Cardiac Stress Testing After Coronary Revascularization

Arti Dhoot, MD[a], Shuangbo Liu, MD[a], Anamaria Savu, PhD[b], Zain M. Cheema, BHSc[a], Robert C. Welsh, MD[b], Kevin R. Bainey, MD, MSc[b], Dennis T. Ko, MD, MSc[c,d], Sanjeev P. Bhavnani, MD[e], Shaun G. Goodman, MD, MSc[a,b,f], Padma Kaul, PhD[b], and Akshay Bagai, MD, MHS[a,f,*]

Unless prompted by symptoms or change in clinical status, the appropriate use criteria consider cardiac stress testing (CST) within 2 years of percutaneous coronary intervention (PCI) and 5 years of coronary artery bypass grafting (CABG) to be rarely appropriate. Little is known regarding use and yield of CST after PCI or CABG. We studied 39,648 patients treated with coronary revascularization (29,497 PCI; 10,151 CABG) between April 2004 and March 2012 in Alberta, Canada. Frequency of CST between 60 days and 2 years after revascularization was determined from linked provincial databases. Yield was defined as subsequent rates of coronary angiography and revascularization after CST. Post PCI, 14,195 (48.1%) patients underwent CST between 60 days and 2 years, while post CABG, 4,469 (44.0%) patients underwent CST. Compared with patients not undergoing CST, patients undergoing CST were more likely to be of younger age, reside in an urban area, have higher neighborhood median household income, but less medical comorbidities. Among PCI patients undergoing CST, 5.2% underwent subsequent coronary angiography, and 2.6% underwent repeat revascularization within 60 days of CST. Rates of coronary angiography and repeat revascularization post-CST among CABG patients were 3.6% and 1.1%, respectively. Approximately one-half of patients undergo CST within 2 years of PCI or CABG in Alberta, Canada. Yield of CST is low, with only 1 out of 38 tested post-PCI patients and 1 out of 91 tested post-CABG patients undergoing further revascularization. In conclusion, additional research is required to determine patients most likely to benefit from CST after revascularization. **(Am J Cardiol 2020;136:9−14)**

The Appropriate Use Criteria considers cardiac stress testing (CST) to be rarely appropriate within 2 years after percutaneous coronary intervention (PCI) and within 5 years after coronary artery bypass grafting (CABG), unless prompted by symptoms or other changes in clinical status.[1] The current American College of Cardiology Foundation/American Heart Association/Society for Cardiovascular Angiography and Intervention practice guidelines also recommend against routine stress testing for asymptomatic patients after PCI procedures (class III).[2] Despite absence of evidence establishing impact of routine CST after revascularization on clinical outcomes, CST is commonly performed after PCI in the United States, both among fee-for-service community practice and integrated healthcare systems.[3] Findings were similar in Ontario, Canada, with more than one-half of patients undergoing at least 1 CST within 2 years of PCI.[4,5] Yield of such stress testing was low, with only 1 in 30 tested patients undergoing subsequent revascularization. Although there is now knowledge of the patterns of CST after PCI, little is known regarding use and yield of CST after CABG. To address these gaps, in this population-based study, we sought to determine patterns of CST after revascularization both PCI and CABG, in Alberta, Canada. We specifically aimed to ascertain the frequency and timing of CST within 2 years of PCI and CABG, as well as downstream coronary angiography and revascularization that occurred as a consequence of stress testing.

Methods

The study population was identified from the Alberta Discharge Abstract Database, which records information of all acute hospitalizations (dates, principal diagnosis and up to 24 other diagnoses, procedures, lengths of stay, and discharge status) and the National Ambulatory Care Reporting System, which records all visits to hospital-based physician

[a]Terrence Donnelly Heart Centre, St Michael's Hospital, University of Toronto, Toronto, Ontario, Canada; [b]Canadian Virtual Coordinating Center for Global Collaborative Cardiovascular Research Centre, University of Alberta, Edmonton, Alberta, Canada; [c]Institute for Clinical Evaluative Sciences, Toronto, Ontario, Canada; [d]Schulich Heart Centre, Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Ontario, Canada; [e]Division of Cardiology, Scripps Clinic and Research Foundation, San Diego, California; and [f]Li Ka Shing Knowledge Institute of St. Michael's Hospital, Toronto, Ontario, Canada. Manuscript received June 22, 2020; revised manuscript received and accepted August 28, 2020.

