Infrainguinal bypass under triple nerve block in patients with severely compromised left ventricular ejection fraction and chronic limb-threatening ischemia

Muzafar Mamatkulov, MD,[a] Nikolai Naumov, MD,[a] Pavel Kurianov, PhD,[b] Alexey Yaroslavsky, MD,[a] Alexey Sergeev, MD,[c] *and* Anastasia Voronova, MD,[a] *Yaroslavl and Saint Petersburg, Russia*

ABSTRACT

A severely compromised left ventricular ejection fraction (LVEF) is a major limitation for lower extremity bypass reconstruction both under general anesthesia or neuraxial anesthesia (NA). A series of eight infrainguinal bypass procedures were performed under peripheral nerve block in five patients (three males and two females; median age, 67 years) with chronic limb-threatening ischemia and a preoperative LVEF of 35% or less (median, 27%; range, 20%-35%). There were no conversions to neuraxial anesthesia/general anesthesia or early postoperative complications. This study showed that open infrainguinal reconstructions can be performed safely under peripheral nerve blockade in this vulnerable category of patients. (J Vasc Surg Cases Innov Tech 2021;7:450-3.)

Keywords: Chronic limb-threatening ischemia; Left ventricular ejection fraction; Systolic dysfunction; Bypass; Peripheral nerve block

Bypass surgery remains one of the cornerstones of revascularization strategy for chronic limb-threatening ischemia (CLTI), particularly in patients with long femoropopliteal occlusions.[1] However, congestive heart failure (CHF) owing to a compromised left ventricular ejection fraction (LVEF) is a major limitation for open noncardiac surgery owing to high perioperative risk.[2-10] Avoiding general anesthesia (GA) in favor of neuraxial anesthesia (NA) or regional analgesia has been suggested as one of the ways to decrease the perioperative risks in this vulnerable patient category.[11-14] GA implies the use of substances that might compromise central hemodynamics.[15,16] NA does not affect the heart directly, but tends to cause acute hypotension owing to peripheral vasodilation.[16-18] Peripheral nerve block (PNB) of the lower limb is thought to be bereft of these pitfalls.[11,12,19] However, high-quality evidence on open infrainguinal reconstructions under regional nerve block have been very sparse.[20] This retrospective single-arm clinical study describes the results of several infrainguinal bypass procedures performed in patients with CLTI with severely compromised LVEF under regional nerve blockade.

METHODS

This single-center single-arm retrospective study was conducted in accordance with the Declaration of Helsinki and approved by the institutional ethics board. All patients provided informed consent for the procedure and publication of their clinical data. The study included patients with preoperative LVEF of greater than 35% according to echocardiography who had CLTI owing to peripheral arterial disease and underwent open lower limb revascularization under regional nerve blockade.

Demographics and clinical characteristics, surgical risk, operative details, course of anesthesia, early outcomes (30-day mortality, perioperative complications, hospital stay) and long-term variables (overall survival, limb salvage, bypass primary patency, freedom from target lesion revascularization and healing rate at 6 months) were evaluated.

All patients underwent basic clinical evaluation by a vascular specialist, appropriate laboratory tests, preoperative echocardiography, and vascular imaging. Surgical risk was defined for each patient using the risk scoring system developed by the American College of Surgeons' National Surgical Quality Improvement Program. The Weibull parametric regression model was used to predict survival at 6 months, 1 year, and 2 years.[11]

Patients were premedicated with 5 mg of intramuscular diazepam and 1 mg of intramuscular atropine. The regional nerve block was performed by an appropriately trained surgeon from the vascular team who injected a local anesthetic solution around the sciatic nerve, femoral nerve, and two branches (anterior and posterior) of the obturator nerve under ultrasound guidance with 20.0 to 40.0 mL of a mixture of 0.2%

From the Department of Vascular Surgery, Railway Clinical Hospital, Yaroslavl[a]; the Center on Diabetic Foot and Surgical Infection, St.-George's Hospital, Saint Petersburg[b]; and the Department of Anesthesia and Critical Care, Railway Clinical Hospital, Yaroslavl.[c]

Author conflict of interest: none.

