Published in final edited form as:

Am Heart J. 2010 January ; 159(1): 125. doi:10.1016/j.ahj.2009.10.023.

Quantitative Impact of Cardiovascular Risk Factors and Vascular Closure Devices on the Femoral Artery after Repeat Cardiac Catheterization

Klaus A. Tiroch, MD, PhD^{a,b}, Michael E. Matheny, MD, MSc, MPH^{c,d}, and Frederic S. Resnic, MD, MSc^a

^a Brigham and Women's Hospital, Boston, MA

^b Deutsches Herzzentrum, Munich, Germany

^c Vanderbilt University, Nashville, TN

^d Department of Veterans Affairs, Nashville, TN

Abstract

Background—We evaluated the exact quantitative long-term impact of repeated catheterizations, vascular closure devices (VCDs) and cardiovascular risk factors on the femoral artery after cardiac catheterization.

Methods—A total of 2,102 available femoral angiograms from 827 consecutive patients were analyzed using caliper-based quantitative vascular analysis (QVA). These patients underwent coronary interventions between 01/2005-04/2007, and had at least one additional catheterization procedure through the ipsilateral femoral access site from 12/2001 until 01/2008. Multivariate analysis was performed to control for confounding variables. The primary outcome was change in artery size.

Results—The average punctured artery diameter was 6.5mm±2.1mm. The average time between first case and last follow-up was 349 days. There was no significant change of the punctured artery size over time after the index procedure (P=0.15) and no change associated with the use of VCDs (P=0.25) after multivariate analysis. Smaller arteries were associated with female gender (−1.22mm, P<0.0001), presence of angiographic peripheral vascular disease (PVD, −1.19mm, P<0.0001), and current (−0.48mm, P=0.001) or former (−0.23mm, P=0.01) smoking status, while previous statin therapy was associated with an increase in artery size (+0.47mm, P<0.0001). VCDs were used less often compared to manual compression in cases preceding the first detection of angiographic PVD (P<0.001).

Address for correspondence and for reprints: Klaus Tiroch, MD, PhD; Frederic S. Resnic, MD MSc, Brigham and Women's Hospital; Department of Cardiovascular Medicine, 75 Francis Street; Boston, MA 02115, klaustiroch@hotmail.com, Tel.: +1-617-732-7133, Fax: +1-617-732-7122.

Disclosures

Dr. Resnic has received honoraria (all <\$10,000) from St. Jude Medical, Abbott Vascular, PLC Inc., and served as consultant/on the advisory board (all <\$10,000) for St. Jude Medical, PLC Inc., Cordis Corp., Abbott Vascular. Dr. Tiroch has received honoraria (\$1,500) from Cardiva Medical Inc.. All other authors have nothing to disclose. This study was supported by a research grant from the "National Institutes of Health" (R01-LM008142 to F.R.).

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conclusion—VCDs are not associated with a change in the artery size or progression of PVD. Overall, there is no change in vessel size over time after repeat catheterizations, with a decrease in vessel size associated with current and former smoking, and an increase with previous statin therapy.

Keywords

vascular closure device; statin therapy; smoking; femoral artery

INTRODUCTION

Despite the steep increase in the number of cardiac catheterization procedures and coronary interventions, only limited data is available regarding the long-term quantitative impact of multiple catheterization procedures, of patient-specific cardiovascular risk factors, and the use of vascular closure devices on the femoral artery. Repeated catheterizations through the same access site are associated with specific complications and negative long-term outcome depending on closure approach, angiographic predictors assessed by the femoral angiogram, and patients' baseline characteristics, especially cardiovascular risk factors.[1–6] Statin therapy provides additional benefit regarding vascular anatomy on top of its cholesterol and lipid-lowering properties, as assessed by carotid intimal-medial thickness measurements.[7]

Vascular closure device (VCD) utilization has grown significantly over the last decade, and there have been conflicting reports regarding their association with specific complications and outcome.[3–5,8–11] In this study, we evaluated 2,102 femoral angiograms performed between December 2001 and January 2008 at our institution for 827 consecutive patients with multiple catheterization procedures using quantitative vascular analysis. To our knowledge, this is the first study to assess systematically the exact quantitative changes of the femoral artery in a large population with long-term follow-up depending on VCD use, cardiovascular risk factors like smoking status, diabetes mellitus, hyperlipidemia with or without statin therapy, presence of peripheral vascular disease (PVD), puncture location and access site anatomy using a multivariate analysis to control for possible confounding variables.

