (CKD), and impaired cardiac function, which can result in a poor functional prognosis due to the stress caused by these conditions.[5,6] These high risk patients with CLTI due to infrapopliteal arterial lesions are more frequently treated by endovascular therapy (EVT) to avoid the operative risks and the use of GA.[7,8] However, the European Society of Cardiology and the European Society for Vascular Surgery guidelines recommend bypass grafting using the great saphenous vein (GSV) as the highest grade for infrapopliteal revascularisation.[1] The SPINACH study also revealed that surgical revascularisation remains preferable in some patients, such as those with extensive tissue loss with/without severe infection.[9]

Being a less stressful anaesthetic technique, ultrasound guided lower extremity nerve blockade (UGNB) can be used in infragenicular bypass surgery (IGBS). UGNB is frequently used in elderly patients to limit excessive sedation while providing excellent pain control.[10] The aim of this study was to evaluate the usefulness of UGNB using peri-operative results, including anaesthetic stress and post-operative clinical outcomes, compared with GA, in patients undergoing IGBS.

METHODS

Fifty-nine consecutive patients with CLTI (67 limbs) treated with IGBS under UGNB between January 2012 and December 2017 at Asahikawa Medical University Hospital were analysed. UGNB for IGBS was started at this institute in 2012 to reduce anaesthetic stress in high risk patients with CLTI. Over the same period, 128 consecutive patients with CLTI (151 limbs) underwent IGBS under GA. Eight patients (14 limbs) were excluded because bilateral revascularisation was performed simultaneously, a prosthetic graft was used, extra-anatomic bypass was performed for inflow reconstruction, or free flap surgery was performed simultaneously with IGBS. Finally, 116 consecutive patients with CLTI (137 limbs) who underwent IGBS under GA were included to compare the clinical impact of UGNB. This was a single centre study that was approved by the regional ethics committee of Asahikawa Medical University. Informed consent was not obtained from the patients because the study was retrospective in nature.

The indication for revascularisation was CLTI, which was diagnosed as rest pain, ischaemic foot ulceration, or gangrene and evaluated by the Wound, Ischaemia, and Foot Infection (WIfI) classification.[11] In this study, bypass surgery was selected under the following conditions: (1) the femoropopliteal and or infrapopliteal segments with TASC C-D lesions; (2) a vein graft was available; and (3) the patient

was ambulatory before CLTI onset even if non-ambulatory on admission. UGNB was indicated according to high risk comorbidities and the surgeon's decision. In addition, important criteria were ipsilateral GSV and short saphenous vein (SSV) availability because the vein had to be harvested from the anaesthetised lower extremity. Upper extremity veins (UEVs) were also evaluated as a second option. Pre-operative ultrasound vein mapping (>2.0 mm diameter) was crucial to determining vein graft availability. When the vein criteria were not satisfied, bypass surgery under UGNB was excluded. Bypass surgery proceeded without discontinuing antiplatelet therapy, but anticoagulant therapy was discontinued, regardless of anaesthetic method.

Surgical techniques

Bypasses for arterial lesions distal to the below knee popliteal artery (BKP) were performed using vein grafts. An UEV was harvested under local anaesthesia or brachial plexus blockade if needed. EVT, endarterectomy with or without patch angioplasty, was employed for inflow lesions.

Ultrasound guided lower extremity nerve blockade

After induction of sedation with dexmedetomidine in the operating room, ultrasound guided femoral nerve and sciatic nerve blockade, with or without obturator nerve blocks, was performed using levobupivacaine. Oxygen administration was performed via a face mask, and the airway was not secured. For inguinal incisions, local anaesthesia was applied in the operative field, and a small amount of fentanyl (25–50 μg) was used if the patient complained of pain or developed involuntary movement. After surgery, all patients were observed in the post-operative intensive care unit (ICU) until the next morning (see the details in the Supplementary material)

General anaesthesia technique

After securing peripheral and central venous lines in the operating room, anaesthesia was induced with propofol (with the target blood concentration gradually increased from approximately 1.0 μg/mL) and remifentanil (at approximately 0.3 μg/kg/min) using a target controlled infusion pump; tracheal intubation was then performed. Propofol, with remifentanil and fentanyl, was used to maintain the anaesthesia. To avoid shivering, after the operation, patients were immediately moved to the post-operative ICU without awakening from GA.[12]

