A Population-Based Study on the Use of Stress Testing after Percutaneous Coronary Interventions

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ABSTRACT

Background:

Although routine stress testing was once considered common practice after percutaneous coronary intervention (PCI) for the detection of in-stent restenosis or suboptimal results, recent studies suggest that they are rarely indicated. Our main objectives were to evaluate contemporary use of stress testing after PCI, assess temporal trends in utilization, and determine factors associated with their use.

Methods:

We conducted an observational study of all patients who had undergone PCI in Ontario, Canada from April 1, 2004 and March 31, 2012. The main outcome was stress testing within two years of PCI. Multivariable logistic regression models were constructed to determine factors associated with the use of stress tests.

Results:

Our cohort included 128,380 patients who received PCI procedures. The 2-year rate of stress testing significantly decreased from 68.1% for patients who received PCI in 2004 to 60.4% in 2012 (P < 0.001). Similar reductions were observed regardless of patients' risk of restenosis and types of stents received. Patients who were older, had diabetes, prior myocardial infarction, heart failure or other comorbidities were significantly less likely to receive stress tests. In contrast, patients with higher income and whose PCI was performed in a non-teaching hospitals were significantly more likely to receive stress testing.

Interpretation:

We observed a decreasing trend in the use of stress testing after PCI procedures over time. However, stress tests were not performed in accordance to patients' higher baseline risk of adverse outcomes or risk of restenosis. Instead, many non-clinical factors were associated with higher use of stress tests.

INTRODUCTION

It was only a decade ago when in-stent restenosis was considered the Achilles' heel of Percutaneous Coronary Intervention (PCI) procedures.[1] At that time, stress testing was recommended in patients who had undergone PCI to detect potential in-stent restenosis or progression of coronary atherosclerosis.[2] With the advent of the new drug eluting stents (DES), rates of in-stent restenosis have dramatically reduced and currently range from to 0-16% after PCI.[1] Recent reports have consistently shown that routine ischemic evaluations are of low diagnostic yield for patients after PCI.[3, 4] In the latest practice guidelines, a class III recommendation was given to routine stress testing for asymptomatic patients after PCI procedures.[5] The appropriateness use criteria identified that stress testing is rarely indicated within two years after PCI procedures.[6] The "Choosing Wisely Initiative" has supported the latest guidelines and also suggested that routine stress tests may lead to unnecessary invasive procedures (and potentially unnecessary radiation exposure when nuclear perfusion imaging is concomitantly performed) without any proven impact on patients' outcomes.[7]

Most of the studies evaluating the use of ischemic evaluations after PCI have been conducted in the United States,[8-10] which has different methods in financing health care when compared with the Canadian health care system.[11, 12] In fact, little is known about the patterns of stress testing after PCI in the Canadian setting. To address this gap in knowledge, the main objectives of this study were to evaluate contemporary use of stress testing after PCI, assess temporal trends in utilization, and determine factors associated with their use.

METHODS

Data sources

PCI data were obtained from the Cardiac Care Network of Ontario Cardiac Registry, which collects information on all patients undergoing cardiac catheterization, PCI, cardiac surgery, and electrophysiology procedures in Ontario. Nurse coordinators at each cardiac invasive center gather data on demographics, clinical characteristics, procedure characteristics (including stent type) and relevant comorbid conditions. Our group has used these data extensively to perform evaluative analyses.[12-15] The Ontario Health Insurance Plan claims database, which captures information on services provided by practicing physicians, was used to identify physician visits and ischemic evaluations. The Canadian Institute of Health Information Discharge Abstract Database, which includes information regarding hospitalizations, was used to identify in-hospital stress testing and additional comorbidities. The Ontario Registered Persons Database, which contains vital statistics for all Ontarians, was used to determine rural residency and mortality after the index event. Statistics Canada Census data were used to determine socioeconomic status of each patient. These datasets were linked using unique encoded identifiers and analyzed at the Institute for Clinical Evaluative Sciences.