METHODS

All 827 consecutive patients undergoing coronary interventions between 01/2005-04/2007, and at least one more catheterization procedure through the ipsilateral femoral access site with available femoral angiograms from 12/2001 until 01/2008, were enrolled in this cohort evaluation. A total of 2,102 femoral angiograms were analyzed using quantitative vascular analysis (QVA). Clinical, demographic, procedural, and in-hospital outcomes were collected via a prospective cardiac catheterization database.[12] Missing information was included from patient's charts.

As per our institutional policy, all patients undergoing cardiac catheterization had a standardized femoral angiogram in an ipsilateral oblique view without significant cranial or caudal angulations. In order to include all-comers into this study and to avoid selection bias, the femoral angiogram available for the vast majority of patients undergoing cardiac catheterization at our institution was the best feasible method for assessing relevant impact of puncture and closure on the femoral artery. Trained angiographic reviewers blinded to clinical patient-related data reviewed all angiograms at the Brigham and Women's Hospital. Using the contrast filled femoral sheath as the calibration source, hand-caliper based quantitative angiographic analyses were performed. The femoral angiographic findings studied included the artery punctured, size of this artery, site of arterial puncture relative to the bifurcation, size of the common femoral artery at the site of the pelvic brim, and presence of peripheral vascular disease in major arteries, defined as visual stenosis $\geq 50\%$. The femoral head was divided in

thirds from top to bottom. A puncture site at or above the upper third of the femoral head was defined as “high stick location”, while a puncture site at or below the lower third was defined as “low stick location” (Figure 1).

PCI procedures were performed according to the standard American College of Cardiology/American Heart Association guidelines. All patients undergoing stent placement received aspirin and clopidogrel. Intraprocedural anticoagulation and anti-platelet therapy including heparin, Glycoprotein IIb/IIIa inhibitors (eptifibatide or abciximab), and bivalirudin were used at the discretion of the performing operator. VCDs were used routinely on all cases unless contraindicated. Contraindications to VCD deployment included $\geq 50\%$ narrowing due to calcification or plaque in the punctured artery, arterial stick positioned right at or below the femoral arterial bifurcation site, and diameter of punctured artery $< 4\text{mm}$. The VCDs used were Angioseal (St. Jude Medical, St. Paul, Minnesota), Starclose (Abbott Vascular, Redwood Shores, California), or Perclose Proglide (Abbott Vascular, Redwood Shores, California). Standard manual compression was used for patients not considered eligible for VCDs. Sheath removal was performed at an Activated Clotting Time $< 160\text{msec}$ when manual compression was used, and immediately after the procedure for VCDs.

Statistical analyses were performed within SAS 9.1.2 (Cary, NC) using multivariate linear regression with adjustment for repeated measurements for each patient. The change in artery size (mm) was considered as the dependent variable, and independent variables included in the analysis included: previous VCD use, number of days between procedures, number of catheterizations per patient, puncture of the left femoral artery, angiographic PVD, female gender, black race, other/unknown race, body mass index, hyperlipidemia, previous statin therapy, diabetes mellitus, current smoking and former smoking. Chi-square test or Fisher's Exact test were used as appropriate to compare categorical data, and 2-tailed unpaired Student's t test for continuous variables. A 2-sided p-value < 0.05 was considered statistically significant.

All patients gave informed consent for the diagnostic and interventional coronary catheterizations. This study was performed under institutional review board review and approval at Brigham and Women's Hospital. This study was supported by a research grant from the “National Institutes of Health” (R01-LM008142 to F.R.). The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents.