Data collection

Data regarding patient risk factors, comorbidities and medications were obtained pre-operatively upon admission. Intra-operative outcome measures included procedure duration measured from skin incision to skin closure and simultaneous minor amputation and debridement after revascularisation, the time to leave the operating room after surgery (there is no recovery room in the hospital),

volumes of intravenous fluid infused, blood loss and blood transfusion, and amount of vasopressors administered. Fluid infusions and vasopressors were given to maintain a systolic blood pressure of greater than 90 mmHg. Volume infusion was primarily used to maintain blood pressure and a urine volume of >1 mL/kg/h for non-dialysis patients; conversely catecholamines were used primarily to maintain blood pressure, with limited use of volume infusion, for dialysis patients. All patients were retrospectively assigned an intraoperative catecholamine index value, modifying the Inotropic Score described by Wernavsky[13] using the following equation: catecholamine index = (dopamine dose [µg/kg/min] × 1) + (dobutamine dose [µg/kg/min] × 1) + (norepinephrine dose [µg/kg/min] × 100). The total amount of bolus administered ephedrine or phenylephrine was also calculated. Mean arterial blood pressure (MAP) measurements before induction of anaesthesia and the minimum MAP until surgery was started were collected from the anaesthesia records. Post-operative outcome measures included fluid infusion and blood transfusion volumes, duration of catecholamine use in days, time period to resumption of a clear liquid or solid food diet, use of analgesics, and the occurrence of delirium within 7 days after surgery. The identification of delirium after surgery was based on assessments using the NEECHAM confusion scale. Patients with scores <24 were categorised as experiencing delirium. The assessments were administered by bedside nurses.[14,15] Major complications within 30 days after surgery, included mortality, graft occlusion, major amputation, cardiac complications, and other adverse events. Mid term clinical outcomes, such as three year amputation free survival (AFS), limb salvage, graft patency, and the one year wound healing rate, were also evaluated. To assess the suitability of UGNB for bypass surgery, the pain numerical rating scale (NRS), which is a scale from 0 to 10, with 0 indicating no pain and 10 indicating unbearable pain, was administered to patients immediately after surgery for the UGNB group only, and on the day after surgery for both groups.[16] Surgeon satisfaction was also evaluated based on the operation record and anaesthesia chart, which noted the occurrence of involuntary movement, patient complaints, haemodynamic instability, and postoperative complications such as HF, neurological disorders, and acute renal failure after bypass surgery. The surgeon's impression was categorised into three groups: satisfied, neutral, and unacceptable for each anaesthetic method.

Matched analysis

In the analysis of the clinical outcomes comparing the UGNB group with the GA group, propensity score matching methods were employed to minimise background differences. A logistic regression analysis model was created to estimate the likelihood of undergoing bypass surgery under UGNB. The covariates entered into the model included age, sex, body mass index (BMI), DM, CKD on regular dialysis, IHD, cerebrovascular disease, respiratory failure, non-

ambulatory status, ejection fraction (EF), WIfI stage, anastomosis sites and serum albumin levels. Propensity scores were calculated according to the logistic regression model that was employed for one to one matching according to a less than 0.02 difference in propensity scores between the two groups.

Statistics

An unpaired t test or Mann—Whitney U test was used to compare continuous variables between the two groups, and a chi-square test was used to compare the proportions between the two groups. A p value of < .05, as assessed using SPSS version 25 (IBM, Armonk, NY, USA), was considered statistically significant. The data are presented as the mean and standard deviation of the mean. The propensity matching was also processed through SPSS.

RESULTS

The main indication for UGNB was the presence of a cardiac comorbiditiy, including a low EF and chronic HF, particularly for dialysis patients. Other factors, such as respiratory failure, stroke with disability, and sarcopenia, were indicators for non-dialysis patients (Table 1). The IGBS procedures performed under UGNB are summarised in Table 2. A single vein graft was placed in 89.5% of cases (60 limbs), and in situ saphenous vein grafting was used most. Infrapopliteal arterial lesions are the most frequently identified targets in high risk patients with CLTI, especially those with DM and ESRD,[17] and the malleolar bypasses were representative in this study. In all cases, bypass surgery was accomplished

Table 1. Indications for ultrasound guided lower extremity nerve blockade for 67 infragenicular artery bypasses