Study population

The study population consisted of patients older than 18 years who had a PCI procedure from April 1, 2004 to March 31, 2012. Patients with invalid health card numbers, who had previous PCI or previous coronary artery bypass grafting surgery, or were not residents of Ontario were excluded. We did not include patients who had prior cardiac revascularizations in order to evaluate the initial care patterns after first PCI. For patients who had multiple PCI procedures during the study period, the first procedure was considered as the index event for the study inclusion.

Main outcome

The main outcome of our study was stress testing within two years of PCI. A two-year timeframe after PCI was chosen because practice guidelines suggest stress testing within this window is rarely indicated.[6] We considered stress testing as exercise or pharmacological tests, with or without an accompanying imaging modality. Performance of these tests was identified using a combination of billing codes from Ontario Health Insurance Plan (G112, G174, G319, G567-8, G571-2, J607-8, J807-8) and the Discharge Abstract Database using Classification of Health Intervention code (2HZ08E).

Statistical analysis

The patient cohort was categorized by the Canadian fiscal year (April 1 to March 31) of the index PCI procedure. Temporal trends in baseline characteristics of a) all PCI patients and b) patients who received stress testing were evaluated using the Cochran-Armitage Trend test for categorical variables, and linear regression for continuous variables, using procedure year as the independent variable. Temporal trends in stress testing at two years were evaluated in all patients, and according to predicted baseline risk of repeat revascularization, stent types (bare metal stent or DES), and both risk and stent type. Predicted risk of revascularization was modelled using logistic regression with the following variables in accordance to our prior study: age, diabetes status, stent length, and stent size.[16]

We compared demographic, clinical and procedural characteristics among patients who received ischemic evaluations within two years versus those who did not. This was done using chi-square tests for categorical variables and t-tests for continuous variables. Multivariable logistic regression models were developed to assess the association between clinical and non-clinical factors in the use of ischemic evaluation. Candidate variables were selected based on prior literature and clinical knowledge, and included: demographic factors (age, sex, income, rural residency), cardiac risk factors (diabetes, hypertension, dyslipidemia, smoking), angina classification, comorbidities (myocardial infarction, heart failure, peripheral vascular disease, cerebrovascular disease, renal failure, chronic obstructive pulmonary disease), PCI characteristics (stent type, size, length) and teaching hospital status.

Data were analyzed with SAS version 9.3 (SAS Institute Inc., Cary, NC). This study was approved by the institutional review board at Sunnybrook Health Sciences Centre, Toronto, Canada. Informed consent was not required in accordance with Ontario law, which permits the use of administrative data for research purposes by prescribed entities. Two-tailed p values less than 0.05 were considered significant.

RESULTS

Study cohort

From April 1, 2004 to March 31, 2012, 191,614 patients over the age of 18 years received PCI procedures in Ontario, Canada. We excluded 41,557 records because of multiple PCI procedures during the study period and 21,677 records because of prior PCI or coronary artery bypass grafting surgery. After these exclusions, our final cohort included 128,380 patients.

Characteristics of PCI patients

The mean age of the patients undergoing PCI was 63.1 years, 71.2% were men, and the overall use of DES was 42.1%. Over the study period (Table 1), we observed increasing mean age from 62.3 years in 2004 to 64.1 years in 2012, increasing rates of diabetes (28.6% to 33%), hypertension (68% to 74.7%), and hyperlipidemia (53.7% to 63.2%). There were also significantly higher rates of prior myocardial infarction, renal failure, and chronic obstructive pulmonary disease for patients who had PCI in 2012 as compared with 2004.

The characteristics of patients who received stress testing within two years of PCI categorized by fiscal year are shown in Appendix Table 1. The mean age of the patients who received stress tests after PCI was 60.7 years, 74.9% were men, and the overall use of DES was 46.2%. Temporal changes in characteristics among patients who received stress test mirrored the overall PCI cohort with higher rates of cardiac risk factors and comorbidities. Stress testing was performed more frequently among patients with DES and single vessel stenting in 2012 as compared with 2004.