RESULTS

Baseline, procedural and outcome data from 2,102 coronary catheterization cases with available femoral angiograms from 827 patients were analyzed. All 827 patients were consecutive patients with a high cardiovascular risk profile who underwent coronary interventions between 01/2005-04/2007, and represented therefore a higher-risk population for vascular complications and the development of PVD. The average time between catheterization procedures was 129 days and between the first and last available case 349 days, with a maximum follow-up length of 1841 days. The average punctured artery diameter was $6.5\text{mm} \pm 2.1\text{mm}$. Hyperlipidemia was present in 79% with previous statin therapy in 5% of patients. Hemostasis was achieved using manual compression (21%), AngioSeal (57%), Starclose (3%), and Perclose (19%). The standard error of the mean ranged between 0.1055mm and 0.148mm for the respective operator without significant differences ($P > 0.12$). 214 cases ($> 10\%$) were reevaluated by a different operator blinded for the previous evaluation, showing no significant differences regarding the assessment of the vessel size ($P > 0.18$). Biplane views were available for 108 cases. There were no significant differences when comparing the two measurements of the femoral artery from the biplane views ($P > 0.24$).

No significant change of the femoral artery was observed comparing the baseline procedure and the last follow-up for the entire population in the univariate analysis, while a decrease of the femoral artery size was observed for current and former smokers, and an increase of the artery was observed for patients with hyperlipidemia and patients with previous statin therapy (Table 1). No change of the femoral artery diameter was present for subgroups with other baseline characteristics, including hypertension, diabetes mellitus, prior myocardial infarction, prior percutaneous coronary intervention, chronic renal insufficiency, acute ST elevation myocardial infarction at presentation, or the total number of catheterization per patient.

Regarding the procedural characteristics, no significant differences of the femoral artery size from baseline to the last follow-up were observed for the specific subgroups (Table 2). The use of VCD as well as the specific VCDs Angioseal, Starclose or Perclose were not associated with a significant change of the femoral artery diameter. Overall, the analysis regarding the change of the femoral artery size from baseline to the last follow-up available revealed 486 patients who had no change or an increase of the femoral artery size, while 341 patients had a decrease of the femoral artery size. There were no significant differences in the baseline and procedural characteristics between these two groups with the exception of a higher rate of acute ST-elevation myocardial infarctions and a lower platelet count in the group with increasing artery size.

We also evaluated selection differences regarding the use of VCDs compared to manual compression. Patients receiving VCDs were younger (66 ± 12 vs. 68 ± 13 years, $P<0.001$), heavier (86 ± 18 vs. 82 ± 19 kg, $P<0.001$), more likely of male gender (71% vs. 59%, $P<0.001$), had more prior PCIs (54% vs. 48%, $P=0.02$), less documented PVD (13% vs. 27%, $P<0.001$), and lower platelet counts (227 ± 68 vs. 236 ± 72 , $P=0.02$) as compared to patients with manual compression, while no difference was observed for other baseline characteristics. Procedural characteristics observed more frequent with VCD use were percutaneous coronary interventions (76% vs. 54%, $P<0.001$), acute ST-elevation myocardial infarctions (10% vs. 6%, $P=0.01$), Glycoprotein IIb/IIIa use (30% vs. 18%, $P<0.001$), longer fluoroscopy time (22 ± 17 vs. 20 ± 18 min, $P=0.03$) and higher contrast amounts (186 ± 98 vs. 163 ± 98 ml, $P<0.001$), while intra-aortic balloon pumps were usually pulled later in the intensive care unit with subsequent manual compression (1.6% vs. 3.4%, $P=0.03$). No differences were observed regarding retroperitoneal bleeding (0.36% vs. 0.23%, $P=0.899$), or the need for transfusions (1.1% vs. 1.4%, $P=0.757$) when comparing cases with VCD use and manual compression.

The analysis of femoral angiograms showed that VCDs were used more often for the right femoral artery (97% vs. 91%, $P<0.001$) and for larger arteries (6.6 ± 2.1 vs. 5.7 ± 2.1 , $P<0.001$), and less often with low stick (34% vs. 46%, $P<0.001$) and puncture below the bifurcation (7% vs. 29%, $P<0.001$) or in the presence of PVD (12% vs. 30%, $P<0.001$). The respective measurements in mm of the femoral artery size at the index procedures and at the follow-up catheterizations were 6.51 ± 2.08 and 6.46 ± 2.11 ($P=0.688$) for the 566 patients with two catheterizations, 6.31 ± 2.05 and 6.57 ± 2.30 ($P=0.275$) for the 169 patients with three catheterizations, and 6.36 ± 2.35 and 6.68 ± 2.41 ($P=0.353$) for the 96 patients with more than three and up to eleven catheterizations, respectively. When analyzed separately by respective artery, repetitive catheterizations or VCD usage still had no effect on the artery size over time ($P\geq 0.14$). Out of 194 patients with PVD, PVD was detected for the first time in 81 patients. VCDs were used less often compared to manual compression in the cases preceding the first detection of PVD ($P<0.001$).

