Clinical Outcomes of Common Femoral Thromboendarterectomy with Bovine Pericardium Patch Angioplasty

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Background: The purpose of the study is to evaluate the efficacy of thromboendarterectomy (TEA) for common femoral occlusive disease using bovine pericardium patch angioplasty.

Methods: The subjects were patients who underwent TEA for common femoral occlusive disease with bovine pericardium patch angioplasty from October 2020 to August 2021. The study had a prospective, multicenter, and observational design. The primary end point was primary patency (freedom from restenosis). The secondary end points were secondary patency, amputation-free survival (AFS), postoperative wound complication, hospital death within 30 days, and major adverse cardiovascular events (MACE) within 30 days.

Results: Forty-seven TEA procedures with a bovine patch were performed in 42 patients (34 males; median age, 78 years; diabetes mellitus, 57%; end-stage renal disease with hemodialysis, 19%). Clinical presentations were intermittent claudication (68%) and critical limb-threatening ischemia (32%). Sixteen (34%) limbs underwent TEA alone and 31 (66%) underwent a combined procedure. Surgical site infection (SSI) occurred in 4 limbs (9%) and lymphatic fistulas in 3 limbs (6%). One limb with SSI required surgical debridement 19 days after the procedure, and 1 limb (2%) without postoperative wound complications required additional treatment due to acute bleeding. Hospital death within 30 days occurred in 1 case due to panperitonitis. There was no MACE within 30 days. Claudication was improved in all cases. Postoperative ABI of 0.92 [0.72−1.00] was significantly higher than the preoperative value ($P < 0.001$). The median follow-up period was 10 months [9−13 months]. One limb (2%) required additional endovascular therapy due to stenosis at the endarterectomy site at 5 months

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postoperatively. Primary and secondary patencies were 98% and 100% at 12 months, respectively, and the AFS rate was 90% at 12 months.
Conclusions: Common femoral TEA with bovine pericardium patch angioplasty has satisfactory clinical outcomes.

INTRODUCTION

Thromboendarterectomy (TEA) has been the first choice for revascularization of common femoral artery (CFA) occlusive lesions for many years due to its high technical success, long-term patency, and durability.[1–5] Recently, there have been significant advances in devices and techniques for endovascular therapy (EVT) for the superficial femoral artery (SFA) and/or popliteal artery, and this approach is now widely used worldwide. Several studies have also shown the effectiveness of EVT for CFA occlusive lesions[6–8] and it is uncertain whether CFA TEA will remain as the gold standard treatment. Although TEA has a better patency rate, it is also associated with more postoperative complications such as surgical site infection (SSI), lymphatic fistula, and longer hospitalization, compared to EVT.

In the past decade, TEA has mainly been performed with patch angioplasty (venous patch or prosthetic patch). Venous patches have the potential for complications due to increased operative time and longer incision lines, which can result in higher postoperative comorbidity including wound complications, and prosthetic patches can cause severe complications from infection. TEA is now often combined with simultaneous EVT, which results in a longer operative time, more intraoperative bleeding, and more postoperative complications than in isolated TEA. However, in the endovascular era, the goal of vascular surgeons should be to perform less invasive TEA.

A bovine pericardium patch (Xenosure®, LeMaitre Vascular, Burlington, MA, USA) for use in TEA has been available in Japan since 2020. However, it is unclear if use of this patch will reduce complications of TEA. Therefore, the purpose of this study is to assess the clinical outcomes of TEA with bovine pericardium patch angioplasty.

METHODS

Subjects

The subjects were 42 patients (47 limbs) who underwent TEA with bovine pericardium patch angioplasty between October 2020 and August 2021. The patients were enrolled in the HALLOWEEN (**H**iroshim**A** prospective mu**L**ticenter study to eva**L**uate endarterect**O**my **W**ith bovin**E** p**E**ricardium patch for commo**N** femoral occlusive lesions) registry in a prospective, multicenter, observational study conducted at 9 centers in Japan. Patients who had undergone previous TEA and TEA for acute limb ischemia were excluded. Patient characteristics, operative details, hospital outcomes, and short-term outcomes were collected from the HALLOWEEN registry. The primary end point was primary patency (i.e., freedom from restenosis). The secondary end points were secondary patency, amputation-free survival (AFS), wound complication, hospital mortality within 30 days, and major adverse cardiovascular events (MACE) within 30 days.