Trends in the use of ischemic evaluations

Figure 1 shows the trends in use of stress testing within 6 months, and 2 years after PCI procedures. The 2-year rate of stress testing significantly decreased from 68.1% for patients who received PCI in 2004 to 60.4% in 2012 (P < 0.001). Trends in ischemic evaluations according to predicted revascularization risk and stent type is shown in Figure 2a and 2b. Patients who had high, medium or low predicted risk of repeat revascularization had similar rates of testing and similar declining trends of testing. A similar decline was also seen among patients who received bare metal stents and DES. Higher rates of ischemic evaluations were observed consistently among patients who received DES in the entire study period, irrespective of their risk of predicted repeat revascularization (Figure 2).

Factors associated with ischemic evaluations

Comparison between patients who had testing and no testing is shown in Table 2. Patients who received testing were significantly younger (60.7 years vs. 67.6 years), more likely to be men, at higher income quintile, and received PCI in a non-teaching hospital. Patients who were tested were also more likely to have fewer cardiac risk factors, and fewer comorbidities (mean Charlson's score 0.47 vs. 0.90).

A multivariable model incorporating factors to predict the use of stress testing within two years is shown in Table 2. We observed lower odds of stress testing according to procedure year (OR 0.96, 95% CI 0.96-0.97) after adjusting for clinical and non-clinical factors. Older age, cardiac risk factors, and prior comorbidities were associated with significantly lower odds of stress testing. Each year increase in age was associated with lower odds or stress testing (OR 0.958, 95% CI 0.957-0.959). Patients who had prior myocardial infarction (OR 0.86, 95% CI 0.83-0.88), heart failure (OR 0.57, 95% CI 0.54-0.60) or bare metal stent implantation (OR 0.87, 95% CI 0.84-0.89) were associated with significantly lower odds of ischemic evaluations.

For non-clinical factors, patients who had PCI procedures performed in a non-teaching hospital almost had twice the odds of having ischemic evaluations after PCI (OR 1.90, 95% CI 1.85-1.95). Other non-clinical factors that were independently associated with ischemic evaluations included higher income quintile where a graded response was observed, and urban residency (OR 1.19, 95% CI 1.15-1.23).

INTERPRETATION

Several key findings were demonstrated in this population-based study of patients who received PCI procedures in Ontario, Canada. First, we observed a declining trend in the use of stress testing during the study period, which was consistent in all patient subgroups. Despite the encouraging trend, more than 60% of patients who received PCI in 2012 still received stress tests within 2 years of having PCI. Further, the use of stress testing was not based on the patients' risk of adverse events or their risk of restenosis. Instead, the performance of stress testing appeared discretionary favoring patients who were younger, at higher socioeconomic status, had fewer comorbidities, and who underwent PCI at non-teaching facilities. These finding, together with recent reports demonstrating the low diagnostic yield of routine stress testing after PCI, suggest there is an opportunity to reduce routine stress testing in this population may potentially optimize health care resource utilization.

The United States market-oriented health care system with limited governmental control is different from Canada's single-payer system with governmental reimbursement of most health care services. [11, 12] In Ontario, the provincial government sets targets on procedure volumes and number of cardiac catheterization facilities based on the anticipated needs of the population. In contrast, the majority of the stress tests are performed in the ambulatory setting in which the government reimburses the fees associated with these tests without a threshold. Our group has previously shown that the United States performs almost twice as many cardiac invasive procedures in stable coronary disease as Canada.[11, 12] It is therefore interesting to see that rates of stress testing after PCI appear in line with those reported from the United States. For example, Shah and colleagues evaluated a national health insurance claims database from 2004 to 2007, and found 61% aged 18 to 64 years received stress tests within 2 years after PCI.[8] In the Medicare population, rate of stress testing was estimated at 49%.[9] The rate at the Veterans Affair population was slightly lower at 40%.[10]