In the final multivariate analysis model, there was no significant change of the punctured artery size over time after the index catheterization procedure ($P=0.15$) and no change associated with the use of VCDs ($P=0.25$) (Table 5). Smaller arteries were associated with the presence of angiographic peripheral vascular disease ($P<0.0001$), female gender ($P<0.0001$), and current

($P=0.001$) or former ($P=0.01$) smoking status, while previous statin therapy was associated with an increase in artery size ($P<0.0001$). In the quantitative analysis, the size difference of the artery was -1.19 mm in patients with PVD, -1.22 mm in women, -0.48 mm in current smokers, -0.23 mm in former smokers, 0.47 mm in patients with statin therapy, and 0.02 mm per unit increase in BMI (kg/m^2).

DISCUSSION

In summary, this analysis found no change in vessel size over time after repeat catheterizations and no association of VCD use with a change in the artery size or progression of PVD. A decrease in vessel size was associated with current and former smoking, and an increase with previous statin therapy.

The number of diagnostic and interventional coronary catheterization has grown significantly over the past decade, but little is known about the exact quantitative impact on the femoral artery after multiple catheterizations through the same access site, of patient specific cardiovascular risk factors and therapies, and the use of different closure approaches.[14,17]

Despite the importance of proper manual compression technique to procedural outcomes and patient comfort, there has been sparse literature to establish a widely accepted standard for practice. A wide variety of healthcare workers perform manual compression, leading to significant variation in techniques, skill levels, and protocols for manual compression methods and hold times. Time to ambulation also varies widely across institutions. Manual compression can cause inflammation and scarring of the arteriotomy and surrounding soft tissue, which may lead to vessel stenosis and limit ability for re-access.[18] In a porcine model of arterial closure, mononuclear infiltrate and fibrous deposition were seen 30 days after percutaneous arterial sheath insertion in the arterial wall and subcutaneous tissues.[18] This was due to fat necrosis related to pressure injury from both manual compression and device implantation. A study in 105 patients who underwent surgery after catheterization with surgical exposure of the femoral artery evaluated the external appearance of the healed femoral arteriotomy. A semi-quantitative method was used to assess the severity of periadventitial morphologic changes. Significant scarring and inflammation was observed to a similar degree after VCDs and manual compression.[19] After multiple catheterizations, patients can develop substantial fibrotic tissue similar to a corset around the vessel with difficult subsequent puncture, but the exact long-term effect on the femoral artery due to changes of the surrounding tissue is not well understood. In addition, cardiovascular risk factors can promote the development of arteriosclerosis in the femoral artery wall, while statin therapy and smoking cessation can be protective.[1,3]

Our study found no overall significant changes of the femoral artery after multiple catheterizations as assessed by exact quantitative measurements. To our knowledge, this study evaluated for the first time systematically the impact of baseline and procedural characteristics, the number of total catheterizations per patient, the puncture location and punctured artery, and the use of specific VCDs, on the size of the femoral artery over time. Former and current smoking was associated with a significant decrease in vessel size, and this observation was more pronounced in current smokers, reflecting the positive effect of smoking cessation. While hyperlipidemia is a risk factor for peripheral artery disease, statin therapy was found to have a protective effect regarding the progression of arteriosclerosis as assessed by carotid intimal-medial thickness measurements in the ENHANCE trial.[7] Similarly, our study found a highly significant protective effect on the peripheral vasculature, specifying for the first time the exact increase in vessel size with previous statin therapy in a large population based on quantitative vascular analysis. Overall, this study found that cardiovascular risk factors and the prevention

of these risk factors have a significant impact on progression or regression of the underlying atherosclerosis within the vessel.