Indication	Non-dialysis cases ($n = 28$ procedures)	Dialysis cases ($n = 39$ procedures)
Cardiac comorbidities	13 (54)	33 (85)
Impaired cardiac function (EF < 45%)	5 (38)	16 (48)
Chronic heart failure	3 (23)	14 (42)
Severe aortic valve stenosis[a]	2 (15)	3 (9)
Unstable angina	3 (23)	0
Respiratory failure[b]	4 (14)	3 (8)
Stroke with disability	3 (11)	2 (5)
Other comorbidities	8 (29)	1 (3)
Obesity	1 (13)	0
Sarcopenia[c]	3 (38)	0
Chronic kidney disease (stage 4)	1 (13)	0
Bowel ischaemia	1 (13)	0
Autoimmune pancreatitis	0	1 (100)
Emergency	2 (25)	0

Data are presented as n (%). EF = ejection fraction.
[a] Valve area < 1.0 cm².
[b] Chronic obstructive pulmonary disease with oxygen dependent/PaO₂ < 60 mmHg with room air.
[c] Progressive loss of muscle mass.

Table 2. Characteristics of the infragenicular bypass procedures under ultrasound guided lower extremity nerve blockade

	67 procedures
Single vein graft	60 (90)
GSV	56 (93)
SSV	2 (3)
UEV	2 (3)
Spliced vein graft	7 (10)
GSV with SSV or UEV	6 (86)
UEV	1 (14)
Graft placement method	
In situ	45 (75)
Non-reversed translocation	12 (20)
Reversed	3 (5)
Proximal anastomosis	
Femoral artery	41 (61)
Common femoral artery	32 (78)
Superficial femoral artery	7 (17)
Profunda femoral artery	2 (5)
Below knee popliteal artery	26 (39)
Distal anastomosis	
Below knee popliteal artery	8 (12)
Crural artery	8 (12)
Pedal artery	51 (76)

Data are presented as *n* (%). GSV = great saphenous vein; SSV = short saphenous vein; UEV = upper extremity vein.

with UGNB without conversion to GA. Thirteen cases (19.4%) complained about pain or slept badly during the operation, with a pain NRS of 0.2 ± 0.9 immediately after surgery. Regarding the side effects of UGNB, there were no nerve blockade puncture site haematomas or neurological disorders after surgery. Although BMI was more than 30.0 in six cases (9.0%), the UGNB procedure was completed, and the desired effect was obtained without difficulty.

Compared with the GA group, the UGNB group had significantly more frequent respiratory failure (10.7% vs. 3.6%; *p* = .05), significantly lower EF values (50.3% vs. 56.4%; *p* < .01) and serum albumin concentrations (3.1 vs. 3.3 g/dl, *p* = .03) (Table 3, left). To minimise these background biases, the propensity score matching method was employed (Table 3, right). Fifty-six matched pairs were extracted, and the clinical outcome analysis is shown in Table 4. Significantly lower intravenously infused fluid volume (1831 ± 990 vs. 2335 ± 931 mL; *p* < .01), catecholamine index (2.9 ± 4.6 vs. 5.9 ± 6.5; *p* < .01), as well as less ephedrine (5.0 ± 6.7 vs. 13.3 ± 14.3 mg; *p* < .01) and phenylephrine use (0.2 ± 0.2 vs. 0.5 ± 0.6 mg; *p* < .01), were recorded intraoperatively in the UGNB group compared with the GA group. Additionally, the minimum MAP during the induction of anaesthesia was significantly higher in the UGNB group(74 ± 15 vs. 55 ± 14; *p* < .01), although there was no difference in the MAP during the pre-induction phase of anaesthesia. The UGNB group required a significantly lower volume of intravenous fluids after surgery (1663 ± 1704 vs. 2356 ± 1753 mL; *p* = .03) and resumed a liquid and solid food diet significantly earlier than the GA group (0.7 ± 0.6 vs. 1.9 ± 1.9 day and 1.1 ± 0.4 vs. 2.3 ± 1.9 day; *p* < .01 for each). Mortality and major amputations within one month after surgery were not observed in the two groups of matched pairs. Graft thrombosis occurred with equal frequency in the two groups (8.9 vs. 7.1%; *p* = .73). Cardiac complications were significantly more frequent in the GA group (14.3 vs. 42.9%; *p* < .01); nevertheless, acute coronary syndrome was not observed in either group. A significantly greater tendency towards electrocardiogram abnormalities, which mostly included supraventricular arrhythmia, requiring medical management, and HF with respiratory failure, which required intubation, temporary dialysis or high dose of diuretics, was observed in the GA group. No differences in