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*Corresponding author: Tel: (416) 864-6060, ext. 5783; fax: (416) 864-5989.

E-mail address: akshay.bagai@unityhealth.to (A. Bagai).

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offices or emergency departments and includes up to 10 diagnostic fields. This was cross-referenced with 3 other databases maintained by the Alberta Ministry of Health: (1) Practitioner Claims Database, which tracks all physicians' claims from outpatient services and records up to 3 diagnostic codes per encounter; (2) Population Registry, which records basic demographic and geographic information for all 4.1 million citizens registered with Alberta Health Insurance Care Plan; and (3) Vital Statistics - Deaths, which records all deaths in the province. While each patient has a unique personal identifier to allow linkage of patient information across the databases, only de-identified data was used for this project. These data have been used previously to perform evaluative analyses by our group.[6−8]

We identified all PCI and CABG procedures performed between April 1, 2004 and March 31, 2012 in Alberta, Canada (n = 49,044) (Figure 1). We excluded revascularization procedures on the following patients: age <18 years (n = 14), non-Albertan residents (n = 359), lost to follow-up within 2 years of revascularization (n = 504), had competing events (death and/or angiography and/or revascularization) within 60 days of index revascularization procedure (n = 4,397). Only the first revascularization procedure among patients undergoing multiple revascularization procedure during the study period was included (excluded n = 4,122 procedures). The final analysis cohort consisted of 39,648 patients undergoing their first revascularization procedure within the study period: 29,497 were treated with PCI and 10,151 were treated with CABG.

CST between 60 days and 2 years of index PCI or CABG were identified from the linked National Ambulatory Care Reporting System and Practitioner Claims Databases using Canadian Codes of Health Interventions (2HZ08EJ, 2HZ08EK) and billing codes (03.41A, 03.41D). Both exercise and pharmacological stress tests were included, with or without an accompanying imaging modality. CSTs performed within 60 days of revascularization were excluded as they may relate to cardiac rehabilitation or assessment of residual ischemia. We compared demographic and clinical characteristics among patients who received at least 1 stress test between 60 days and 2 years after revascularization (separately by type of index revascularization [PCI or CABG]) versus those who did not. Categorical variables are presented using count and percentage and compared using chi-square test. Continuous variables are presented using mean and standard deviation and compared using *t* test. Among patients that underwent CST, rates of subsequent angiography and revascularization (PCI and CABG) within 60 days of CST were determined using Canadian Codes of Health Interventions codes (coronary angiography: 1.IJ.26, 3.IP.10, PCI: 1.IJ.50, CABG: 1.IJ.76). The 60-day window was chosen to capture sequential procedures most likely to result from stress testing. Multivariable Cox proportional hazard models were used to determine factors