The other clinical and procedural variables were distributed similarly when comparing VCD cases and manual compression cases, or cases with increase or reduction of the femoral artery size over time. The significant increase of the femoral artery observed at the follow-up in patients with acute ST-elevation myocardial infarctions at the baseline procedure might be related to the high adrenergic state with generalized vascular contraction during the index procedure compared to mostly elective follow-up catheterizations.

Vascular closure devices have become popular for achieving hemostasis of the femoral arteriotomy site after catheterization procedures due to advantages in patient comfort and early ambulation.[1,2] We observed a significantly shorter length of in-hospital stay with the use of VCDs in this study. However, there have been conflicting reports regarding safety and efficacy of the various types of available VCDs.[3–5,9,10] Two recently published meta-analyses including 37 trials with 4,000 patients and 30 trials with 37,066 patients showed no difference regarding efficacy and safety of closure devices compared to manual compression.[15,16] A recent large review from our institution reported a lower risk-adjusted access-site complication rate for VCDs compared to manual compression after assessing 12,937 consecutive patients undergoing diagnostic and interventional catheterization.[10]

Procedures with usage of VCD were more complex in this study, as reflected by the higher number of interventional procedures and ST-elevation myocardial infarctions, by the increased use of contrast amounts and Glycoprotein IIb/IIIa inhibitors, and by longer fluoroscopy times. Manual compression was used more frequent with arterial puncture below the femoral bifurcation and smaller arteries. When analyzed separately by respective artery, repetitive catheterizations or VCD usage still had no effect on the artery size over time.

The present retrospective cohort study has limitations as it represents a non-randomized review of prospectively acquired data regarding the change of the femoral artery size in a single large academic centre with extensive experience with VCDs. The majority of patients had only two catheterizations, while 261 patients had three or more catheterizations, but no differences regarding change in femoral artery size were observed in the respective subgroups. In patients with PVD or low puncture, hemostasis was achieved significantly more often by manual compression than using VCDs, but this study shows the safety and efficacy of manual compression for this subset of patients without negative long-term impact on the femoral artery size. On the other hand, VCD are effective for achieving expedite hemostasis and are safe with long-term preservation of the architecture and size of the femoral artery when used according to the manufacturer instruction.

The differences in the femoral artery size observed in our study associated with smoking or with statin therapy were less than 10% of the femoral artery size, and might therefore be regarded as modest, but these changes were observed after an average follow-up time of 349 days. Given the highly significant p-values, the expected changes of the femoral artery over decades emphasize the importance of smoking cessation and statin therapy.

Conclusion

VCDs are not associated with a change in the artery size or progression of PVD. Overall, there is no change in vessel size over time after repeat catheterizations, with a decrease in vessel size associated with current and former smoking, and an increase with previous statin therapy.

Acknowledgments

This study was supported by a research grant from the “National Institutes of Health” (R01-LM008142 to F.R.).