Patient Selection and TEA Method

TEA was often selected as the initial revascularization method for a CFA occlusive lesion during the study period. Patients who agreed to enrollment in the HALLOWEEN registry underwent TEA with bovine pericardium patch (Xenosure®) angioplasty. All revascularizations were performed under general anesthesia. Proximal CFA endarterectomy was extended until the stenosis was resolved, whereas the distal site of endarterectomy (SFA and/or deep femoral artery (DFA)) was determined based on the individual anatomy. Distal intimal fixation was performed at the discretion of the surgeon. Additional EVT and/or bypass for proximal and/or distal lesions were performed if needed. Prophylactic antibacterial agents were used for 1 day postoperatively and wound cleaning using saline was performed just before wound closure to prevent SSI, and the wound was sutured tightly to prevent lymphatic complication. Technical success was assessed by intraoperative completion angiography, postoperative duplex ultrasound (DUS), or contrast-enhanced computed tomography (CT).

Definitions

Primary patency of TEA lesions was defined as freedom from target lesion revascularization and freedom from restenosis, with restenosis defined as peak systolic velocity ratio (PSVR) $\geq$2.8 on DUS or $\geq$50% restenosis on follow-up CT or angiography.[9] Technical success was defined as remaining stenosis

<30%. Major amputation was defined as limb loss above ankle level, and limb salvage as freedom from major amputation. MACE was defined as cardiovascular death, nonfatal myocardial infarction, unstable angina, congestive heart failure, stroke, or another cardiovascular event requiring hospitalization.

Medication

All patients were taking at least 1 antiplatelet agent (aspirin 100 mg daily or clopidogrel 75 mg daily) preoperatively and this was continued lifelong. Patients who underwent combined endarterectomy with EVT or bypass were treated with double antiplatelet therapy in principle, but this decision was left to the discretion of the surgeon, taking into account the bleeding risk. All patients with hypercholesterolemia were treated with statins.

Follow-up Program

Ankle-brachial index (ABI) was measured during hospitalization. In patients with intermittent claudication, follow-up in the outpatient clinic was performed at 1, 3, 6, and 12 months with ABI measurement and/or DUS, and annually thereafter. In patients with critical limb-threatening ischemia (CLTI), follow-up was performed at 1, 2, 3, 4, and 6 months with wound clinic, ABI measurement, and/or DUS and every 3 months thereafter. Further investigation (including angiography or CT) was performed for cases with recurrent symptoms, PSVR ≥2.8 on DUS, or a decrease in ABI of ≤0.15 from the postoperative baseline.

Ethics

All patients provided written informed consent. This study was approved by the ethics committee of JA Hiroshima General Hospital (Hiroshima, Japan; approval number: 20−61).

Statistical Analysis

Continuous variables are presented as medians [25th−75th percentile], and categorical variables as absolute values and percentages. According to the recommended standards published by the Society for Vascular Surgery, primary patency, secondary patency, survival rate, limb salvage rate, and AFS rate were calculated using Kaplan-Meier analysis with a log-rank test.[10] Bleeding volume and operative time were compared between isolated TEA and combined TEA using an unpaired Student's *t*-test. Comparison between preoperative and postoperative ABI was made by Wilcoxon paired test. $P < 0.05$ was considered to be significant. Statistical analysis was performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).[11]

RESULTS

A total of 47 TEA procedures were performed on 42 patients (34 males, 8 females) during the study period (Fig. 1). Patient characteristics are shown in Table I. The median age was 78 [74−81] years, 57% had diabetes mellitus, and 19% had end-stage renal disease that required hemodialysis. Indications for treatment were intermittent claudication (68%) and CLTI (32%): 11% had rest pain and 21% had tissue loss.

Details of the operative procedures are shown in Table II. All procedures were performed under general anesthesia. Isolated TEA was performed for 16 limbs (34%) and combined procedures were used for 31 limbs (66%). Seventeen TEA procedures (36%) were performed for isolated CFA, 20 (42%) for CFA and SFA, and 2 (4%) for CFA and DFA lesions. The median length of the bovine patch was 50 [43−55] mm. Combined TEA procedures had a significantly longer operative time than isolated TEA (210 [173−259] vs. 119 [105−147] min, $P < 0.001$) and greater intraoperative bleeding (168 [93−340] vs. 50 [30−80] mL, $P < 0.001$).