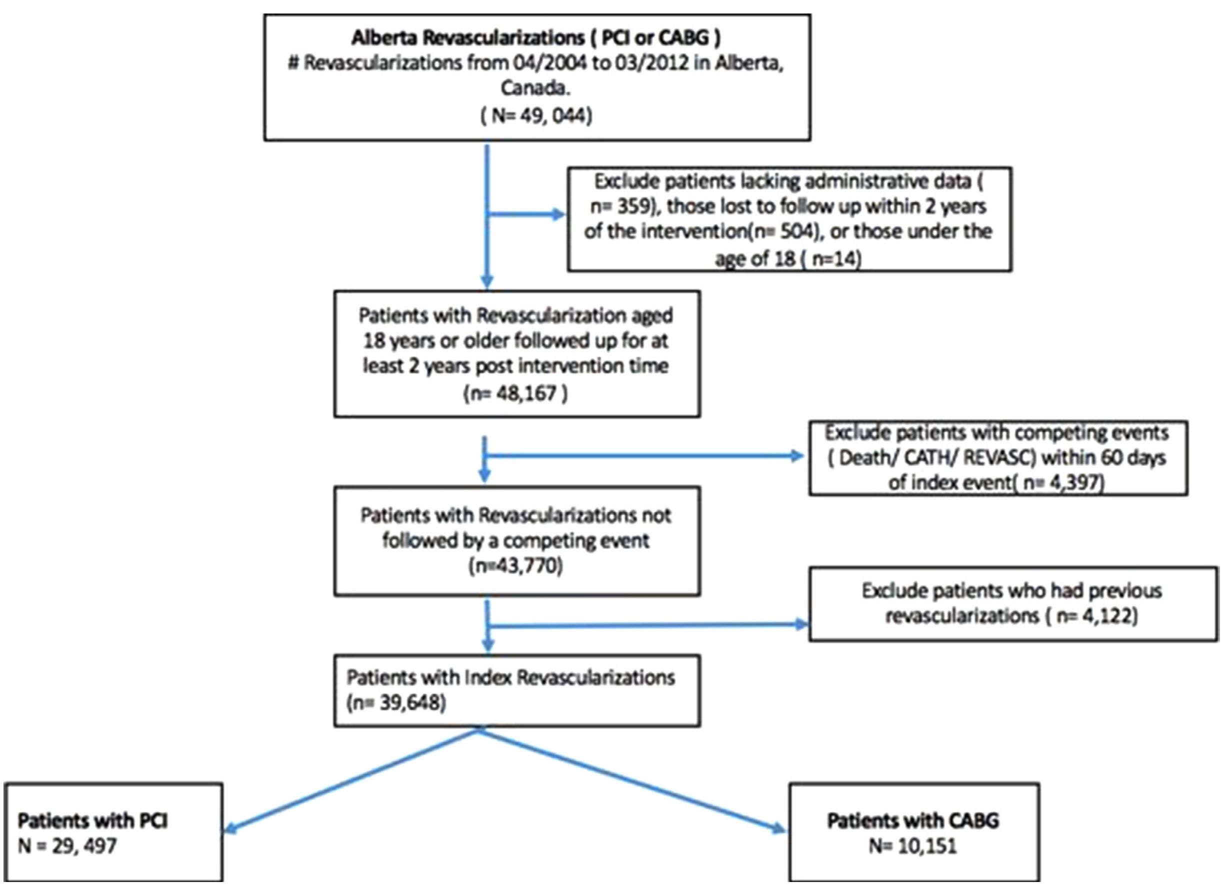

Figure 1. Description of study cohort.

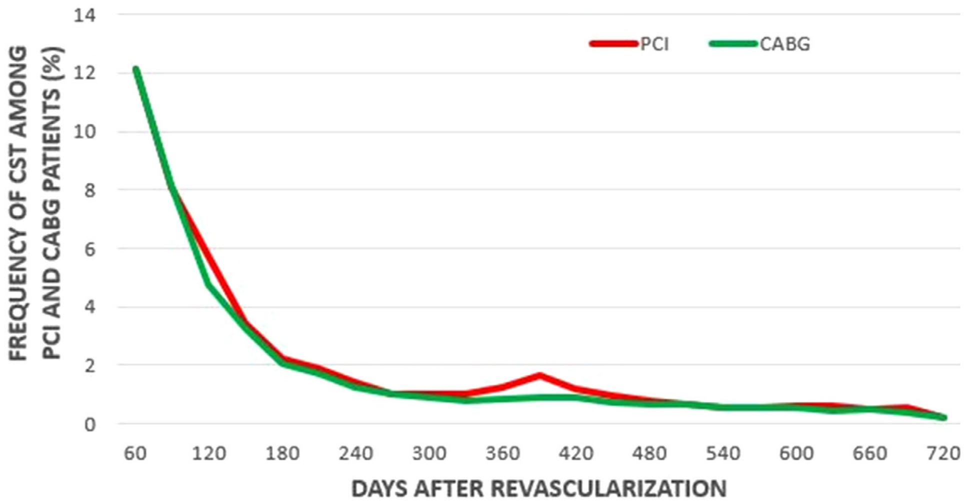

Figure 2. Timing of cardiac stress testing after percutaneous coronary intervention & coronary artery bypass grafting.

independently associated with performing CST separately by type of revascularization. Adjustment covariates included age, sex, residence (urban versus rural), neighborhood median household income, and medical comorbidities (diabetes, hypertension, myocardial infarction, congestive heart failure, cerebrovascular disease, peripheral arterial disease, renal failure, and chronic obstructive pulmonary disease). Adjusted hazard ratios and 95% confidence intervals are reported. Data analysis was generated using SAS software, version 9.4 (SAS Institute, Inc, Cary, North Carolina). The study was approved by the University of Alberta Institutional Review Board.

