Received: 23 March 2022 | Revised: 1 July 2022 | Accepted: 6 September 2022

DOI: 10.1002/ccd.30405

ORIGINAL ARTICLE - CLINICAL SCIENCE

WILEY

Real-world VASCADE closure device versus manual compression use and outcomes in patients with severe common femoral artery disease

Sameer Nagpal MD[1] | Lindsey E. Scierka MD, MPH[1] | Yulanka Castro-Dominguez MD[1] | Dhruv Kansal MD[1] | Steffne Kunnirickal MD[1] | Yasin Hussain MD[1] | Keith Love MD[1] | Edouard Aboian MD[2] | Kim G. Smolderen PhD[1,3] | Carlos Mena-Hurtado MD[1]

[1]Department of Internal Medicine, Vascular Medicine Outcomes (VAMOS) Program, Section of Cardiology, Yale University, New Haven, Connecticut, USA

[2]Department of Vascular Surgery, Yale University, New Haven, Connecticut, USA

[3]Department of Psychiatry, Yale School of Medicine, New Haven, Connecticut, USA

Correspondence
Carlos Mena-Hurtado, MD, 789 Howard Ave, New Haven, CT 06520-8017, USA.
Email: carlos.mena-hurtado@yale.edu

Funding information
Cardiva Medical, Inc.

Abstract

Background: The VASCADE closure device deploys an extravascular collagen plug. Its use in those with access site disease undergoing peripheral vascular intervention (PVI) is unknown. We aimed to evaluate the efficacy and safety of the VASCADE closure device compared to manual compression (MC) in patients with moderate femoral access site disease.

Methods: We performed a single-center, retrospective review of patients undergoing PVI with at least moderate access site disease. Our institutional database was linked to the Vascular Quality Initiative database, and 200 patients were selected from a 1:1 propensity-matched cohort. Data on procedural metrics and outcomes up to 30-days were abstracted.

Results: There were 103 procedures that used VASCADE and 97 used MC. Baseline variables were similar between groups. The mean age was 68.2 ± 11.2 years and 37.6% were women. Closing mean activated clotting time (ACT) was shorter in VASCADE (198 s VASCADE vs. 213 s MC; $p = 0.018$). There was a nonsignificant decrease in external compression device use with VASCADE (VASCADE 19.0% vs. MC 28.1%; $p = 0.15$). At 30-days, there was a nonsignificant reduction in hematoma with VASCADE (3.8% vs. 7.8% MC; $p = 0.25$) and no difference in retroperitoneal bleeding (0.5%). Pseudoaneurysm rate was similar (1.3% VASCADE vs. 1.7% MC; $p = 0.79$). The 30-day mortality rate was similar between the two groups and not related to the procedure (1.3% VASCADE vs. 0.9% MC; $p = 0.79$).

Conclusion: In patients undergoing PVI with at least moderate access site disease, safety and efficacy after using VASCADE was comparable with MC.

KEYWORDS
peripheral artery disease, peripheral Intervention, procedural outcomes, vascular, closure

1 | INTRODUCTION

The vast majority of peripheral vascular interventions (PVIs) are performed via percutaneous access of the common femoral artery (CFA).[1–4] Hemostasis is most commonly achieved by manual compression (MC) but is often time consuming, personnel intensive, and requires interruption of anticoagulation and prolonged bed rest. It is associated with patient discomfort, pain medication use, urinary retention, and a longer time to ambulation.[5] Vascular closure devices were designed to reduce the time to hemostasis, time to ambulation, and improve patient comfort.[6–8] However, device failure is associated with a significant increase in vascular complications.[9,10] As such, vascular closure devices are rarely used in patients with common femoral artery disease.

The VASCADE Vascular Closure System (Cardiva Medical, Inc.), an FDA-approved closure device for both arterial and venous access sites,[11] is designed to deliver a resorbable collagen patch limited to the extravascular arteriotomy site. Compared with MC, VASCADE demonstrated a high success rate, decreased time to hemostasis and ambulation, as well as non-inferiority in major access site-related complications.[12] Given the lack of an intravascular retained component, it may play a role in patients with CFA disease although this has not been studied in real-world practice. In this study, we aimed to (1) evaluate the efficacy and (2) safety of the VASCADE closure device compared to MC in a high-risk population with severe PAD using real-world observational registry data.

2 | METHODS

2.1 | Study design and patients

We conducted a single-center, retrospective, electronic medical record (EMR) review to identify all PVIs performed at Yale-New Haven Hospital (YNHH) from January 2014 to September 2020. We linked our institutional procedural database of internal data elements (patient demographics, medical history, and preprocedural testing results) with that of the Vascular Quality Initiative (VQI) during the same period through an indirect matching strategy (using age, sex, height, and day of the week of the procedure) to further enrich the cohort characterization. After matching, two interventional cardiologists reviewed the aorto-iliac and femoral access angiograms of all patients. Those with at least moderate fluoroscopic calcification or moderate (50%) angiographic stenosis which would preclude the use of intravascular or suture-mediated closure devices were included.