Correspondence: Pavel Kurianov, PhD, Center on Diabetic Foot and Surgical Infection, St.-George's Hospital, 1 Severny Prospect, 194354 Saint-Petersburg, Russia (e-mail: pkurjanov@gmail.com).

The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

https://doi.org/10.1016/j.jvscit.2021.05.004

Table I. Baseline demographic and clinical characteristics of patients

Patient No., age, and sex	CLTI signs	Estimated ACS NSQIP perioperative death risk, %	Estimated survival, %			LVEF, %	BMI	Comorbidities	Medications	WIfI stage	CTA/DSA data
			6 months	1 year	2 years						
Patient 1: 57 years old, male	Rest pain Tissue loss	7.7	84.0	75.0	63.0	23.0	18.2	HTN CAD CHF History of MI	Diuretics Statins OAC ACEI	4	CFA stenosis SFA CTO PA CTO
Patient 2: 66 years old, male	Rest pain Tissue loss	8.0	93.0	89.0	83.0	20.0	25.3	HTN CAD CHF AF (chronic)	Diuretics Statins Clopidogrel OAC BB ACEI	4	PA CTO
Patient 3: 67 years old, male[a]	Rest pain	7.8	97.0	95.0	92.0	35.0	35.9	HTN CAD CHF AF (chronic) Hypoalbuminemia	Diuretics Statins OAC BB	1	SFA CTO PA CTO
Patient 4: 71 years old, female	Rest pain Tissue loss	6.7	93.0	89.0	83.0	33.0	28.7	HTN CAD CHF DM	Diuretics Statins Clopidogrel BB	4	SFA CTO PA CTO
Patient 5: 72 years old, female[b]	Rest pain Tissue loss	7.4	92.0	88.0	81.0	27.0	21.3	HTN CAD CHF History of MI AF (chronic)	Diuretics Statins Clopidogrel OAC BB ACEI CCB	4	Both sides: SFA CTO ATA CTO PTA CTO

ACEI, Angiotensin-converting enzyme inhibitor; *ACS NSQIP*, American College of Surgeons' National Surgical Quality Improvement Program; *AF*, atrial fibrillation; *ATA*, anterior tibial artery; *BB*, beta-blocker; *BMI*, body mass index; *CAD*, coronary artery disease; *CCB*, calcium channel blocker; *CFA*, common femoral artery; *CHF*, congestive heart failure; *CLTI*, chronic limb-threatening ischemia; *CTA*, computed tomography angiography; *CTO*, chronic total occlusion; *DM*, diabetes mellitus; *DSA*, digital subtraction angiography; *HTN*, hypertension; *LVEF*, left ventricular ejection fraction; *MI*, myocardial infarction; *OAC*, oral anticoagulants; *PA*, popliteal artery; *PTA*, posterior tibial artery; *SFA*, superficial femoral artery; *WIfI*, Society of Vascular Surgery Wound, Ischemia, foot Infection grading system.
[a]This patient had three consecutive infrainguinal bypass reconstructions performed under peripheral nerve block on the same limb within a 6-month interval.
[b]This patient had two bypass infrainguinal reconstructions performed on different limbs within a 2-month interval.

ropivacaine (2 mg/kg body weight) and 4.0 mL of 0.4% dexamethasone, added to 40.0 mL with normal saline. No nerve stimulator was used. When necessary, the skin below the inguinal ligament was anesthetized with additional injections of 1.0% lidocaine. A technically successful nerve block was confirmed by pin-prick test before proceeding to intervention and by direct contact to the patient within the course of surgical procedure. Another way to control the course of anesthesia was intraoperative monitoring, including noninvasive blood pressure measurement, electrocardiography, and pulse oximetry.

All bypass procedures were performed with an autologous vein and according to a standard of care approach. All patients underwent duplex ultrasound examination the day after the intervention to assess early patency of the bypass. After discharge, patients were followed up by telephone at 3-month intervals. Primary patency of vein conduit was assessed at 6 months with duplex ultrasound examination.

Anesthesia was considered adequate if the patient experienced no limb pain during the intervention and no significant changes in vital signs were detected.