Stress testing was once considered routine after PCI procedures because it is commonly believed that symptoms after PCI procedures are not a reliable indicator of restenosis and/or progression of coronary artery disease.[2] Thus, objective evaluation of ischemia was believed to be helpful in the detection of in-stent restenosis or suboptimal interventional results.[2, 17] As outcomes of PCI have improved substantially over time, many guidelines have now considered routine stress testing for asymptomatic patients after coronary revascularization to be unnecessary.[5, 6] Although a declining trend in stress testing was observed in our cohort, future efforts are required to continue to monitor the use of stress testing to ensure this declining practice continues to occur.

The term "treatment risk paradox" has been previously described by our group as a pervasive pattern in medicine whereby treatment propensity decreases as patient risk increases.[18] In a similar manner, we observed that patients who are at highest risk of adverse cardiac outcomes or in-stent restenosis were much less likely to receive ischemic testing. In addition, non-clinical factors such as the location where the procedure was performed, the place of residence of the patient, and the socioeconomic status of the patient were associated with stress test use. It has been previously shown that patients who are part of the higher income bracket are less satisfied with the Canadian health care system than patients at lower income levels.[19] In addition, it is likely that patients at higher socioeconomic status have greater access to stress testing facilities. It is possible that a proportion of the stress tests were performed for the purpose of reassuring patients at higher socioeconomic levels.

Several limitations of our study warrant consideration. First, several studies from the United States used a 90 day blanking period to exclude patients who had stress test as part of cardiac rehabilitation. However, this strategy was not used in our study because it would exclude many stress tests that are not related to cardiac rehabilitation because access to rehabilitation is more limited in Canada. Using data from a clinical rehabilitation registry, we estimated that only 5.8% of patients were referred to cardiac rehabilitation for cardiopulmonary assessments within 90 days of PCI, as compared with 25.9% of patients who received stress test after PCI in this period. Second, our datasets do not include any information on whether patients undergoing stress tests were symptomatic or asymptomatic prior to their assessment. However, this limitation is inherent to most of the studies on this topic that are unable to determine appropriateness of the stress test itself.[9] Accordingly, our study cannot be definitively to suggest that the stress test are inappropriate after PCI. Nevertheless, observations from our study and others are consistent that additional efforts are needed to ensure appropriate use of stress tests after PCI procedures in the future.

In summary, clinicians appear to have responded to recent evidence by reducing the number of ischemic evaluations after PCI. However, there remains a treatment risk paradox whereby other factors apart from the risk of restenosis influence the likelihood of a patient receiving these tests. Understanding how to manage patient and clinician expectations in order to align with the latest clinical information and practicing guidelines may be important in further reducing the use of routine stress testing after PCI.

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Figure legends

Figure 1: Trends over time (2004 to 2012) in stress test rates within 6 months and 2 years of PCI procedures.

Figure 2a: Trends over time (2004 to 2012) in stress test rates categorized by risk of in stent restenosis (low risk, medium risk and high risk).

Figure 2b: Trends over time (2004 to 2012) in stress test rates divided by type of stent used during PCI (DES versus BMS).

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Table 1. Trends in the demographic and clinical characteristics of patients who underwent PCI from fiscal year 2004 to 2012