This study was conducted according to the US FDA standards of Good Clinical Practice (FDA Title 21 Code of Federal Regulations part 11, 50, 54, 56, and 812), the Declaration of Helsinki, and the ICH Guidelines. The protocol was approved by the Yale Institutional Review Board (IRB, protocol 2000028947). This study was sponsored by Cardiva Medical (Santa Clara, CA). The study sponsor had no input on the study design, results, or publication. The data that support the findings of this study are available from the Vascular Quality Initiative but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Vascular Quality Initiative.

2.2 | VASCADE® device use

The VASCADE device is compatible with 5, 6, or 7 French (Fr) introducer sheaths and consists of an expandable nitinol disk that assists in locating the vessel wall and provides temporary hemostasis. A retractable, lockable sleeve houses a bovine-derived collagen patch to be delivered to the extravascular arteriotomy site. After the procedure, using a standard sterile technique, the VASCADE device is inserted through the existing introducer sheath. Under fluoroscopy, the disk is deployed in the lumen of the artery, with caution to avoid deploying the disk within very tortuous or stented segments of the vessel.

The sheath is then removed over the device, and under fluoroscopy, the disc is brought against the vessel wall at the arteriotomy site to achieve temporary hemostasis. The protective sleeve is unlocked and retracted, exposing the collagen patch in the tissue tract at the arteriotomy site. The disk is collapsed, and the device is removed, leaving only the collagen patch behind in the tissue tract. There are no intravascular components. The patch expands upon exposure of the collagen to blood and surrounding tissue fluid, filling the tissue tract and promoting hemostasis (Figure S1). Manual compression for 5 min is then used to decrease or stop any tissue tract bleeding until full hemostasis is achieved.

2.3 | Manual compression use

After flushing of the introducer sheath, removal of a 5, 6, or 7 Fr introducer sheath at our institution is routinely performed using a brief period of obliterative manual compression at or just above the arteriotomy site for approximately 3–4 min per French size until full hemostasis is achieved. In case of recurrent nonpulsatile bleeding or hematoma formation, an external compression device is applied, typically for 4 h at 40 mmHg of pressure, and then removed.

2.4 | Statistical analysis

To create balanced cohorts for comparison, a propensity matching algorithm was applied using 19 baseline variables. We chose for propensity matching, which maximizes the balancing of covariates, with straightforward interpretation, at the expense of excluding unmatched individuals.[13–15] A precision of 0.01% for finding the nearest propensity score matching was applied. Comparisons were repeated in the propensity-matched cohort to examine whether balanced comparator groups were achieved. The criteria for

achieving adequate balance were realized through visual inspection of the distribution of the propensity scores in both comparison groups, the statistical significance level, and the calculation of standardized differences.

Categorical variables were presented as counts and percentages and continuous variables were shown as mean ± standard deviations or medians and interquartile ranges as appropriate. Categorical data were analyzed via Chi-square tests and continuous variables between the two groups (MC vs. VASCADE) were compared with student *t*-tests or nonparametric equivalents, as appropriate. Effect size values were calculated as Cohen's *d* for continuous variables and Cramer's V for categorical variables. Data were analyzed as complete case analyses using SPSS 26.0, using Python Essentials FUZZY command (IBM Co.). All tests were two-tailed and *p*-values <0.05 were considered significant.

3 | RESULTS

3.1 | Study group derivation

A total of 3240 procedures and associated basic patient demographic information were obtained through the Joint Data Analytics Team at YNHH. After applying the indirect matching algorithm, we were able to match 1,934 procedures (including duplicates). EMR charts of duplicate matches were manually reviewed for more specific procedural details to allow for more precise matching. There were 1493 unique matched procedures between the YNHH and VQI databases. Of these, 714 utilized manual compression and 404 used VASCADE. The propensity matching process yielded 381 separate procedures in each group. Group characteristics, statistical significance levels, and standardized mean differences for pre-matched and post-matched cohorts are shown in Tables SI and SII. Among these, there were 200 patients with at least moderate femoral access site disease as assessed by two independent investigators. This yielded two final cohorts, including 103 procedures in which VASCADE was used, and 97 procedures in which MC was used (Figure 1). Figure 2 shows the distribution of propensity scores before and after propensity score matching, demonstrating relatively balanced final cohorts.

3.2 | Patient demographics

Table 1 displays the patient demographics and medical history. The average age was 68.16 ± 11.20, with no significant difference between the two groups ($p = 0.674$). Patients receiving VASCADE had a higher rate of Hispanic or Latino ethnicity compared with MC (10.7% vs. 2.1%; $p = 0.01$). A total of 124 patients were male (62%) with no significant gender differences ($p = 0.404$). The average BMI was 27.4 [24.24–30.65], and similar between both groups ($p = 0.815$). There was no significant difference in the rates of hypertension, diabetes, end-stage renal disease, coronary artery disease, or prior coronary artery bypass graft surgery or percutaneous coronary intervention.

Those receiving VASCADE had a nonsignificant trend toward higher rates of prior PVI compared with the MC cohort (77.7% vs. 69.1%; $p = 0.169$). There was a nonsignificant trend toward higher rates of prior CFA endarterectomy in those with MC compared with VASCADE (17.9% vs. 7.2%; $p = 0.69$). Patients treated with MC had significantly higher rates of prior lower extremity bypass (11.3% vs. 3.9%; $p = 0.045$).