RESULTS

A total of five patients (three males and two females) underwent eight infrainguinal bypass reconstructions under PNB (Table I). The median patient age was 67 years (range, 57-72 years), the median LVEF was 27% (range, 20%-35%). The calculated perioperative mortality risk ranged from 6.7% to 8.0%, the predicted 2-year survival was 63.0% to 92.0%. Distribution of comorbidities was typical for CLTI with hypertension and coronary artery disease, with CHF being evident in most patients. None of the patients had acutely decompensated CHF. Preoperative angiography revealed extremely long femoropopliteal occlusions (>30 cm) involving both superficial the femoral and popliteal arteries in five of the eight patients (62.5%).

The anesthesia was adequate with complete pain control in all patients, no significant limb motion issues, and no conversions to NA or GA. No patient developed a significant change in heart rate or blood pressure or required inotropic support during or after the intervention. The median duration of the surgery was 275 minutes (range, 150-360 minutes) (Table II). The median postoperative

Table II. Procedural details and 30-day outcomes

Patient No., age, and sex	Procedure time, minutes	Proximal anastomosis site	Distal anastomosis site	Conduit type	Hospital stay, days	30-Day outcomes
Patient 1: 57 years old, male	300	External iliac artery (terminal portion)	Posterior tibial artery	Spliced vein graft (GSV + LSV)	5	Uneventful recovery
Patient 2: 66 years old, male	280	Superficial femoral artery	Peroneal artery	Single-segment vein conduit (GSV)	5	Uneventful recovery
Patient 3: 67 years old, male	150	Common femoral artery	Posterior tibial artery	Single-segment vein conduit (GSV)	11	Uneventful recovery
	285	Common femoral artery	Posterior tibial artery	Single-segment vein conduit (GSV)[a]	6	Uneventful recovery
	270	Common femoral artery	Posterior tibial artery	Spliced vein graft (GSV + LSV)	4	Uneventful recovery
Patient 4: 71 years old, female	360	Common femoral artery	Peroneal artery	Single-segment vein conduit (GSV)	4	Uneventful recovery
Patient 5: 72 years old, female	210	Common femoral artery	Popliteal artery	Single-segment vein conduit (GSV)	3	Uneventful recovery
	270	Common femoral artery	Popliteal artery	Single-segment vein conduit (GSV)	3	Uneventful recovery

GSV, Greater saphenous vein; *LSV*, lesser saphenous vein.
[a]The GSV was harvested from the contralateral limb.

hospital stay was 4.5 days (range, 3-11 days). There were no perioperative deaths, and none of the patients developed bypass failure or underwent major amputation within 30 days postoperatively. The 6-month primary patency, limb salvage, amputation-free survival, freedom from target lesion revascularization, and foot healing rates were all 87.5%. The overall survival rate was 100%.

DISCUSSION

HF remains highly prevalent in the elderly population,[21,22] with nearly one-half of all HF cases being due to impaired LV systolic function.[23] In turn, a compromised LVEF remains a the key factor in predicting perioperative mortality in noncardiac interventions,[2-10] particularly those performed for CLTI owing to peripheral arterial disease.[24-26]

Issues associated with GA in HF with a reduced LVEF include maintaining forward flow to prevent coronary ischemia, pulmonary hypertension, and end-organ dysfunction, as well as the need to promote inotropy without inducing or worsening ischemia.[15,16] Therefore, patients with extremely low LVEF may be deemed unfit for open surgery under GA.[16]

NA (spinal or epidural) carries a risk of hypotension during or immediately after the intervention,[16,18] which increases perioperative mortality[27] and is a particular issue in diabetic patients owing to cardiovascular autonomic neuropathy.[17]

Large comparative studies of GA vs NA in patients undergoing lower extremity bypass did not stratify patients according to LVEF.[13,14,28] In the only published comparative study of PNB vs GA in infrainguinal bypass procedures by Kikuchi et al,[20] the median LVEF in patients treated under nerve blockade was nearly normal (50.3%) and, again, no stratification was performed based on this factor.

Based on the study by Rohde et al,[5] we used 35% or lower as a threshold for defining a severely compromised LVEF as measured by two-dimensional echocardiography.

