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Preprocedural Cross-Sectional Imaging Prior to Percutaneous Peripheral Arterial Disease Interventions

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Abstract

Preprocedural cross-sectional imaging (PCSI) for peripheral artery disease (PAD) may vary due to patient complexity, anatomical disease burden, and physician preference. The objective of this study was to determine the utility of PCSI prior to percutaneous vascular interventions (PVIs) for PAD. Patients receiving first time lower extremity angiograms from 2013 to 2015 at a single institution were evaluated for PCSI performed within 180 days, defined as computed tomography angiography (CTA) or magnetic resonance angiography (MRA) evaluating abdominal to pedal vasculature. The primary outcome was technical success defined as improving the target outflow vessels to <30% stenosis. Of the 346 patients who underwent lower extremity angiograms, 158 (45.7%) patients had PCSI, including 150 patients had CTA and 8 patients had MRA. Of these, 48% were ordered by the referring provider (84% at an outside institution). Preprocedural cross-sectional imaging was performed at a median of 26 days (interquartile range: 9-53) prior to the procedure. The analysis of the institution's 5 vascular surgeons identified PCSI rates ranging from 31% to 70%. On multivariate analysis, chronic kidney disease (odds ratio [OR] = 0.35; 95% confidence interval [CI]: 0.17-0.73) was associated with less PSCI usage, and inpatient/emergency department evaluation (OR = 3.20; 95% CI: 1.58-6.50) and aortoiliac disease (OR = 2.78; 95% CI: 1.46-5.29) were associated with higher usage. After excluding 31 diagnostic procedures, technical success was not statistically significant with PSCI (91.3%) compared to without PCSI (85.6%), P = .11. When analyzing 89 femoral–popliteal occlusions, technical success was higher with PCSI (88%) compared to procedures without (69%) P = .026. Our analysis demonstrates that routine ordering of PCSI may not be warranted when considering technical success of PVI; however, PCSI may be helpful in treatment planning. Further studies are needed to confirm these findings in another practice setting, with more prescriptive use of PCSI to improve procedural success, and thereby improve the value of PCSI.

Keywords

CT angiography; MRA; peripheral artery disease; preoperative imaging

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Introduction

Reducing radiologic examinations have been a focus of cost reduction in health-care systems.[1,2] However, this undertaking may be especially difficult in the workup and treatment of lower extremity peripheral artery disease (PAD). In addition to a comprehensive physical examination with or without hand-held Doppler studies, preoperative imaging options include ankle–brachial indices (ABIs), arterial duplex ultrasound (DUS), and cross-sectional imaging: computed tomography angiography (CTA) or magnetic resonance angiography (MRA). Each modality has varying limitations, benefits, and associated costs.[3-6] Furthermore, treating or referring physicians may order these tests according to practice preference, patient presentation, comorbidities, facility resources, or financial incentives. For example, a CTA may be ordered on the weekend if the institution's vascular laboratory is unavailable or the patient has aortoiliac disease, which makes DUS less reliable. Conversely, arterial DUS may be ordered if the patient has a contrast allergy or renal insufficiency.

As arterial angiography is both diagnostic and therapeutic, controversy exists regarding the type and necessity of preoperative cross-sectional imaging (PCSI). Currently, no consensus guidelines exist regarding the need for PCSI in the workup of PAD.[7-9] Although guidelines note that preoperative imaging is important for treatment planning; PCSI is not noted to be superior to DUS nor absolutely necessary prior to intervention. The objective of this study was to determine the utility of PCSI by evaluating technical success of percutaneous vascular interventions (PVIs) for PAD. We evaluated the variability of PCSI by provider and evaluated the factors affecting PCSI usage. We also sought to describe the contrast load and radiation exposure associated with CTA and whether obtaining PSCI would reduce intraoperative contrast volume, radiation exposure, and procedure time.