Results

Among 29,497 patients treated with PCI, 14,195 (48.1%) underwent at least 1 CST between 60 days and 2 years after PCI. Majority of the CST was performed early between 60 days and 180 days (61%) with additional spike in incidence of stress testing at approximately 1 year (Figure 2). Compared with patients who did not undergo a stress test, those who underwent CST were younger, more likely to be male, reside in an urban area, and have higher neighborhood median household income (Table 1). These patients were less likely to have medical comorbidities including diabetes, congestive heart failure, cerebrovascular disease, peripheral vascular disease, renal failure or chronic obstructive lung disease. After multivariable adjustment, male sex, and higher neighbourhood median household income were associated with increased probability of CST, while older age, residence in a rural area, and presence of medical comorbidities were associated with lesser CST after PCI (Table 2). Among PCI treated patients undergoing stress testing, 5.2% underwent subsequent coronary angiography,

Table 1
Baseline characteristics of patients undergoing cardiac stress testing post percutaneous coronary intervention and coronary artery bypass grafting

Variable	PCI				CABG			
	Stress Test		Total	p value	Stress Test		Total	p value
	No	Yes			No	Yes		
Number of patients	15302 (51.9%)	14195 (48.1%)	29497	-	5682 (56.0%)	4469 (44.0%)	10151	-
Age, mean ± SD, years	64.8 ± 12.4	60.9 ± 10.8	62.9 ± 11.8	<0.0001	68.2 ± 10.2	64.6 ± 9.8	66.6 ± 10.2	<0.0001
Men	11210 (73.3%)	11224 (79.1%)	22434 (76.1%)	<0.0001	4467 (78.6%)	3839 (85.9%)	8306 (81.8%)	<0.0001
Residing in a rural area	3435 (22.4%)	2458 (17.3%)	5893 (20.0%)	<0.0001	1321 (23.2%)	703 (15.7%)	2024 (19.9%)	<0.0001
Neighborhood median household income								
Lowest quintile	3152 (20.6%)	2418 (17.0%)	5570 (18.9%)	<0.0001	1274 (22.4%)	735 (16.4%)	2009 (19.8%)	<0.0001
Second quintile	3438 (22.5%)	2846 (20.0%)	6284 (21.3%)		1256 (22.1%)	865 (19.4%)	2121 (20.9%)	
Third quintile	3192 (20.9%)	2694 (19.0%)	5886 (20.0%)		1238 (21.8%)	849 (19.0%)	2087 (20.6%)	
Fourth quintile	2877 (18.8%)	2809 (19.8%)	5686 (19.3%)		1006 (17.7%)	917 (20.5%)	1923 (18.9%)	
Highest quintile	2643 (17.3%)	3428 (24.1%)	6071 (20.6%)		908 (16.0%)	1103 (24.7%)	2011 (19.8%)	
Diabetes mellitus	4426 (28.9%)	3184 (22.4%)	7610 (25.8%)	<0.0001	2202 (38.8%)	1574 (35.2%)	3776 (37.2%)	0.0003
Hypertension	11153 (72.9%)	9368 (66.0%)	20521 (69.6%)	<0.0001	4848 (85.3%)	3701 (82.8%)	8549 (84.2%)	0.0006
Myocardial infarction	11236 (73.4%)	10122 (71.3%)	21358 (72.4%)	<0.0001	3189 (56.1%)	2337 (52.3%)	5526 (54.4%)	0.0001
Congestive heart failure	1939 (12.7%)	903 (6.4%)	2842 (9.6%)	<0.0001	1507 (26.5%)	650 (14.5%)	2157 (21.2%)	<0.0001
Cerebrovascular disease	677 (4.4%)	405 (2.9%)	1082 (3.7%)	<0.0001	604 (10.6%)	289 (6.5%)	893 (8.8%)	<0.0001
Peripheral arterial disease	925 (6.0%)	514 (3.6%)	1439 (4.9%)	<0.0001	842 (14.8%)	469 (10.5%)	1311 (12.9%)	<0.0001
Renal failure	1090 (7.1%)	498 (3.5%)	1588 (5.4%)	<0.0001	675 (11.9%)	298 (6.7%)	973 (9.6%)	<0.0001
Chronic obstructive lung disease	2236 (14.6%)	1403 (9.9%)	3639 (12.3%)	<0.0001	1271 (22.4%)	776 (17.4%)	2047 (20.2%)	<0.0001

SD = standard deviation.