Hospital outcomes are summarized in Table III. Postoperative ABI was 0.92 [0.72−1.00] with a significant improvement compared to the preoperative value ($P < 0.001$) (Fig. 2). Intermittent claudication and rest pain disappeared in all patients. Of 10 patients with tissue loss, wound healing was achieved in 8 (80%). SSI occurred in 4 limbs (9%) and lymphatic fistulas in 4 limbs (9%). One limb with SSI required surgical debridement 19 days after the procedure. The anterior surface of the bovine pericardium patch was not fully adherent to surrounding tissue when surgical debridement was performed, but wound healing was achieved due to debridement and wound closure. One limb (2%) required additional treatment due to acute bleeding. Hospital death within 30 days occurred in 1 case (2%) due to panperitonitis. There was no MACE within 30 days. The median postoperative hospital stay was 11 [9−16] days. Wound complication and hospital stay in isolated TEA cases did not differ from those in combined TEA cases ($P = 0.44$, $P = 0.20$).

The median follow-up period was 20 [16−22] months. One patient (2%) suffered recurrent

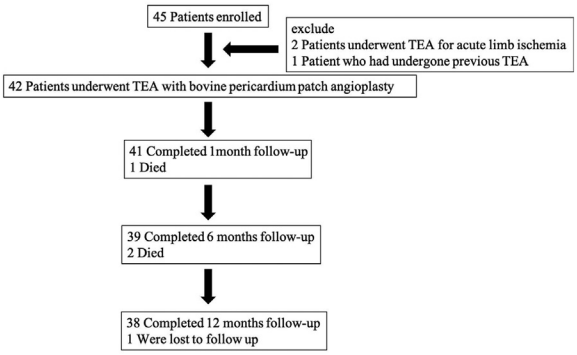

Fig. 1. Screening and follow-up.

ischemic resting pain due to restenosis at the endarterectomy site, and underwent EVT at 5 months postoperatively. Primary and secondary patencies were 98% and 100%, respectively, at 12 months (Fig. 3A). During follow-up, 8 patients died due to ischemic heart disease ($n = 2$), heart failure ($n = 2$), pneumonia ($n = 2$), stroke ($n = 1$), and panperitonitis ($n = 1$), and 3 limb required major amputation after 1, 7, and 12 months. The 12-month limb salvage and AFS rates were 93% (Fig. 3B) and 87% (Fig. 3C), respectively, and the 12-month survival rate was 90% (Fig. 3D).

Bovine pericardium patches were punctured in 5 cases at 3, 5, 7, 9, and 9 months after TEA due to EVT for other peripheral occlusive lesions. Hemostatic devices were used in all cases (Exoseal: Cordis Corp., Bridgewater, NJ, USA, or ProGlide: Abbott Vascular, Santa Clara, CA, USA). Hemostasis was achieved in all cases without hematoma or pseudoaneurysm.

Table I. Baseline characteristics in patient who underwent common femoral endarterectomy with a bovine patch angioplasty

Variables	*N* (%)
Patients/limbs	42/47
Age	78 [74−81]
Male	34 (81)
Body mass index (kg/m^2)	22.4 [21.1−24.6]
Preoperative ankle-brachial index	0.57 [0.39−0.68]
Comorbidities	
Hypertension	37 (88)
Smoking history	34 (81)
Renal insufficiency (eGFR < 60 mL/min/1.73 m^2)	26 (62)
Diabetes mellitus	24 (57)
Hyperlipidemia	24 (57)
Coronary artery disease	17 (40)
Chronic kidney disease on hemodialysis	8 (19)
Cerebrovascular disease	5 (12)
Clinical presentation	
Claudication	32 (68)
Rest pain	5 (11)
Tissue loss	10 (21)
Preoperative medication	
Statin	23 (55)
Antiplatelet	39 (93)
Anticoagulation	11 (26)

Data are presented as *n* (%) or median values [interquartile range].
N, number; eGFR, estimated glomerular filtration rate.

DISCUSSION

There were 3 main results in this study. First, TEA with a bovine pericardium patch has favorable primary patency. Second, the wound complication rate after this procedure was 17%, which was acceptable. Third, the CFA after endarterectomy with bovine pericardium angioplasty provides a safe and suitable access site for EVT in the follow-up period.

