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. 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. 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. GA implies the use of substances that might compromise central hemodynamics. NA does not affect the heart directly, but tends to cause acute hypotension owing to peripheral vasodilatation. Peripheral nerve block (PNB) of the lower limb is thought to be bereft of these pitfalls. However, high-quality evidence on open infrainguinal reconstructions under regional nerve block have been very sparse. 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.

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%...
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 femoro-popliteal occlusions (>30 cm) involving both superficial 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 I). The median postoperative

### Table I. Baseline demographic and clinical characteristics of patients

| Patient No., age, and sex | CLTI signs | Estimated ACS NSQIP perioperative death risk, % | Estimated survival, % | Comorbidities | Medications | WIfI stage | CTA/DSA data |
|---------------------------|------------|-----------------------------------------------|-----------------------|---------------|-------------|------------|--------------|
| Patient 1: 57 years old, male | Rest pain | 7.7 | 84.0 | 75.0 | 63.0 | 23.0 | 18.2 | HTN, CAD, CHF, History of MI | Diuretics, Statins, OAC, ACEI | 4 | SFA CTO, PA CTO |
| Patient 2: 66 years old, male | Rest pain | 8.0 | 93.0 | 89.0 | 83.0 | 20.0 | 25.3 | HTN, CAD, CHF, AF (chronic) | Diuretics, Statins, Clonipigol, OAC, BB, ACEI | 4 | PA CTO |
| Patient 3: 67 years old, male | 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 | 6.7 | 93.0 | 89.0 | 83.0 | 33.0 | 28.7 | HTN, CAD, CHF, DM | Diuretics, Statins, Clonipigol, BB | 4 | SFA CTO, PA CTO |
| Patient 5: 72 years old, female | Rest pain | 7.4 | 92.0 | 88.0 | 81.0 | 27.0 | 21.3 | HTN, CAD, CHF, History of MI, AF (chronic) | Diuretics, Statins, Clonipigol, 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.

aThis patient had three consecutive infrainguinal bypass reconstructions performed under peripheral nerve block on the same limb within a 6-month interval.

bThis patient had two bypass infrainguinal reconstructions performed on different limbs within a 2-month interval.
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 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 mortality27 and is a particular issue in diabetic patients owing to cardiovascular autonomic neuropathy.19

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 anesthesia.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

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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) | 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.

*The GSV was harvested from the contralateral limb.
to better define the category of patients who may benefit from this type of anesthesia.

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