References

1. Popma JJ, Satler LF, Pichard AD, et al. Vascular complications after balloon and new device angioplasty. *Circulation* 1993;88:1569–1578. [PubMed: 8403304]
2. Sabo J, Chlan LL, Savik K. Relationships among patient characteristics, comorbidities, and vascular complications post-percutaneous coronary intervention. *Heart Lung* 2008 May-Jun;37(3):190–5. [PubMed: 18482630]
3. Schnyder G, Sawhney N, Whisenant B, et al. Common femoral artery anatomy is influenced by demographics and comorbidity: implications for cardiac and peripheral invasive studies. *Catheter Cardiovasc Interv* 2001;53:289–295. [PubMed: 11458402]
4. Dangas G, Mehran R, Kokolis S, et al. Vascular complications after percutaneous coronary interventions following hemostasis with manual compression versus arteriotomy closure devices. *J Am Coll Cardiol* 2001;38:638–644. [PubMed: 11527609]
5. Tiroch KA, Arora N, Matheny ME, et al. Risk predictors of retroperitoneal hemorrhage following percutaneous coronary intervention. *Am J Cardiol* 2008 Dec 1;102(11):1473–6. [PubMed: 19026298]
6. Sherev DA, Shaw RE, Brent BN. Angiographic predictors of femoral access site complications: implication for planned percutaneous coronary intervention. *Catheter Cardiovasc Interv* 2005;65:196–202. [PubMed: 15895402]
7. Greenland, Philip; Lloyd-Jones, Donald. Critical Lessons From the ENHANCE Trial. *JAMA* 2008;299(8):953–955. [PubMed: 18314439]
8. Rickli H, Unterweger M, Sutsch G, et al. Comparison of costs and safety of a suture-mediated closure device with conventional manual compression after coronary artery interventions. *Catheter Cardiovasc Interv* 2002;57:297–302. [PubMed: 12410501]
9. Duffin DC, Muhlestein JB, Allisson SB, et al. Femoral arterial puncture management after percutaneous coronary procedures: a comparison of clinical outcomes and patient satisfaction between manual compression and two different vascular closure devices. *J Invasive Cardiol* 2001;13:354–362. [PubMed: 11385148]
10. Resnic FS, Arora N, Matheny M, et al. A cost-minimization analysis of the angio-seal vascular closure device following percutaneous coronary intervention. *Am J Cardiol* 2007;99:766–770. [PubMed: 17350361]
11. Arora N, Matheny M, Sepke C, et al. A propensity analysis of the risk of vascular complications after cardiac catheterization procedures with the use of vascular closure devices. *Am Heart J* 2007;153:606–611. [PubMed: 17383300]
12. Brindis RG, Fitzgerald S, Anderson HV, et al. The American College of Cardiology-National Cardiovascular Data Registry (ACC-NCDR): building a national clinical data repository. *J Am Coll Cardiol* 2001;37:2240–2245. [PubMed: 11419906]
13. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology* 1982;143:29–36. [PubMed: 7063747]
14. Tu TM, Tremmel JA. Management of Femoral Arterial Access: To Close or Hold Pressure? Manual compression may not be benign, but is it the lesser of two evils? *Endovasc Today* 2007;11:38–42.
15. Koreny M, Riedmuller E, Nikfardjam M, et al. Arterial puncture closing devices compared with standard manual compression after cardiac catheterization: systematic review and meta-analysis. *JAMA* 2004;291:350–357. [PubMed: 14734598]
16. Nikolsky E, Mehran R, Halkin A, et al. Vascular complications associated with arteriotomy closure devices in patients undergoing percutaneous coronary procedures: a meta-analysis. *J Am Coll Cardiol* 2004;44:1200–1209. [PubMed: 15364320]
17. Turi ZG. An evidence-based approach to femoral arterial access and closure. *Rev Cardiovasc Med* 2008;9(1):7–18. [PubMed: 18418305]

18. Silver FH, Quintero L. Comparison of the histological responses observed at the arterial puncture site after employing manual compression and a new collagen technology to achieve hemostasis. *Cath Lab Digest* 2004;11:52–58.
19. Allie DE, Hebert CJ, Walker CM. Manual compression may not be benign. *Endovasc Today* 2003;4:42–46.
20. Martin JL, Pratsos A, Magargee E, et al. A randomized trial comparing compression, Perclose Proglide and Angio-Seal VIP for arterial closure following percutaneous coronary intervention: the CAP trial. *Catheter Cardiovasc Interv* 2008;71(1):6–7. [PubMed: 18098174]

Figure 1.

Quantitative vascular analysis. Sites of measurement of the contrast filled femoral sheath, the artery punctured, size of this artery, site of arterial puncture relative to the bifurcation, and size of the common femoral artery at the site of the pelvic brim. The femoral head was divided in thirds from top to bottom, and a puncture site at or above the upper third of the femoral head was defined as “high stick location”, while a puncture site at or below the lower third was defined as “low stick location”.