Table 2 displays the use of peri-procedural anticoagulation, antiplatelet, and statin therapy. The use of dabigatran, rivaroxaban, and warfarin was not significantly different between those receiving VASCADE or MC. Aspirin and P2Y12 inhibitors were used in majority of the patients, with no significant difference between the two groups.

3.3 | Procedural characteristics

Table 3 demonstrates the intra-procedural characteristics. 6Fr sheaths were most used with similar rates between the two groups. There was a nonsignificant trend toward more 7Fr sheath use in those receiving MC (37.1% vs. 24.3%). Critical limb ischemia was present in 19.5% of cases. More than 1 access site was used in 10.4% of patients with MC and 6.8% of patients with VASCADE, not reaching statistical significance ($p = 0.065$).

Most cases were retrograde femoral access (97.5%) with the remaining performed in an antegrade fashion (2.5%). Access was fluoroscopically guided in 97% of cases. Activated Clotting Time (ACT) before closure was higher in those receiving MC (205 vs. 196; $p = 0.009$). Systolic blood pressure was also higher in those receiving MC (140.55 ± 23.94 mmHg vs. 147.74 ± 24.64 mmHg; $p = 0.04$).

Access was within the common femoral artery in 179 patients, SFA in 16 patients, EIA in 3 patients, and Profunda in 2 patients. The mean access site stenosis in the left common femoral artery was 21.83 ± 12.1% for VASCADE and 31.66 ± 12.96% for MC, and in the right common femoral artery was 25.35 ± 12.57 for VASCADE and 26.29 ± 12.47% for MC. Moderate-severe fluoroscopic calcification was present in 47.5% of access sites. The mean minimum lumen diameter of the access sites was 4.3 mm. External iliac artery stents were present in 3.8% of cases with VASCADE and 3.1% of cases with MC. Ostial SFA stenting was present in 8.3% of cases with VASCADE, and 10.3% of cases with MC. Details on the angiographic core lab analysis of femoral access site anatomy are shown in Table S3.

3.4 | Postprocedural outcomes

Table 4 summarizes the 48 h and 30-day postprocedural outcomes. An external compression device was more commonly required in conjunction with MC, rather than VASCADE (18.4% VASCADE vs. 30.2% MC at 48 h; $p = 0.05$). Immediate device failure was noted in 2.9% of cases of VASCADE use. Any access site bleeding occurred