Methods

A retrospective review of a prospectively maintained database was performed on all lower extremity PVI for PAD at our institution from January 2013 to December 2015. We evaluated the first revascularization procedure during the time period and evaluated perioperative clinical notes and radiology records prior to the procedure. Procedures for nonatherosclerotic PAD or aneurysmal disease were also excluded. This study was approved by the Stanford Research Compliance Office; patient consent was waived given the retrospective nature of the study.

Preoperative Cross-Sectional Imaging

Medical and radiographic records were evaluated regarding the presence of CTA abdomen with runoff to the pedal vessels or MRA including femoral to pedal evaluation. We included PCSI within 180 days prior to the initial PVI. Clinical notes were queried to evaluate whether the PCSI was performed at our institution or another institution. Next, we evaluated whether PCSI was ordered by the treating surgeon or another provider which may have been from the same institution or another institution. Lastly, we queried radiographic reports to note the contrast volume delivered and radiation exposure noted as milliGray (mGy) during preoperative CTA.

Disease Distribution and Severity

The distribution of disease was classified into aortoiliac, common femoral, superficial femoral/popliteal arteries (SFA-pop), and tibial vessels. Tibial runoff was determined by the presence of <50% stenosis within each tibial vessels to the ankle. Bilateral disease was classified of ≥1 arterial segment with ≥50% stenosis on both extremities. Disease severity was evaluated from CTA and MRA radiographic reports and source images. For patients without PCSI, intraoperative angiograms and operative reports were reviewed by 2 vascular surgeons to identify stenosis ≥50% in each of the above vessels distributions. Occlusions within the SFA-pop were documented by cessation of flow by PCSI or intraoperative angiograms.

Procedure Success and Intraoperative Details

Procedure success was defined as improving inflow (aortoiliac) stenosis/occlusions to <30% or revascularization of the target outflow (SFA-pop/tibial vessels) to <30% stenosis.[10,11] For example, if a patient had successful revascularization of the common iliac artery and superficial artery, but no attempt at tibial vessel revascularization, then this was considered a procedural success. If a patient had only tibial disease and did not have improvement in the tibial vessel stenosis/occlusion, then this was considered a procedure failure. Those without an attempted crossing due to severe disease or planned bypass were excluded from the technical success calculations. Radiation time, radiation exposure, and iodinated contrast were also noted. Procedure times were calculated from the safety pause to sheath removal. If a femoral endarterectomy was performed at the same time as PVI, the time only for the endovascular portion of the procedure was noted.

Factors Affecting PCSI

In addition to patient comorbidities, we also evaluated whether patients were evaluated in the inpatient or emergency department (ED) setting, defined as a nonclinic visit consult. Patients may have been admitted to another service, for example, lower extremity wound, or directly admitted to the vascular surgery team from the ED. The presence of preoperative ABI and/or lower extremity arterial DUS was also evaluated. Finally, we evaluated whether critical limb ischemia was present, defined as rest pain or lower extremity wounds.[10]

Statistical Analysis

The study data were collected using Microsoft Excel (Bellevue, Washington). Data analysis was performed using Stata 15 (College Station, Texas). Descriptive statistics were used for univariate analysis. Multivariable logistic regression was used to evaluate the odds ratio (OR) with 95% confidence interval (95% CI). *P* values <.05 were considered significant.

Results

A total of 346 patients underwent PVI for lower extremity PAD during the study period. The mean ± standard deviation age was 69.1 ± 0.6 with 34% of patients identified as female. A total of 158 (45.7%) patients had PCSI with 150 patients had CTA and 8 patients had MRA. Of these, 48% were ordered by the referring provider (84% at an outside institution). Preprocedural cross-sectional imaging was obtained at a median of 26 days (interquartile range [IQR]: 9-53) prior to the procedure. The median radiation dose of CTAs was 49.7 mGy (IQR: 29.2-78.4). The median iodinated contrast volume administered during CTAs was 140 cc (IQR: 116-145).