Table 2
Factors associated with cardiac stress testing post percutaneous coronary intervention and coronary artery bypass grafting

	Post-PCI		Post-CABG	
	HR (95%CI)	p value	HR (95%CI)	p value
Age (1-year increment)	0.99 (0.99, 0.99)	<0.0001	0.98 (0.98, 0.98)	<0.0001
Male	1.12 (1.07, 1.16)	<0.0001	1.34 (1.23, 1.46)	<0.0001
Rural area	0.80 (0.77, 0.84)	<0.0001	0.73 (0.67, 0.79)	<0.0001
Neighborhood median household income (per $10,000 increment)	1.03 (1.02, 1.04)	<0.0001	1.06 (1.04, 1.07)	<0.0001
Diabetes	0.87 (0.84, 0.91)	<0.0001	0.97 (0.91, 1.03)	0.3547
Hypertension	0.91 (0.87, 0.94)	<0.0001	0.98 (0.90, 1.06)	0.5498
Myocardial infarction	0.92 (0.88, 0.95)	<0.0001	0.93 (0.88, 0.99)	0.0194
Congestive heart failure	0.73 (0.68, 0.78)	<0.0001	0.67 (0.61, 0.73)	<0.0001
Cerebrovascular disease	0.93 (0.84, 1.03)	0.1558	0.81 (0.72, 0.91)	0.0005
Peripheral vascular disease	0.82 (0.75, 0.89)	<0.0001	0.85 (0.77, 0.94)	0.001
Renal failure	0.77 (0.70, 0.84)	<0.0001	0.75 (0.66, 0.84)	<0.0001
Chronic obstructive pulmonary disease	0.86 (0.81, 0.91)	<0.0001	0.97 (0.90, 1.05)	0.4512

and 2.6% underwent repeat revascularization within 60 days of CST.

Among 10,151 patients treated with CABG, 4,469 (44.0%) underwent at least 1 CST between 60 days and 2 years after CABG. Similar to the PCI cohort, majority of the CST was performed early within 180 days after CABG (64%), but unlike the PCI cohort, there was no spike in incidence of CST at the 1-year mark. Compared with CABG treated patients who did not undergo CST, CABG treated patients who underwent CST were younger, more likely to be male, reside in an urban area, have higher neighborhood median household income, and less likely to have medical comorbidities including congestive heart failure, peripheral arterial disease and renal failure. After multivariable adjustment, similar to the PCI cohort, male sex and higher neighbourhood median household income were associated with higher probability of CST, while older age, rural residence and medical comorbidities such as myocardial infarction, congestive heart failure, cerebrovascular disease, peripheral arterial disease, and renal failure were associated with lower probability of CST (Table 2). Rates of coronary angiography and repeat revascularization post-CST among CABG treated patients were 3.6% and 1.1%, respectively.

Discussion

In this population-based study of 39,648 patients treated with PCI or CABG in Alberta, Canada, several observations regarding practice of stress testing after revascularization emerge. Approximately one-half of patients underwent CST within 2 years of revascularization. Rates of CST are similar among PCI and CABG patients. Younger patients with less comorbidities were more likely to undergo CST, and the yield of CST leading to subsequent cardiac catheterization or revascularization was low.

Our finding that nearly half (48.1%) of PCI treated patients underwent CST between 60 days and 2 years after PCI in Alberta, Canada are in line with observations in the fee-for-service community practice in the United States, where Shah et al[3] found that 61% of privately insured patients aged <65 years underwent stress testing between 90 days and 2 years after PCI. Findings in Alberta, Canada are also similar to findings from Ontario, Canada, where CST rate during the same time period after PCI was 51.3%.[4] Unlike these other cohorts, in this study, we did not exclude patients with limited life expectancy (cancer, dementia, liver disease, end stage renal disease requiring dialysis), patients much less likely to undergo CST. The rates of stress testing are far greater than the 1-year rates of angina symptoms reported previously in PCI treated patients (15% to 18%),[9,10] suggesting a considerable proportion of stress testing is being performed in asymptomatic patients. Although some stress tests performed for purposes of cardiac rehabilitation or exercise prescription may be reasonable in asymptomatic patients, we used a 60-day blanking period post PCI to account for and not count such CSTs.