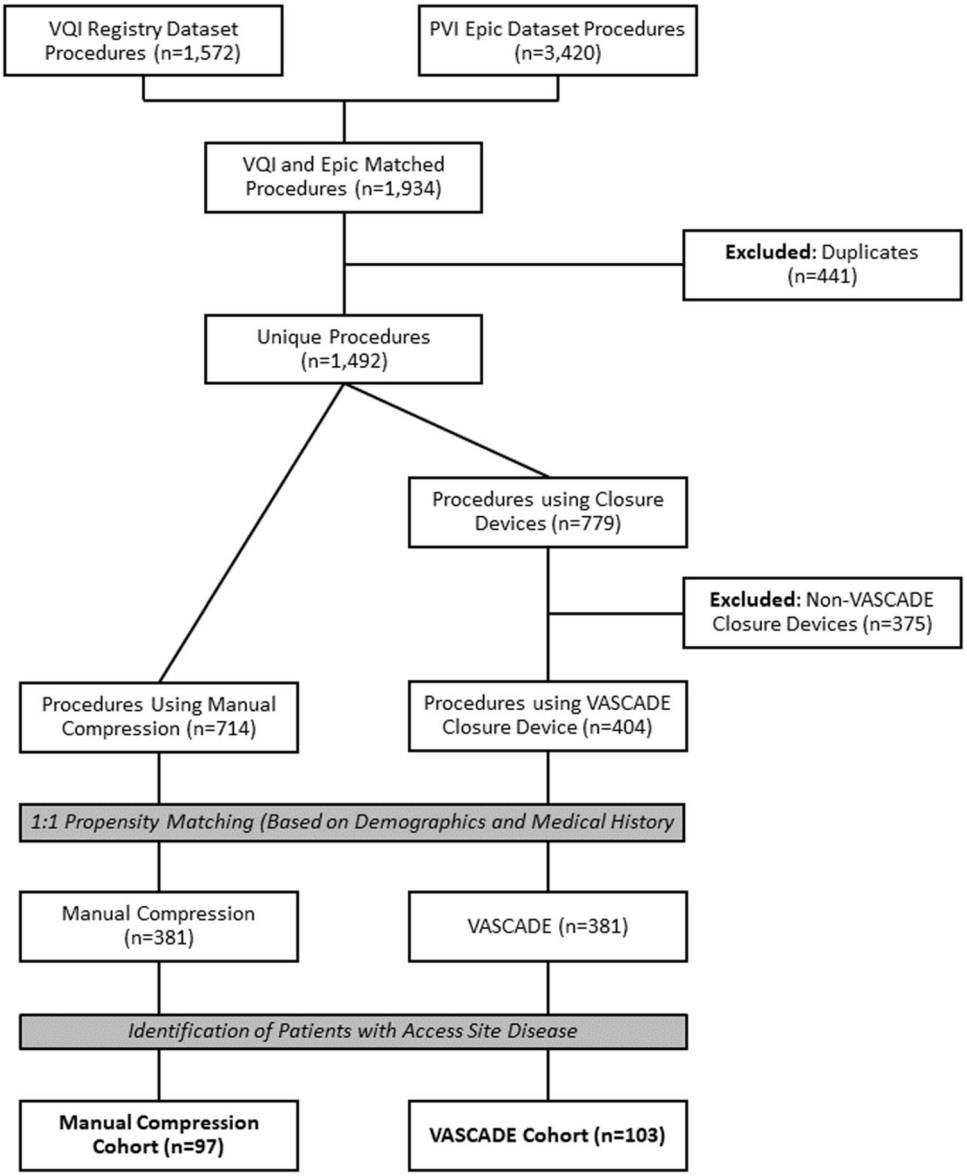

FIGURE 1 Flowchart of derivation of the final VASCADE and manual compression cohorts. PVI, peripheral vascular intervention; VQI, vascular quality initiative.

in 15.5% of cases with VASCADE, and 18.6% of cases treated with MC. Only 2 of 34 cases of access site bleeding occurred beyond 48 h. There was a nonsignificant trend toward a lower 30-day hematoma rate with VASCADE (3.9% VASCADE vs. 9.3% MC; $p = 0.12$). Within 30 days, one patient in each group (1%) required transfusion for access site bleeding, both for retroperitoneal bleeding.

There was one case of acute ipsilateral limb ischemia, in a patient who received MC, and one case of arterial dissection, in a patient who received VASCADE. New ipsilateral DVT was noted in 1% of patients in each group. There was a nonsignificant trend toward increased pseudoaneurysms with VASCADE (4.9% vs. 1.0%; $p = 0.11$). No patients had a post-procedural arteriovenous fistula. 30-day mortality was equal at 1.0% in both groups and unrelated to the index procedure.

4 | DISCUSSION

Our study demonstrates a comparable safety profile of the VASCADE closure device and MC with respect to both minor and major complications. Bleeding, thrombosis, infection, vessel injury, or death rates at 30 days were comparable across groups. VASCADE demonstrated an increased efficacy in achieving hemostasis, measured by a significantly lower rate of external compression device requirement compared with MC at 30 days.

The aim of our study was to examine the safety and efficacy of VASCADE compared with MC in higher-risk patients with access site disease undergoing PVI. Unique features of this study include (1) comparison of propensity matched cohorts, (2) inclusion of patients with PAD involving the access site, and (3) large single center "real world" experience.