Patients with PCSI had lower rates of chronic kidney disease stage 3 or greater (9%) compared to those without PCSI (21%), $P = .002$, see Table 1. The majority of PVI was performed for claudication, and the indications for PVI did not differ between patients with PSCI compared to those without. Patients with PSCI had higher rates of aortoiliac disease, common femoral disease, and SFA-pop occlusions. Patients with PSCI also had lower rates of an additional arterial DUS or ABI. Inpatient/ED evaluations were also more common in patients with PSCI. On multivariate analysis, preoperative ABI/DUS (OR = 0.33; 95% CI: 0.15-0.74) and chronic kidney disease (OR = 0.47; 95% CI: 0.22-0.97) had the strongest effect against PCSI, and SFA–pop occlusion (OR = 3.24; 95% CI: 1.84-5.71), inpatient/ED evaluation (OR = 3.11; 95% CI: 1.55-6.24), and aortoiliac disease (OR = 2.60; 95% CI: 1.41-4.78) had most strongly predicted PCSI, see Table 2.

The analysis of 5 vascular surgeons identified PCSI rates ranging from 30% to 62%, see Figure 1. Of the 158 PCSI studies, 76 (48%) were ordered prior to referral to a vascular surgeon at our institution. The range of PSCI ordered by the treating vascular surgeon ranged from 3% to 41%.

After excluding 31 diagnostic procedures, technical success was not statistically significant with PSCI (91.3%) compared to those without (85.6%), $P = .11$. When analyzing a subgroup of 89 femoral–popliteal occlusions, technical success was higher for patients with PCSI (88%) compared to those without (69%) $P = .026$, see Figure 2. In addition, there were a higher number of diagnostic angiograms, that is, no attempted treatment, for patients without PSCI (8.8%) than those with PSCI (5.1%), $P = .05$.

Intraoperative times were not statistically significant between the patients with or without PSCI (median time 90 minutes [IQR: 60-120] for both groups). Similarly, fluoroscopic time was not statistically significant between the patients with or without PSCI. Radiation exposure and intraoperative contrast volume did not significantly differ between the 2 groups, see Table 3.

Discussion

This study highlights variation in PCSI usage prior to PVI for PAD. First, PCSI is not associated with higher procedural success when comparing all types of interventions for lower extremity PAD. This suggests that routine PCSI is not warranted prior to PVI. However, as PCSI was associated with increased procedural success for SFA–pop occlusions, this shows that for technically challenging lesions having an arterial road map prior may be beneficial. Previous reports have shown that preoperative CTA findings may help predict technical success in the SFA/pop occlusions and tibial occlusions, and this may be important in discussing the risks and benefits of PVI during patient counseling.[12,13] Furthermore, PCSI may reduce the number of diagnostic angiograms (no attempted percutaneous intervention) compared to those without PCSI. As the Center for Medicare

Services may not reimburse for both PCSI and a diagnostic angiogram, PCSI may reduce the need for invasive imaging by determining whether a concomitant endarterectomy or surgical bypass is required.

Second, PCSI was not associated with a lower radiation exposure, contrast volume, or procedure time. This demonstrates that although PCSI may help with preoperative planning by visualizing the entire arterial system, this may not help reduce the above metrics in general. Although CTA exposes the patient to additional radiation exposure and contrast volume, having PCSI did not decrease the overall radiation exposure and time. Evaluating the long-term stochastic effects of radiation exposure at 2 different settings is beyond the scope of this study.[14]

Third, physicians vary in their individual practice in obtaining PCSI. Our results showed that PCSI varies from 30% to 62% by the provider. Furthermore, it is not just the treating vascular surgeon obtaining PCSI but also referring physicians who contributed 48% of studies obtained. This rate may vary beyond a vascular surgeon group practice and may vary differently when treated by providers who only perform PVI and not surgical revascularization, for example, interventional cardiologists and interventional radiologists.