Table 3. Baseline characteristics of patients undergoing infragenicular artery bypass surgery according to anaesthesia method

	Overall series			Propensity score matched pairs		
	UGNB (67 limbs)	GA (137 limbs)	*p*	UGNB (56 limbs)	GA (56 limbs)	*p*
Median age (range) - yrs	72 (46−90)	71 (39−88)	.44	72 (46−90)	72 (39−89)	.83
Male gender	41 (61.2)	100 (73.0)	.11	35 (62.5)	34 (60.7)	1.00
Median body mass index (range) − kg/m²	21.6 (13.5−35.1)	22.1 (13.5−32.5)	.37	21.5 (13.5−32.9)	21.8 (13.5−32.0)	.64
Diabetes	55 (82.1)	99 (72.3)	.12	45 (80.4)	43 (76.8)	.82
CKD on regular dialysis	39 (58.2)	67 (48.9)	.23	30 (53.6)	32 (57.1)	.85
Ischaemic heart disease	40 (59.7)	80 (58.4)	.88	32 (57.1)	31 (55.4)	1.00
Cerebrovascular disease	19 (28.4)	40 (29.2)	1.00	15 (26.8)	11 (19.6)	.50
Respiratory failure	7 (10.7)	5 (3.6)	.05	4 (7.1)	5 (8.9)	1.00
Non-ambulatory status	25 (37.3)	46 (33.6)	.64	20 (35.7)	19 (33.9)	1.00
Median ejection fraction (range) - %	50.3 (13.0−71.0)	56.4 (20.0−74.0)	< .01	52.8 (13.0−71.0)	52.4 (20.0−69.0)	.83
Median serum albumin (range) - g/dL	3.1 (1.4−4.5)	3.3 (1.6−4.5)	.03	3.2 (2.0−4.5)	3.2 (1.6−4.5)	.92
WIfI clinical stage 4	35 (52.2)	74 (54.0)	.94	29 (51.8%)	33 (58.9)	.48
Proximal anastomosis (femoral)	41 (61.2)	89 (65.0)	.65	21 (37.5%)	17 (30.4)	.55
Distal anastomosis (foot)	51 (76.1)	98 (71.5)	.73	41 (73.2%)	45 (80.4)	.62
Propensity score				0.392	0.393	.97

Values are presented as *n* (%) unless stated otherwise. UGNB = ultrasound guided lower extremity nerve blockade; GA = general anaesthesia; CKD = chronic kidney disease; WIfI = Wound, Ischaemia, and Foot Infection classification.

Table 4. Comparison of clinical outcomes after infragenicular artery bypass surgery between propensity score matched pairs (UGNB *versus* general anaesthesia)

	UGNB (56 limbs)	GA (56 limbs)	*p* value
Intra-operative variables			
Procedure duration (min)	411 ± 118	416 ± 154	.86
Intravenous fluids (mL)	1831 ± 990	2335 ± 931	< .01
Blood loss (mL)	298 ± 286	284 ± 280	.80
Blood transfusion (mL)	254 ± 341	380 ± 386	.07
Catecholamine index [a]	2.9 ± 4.6	5.9 ± 6.5	< .01
Ephedrine (mg)	5.0 ± 6.7	13.3 ± 14.3	< .01
Phenylephrine (mg)	0.2 ± 0.2	0.5 ± 0.6	< .01
Pre-induction MAP (mmHg)	102 ± 16	103 ± 19	.65
Minimum MAP (mmHg)	74 ± 15	55 ± 14	< .01
Post-operative variables			
Intravenous fluids (mL)	1633 ± 1704	2356 ± 1753	.03
Albumin infusion (mL)	109 ± 260	209 ± 393	.12
Blood transfusion (mL)	179 ± 217	167 ± 229	.77
Duration of catecholamine use (days)	1.6 ± 2.2	2.3 ± 1.7	.08
Time period to resume a clear liquid diet (days)	0.7 ± 0.6	1.9 ± 1.9	<.01
Time period to resume a solid food diet (days)	1.1 ± 0.4	2.3 ± 1.9	<.01
Thirty-day complications			
Mortality	0	0	1.00
Major amputation	0	0	1.00
Graft thrombosis	5 (8.9)	4 (7.1)	.73
Cardiac complications	8 (14.3)	24 (42.9)	<.01
ECG abnormalities	7 (12.5)	14 (25.0)	.07
Heart failure	4 (7.1)	15 (26.8)	<.01
Acute coronary syndrome	0	0	1.00
Stroke	2 (3.6)	1 (1.8)	.50
Pneumonia	0	3 (5.4)	.08
Ischaemic colitis	2 (3.6)	0	.15
Wound complication	7 (12.5)	8 (14.3)	.78
Delirium	10 (17.9)	32 (57.1)	<.01
Mean NEECHAM confusion scale ± SD	24.6 ± 4.8	21.7 ± 4.6	<.01
Mean hospital stay ± SD - d	55 ± 63	69 ± 67	.30