The procedure time in our study ranged from 150 to 300 minutes, which was substantially longer than the duration of, for example, minor foot amputations performed under regional anasthesia.[29] Still, the PNB allowed completion of the intervention successfully. We observed no significant issues related to voluntary or involuntary limb motions during surgery, probably owing to obturator nerve block, which was avoided by other authors.[20]

Despite significant National Surgical Quality Improvement Program-calculated mortality, there were no early deaths in our study. The predicted 2-year survival was well above 50%. Importantly, all of our patients had very long and totally occluded femoropopliteal lesions; thus, no endovascular approach could be reasonably considered as a first-line strategy.

CONCLUSIONS

Overall, this study showed that even the most time consuming and complicated open infrainguinal reconstructions can be done safely under PNB in select patients with CLTI with severely compromised left ventricular systolic function. Larger comparative studies are needed

to better define the category of patients who may benefit from this type of anesthesia.

REFERENCES

1. Conte MS, Bradbury AW, Kolh P, White JV, Dick F, Fitridge R, et al. Global vascular guidelines on the management of chronic limb-threatening ischemia. Eur J Vasc Endovasc Surg 2019;58:S1-109.
2. Takase B, Younis LT, Byers SL, Shaw LJ, Labovitz AJ, Chaitman BR, et al. Comparative prognostic value of clinical risk indexes, resting two-dimensional echocardiography, and dipyridamole stress thallium-201 myocardial imaging for perioperative cardiac events in major nonvascular surgery patients. Am Heart J 1993;126:1099-106.
3. Kontos MC, Brath LK, Akosah KO, Mohanty PK. Cardiac complications in noncardiac surgery: relative value of resting two-dimensional echocardiography and dipyridamole thallium imaging. Am Heart J 1996;132:559-66.
4. Halm EA, Browner WS, Tubau JF, Tateo IM, Mangano DT. Echocardiography for assessing cardiac risk in patients having noncardiac surgery. Study of Perioperative Ischemia Research Group. Ann Intern Med 1996;125:433-41.
5. Rohde LE, Polanczyk CA, Goldman L, Cook EF, Lee RT, Lee TH. Usefulness of transthoracic echocardiography as a tool for risk stratification of patients undergoing major noncardiac surgery. Am J Cardiol 2001;87:505-9.
6. Hernandez AF, Whellan DJ, Stroud S, Sun JL, O'Connor CM, Jollis JG. Outcomes in heart failure patients after major noncardiac surgery. J Am Coll Cardiol 2004;44:1446-53.
7. Healy KO, Waksmonski CA, Altman RK, Stetson PD, Reyentovich A, Maurer MS. Perioperative outcome and long-term mortality for heart failure patients undergoing intermediate- and high-risk noncardiac surgery: impact of left ventricular ejection fraction. Congest Heart Fail 2010;16:45-9.
8. van Diepen S, Bakal JA, McAlister FA, Ezekowitz JA. Mortality and readmission of patients with heart failure, atrial fibrillation, or coronary artery disease undergoing noncardiac surgery: an analysis of 38 047 patients. Circulation 2011;124:289-96.
9. Lerman BJ, Popat RA, Assimes TL, Heidenreich PA, Wren SM. Association of left ventricular ejection fraction and symptoms with mortality after elective noncardiac surgery among patients with heart failure. JAMA 2019;321:572-9.
10. Smilowitz NR, Berger JS. Perioperative cardiovascular risk assessment and management for noncardiac surgery: a review. JAMA 2020;324:279-90.
11. Bradbury AW, Adam DJ, Bell J, Forbes JF, Fowkes FGR, Gillespie I, et al. Bypass versus angioplasty in severe ischemia of the leg (BASIL) trial: a survival prediction model to facilitate clinical decision making. J Vasc Surg 2010;51:52S-68S.