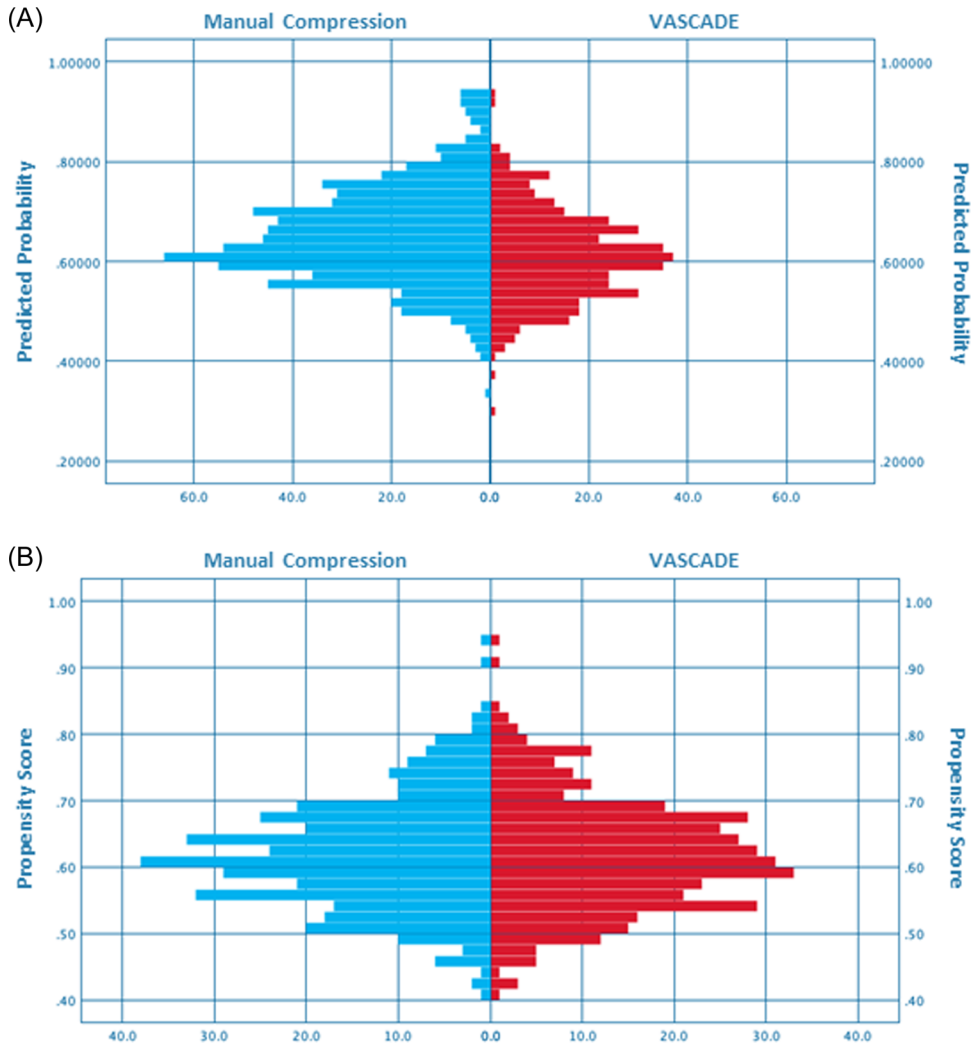

FIGURE 2 Distribution of propensity scores before and after score matching for patients with VASCADE closure versus manual. (A) Distribution of propensity scores before matching for manual compression ($n = 714$, blue) and VASCADE ($n = 404$, red). (B) Distribution of propensity scores after propensity score matching for manual compression ($n = 381$, blue) and VASCADE ($n = 381$, red). [Color figure can be viewed at wileyonlinelibrary.com]

Vascular closure devices are rarely used for femoral access hemostasis in patients with significant access site disease during PVI, and manual compression remains the standard of care. A critical benefit of the VASCADE closure device lies its ability to close the arteriotomy site without the use of retained intravascular components, theoretically allowing safer use in patients with access site disease. Other commonly used closure devices such as Angioseal or Perclose utilize a retained intravascular footplate or sutures, respectively, and are contraindicated in patients with notable common femoral arterial stenosis or calcification. The VASCADE closure device has been previously shown to reduce minor access site complications, time to hemostasis, ambulation, and discharge in a randomized controlled trial, which excluded patients at higher risk for complications related to the access site.[12] The device uses only an extravascular collagen plug to achieve hemostasis, leaving the vessel architecture and lumen unchanged. As such, it has been used extensively at our institution in patients with access site disease undergoing PVI.

The original pivotal RESPECT trial comparing VASCADE to MC in patients without access site disease reported minor vascular complication rates of 1.1% and no major vascular access site complications in a randomized-controlled analysis of 420 patients.[12] Recently, contemporary post-marketing surveillance data from an analysis of the FDA MAUDE database by Case et al., reported 201 major adverse events over 7 years including 11 deaths and 21 cases of a pulseless extremity.[16] Our data did not corroborate the presence of such major vascular complications nor cases of improper device deployment or malfunction. Given the purely extravascular nature of the device's hemostasis mechanism, the device may even be fully retracted from the body should the anatomy prevent safe retraction of the disc to the arteriotomy site. Thus, intra-arterial collagen deployment and vessel thrombosis or embolism is typically due to

TABLE 1 Patient demographics and medical history for the VASCADE and manual compression cohorts

	Total (*n* = 200)	VASCADE (*n* = 103)	Manual compression (*n* = 97)	Effect size*	*p*-value
Age (years)	68.16 ± 11.20	67.71 ± 11.95	68.64 ± 10.40	−0.084	0.674
Race					
White	151 (75.5)	73 (70.9)	78 (80.4)		
Black or African American	33 (16.5)	19 (18.4)	14 (14.4)		
Asian	2 (1.0)	1 (1.0)	1 (1.0)		
Other	14 (7.0)	10 (9.7)	4 (4.1)	0.129	0.345
Ethnicity					
Hispanic or Latino	13 (6.5)	11 (10.7)	2 (2.1)	0.175	0.013
Sex					
Female	76 (38.0)	42 (40.8)	34 (35.1)		
Male	124 (6.20)	61 (59.2)	63 (64.9)	0.059	0.404
Medical history					
BMI (k/m^2)	27.4 [24.24 – 30.65]	27.90 ± 6.59	27.71 ± 4.91	0.033	0.815
Hypertension	195 (97.5)	102 (99.0)	93 (95.9)	0.101	0.153
COPD	60 (30.0)	36 (35.0)	24 (24.7)	0.111	0.115
Diabetes	121 (60.5)	61 (59.2)	60 (61.9)	0.027	0.704
Creatinine	1.00 [0.80–1.25]	1.00 [0.73–1.22]	1.01 [0.84–1.31]	−0.252	0.510
Dialysis dependent	16 (8.0)	9 (8.7)	7 (7.2)	0.028	0.692
Active or former smoking	177 (88.5)	91 (88.3)	86 (88.7)	0.005	0.945
History of CAD	136 (68.0)	73 (70.9)	63 (64.9)	0.063	0.369
History of CABG	49 (24.5)	20 (19.4)	29 (29.9)	0.122	0.085
History of PCI	67 (33.5)	35 (34.0)	32 (33.0)	0.010	0.882
History of dysrhythmia	18 (9.0)	12 (17.4)	6 (10.7)	0.095	0.290
Congestive heart failure	52 (26.0)	27 (26.2)	25 (25.8)	0.005	0.943
	Total (*n* = 200)	**VASCADE (*n* = 103)**	**Manual compression (*n* = 97)**	**Effect size***	***p*-value**
Peripheral vascular disease history					
History of aneurysm repair	6 (3.0)	3 (2.9)	3 (3.1)	0.005	0.940
Prior CEA or CAS	39 (19.5)	15 (14.6)	24 (24.7)	0.128	0.069
Prior lower extremity peripheral vascular intervention	147 (73.5)	80 (77.7)	67 (69.1)	0.097	0.169
Prior common femoral endarterectomy	15 (7.5)	5 (7.2)	10 (17.9)	0.162	0.069
Prior inflow PVI	43 (21.5)	22 (21.4)	21 (21.6)	0.004	0.960
Prior lower extremity bypass	15 (7.5)	4 (3.9)	11 (11.3)	0.141	0.045
History of Amputation	42 (21.0)	25 (24.3)	17 (17.5)	0.083	0.242
Pre-procedure ABI	0.69 ± 0.28	0.69 ± 0.24	0.69 ± 0.33	0.003	0.853