Values for intra- and postoperative management are presented as mean ± standard deviation (SD); values for early complications are presented as *n* (%) unless stated otherwise. UGNB = ultrasound guided lower extremity nerve blockade; GA = general anaesthesia; MAP = mean arterial pressure; ECG = electrocardiogram; SD = standard deviation.
[a] Catecholamine index = (dopamine dose [μg/kg/min] × 1) + (dobutamine dose [μg/kg/min] × 1) + (norepinephrine dose [μg/kg/min] × 100).

other complications, including neurological complications that required intervention by a neurologist, or in the length of hospital stay were observed between the two groups. The incidence of delirium after surgery was significantly lower in the UGNB group than in the GA group (17.9 vs. 57.1%; *p* < .01). In addition, although procedure duration did not differ between the two groups, the time to leave the operating room was significantly shorter in the UGNB group (12.0 ± 2.8 vs. 21.2 ± 5.8 min; *p* < .01). In terms of post-operative pain, there was no difference in NRS scores on the day after surgery or the need for pain medication within seven days after surgery between the two groups.

Table 5. Comparison of anaesthesia related outcomes between propensity score matched pairs undergoing infragenicular bypass surgery (ultrasound guided nerve block *versus* general anaesthesia)

	UGNB (56 limbs)	GA (56 limbs)	*p*
Time required for anaesthesia at the time of surgery			
Mean anaesthesia induction time ± SD - min	48.3 ± 5.4	50.5 ± 6.3	.18
Mean time to leave the operating room after surgery ±SD - min	12.0 ± 2.8	21.2 ± 5.8	<.01
Patient satisfaction			
Mean pain numerical rating score ± SD	0.62 ± 1.1	0.85 ± 1.5	.63
Post-operative pain medication use	39 (70.9)	41 (75.9)	.55
Surgeon satisfaction			
Satisfied	42 (75.0)	31 (55.4)	.01
Neutral	10 (17.8)	8 (14.3)	
Unacceptable	4 (7.1)	17 (30.3)	

Data are presented as *n* (%), unless indicated otherwise. UGNB = ultrasound guided lower extremity nerve blockade; GA = general anaesthesia; SD = standard deviation. The Bonferroni correction was applied to the p value associated with multiple comparison.

Thus, bypass surgery under UGNB seems to be an acceptable procedure compared with GA. In addition, most surgeons were also satisfied (Table 5).

Regarding midterm clinical outcomes (Fig. 1), three year AFS, limb survival, and primary and secondary graft patency rates were similar between the two groups. The wound healing rate tended to be higher in the UGNB group, but this difference was not significant (*p* = .16).