We found that patients with greater comorbidities, that is, higher risk, were less likely to undergo stress testing, a finding of risk-treatment paradox observed previously in other cohorts.[11,12] Our finding that greater neighborhood median household income and urban residence were independently associated with greater likelihood of stress testing, highlights that even in a system with universal health care and equal access, factors other than patient risk are at play to determine access to and utilization of health care resources. Shah et al found that nuclear and echocardiographic stress testing following revascularization were more frequent among patients treated by physicians who billed for technical fees, professional fees, or both compared with those treated by physicians who did not bill for these services.[13] Physician payment for the most part is fee-for-service in Canada, creating incentives for over-testing. Given that the noninvasive tests are performed outside of the hospitals and are not regulated or capped in either province by the provincial government, the single payer in Canada, it is not surprising that that practice patterns are similar in Ontario and Alberta. The finding that only 5.2% of patients with stress testing underwent coronary angiography suggests that testing in this population identified a very small proportion of patients that either had positive stress test results or other indications for further invasive investigations. The overall rate of repeat revascularization after stress testing was extremely low (2.6%), a proportion that would be even lower if all patients were subjected to routine testing after PCI. Small fraction of patients that underwent revascularization after coronary angiography suggests high incidence of false-positive tests, although it is feasible that a certain proportion of patients had lesions not amenable for intervention. In the era of bare metal stents and early general drug eluting stents, where rates of restenosis were much greater, stress testing following PCI with stenting was not shown to be associated with improvement in clinical outcomes.[3,14] With use of current generation drug eluting stents, which have much lower rates of target lesion failure[15] the utility of routine stress testing post PCI is even further diminished.

Although PCI related re-stenosis rates have markedly decreased with current generation drug eluting stents, late complications post-CABG still remain a concern. Graft failure occurs in up to fifteen percent of early post-CABG patients.[16,17] Although CST post-CABG does identify graft failure[18] and patients at increased risk of adverse clinical outcomes,[19–21] no study has concluded that earlier detection leads to improved clinical outcomes. Routine use of tests that have prognostic value is of little use unless the results can be used to improve prognosis. Therefore, due to lack of data for outcomes benefit, current American College of Cardiology Foundation/American Heart Association/ Society for Cardiovascular Angiography and Intervention practice guidelines for the management of stable ischemic coronary artery disease do not support the use of routine CST in asymptomatic patients within 5 years post-CABG.[2] Our finding that 44% of CABG treated patients underwent CST between 60 days and 2 years after CABG in Alberta, Canada demonstrates that increased utilization of CST after CABG, similar to post PCI, has occurred in the absence of evidence establishing the impact of routine CST on clinical outcomes. Furthermore, the yield of such widespread stress testing in post-CABG patients on downstream repeat coronary angiography and revascularization was even lower compared with post-PCI patients. It has been suggested that highest risk patients, such as, post-CABG may be referred directly for coronary angiography. We found that 4.3% of patients in our post-CABG cohort underwent cardiac catheterization directly without an intervening CST. Whether testing maybe beneficial in certain, high-risk populations such as those that may not have achieved complete revascularization, and is cost-effective requires further investigation.

The present observations are derived from an administrative database, with no information on symptomatic status and clinical presentation at time of the stress test. Thus, the appropriateness of the CST cannot be determined from this study. We did use a 60-day blanking period similar to several other prior studies to exclude stress tests performed as part of cardiac rehabilitation or evaluation of residual ischemia. Beyond clinical indications, we are also unable to determine the impact of physician and/or patient preferences in influencing stress testing. Finally, the results of the stress tests and its impact on change in medical therapy, patient lifestyle, and clinical outcomes cannot be determined from this study. Although stress tests in themselves are of low risk, associated with minimal risk of ventricular arrhythmia, or myocardial infarction, they do have inherent limitations in accuracy, particular specificity, with false-positive results exposing patients to risks of additional invasive investigations and treatments.