Note: All values are listed as n (%) unless otherwise specified.

Abbreviations: ABI, Ankle Brachial Index; BMI, Body Mass Index; CABG, coronary artery bypass graft; CAD, coronary artery disease; CAS, carotid artery stent; CEA, carotid endarterectomy; COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention; PVI, peripheral vascular intervention.

*Effect size values were calculated as Cohen's *d* for continuous variables and Cramer's V for categorical variables.

TABLE 2 Peri-procedural medical therapy use for patients in the VASCADE and manual compression cohorts

	Total (*n* = 200)	VASCADE (*n* = 103)	Manual compression (*n* = 97)	Effect size*	*p*-value
Oral anticoagulation					
Dabigatran	4 (2.0)	3 (2.9)	1 (1.0)	0.067	0.342
Rivaroxaban	22 (11.0)	12 (11.7)	10 (10.3)	0.021	0.762
Warfarin	21 (10.5)	10 (9.7)	11 (11.3)	0.027	0.707
Other Anticoagulation	1 (0.5)	0 (0.0)	1 (1.0)	0.073	0.302
Oral antiplatelet therapy					
Aspirin	182 (91.0)	93 (90.3)	89 (91.8)	0.026	0.718
P2Y12 inhibitor	123 (61.5)	68 (66.7)	55 (56.7)	0.103	0.148
Anti-lipid therapy					
Statin	172 (86.0)	86 (83.5)	86 (88.7)	0.074	0.293

All values are listed as *n* (%) unless otherwise specified.

*Effect size values were calculated as Cohen's *d* for continuous variables and Cramer's V for categorical variables.

TABLE 3 Procedural characteristics for patients with VASCADE closure versus manual compression

Procedural characteristics	Total (*n* = 200)	VASCADE (*n* = 103)	Manual compression (*n* = 97)	Effect size*	*p*-value
Sheath size					
5Fr	7 (3.5)	5 (4.9)	2 (2.0)		
6Fr	132 (66.0)	73 (70.9)	59 (60.8)		
7Fr	61 (30.5)	25 (24.3)	36 (37.1)	−0.304	0.069
Procedural indication					
Asymptomatic	41 (20.0)	19 (18.8)	22 (22.9)	0.051	0.478
Claudication	125 (62.5)	64 (62.1)	61 (62.9)	0.008	0.913
Rest Pain	17 (8.5)	10 (9.9)	7 (7.4)	0.043	0.544
Tissue Loss	22 (11.0)	12 (11.9)	10 (10.6)	0.020	0.784
Acute ischemia	2 (1.0)	1 (1.0)	1 (1.0)	0.004	0.959
Access					
>1 access site	17 (8.5)	7 (6.8)	10 (10.4)	0.065	0.361
Femoral retrograde	195 (97.5)	101 (98.1)	94 (96.9)		
Femoral antegrade	5 (2.5)	2 (1.9)	3 (3.1)	0.037	0.602
Fluoroscopy guided	194 (97.0)	101 (100.0)	93 (98.9)	0.074	0.299
Fluoroscopy time	13.55 [9.20 – 19.60]	12.80 [8.43 – 17.90]	14.85 [10.13 – 22.35]	−0.368	0.155
Contrast volume used (ml)	120.00 [90.00 – 150.00]	120 [90.00–150.00]	120 [90.00 – 150.00]	−0.059	0.904
Arterial blood pressure at closure					
Systolic (mmHg)	144.00 ± 24.48	140.55 ± 23.94	147.74 ± 24.64	−0.296	0.040
Diastolic (mmHg)	71.38 ± 11.41	70.62 ± 12.53	72.21 ± 10.06	−0.140	0.329
ACT before closure (seconds)	200.00 [181.00 – 217.00]	196.00 [181.00 – 209.00]	205.00 [181.00 – 234.00]	−0.377	0.009

Note: All values are listed as *n* (%) unless otherwise specified.

Abbreviations: ACT, activated clotting time; Fr, French.

*Effect size values were calculated as Cohen's *d* for continuous variables and Cramer's V for categorical variables.