12. Pisansky AJB, Brovman EY, Kuo C, Kaye AD, Urman RD. Perioperative outcomes after regional versus general anesthesia for above the knee amputations. Ann Vasc Surg 2018;48:53-66.
13. Sgroi MD, McFarland G, Mell MW. Utilization of regional versus general anesthesia and its impact on lower extremity bypass outcomes. J Vasc Surg 2019;69:1874-9.
14. Bisgaard J, Torp-Pedersen C, Rasmussen BS, Houlind KC, Riddersholm SJ. Editor's choice — regional versus general anaesthesia in peripheral vascular surgery: a propensity score matched nationwide cohort study of 17359 procedures in Denmark. Eur J Vasc Endovasc Surg 2021;61:430-8.
15. Chua JH, Nguyen R. Anesthetic management of the patient with low ejection fraction. Am J Ther 2015;22:73-9.
16. Allman KG, Wilson IH, editors. Oxford handbook of anesthesia. Oxford, UK: Oxford University Press; 2016.
17. Maser RE, Lenhard MJ. Cardiovascular autonomic neuropathy due to diabetes mellitus: clinical manifestations, consequences, and treatment. J Clin Endocrinol Metab 2005;90:5896-903.
18. Shamshery C, Kannaujia A, Madabushi R, Singh D, Srivastava D, Jafa S. Prevention of hypotension induced by combined spinal epidural anesthesia using continuous infusion of vasopressin: a randomized trial. Anesth Essays Res 2016;10:568-73.
19. Lin R, Hingorani A, Marks N, Ascher E, Jimenez R, McIntyre T, et al. Effects of anesthesia versus regional nerve block on major leg amputation mortality rate. Vascular 2013;21:83-6.
20. Kikuchi S, Yamaguchi T, Miyake K, Uchida D, Koya A, Iida T, et al. Effectiveness and safety of ultrasound guided lower extremity nerve blockade in infragenicular bypass grafting for high risk patients with chronic limb threatening ischemia. Eur J Vasc Endovasc Surg 2019;58:206-13.
21. Curtis LH, Whellan DJ, Hammill BG, Hernandez AF, Anstrom KJ, Shea AM, et al. Incidence and prevalence of heart failure in elderly persons, 1994-2003. Arch Intern Med 2008;168:418-24.
22. Djousse L, Driver JA, Gaziano JM. Relation between modifiable lifestyle factors and lifetime risk of heart failure. JAMA 2009;302:394-400.
23. Owan TE, Redfield MM. Epidemiology of diastolic heart failure. Prog Cardiovasc Dis 2005;47:320-32.
24. Bode RH Jr, Lewis KP, Zarich SW, Pierce ET, Roberts M, Kowalchuk GJ, et al. Cardiac outcome after peripheral vascular surgery. Comparison of general and regional anesthesia. Anesthesiology 1996;84:3-13.
25. Shiraki T, Iida O, Takahara M, Okamoto S, Kitano I, Tsuji Y, et al. Predictive scoring model of mortality after surgical or endovascular revascularization in patients with critical limb ischemia. J Vasc Surg 2014;60:383-9.
26. Khaira KB, Brinza E, Singh JD, Amsterdam EA, Waldo SW, Tong K, et al. Long-term outcomes in patients with critical limb ischemia and heart failure with preserved or reduced ejection fraction. Vasc Med 2017;22:307-15.
27. Monk TG, Bronsert MR, Henderson WG, Mangione MP, John Sum-Ping ST, Bentt DR, et al. Association between intraoperative hypotension and hypertension and 30-day postoperative mortality in noncardiac surgery. Anesthesiology 2015;123:307-19.
28. Christopherson R, Beattie C, Frank SM, Norris EJ, Meinert CL, Gottlieb SO, et al. Perioperative morbidity in patients randomized to epidural or general anesthesia for lower extremity vascular surgery. Perioperative Ischemia Randomized Anesthesia Trial Study Group. Anesthesiology 1993;79:422-34.
29. Kim NY, Lee K, Bai SJ, Hong JH, Lee J, Park JM, et al. Comparison of the effects of remifentanil-based general anesthesia and popliteal nerve block on postoperative pain and hemodynamic stability in diabetic patients undergoing distal foot amputation: a retrospective observational study. Medicine (Baltimore) 2016;95:e4302.

Submitted Mar 9, 2021; accepted May 6, 2021.