Characteristics	2004 N=13,733	2005 N=14,299	2006 N=14,462	2007 N=13,341	2008 N=13,778	2009 N=14,299	2010 N=14,862	2011 N=14,531	2012 N=15,075	*P*-value for trend
Demographics										
Age, mean ± SD, years	62.3 ± 11.9	62.7 ± 12.0	62.7 ± 12.0	62.6 ± 12.1	62.9 ± 12.3	63.1 ± 12.4	63.5 ± 12.4	63.9 ± 12.5	64.1 ± 12.4	0.007
Men	71.6%	71.8%	72.9%	72.0%	71.1%	70.3%	70.3%	70.5%	70.2%	<0.001
Residing in a rural area	15.3%	14.9%	14.7%	15.1%	14.4%	14.5%	15.1%	15.0%	14.9%	0.749
Income quintile										
1 (lowest)	19.7%	20.4%	20.1%	20.2%	19.7%	19.8%	20.5%	19.9%	19.9%	0.875
2	21.1%	20.6%	21.1%	20.2%	20.3%	20.3%	20.4%	20.0%	20.7%	0.072
3	19.5%	20.1%	18.9%	19.3%	20.1%	20.0%	19.8%	20.5%	20.2%	0.015
4	20.2%	19.6%	19.8%	20.4%	19.8%	20.4%	19.6%	20.1%	20.2%	0.603
5 (highest)	19.1%	19.0%	19.7%	19.6%	19.7%	19.1%	19.3%	19.1%	18.6%	0.207
CCS angina classification										
0	7.0%	7.3%	6.5%	5.0%	5.4%	5.2%	5.4%	5.5%	6.2%	<0.001
1	5.2%	5.0%	4.7%	3.5%	3.6%	4.1%	4.5%	4.5%	4.8%	0.055
2	14.8%	15.2%	14.7%	12.9%	12.3%	13.0%	12.8%	13.0%	12.1%	<0.001
3	20.0%	19.9%	14.3%	13.2%	11.3%	10.0%	9.0%	8.5%	8.2%	<0.001
4+	45.1%	48.0%	58.3%	64.0%	66.4%	67.2%	68.2%	68.4%	66.5%	<0.001
Cardiac risk factors and comorbidities										
Diabetes	28.6%	29.5%	30.3%	29.7%	30.6%	30.4%	31.8%	31.8%	33.0%	<0.001
Hypertension	68.0%	69.6%	74.2%	73.4%	74.0%	73.5%	74.6%	74.1%	74.7%	<0.001
Hyperlipidemia	53.7%	54.6%	68.8%	67.3%	66.7%	65.7%	65.3%	63.8%	63.2%	<0.001
Myocardial Infarction	45.6%	44.0%	43.0%	46.1%	51.5%	58.5%	58.5%	57.1%	54.0%	<0.001
Heart failure	5.9%	5.5%	7.8%	6.9%	7.0%	6.5%	6.5%	6.0%	6.4%	0.940
History of stroke	1.8%	1.7%	1.5%	1.7%	1.4%	1.5%	1.8%	1.6%	1.7%	0.875
Peripheral vascular disease	5.9%	6.2%	6.2%	6.1%	5.9%	5.7%	5.6%	5.2%	5.2%	<0.001
Renal failure	2.9%	2.9%	2.8%	2.8%	2.8%	3.1%	3.4%	3.7%	3.4%	<0.001

Chronic obstructive pulmonary disease	5.9%	5.6%	7.2%	7.4%	7.1%	7.1%	7.1%	7.1%	7.0%	<0.001
Smoking history	48.8%	49.3%	54.8%	55.7%	53.8%	55.3%	53.4%	51.5%	50.1%	0.017
Charlson's comorbidity index (mean, SD)	0.55 ± 1.03	0.48 ± 1.01	0.50 ± 1.09	0.49 ± 1.09	0.44 ± 1.02	0.44 ± 1.05	0.44 ± 1.06	0.43 ± 1.05	0.45 ± 1.03	<0.001
PCI characteristics										
Stent type										
Drug eluting stent	44.8%	50.5%	46.3%	33.6%	37.1%	37.3%	37.9%	41.9%	49.0%	<0.001
Bare metal stent	62.2%	55.2%	59.5%	69.0%	62.9%	61.5%	61.9%	57.2%	50.0%	<0.001
Number of stented vessels										
1 vessel	53.1%	50.8%	51.1%	53.8%	53.8%	55.2%	56.4%	57.1%	56.9%	<0.001
2 vessels	25.1%	26.0%	26.1%	25.2%	25.8%	25.7%	25.4%	25.2%	25.2%	0.299
3 or more vessels	16.7%	17.4%	18.0%	16.5%	15.0%	13.3%	13.2%	12.6%	13.0%	<0.001
Stent size										
≤3mm diameter	45.8%	49.1%	48.6%	45.1%	45.6%	45.7%	45.9%	48.3%	50.1%	0.001
>3mm diameter	49.2%	45.0%	46.7%	50.3%	48.8%	48.5%	49.2%	46.4%	44.8%	0.002
Total Stent length										
<20 mm	35.3%	33.2%	34.1%	37.5%	34.9%	34.1%	35.0%	33.8%	31.1%	<0.001
≥20 mm	59.7%	61.0%	61.1%	57.9%	59.6%	60.0%	60.0%	60.9%	63.7%	<0.001