Ten patients (11 limbs) could not be matched in the propensity score matching because these patients were too ill to be compared with any patients in the GA group. Among the eight patients who received regular dialysis, three had a very low EF, which ranged between 18% and 41%, three patients had severe HF, and two patients had respiratory failure. In the remaining two non-dialysis patients, one had a very low EF (18%), and the other had very
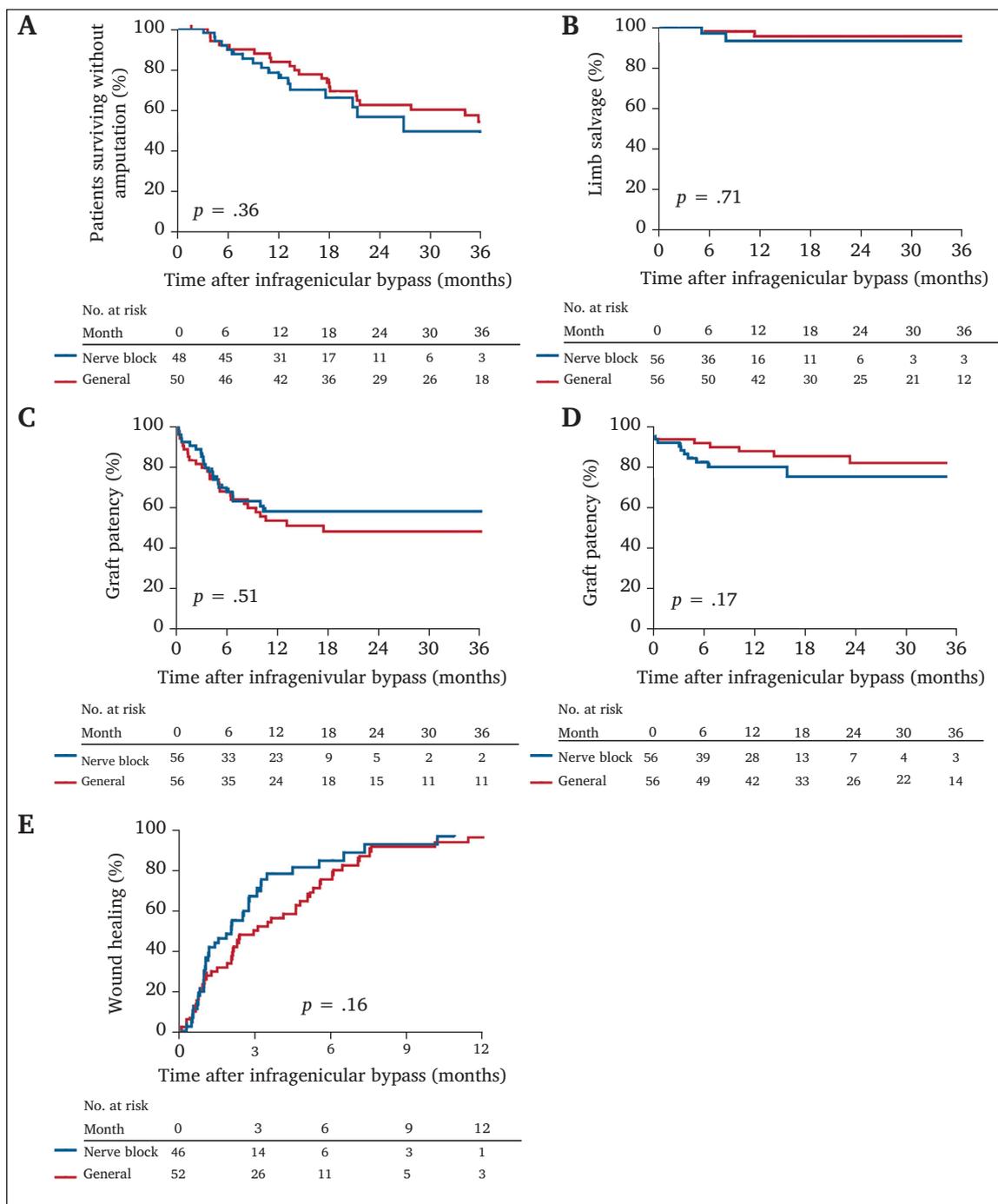

Figure 1. Kaplan–Meier estimates of clinical outcomes after infragenicular bypass surgery comparing 56 propensity score matched pairs (nerve block versus general anaesthesia). (A) amputation free survival rate; (B) limb salvage rate (C) primary graft patency rate; (D) secondary graft patency rate; (E) wound healing rate. UGNB = ultrasound guided lower extremity nerve blockade.

low serum albumin concentration (1.4 g/dL) and stroke. These unmatched patients successfully underwent bypass surgery under UGNB without major post-operative events.

DISCUSSION

The efficacy of UGNB was evaluated retropectively against GA in terms of peri-operative outcomes after an infragenicular bypass for patients with CLTI. Favourable outcomes of UGNB for IGBS were obtained in high risk CLTI patients. These are the first findings to show the advantages of UGNB for IGBS in high risk patients with CLTI.