Lastly, the patient and facility factors associated with PCSI are important to consider in the workup of PAD. Chronic kidney disease and a preoperative ABI/ultrasound were associated with lower rates of PSCI, whereas SFA/pop occlusions, ED/inpatient evaluation, and aortoiliac disease were associated with higher volumes.

We are unable to comment on recommendations on the appropriateness of PCSI and recommendations for ordering PCSI as this was a retrospective analysis. We also note that this study is limited to a group of vascular surgeons; whether these findings are generalizable outside a single institution with other types of treating physicians is yet to be determined. We also did not evaluate clinical improvement after PVI, for example, improvement in walking distance, time to wound healing, ABI improvement or primary patency as patient presentation, and long-term follow-up were heterogeneous. Furthermore, we did not evaluate access selection or treatment adjuncts as a majority were performed from a femoral approach without the use of reentry devices or intravascular ultrasound (IVUS). Lastly, we only evaluated PCSI usage in patients who underwent PVI; the utility of PCSI in the diagnosis of PAD was not evaluated in this study.

In summary, this study highlights the variable use of PSCI within a single institution. Future studies are needed to assess the financial incentives related to PCSI. At our institution, the ultrasound laboratory or cath laboratory is not owned by the physicians. Other physician practices may include ownership of vascular laboratories or office-based laboratories where diagnostic angiograms are incentivized. Conversely, cross-sectional imaging may be financially appealing to certain fee-for-service health-care systems and has been shown to be financially important in the management of other vascular pathologies, such as surveillance for endovascular abdominal aortic aneurysm repair.[15]

Conclusion

In this real-world analysis, inconsistent use of PCSI did not influence procedural outcomes among those undergoing percutaneous revascularization. When PCSI is not necessary for the diagnosis of PAD, the use of PCSI may be reserved for use by the practitioner to plan a strategy for revascularization, when needed. As this retrospective single-institution study describes the variation of PSCI among its providers, this highlights the need for future studies to determine when PCSI improves procedural success and maximizes long-term outcomes.

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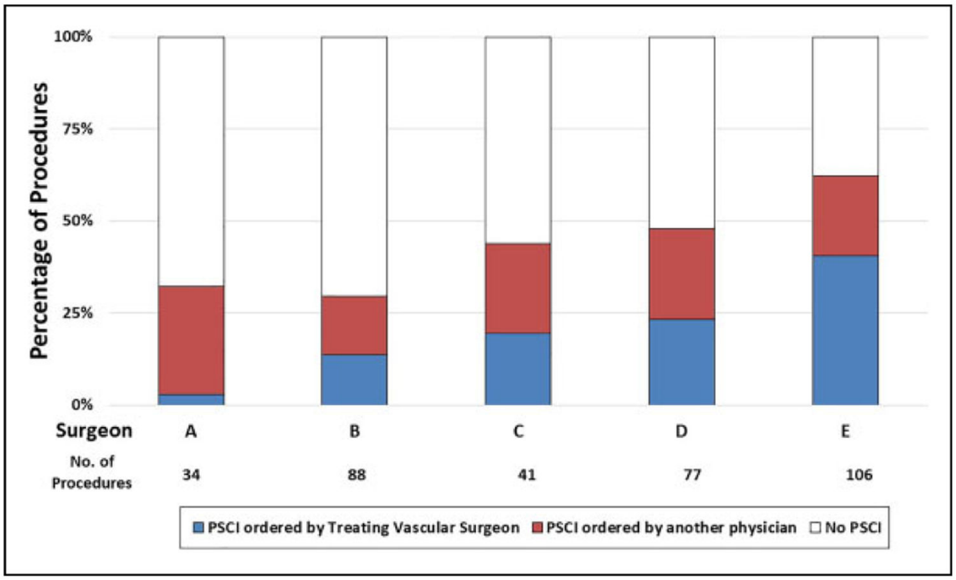

Figure 1.