Approximately one-half of patients undergo CST between 60 days and 2 years of coronary revascularization in Alberta, Canada. Rates of CST are similar after CABG and PCI. Presence of comorbidities is associated with less likelihood of CST, while urban residence and greater neighborhood median household income are associated with greater likelihood of CST. Rate of revascularization post stress testing was very low, similar to other cohorts in the United States and Canada. Further research is needed to better inform the selection of patients most likely to benefit from CST after revascularization.

Authors' Contribution

Arti Dhoot, MD was responsible for conceptualization, and writing original draft; Shuangbo Liu, MD was responsible for conceptualization, and writing original draft; Anamaria Savu, PhD was responsible for methodology, software, and formal analysis; Zain M. Cheema, BHSc was responsible for writing original draft; Robert C. Welsh, MD was responsible for investigation and review and editing; Kevin R. Bainey, MD, MSc was responsible for investigation and review and editing; Dennis T. Ko, MD, MSc was responsible for review and editing; Sanjeev P. Bhavnani, MD was responsible for review and editing; Shaun G. Goodman, MD, MSc was responsible for review and editing and funding acquisition; Padma Kaul, PhD was responsible for conceptualization, methodology, review and editing, project administration, funding acquisition; Akshay Bagai, MD, MHS was responsible for conceptualization, methodology, writing original draft, project administration, supervision and funding acquisition.

Disclosures

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

1. Wolk MJ, Bailey SR, Doherty JU, Douglas PS, Hendel RC, Kramer CM, Min JK, Patel MR, Rosenbaum L, Shaw LJ, Stainback RF, Allen JM, American College of Cardiology Foundation Appropriate Use Criteria Task Force. ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/ SCCT/SCMR/ STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *J Am Coll Cardiol* 2014;63:380–406.
2. Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, Chambers CE, Ellis SG, Guyton RA, Hollenberg SM, Khot UN, Lange RA, Mauri L, Mehran R, Moussa ID, Mukherjee D, Nallamothu BK, Ting HH. American College of Cardiology Foundation. American Heart Association Task Force on Practice Guidelines. Society for Cardiovascular Angiography and Interventions. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention. A report of the

American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *J Am Coll Cardiol* 2011;58: e44–122.