The use of UGNB for both the sciatic and femoral nerves in bypass surgery has been reported only rarely. Mackay et al.[18] and Yazigi et al.[19] reported on infrainguinal arterial bypass with UGNB in 1997 and 2005, respectively, showing very acceptable levels of post-operative morbidity and mortality. Compared with the two earlier reports, the current study adds important evidence regarding lower anaesthetic stress as advantages in favour of UGNB. As shown in this study, the obvious indication for UGNB was a cardiac disorder, especially in patients with CKD on regular dialysis. IGBS with UGNB can be useful for patients that are disinclined to undergo bypass surgery because of the stress of GA due to their multiple comorbidities. Since the large majority of bypasses were to pedal arteries in these patients, the anaesthetic effect on the distal anastomosis area was crucial. The use of ultrasound was important to maximally demonstrate the effect in this area. In particular, blockade of the sural nerve, which supplies the lateral malleolus and the area below the malleolus, is essential when performing a more distal bypass.

Neuraxial anaesthesia is commonly used for lower extremity bypass surgery.[4,20] A meta-analysis of randomised trials that compared peripheral nerve blockade with epidural anaesthesia demonstrated that the neurological complications were usually less harmful than those associated with neuraxial blockade, and the haemodynamics were more stable in patients undergoing UGNB than in those receiving an epidural. UGNB could be advantageous in these aspects.[21] Possible complications of neuraxial anaesthesia, including spinal cord compression caused by a haematoma or abscess, are generally rare (0.1% for haematoma and 0.02% for abscess); however, there is a higher incidence of these complications during vascular surgery.[22] Regarding continuous administration of antiplatelet agents during surgery under neuraxial anaesthesia, aspirin does not significantly increase the risk of spinal haematoma for patients in general.[23] However, half of the patients had CKD on dialysis in this study. ESRD is a definite risk factor for spinal haemorrhage due to drug accumulation, platelet disorders and abnormal platelet vessel wall interactions.[24,25] Nordic guidelines recommend that neuraxial anaesthesia should be avoided unless there are strong indications in patients with chronic renal failure.[25] In addition, elderly patients also have several risk factors for haemorrhagic complications. Thus, avoidance of neuraxial anaesthesia with antiplatelet therapies could be beneficial for the high risk populations in this study. UGNB has a possible advantage over neuraxial anaesthesia as an alternative.

Post-operative delirium is a serious problem in elderly patients because of obstacles to medical care, subsequent prolonged recovery times and longer hospital stays. Post-operative delirium after vascular surgical procedures is a multifactorial disease, which includes patient background, the type of surgery performed and the anaesthesia technique used.[26] Some studies have investigated the association between vascular surgery and post-operative delirium.[27,28] A preventive approach is essential, especially for bypass surgery in elderly patients with CLTI. Vascular surgeons have several options regarding optimal anaesthesia and revascularisation for each PAD patient. UGNB is one option for high risk elderly PAD patients. This study has four limitations. First, it was a single centre, retrospective study, and relatively few subjects were analysed over six years. Second, the indication criteria for UGNB in high risk patients were obscure because there was no evidence regarding the clinical outcome of bypass surgery with UGNB. The propensity matching model of this study excluded some very frail patients who should have been correctly entered as primary candidates, revealing a weakness of the model and leading to an underestimation of the usefulness of the clinical findings. It is hoped that the peri- and post-operative data for UGNB in the current study can contribute to establishing future guidelines regarding an adequate indication for bypass surgery. Therefore, a randomised study that includes a large number of patients with a strictly prospective methodology is needed to guide the use of this approach in the future.

CONCLUSION

IGBS under UGNB for high risk patients with CLTI is effective with a high technical success rate. UGNB has advantages for intra- and post-operative management and could be a useful method for preventing operative complications in this patient population. UGNB allows bypass surgery to be performed in high risk patients with CLTI who are unsuitable for GA. Thus UGNB can widen the indications for infragenicular bypass surgery by reducing anaesthetic stress. To confirm the effectiveness of UGNB for IGBS for future indications, a randomised study should be performed.

CONFLICT OF INTEREST

None.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ejvs.2019.03.023.

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