TEA has commonly been considered superior to EVT in terms of patency for CFA revascularization.[1−4,8,10] Primary patency at 1 year after TEA is reported to be 90−100%,[2−4] and in this study, the 1-year primary patency was 98%, which is comparable to these reports. However, in the only randomized control trial (RCT) of TEA versus EVT for CFA lesions, there was no difference in patency between TEA and EVT.[6] The 2-year primary patency of TEA in the RCT was about 75%, which is lower than in previous reports,[1−4,8,12] and this may explain why patency did not differ between TEA and EVT. In contrast, in a multicenter study in Japan, TEA showed superior patency to EVT,[9] which suggests that TEA may still be a better revascularization method for CFA lesions, even after the many advances in EVT.

TEA clearly has good patency but may also have a higher postoperative complication rate than EVT. A hybrid procedure combining TEA with EVT has become widely used and found to be effective,[13,14] but there is concern about increased complications due to a prolonged operation time and increased blood loss.[15] In the current study, 62% of patients underwent concomitant EVT. Operation times with bovine pericardium and venous patches in TEA for CFA have not been compared, but a similar comparison for the carotid arteries showed that use of a bovine patch reduced the operation time.[16] Therefore, use of a bovine pericardium patch instead

Table II. Operative details of patients who underwent common femoral endarterectomy with a bovine patch angioplasty

Variables	*N* (%)
Patients/limbs	42/47
CFA stenosis	
50−90%	20 (43)
99%	18 (38)
100%	9 (19)
Reference vessel diameter (mm)	9.0 [8.1−9.5]
Nodular calcification	42 (100)
Wall calcification at short axis	
0−180%	9 (19)
Over 180%	36 (81)
General anesthesia	47 (100)
Operation time (min)	185 [120−383]
Bleeding (mL)	100 [50−220]
TEA lesion	
CFA	17 (36)
CFA+SFA	20 (42)
CFA+DFA	2 (4)
Additional AI revascularization	
EVT	11 (23)
Surgical revascularization	0 (0)
Additional infrainguinal revascularization	
EVT	14 (30)
Surgical revascularization	7 (15)
Distal intimal fixation	31 (66)
Length of patch (mm)	50 [43−55]
Technical success	47 (100)

Data are presented as *n* (%) or median values [interquartile range].
Nodular calcification was defined as coral reef-like calcification protruding into the lumen.
N, number; CFA, common femoral artery; TEA, thrombendarterectomy; SFA, superficial femoral artery; DFA, deep femoral artery; AI, aorto-iliac; EVT, endovascular treatment.

Table III. Hospital outcomes in patients who underwent common femoral endarterectomy with a bovine patch angioplasty

Variables	*N* (%)
Patients/limbs	42/47
Hospital death within 30 days	1 (2)
Postoperative ABI	0.92 [0.72−1.00]
Wound complication	9 (19)
Wound infection	4 (9)
Lymphatic fistula	4 (9)
Groin hematoma	1 (2)
Major adverse cardiovascular events within 30 days	0 (0)
Postoperative acute bleeding event	1 (2)
Hospital stay (days)	11 (9−16)

Data are presented as *n* (%) or median values [interquartile range].
N, number; ABI, ankle-brachial index.

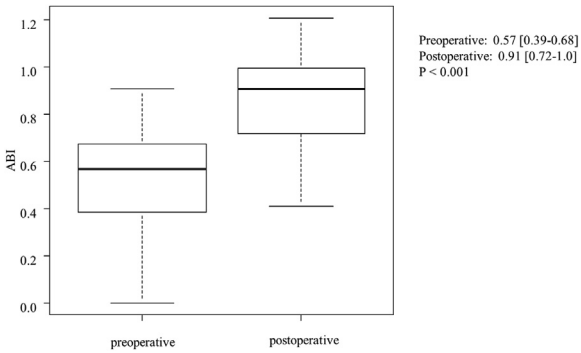

Fig. 2. Comparison of preoperative and postoperative ankle-brachial index (ABI).

of a venous patch may be favorable in cases treated with concomitant EVT.