TABLE 4 Postprocedural 48-h and 30-day outcomes for patients with VASCADE closure versus manual compression

A: 48 h B: 30 days	Total (n = 200)		VASCADE (n = 103)		Manual compression (n = 97)		Effect size*		p-value	
	A	B	A	B	A	B	A	B	A	B
Use of external compression device	48 (24.0)	49 (24.5)	19 (18.4)	19 (18.4)	29 (30.2)	30 (30.9)	0.137	0.145	0.053	0.040
Any access site bleeding	32 (16.0)	34 (17.0)	16 (15.5)	16 (15.5)	16 (16.5)	18 (18.6)	0.013	0.040	0.853	0.570
Requiring transfusion	1 (0.5)	2 (1.0)	0 (0.0)	1 (1.0)	1 (1.0)	1 (1.0)	0.073	0.003	0.302	0.966
Requiring repeat manual pressure	23 (11.5)	24 (12.0)	11 (10.7)	11 (10.7)	12 (12.4)	13 (13.4)	0.026	0.042	0.708	0.554
Hematoma	11 (5.5)	13 (6.5)	4 (3.9)	4 (3.9)	7 (7.2)	9 (9.3)	0.073	0.109	0.301	0.122
Retroperitoneal bleeding	1 (0.5)	2 (1.0)	0 (0.0)	1 (1.0)	1 (1.0)	1 (1.0)	0.073	0.003	0.302	0.966
New ipsilateral acute limb ischemia	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.0)	N/A	0.073	N/A	0.302
New ipsilateral DVT	0 (0.0)	2 (1.0)	0 (0.0)	1 (1.0)	0 (0.0)	1 (1.0)	N/A	0.003	N/A	0.966
Local infection	0 (0.0)	4 (2.0)	0 (0.0)	3 (2.9)	0 (0.0)	1 (1.0)	N/A	0.067	N/A	0.342
Pseudoaneurysm	0 (0.0)	6 (3.0)	0 (0.0)	5 (4.9)	0 (0.0)	1 (1.0)	N/A	0.112	N/A	0.113
Arteriovenous Fistula	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	N/A	N/A	N/A	N/A
Arterial Dissection	1 (0.5)	1 (0.5)	1 (1.0)	1 (1.0)	0 (0.0)	0 (0.0)	0.069	0.069	.331	0.331
Neuropathy < 48 h	1 (0.5)	2 (1.0)	1 (1.0)	1 (1.0)	0 (0.0)	1 (1.0)	0.069	0.003	.331	0.966
Death	0 (0.0)	2 (1.0)	0 (0.0)	1 (1.0)	0 (0.0)	1 (1.0)	N/A	0.003	N/A	0.966

Note: All values are listed as n (%) unless otherwise specified.

Abbreviation: DVT, Deep vein thrombosis.

*Effect size values were calculated as Cohen's d for continuous variables and Cramer's V for categorical variables.

operator error, rather than device malfunction. Thoughtful and detailed education on device utilization under live fluoroscopy should mitigate any major complications in the hands of an experienced and skillful operator, even in a high-risk population, as our study demonstrates.

Despite reporting on a single center study, our experience has identified several key factors for successful use of the VASCADE closure device, which when utilized in the hands of a careful operator can maintain a safe and efficacious profile, even in patients at high risk for vascular complications. At our institution, VASCADE has been used for 7 years with over 4000 devices deployed. As such, its use has expanded to high-risk patients and clinical scenarios with increased operator experience. The device has been safely used in various access points including off-label use within brachial and popliteal arteries, and in both antegrade and retrograde fashions within the CFA. With experience, several key pearls have facilitated its safe and effective use in high-risk cases, namely, those with severe calcification, stenosis, or stenting near the access site. First, the device is always inserted, advanced, and deployed under live fluoroscopy. This is done after careful review of a femoral angiogram with close attention to vessel tortuosity, and areas of stenosis or disease in relation to the bony landmarks, as the need to insert and deploy a temporary intra-vascular disc can result in complications if improperly used. Second, review of the initial access needle puncture site on fluoroscopy will inform the operator of the appropriate location for the intravascular disc to abut the arteriotomy site and avoid premature deployment if the disc is caught against a plaque or calcium proximal to the arteriotomy. Third, if this does occur in a diseased vessel, the disc is advanced slightly, collapsed, retracted just beyond the lesion, and redeployed again before further retraction to the arteriotomy. Fourth, in cases of a stent in the distal external iliac, the sheath is retracted until there is enough room within an unstented portion of the common femoral to deploy the disc, such that it cannot physically interact with the stent struts. These maneuvers, of course, require live fluoroscopy. Finally, in high-risk patients, we do not use the device at a closing ACT higher than 225 s, given the higher bleeding risk in this cohort.

Limitations of this study include its retrospective, single-center nature, and the inherent inconsistencies of merging of two large databases. Despite optimal propensity matching for relevant patient and procedural characteristics, few differences remain between the two cohorts. Patients with MC had slightly higher closing systolic blood pressures and ACT, although both variables remain well within the recommended range for closure based on manufacturer instructions. Those undergoing MC also had higher rates of prior lower extremity bypass, which may suggest a slightly higher burden of disease, although imbalances were minimal given the effect size of <0.10, and bypass was not necessarily involving the access site or the ipsilateral lower extremity, thus its influence upon the results is not certain. Given the non-randomized nature of the study, residual unmeasured confounding or selection bias may persist. Further prospective or randomized controlled data are needed to corroborate the safety and efficacy of this and other closure devices in higher risk patients in whom manual compression is typically employed for hemostasis.