Comparison of preprocedural cross-sectional imaging by physician prior to percutaneous vascular interventions (PVI) for peripheral artery disease (PAD).

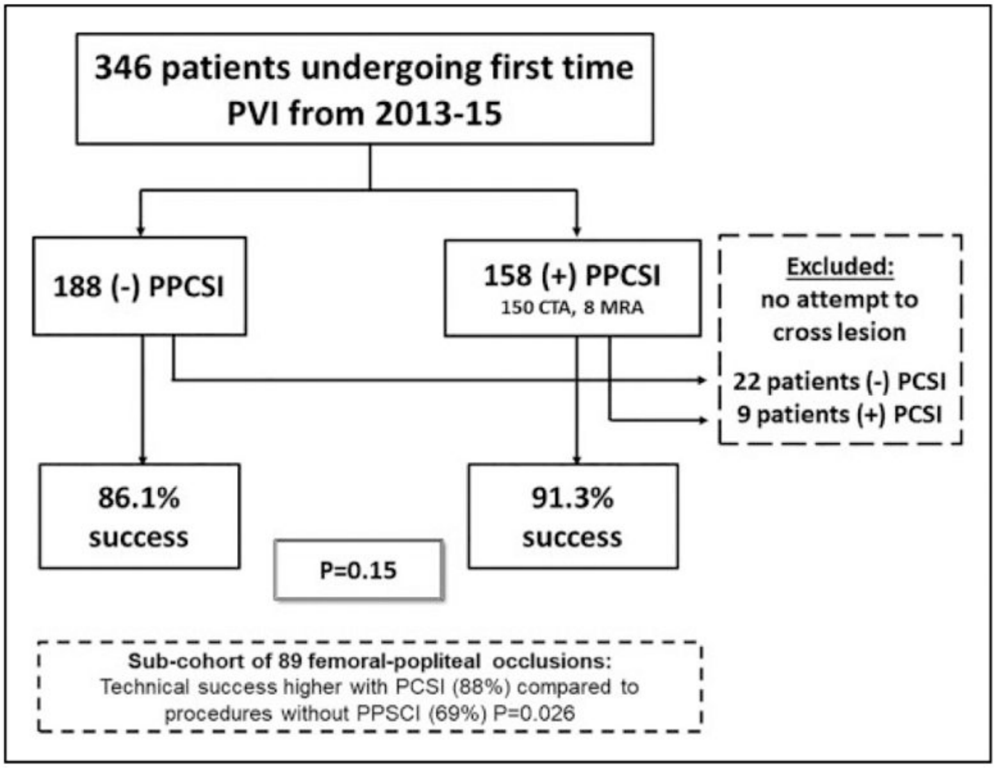

Figure 2.

Flow diagram of outcomes of technical success comparing patients with and without preprocedural cross-sectional imaging (PCSI) prior tofirst percutaneous vascular interventions (PVIs).

Table 1.

Patient Demographics and Characteristics of Those With and Without PCSI.