Table 1

Diameter of the punctured artery at baseline (N=827) and follow-up for the entire population and patients with specific baseline characteristics

Variable	Patients N=	Baseline procedure	Last follow-up	<i>p-value</i>
Entire population	827	6.5 ± 2.2	6.5 ± 2.1	0.845
Female gender	258	5.6 ± 1.9	5.6 ± 2.0	0.999
Hypertension	683	6.5 ± 2.2	6.4 ± 2.1	0.390
Current smoker	124	6.4 ± 2.0	5.8 ± 1.9	<0.01
Former smoker	413	6.5 ± 2.2	6.2 ± 1.8	0.01
Hyperlipidemia	656	6.2 ± 2.2	6.4 ± 2.1	0.03
Previous statin therapy	441	6.3 ± 2.1	6.8 ± 2.1	<0.001
Diabetes mellitus	306	6.5 ± 2.2	6.4 ± 2.0	0.535
Insulin dependent DM	136	6.1 ± 2.2	6.0 ± 2.0	0.695
Prior MI	236	6.7 ± 2.4	6.4 ± 2.2	0.158
Prior PCI	215	6.7 ± 2.4	6.5 ± 2.1	0.358
Creatinine ≥1.5mg/dl	111	6.4 ± 2.4	6.1 ± 2.1	0.323
Acute STEMI	131	6.0 ± 2.2	6.4 ± 2.2	0.099
Patients with <3 catheterizations	566	6.5 ± 2.1	6.5 ± 2.1	0.994
Patients with ≥3 catheterizations	261	6.5 ± 2.1	6.3 ± 2.2	0.289

Artery size is expressed in mm as mean±SD. DM, diabetes mellitus; MI, myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST elevation MI.

Table 2

Diameter of the punctured artery at baseline (N=827) and follow-up for the entire population and patients with specific procedural characteristics

Variable	Patients N=	Baseline procedure	Last follow- up	<i>p-value</i>
Entire population	827	6.5 ± 2.2	6.5 ± 2.1	0.845
PCI case	643	6.5± 2.1	6.4± 2.1	0.393
Arterial Sheath≥7Fr	306	6.5± 2.2	6.5± 2.2	0.999
Left femoral artery	41	6.4± 2.6	6.4± 2.5	0.999
Right heart cath.	94	6.4± 2.3	6.2± 1.9	0.517
GP IIb/IIIa Inhibitors	311	6.6± 2.2	6.4± 2.0	0.236
IABP	19	5.7± 2.3	6.2 ± 2.2	0.498
Angiographic PVD	152	5.5± 2.0	5.4± 2.1	0.671
High stick location	102	6.6± 2.2	6.6± 2.4	0.976
Low stick	327	6.2± 2.2	6.3± 2.2	0.561
Puncture of CFA	692	6.5± 2.2	6.4 ± 2.1	0.387
VCD use	649	6.6 ± 2.2	6.5 ± 2.1	0.402
Angioseal	480	6.6 ± 2.2	6.5 ± 2.2	0.150
Perclose	145	6.4 ± 2.0	6.4 ± 2.0	0.989
Starclose	24	6.5 ± 1.6	6.3 ± 1.5	0.657
Manual compression	178	6.2 ± 2.2	6.3 ± 2.2	0.668

Artery size is expressed in mm as mean±SD. PCI, percutaneous coronary intervention; GP, glycoprotein; IABP, intra-aortic balloon pump; PVD, peripheral vascular disease; CFA; common femoral artery; VCD, vascular closure device.

Table 3

Difference in the femoral artery size after multivariate analysis.

Variable	Estimate (mm)	95% CI	<i>p</i> -value
Change per day after index procedure	0.0002	[−0.0001;0.0004]	0.147
Previous VCD use	−0.04	[−0.12;0.03]	0.246
Female gender	−1.22	[−1.41;−1.04]	<0.001
Change per BMI unit	0.02	[0.01;0.04]	0.003
Current smoker	−0.48	[−0.76;0.04]	0.001
Former smoker	−0.23	[−0.42;−0.05]	0.012
Angiographic PVD	−1.19	[−1.40;−0.98]	<0.001
Hyperlipidemia	0.02	[−0.18;0.23]	0.823
Previous statin therapy	0.47	[0.30;0.64]	<0.001
Diabetes mellitus	−0.06	[−0.25;0.12]	0.504
Left femoral artery	−0.14	[−0.51;0.23]	0.462

Estimate (standardized partial regression coefficient) reveals the larger (+) or smaller (−) size of the femoral artery in mm compared to the rest of the population. VCD, vascular closure device; BMI, body mass index; PVD, peripheral vascular disease.