5 | CONCLUSION

In our large single center retrospective propensity matched cohort study comparing VASCADE closure device and manual compression in high-risk patients with access site PAD, there was no significant difference in minor or major complications at 30 days. VASCADE closure device demonstrated increased efficacy with reduced external compression device use for achieving adequate hemostasis. Further prospective or randomized data is needed to corroborate these findings in high-risk patients, where manual compression remains the standard of care.

ACKNOWLEDGMENTS

The work was supported by an unrestricted research grant from Cardiva Medical, Inc. This funding source had no influence over the design of this study, its execution, analyses, and interpretation, or the decision to submit the results.

CONFLICTS OF INTEREST

Dr. Smolderen reports unrestricted research grants from Cardiva Medical Inc., Cook Medical, Inc., Merck & Co., Inc., Shockwave Medical Inc., and Janssen Pharmaceutical Companies of Johnson & Johnson. She is a consultant for Optum Labs, Inc., and Abbott Laboratories. **Dr. Mena-Hurtado** reports grant funding from Shockwave Medical, Inc. and is a consultant for Abbott Laboratories, Cook Medical, Inc., Optum Labs, Inc. All other authors report no disclosures. The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Vascular Quality Initiative but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Vascular Quality Initiative.

ORCID

Lindsey E. Scierka http://orcid.org/0000-0002-1338-0589
Yasin Hussain http://orcid.org/0000-0003-1451-5147

REFERENCES

1. Goodney PP, Beck AW, Nagle J, Welch HG, Zwolak RM. National trends in lower extremity bypass surgery, endovascular interventions, and major amputations. *J Vasc Surg*. 2009;50(1):54-60.
2. Bangalore S, Bhatt DL. Femoral arterial access and closure. *Circulation*. 2011;124(5):e147-e56.
3. Eickmeyer F, Moysidis T, Nowak T, et al. Trends in lower extremity surgical and endovascular revascularization in Germany. *Vasa*. 2011;40(5):398-403.
4. Wright MA, Steffens D, Huilgol RL. Vascular surgery trends in Australia: 2001–2015: less open surgery, less limb loss and more endovascular intervention. *ANZ J Surg*. 2019;89(4):309-313.
5. Schwartz BG, Burstein S, Economides C, Kloner RA, Shavelle DM, Mayeda GS. Review of vascular closure devices. *J Invasive Cardiol*. 2010;22(12):599-607.
6. Arora N, Matheny ME, Sepke C, Resnic FS. A propensity analysis of the risk of vascular complications after cardiac catheterization procedures with the use of vascular closure devices. *Am Heart J*. 2007;153(4):606-611.
7. Cox T, Blair L, Huntington C, Lincourt A, Sing R, Heniford BT. Systematic review of randomized controlled trials comparing manual compression to vascular closure devices for diagnostic and therapeutic arterial procedures. *Surg Technol Int*. 2015;27:32-44.
8. Noori VJ, Eldrup-Jørgensen J. A systematic review of vascular closure devices for femoral artery puncture sites. *J Vasc Surg*. 2018;68(3):887-99.
9. Bangalore S, Arora N, Resnic FS. Vascular closure device failure: frequency and implications: a propensity-matched analysis. *Circulation: Cardiovasc Interv*. 2009;2(6):549-556.
10. Kennedy SA, Rajan DK, Bassett P, Tan KT, Jaberi A, Mafeld S. Complication rates associated with antegrade use of vascular closure devices: a systematic review and pooled analysis. *J Vasc Surg*. 2021;73(2):722-30.e1.
11. Kiesz RS, Wiernek BK, Wiernek SL, et al. Cardiva catalyst II vascular access management device in percutaneous diagnostic and interventional procedures with same-day discharge (Catalyst II trial). *J Endovasc Ther*. 2011;18(1):46-53.
12. Hermiller JB, Leimbach W, Gammon R, et al. A prospective, randomized, pivotal trial of a novel extravascular collagen-based closure device compared to manual compression in diagnostic and interventional patients. *J Invasive Cardiol*. 2015;27(3):129-136.
13. Austin PC. Some methods of propensity-score matching had superior performance to others: results of an empirical investigation and Monte Carlo simulations. *Biometrical J: J Math Methods Biosci*. 2009;51(1):171-184.
14. Austin PC. Optimal caliper widths for propensity-score matching when estimating differences in means and differences in proportions in observational studies. *Pharm Stat*. 2011;10(2):150-161.
15. Elze MC, Gregson J, Baber U, et al. Comparison of propensity score methods and covariate adjustment: evaluation in 4 cardiovascular studies. *J Am Coll Cardiol*. 2017;69(3):345-57.
16. Case BC, Kumar S, Medranda GA, et al. Contemporary post-marketing adverse events and modes of failure related to VASCADE vascular closure system: the utility of the MAUDE database. *Catheter Cardiovasc Interv*. 2021.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Nagpal S, Scierka LE, Castro-Dominguez Y, et al. Real-world VASCADE closure device versus manual compression use and outcomes in patients with severe common femoral artery disease. *Catheter Cardiovasc Interv* 2022;1-9. doi:10.1002/ccd.30405