3. Shah BR, Cowper PA, O'Brien SM, O'Brien SM, Jensen N, Drawz M, Patel MR, Douglas PS, Peterson ED. Patterns of cardiac stress testing after revascularization in community practice. *J Am Coll Cardiol* 2010;56:1328–1334.
4. Bagai A, Eberg M, Koh M, Koh M, Cheema AN, Yan AT, Dhoot A, Bhavnani SP, Wijeysundera HC, Bhatia RS, Kaul P, Goodman SG, Ko DT. Population-Based study on patterns of cardiac stress testing after percutaneous coronary intervention. *Circ Cardiovasc Qual Outcomes* 2017;10:e003660.
5. Luca SR, Koh M, Qiu F, Koh M, Qiu F, Alter DA, Bagai A, Bhatia RS, Czarnecki A, Goodman SG, Lau C, Wijeysundera HC, Ko DT. Stress testing after percutaneous coronary interventions: a population-based study. *CMAJ Open* 2017;5:E417–e423.
6. Tran DT, Ohinmaa A, Thanh NX, Welsh RC, Kaul P. The healthcare cost burden of acute myocardial infarction in Alberta, Canada. *Pharmacoecon Open* 2018;2:433–442.
7. Kaul P, Savu A, Hamza S, Knudtson ML, Bainey K, Brass N, Armstrong PW, Welsh RC. Outcomes of medically managed patients with myocardial infarction. *Eur Heart J Acute Cardiovasc Care* 2019;8:571–581.
8. Kaul P, Ezekowitz JA, Armstrong PW, Leung BK, Savu A, Welsh RC, Quan H, Knudtson ML, McAlister FA. Incidence of heart failure and mortality after acute coronary syndromes. *Am Heart J* 2013;165:379–385. e2.
9. Venkitachalam L, Kip KE, Mulukutla SR, Mulukutla SR, Selzer F, Laskey W, Slater J, Cohen HA, Wilensky RL, Williams DO, Marroquin OC, Sutton-Tyrrell K, Bunker CH, Kelsey SF, NHLBI-Sponsored Dynamic Registry Investigators. Temporal trends in patient-reported angina at 1 year after percutaneous coronary revascularization in the stent era: a report from the National Heart, Lung, and Blood Institute-sponsored 1997-2006 dynamic registry. *Circ Cardiovasc Qual Outcomes* 2009;2:607–615.
10. Ellis SG, Kereiakes DJ, Metzger DC, Caputo RP, Rizik DG, Teirstein PS, Litt MR, Kini A, Kabour A, Marx SO, Popma JJ, McGreevy R, Zhang Z, Simonton C, Stone GW, ABSORB III Investigators. Everolimus-Eluting bioresorbable scaffolds for coronary artery disease. *N Engl J Med* 2015;373:1905–1915.
11. Mudrick DW, Shah BR, McCoy LA, Lytle BL, Masoudi FA, Federspiel JJ, Cowper PA, Green C, Douglas PS. Patterns of stress testing and diagnostic catheterization after coronary stenting in 250 350 medicare beneficiaries. *Circ Cardiovasc Imaging* 2013;6:11–19.
12. Peterson T, Askew JW, Bell M, Crusan D, Hodge D, Gibbons RJ. Low yield of stress imaging in a population-based study of asymptomatic patients after percutaneous coronary intervention. *Circ Cardiovasc Imaging* 2014;7:438–445.
13. Shah BR, Cowper PA, O'Brien SM, Jensen N, Patel MR, Douglas PS, Peterson ED. Association between physician billing and cardiac stress testing patterns following coronary revascularization. *JAMA* 2011;306:1993–2000.
14. Mak KH, Eisenberg MJ, Tsang J, Okrainiec K, Huynh T, Brown DL. Clinical impact of functional testing strategy among stented and non-stented patients: insights from the ROSETTA Registry. *Int J Cardiol* 2004;95:321–327.
15. Stone GW, Rizvi A, Newman W, Mastali K, Wang JC, Caputo R, Doostzadeh J, Cao S, Simonton CA, Sudhir K, Lansky AJ, Cutlip DE, Kereiakes DJ, SPIRIT IV Investigators. Everolimus-eluting versus paclitaxel-eluting stents in coronary artery disease. *N Engl J Med* 2010;362:1663–1674.
16. Sabik JF 3rd, Lytle BW, Blackstone EH, Houghtaling PL, Cosgrove DM. Comparison of saphenous vein and internal thoracic artery graft patency by coronary system. *Ann Thorac Surg* 2005;79:544–551. discussion 544-551.
17. Rasmussen C, Thiis JJ, Clemmensen P, Efsen F, Arendrup HC, Saunamäki K, Madsen JK, Pettersson G. Significance and management of early graft failure after coronary artery bypass grafting: feasibility and results of acute angiography and re-re-vascularization. *Eur J Cardiothorac Surg* 1997;12:847–852.
18. Bernhardt P, Spiess J, Levenson B, Levenson B, Pilz G, Höfling B, Hombach V, Strohm O. Combined assessment of myocardial perfusion and late gadolinium enhancement in patients after percutaneous coronary intervention or bypass grafts: a multicenter study of an integrated cardiovascular magnetic resonance protocol. *JACC Cardiovasc Imaging* 2009;2:1292–1300.
19. Eisenberg MJ, Wou K, Nguyen H, Duerr R, Del Core M, Fourchy D, Huynh T, Lader E, Rogers FJ, Chaudhry R, Okrainec K, Pilote L. Lack of benefit for routine functional testing early after coronary artery bypass graft surgery: results from the ROSETTA-CABG Registry. *J Invasive Cardiol* 2006;18:147–152.
20. Lauer MS, Lytle B, Pashkow F, Snader CE, Marwick TH. Prediction of death and myocardial infarction by screening with exercise-thallium testing after coronary-artery-bypass grafting. *Lancet* 1998;351:615–622.
21. Cortigiani L, Ciampi Q, Rigo F, Bovenzi F, Picano E, Sicari R. Prognostic value of dual imaging stress echocardiography following coronary bypass surgery. *Int J Cardiol* 2019;277:266–271.