Wound complication rates in TEA have been reported to be 18−26%.[3,6] The rate in this study was 19%, which is similar to these reports. Kuy et al.[17] observed SSI in 33% of cases of surgery for peripheral artery disease, and suggested that the patch itself must be durable against infection. MacMillan et al.[18] obtained successful bovine pericardium patch formation after removal of an infected patch in 4 patients with no recurrence of infection after endarterectomy, suggesting that a bovine pericardium patch may be resistant to infection. In the current study, 1 patient had deep SSI and the anterior surface of the bovine patch was not fully adherent to surrounding tissue. However, wound healing was achieved without patch rupture after debridement and wound closure, indicating durability against infection.

EVT with plain old balloon angioplasty (POBA) alone for CFA has a low patency rate. The patency of EVT with a bare nitinol stent in the CFA is higher than that with POBA, but this type of stent has problems of fracture and difficulty with access in the long term. In the current endovascular era, it is important to remember that the CFA is the main endovascular access site. Katsui et al.[19] found that puncture after TEA was not a problem, especially with patch formation. In this study, EVT was performed by puncturing the patch in a remote area, but both puncture and hemostasis were uneventful. These results suggest that bovine pericardium may be a suitable patch material in the endovascular era.

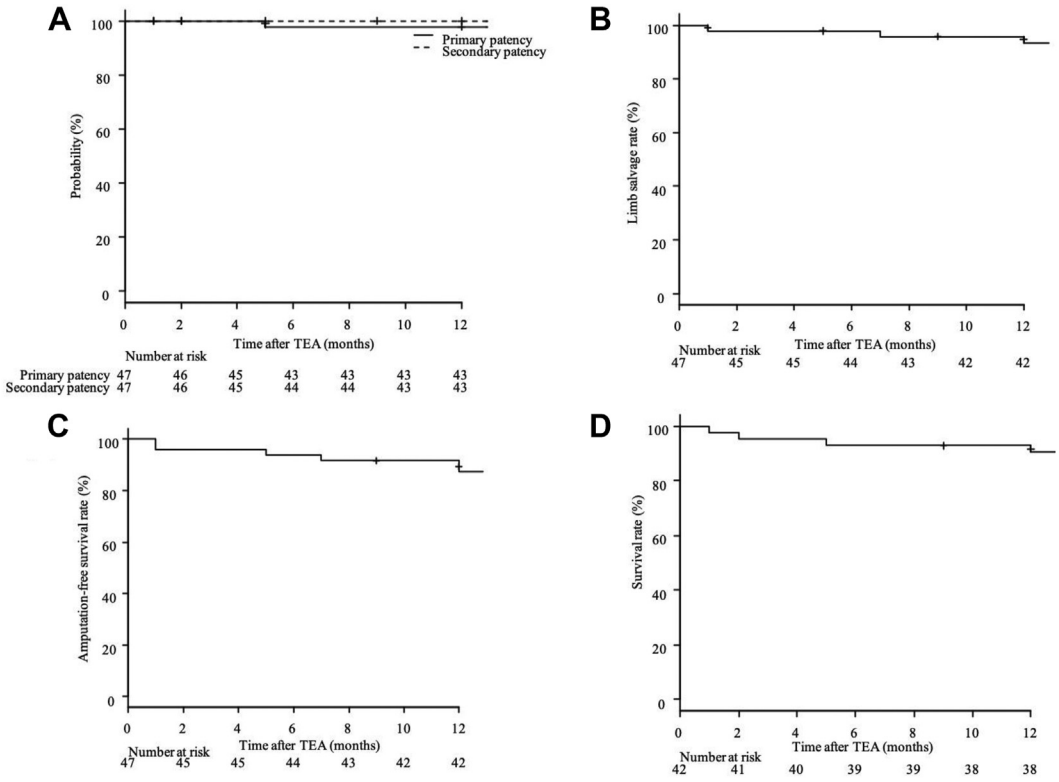

Fig. 3. Cumulative Kaplan-Meier estimates of primary and secondary patency **(A)**, limb salvage rate **(B)**, and amputation-free survival **(C)**, and survival rate **(D)** in patients who underwent common femoral endarterectomy with a bovine pericardium patch angioplasty.

Limitations

This study has several limitations. The observation period was short and only Japanese patients were included in the study. The sample size was relatively small, which may affect the outcomes, especially the comparison between isolated TEA cases and combined TEA cases. We were also unable to compare outcomes with and without patch angioplasty, or outcomes with Xenosure compared to those with other bovine pericardium patches.

CONCLUSION

CFA TEA with bovine pericardium patch angioplasty has satisfactory clinical outcomes.

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