Characteristic	All (n = 364)	No PCSI (n = 188)	PCSI (n = 158)	*P* Value
Age[a]	69.1 ± 0.6	69.7 ± 0.9	68.4 ± 0.9	.29
Female gender	117 (34%)	60 (32%)	57 (36%)	.42
Hypertension	302 (87%)	168 (89%)	134 (85%)	.21
Hyperlipidemia	253 (73%)	143 (75%)	110 (70%)	.18
Diabetes mellitus	183 (53%)	107 (57%)	76 (48%)	.10
Chronic kidney disease ≥ 3	53 (15%)	39 (21%)	14 (9%)	.002
End-stage renal disease	33 (10%)	20 (11%)	13 (8%)	.45
Congestive heart failure	60 (17%)	39 (21%)	21 (13%)	.07
COPD	26 (8%)	13 (7%)	13 (8%)	.64
CVA	55 (16%)	34 (18%)	21 (13%)	.22
Current smoker	55 (16%)	29 (15%)	26 (16%)	.79
Past smoker	196 (57%)	112 (60%)	84 (53%)	.23
Indication				
Claudication	179 (52%)	101 (54%)	78 (49%)	.22
Rest pain	24 (7%)	9 (5%)	15 (9%)	
Wound	143 (41%)	78 (41%)	65 (41%)	
Disease description				
Bilateral disease	297 (86%)	158 (53%)	139 (47%)	.23
Aortoiliac disease	112 (33%)	41 (23%)	71 (44%)	<.001
TASC A[b]	36 (32%)	14 (34%)	22 (31%)	
TASC B	34 (30%)	12 (30%)	22 (31%)	
TASC C	22 (20%)	8 (20%)	14 (20%)	
TASC D	20 (18%)	7 (17%)	13 (18%)	
Common femoral disease	61 (18%)	22 (12%)	39 (25%)	.002
SFA/pop disease	271 (78%)	145 (77%)	126 (80%)	.56
TASC A[b]	50 (18%)	29 (20%)	21 (17%)	
TASC B	67 (25%)	38 (26%)	29 (25%)	
TASC C	70 (67%)	34 (24%)	36 (28%)	

Characteristic	All (n = 364)	No PCSI (n = 188)	PCSI (n = 158)	*P* Value
TASC D	84 (31%)	43 (30%)	41 (33%)	
SFA/pop occlusion	93 (27%)	32 (17%)	61 (39%)	<.001
Tibial disease	250 (72%)	143 (76%)	107 (68%)	.07
Tibial runoff	1.63 ± 0.60	1.60 ± 0.08	1.66 ± 0.09	.61
Preoperative ABI/ultrasound	304 (88%)	175 (93%)	129 (82%)	.001
Inpatient/ED evaluation	59 (17%)	21 (11%)	38 (24%)	.002

Abbreviations: ABI, ankle–brachial index; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; ED, emergency department; PCSI, preprocedural cross-sectional imaging; SFA/pop, superficial femoral/popliteal arteries; TASC, Trans-Atlantic Inter-Society Consensus Document on Management of Peripheral Arterial Disease.

[a] mean ± SD.

[b] Noted as a percentage of those with aorto-iliac/ SFA/pop disease.

Table 2.

Intraoperative Details Comparing Those With and Without PCSI.

Intra-operative Variable[a]	All (n = 315)	No PCSI (n = 166)	PCSI (n = 149)	*P* Value
Procedure time (min)	90 (60-120)	90 (60-120)	90 (60-120)	.16
Radiation time (min)	20.4 (12.8-32.6)	20.0 (12.6-32.9)	21.2 (12.0-30.9)	.61
Contrast volume (cc)	40 (30-60)	40 (30-57)	43 (30-60)	.90
Radiation exposure (mGy)	424 (187-876)	397 (196-810)	494 (159-1075)	.42

Abbreviations: mGy, milliGray; PCSI, preprocedural cross-sectional imaging.

[a]Expressed as median (interquartile range).

Table 3.

Factors Affecting the Usage of Preprocedural Cross-Sectional Imaging.

Variables	Odds Ratio	95% CI	*P* Value
Age (1 year)	0.99	0.97-1.01	.27
Chronic kidney disease	0.47	0.22-0.97	.04
Congestive heart failure	0.54	0.26-1.12	.10
Diabetes mellitus	0.54	0.45-1.28	.31
Aortoiliac disease	2.60	1.41-4.78	.002
Common femoral disease	1.61	0.81-3.22	.18
SFA-pop occlusion	3.24	1.84-5.71	<.001
Inpatient/ED evaluation	3.11	1.55-6.24	.001
Preoperative ABI/ultrasound	0.33	0.15-0.74	.007

Abbreviations: ABI, ankle–brachial index; CI, confidence interval; ED, emergency department; SFA-pop, superficial femoral/popliteal arteries.