*Abbreviations: CCS, Canadian Cardiovascular Society; SD, standard deviation

Table 2. Predictors of stress tests within 2 years of having PCI

Characteristics	Stress test N=83,636	No stress test N=44,744	Odds ratio (95% CI)
Demographics			
Age, mean ± SD, years	60.68 ± 11.25	67.61 ± 12.73	0.958 (0.957-0.959)
Men	74.9%	64.3%	1.22 (1.19-1.26)
Residing in a rural area	14.1%	16.4%	0.84 (0.81-0.87)
Teaching hospital	61.3%	75.9%	0.52 (0.50-0.53)
Income quintile			
1 (lowest)	18.6%	22.8%	Reference
2	20.0%	21.5%	1.29 (1.08-1.17)
3	20.1%	19.5%	1.20 (1.15-1.27)
4	20.8%	18.6%	1.26 (1.21-1.32)
5 (highest)	20.3%	17.3%	1.37 (1.32-1.43)
Procedure year	N/A		0.96 (0.96-0.97)
Canadian cardiovascular society angina classification			
1	4.7%	3.9%	1.22 (1.12-1.32)
2	14.3%	11.9%	1.26 (1.19-1.35)
3	12.6%	12.8%	1.05 (0.98-1.11)
4+	60.7%	62.8%	0.97 (0.92-1.02)
Cardiac risk factors and comorbidities			
Diabetes	27.7%	36.3%	0.83 (0.80-0.85)
Hypertension	69.6%	79.0%	0.95 (0.91-0.98)
Hyperlipidemia	62.8%	64.0%	1.15 (1.12-1.18)
Myocardial Infarction	48.9%	55.0%	0.86 (0.83-0.88)
Heart failure	3.7%	11.8%	0.57 (0.54-0.60)
History of stroke	1.1%	2.7%	0.78 (0.71-0.86)
Peripheral vascular disease	4.1%	8.9%	0.75 (0.71-0.79)
Renal failure	1.8%	5.5%	0.79 (0.72-0.85)
Chronic obstructive pulmonary disease	4.9%	10.5%	0.76 (0.72-0.80)
Smoking history	53.2%	51.1%	0.89 (0.87-0.92)
Mean Charlson's comorbidity index	0.47 ± 1.05	0.90 ± 1.58	0.94 (0.93-0.95)
PCI characteristics			
Stent type			
Drug eluting stent	43.8%	39.0%	Reference
Bare metal stent	59.7%	59.9%	0.87 (0.84-0.89)
Number of stented vessels			
1	46.7%	48.0%	Reference
2	49.4%	44.3%	1.01 (0.98-1.05)
≥3	3.9%	7.7%	1.00 (0.96-1.05)
Stent size			
<3mm diameter	46.7%	48.0%	Reference
≥3mm diameter	49.4%	44.3%	1.05 (1.02-1.08)
Total stent length			
<20 mm	34.8%	33.2%	Reference
≥20 mm	61.2%	59.1%	1.00 (0.96-1.03)

* Abbreviations: CI, confidence intervals; SD, standard deviation; N/Aj, not applicable.

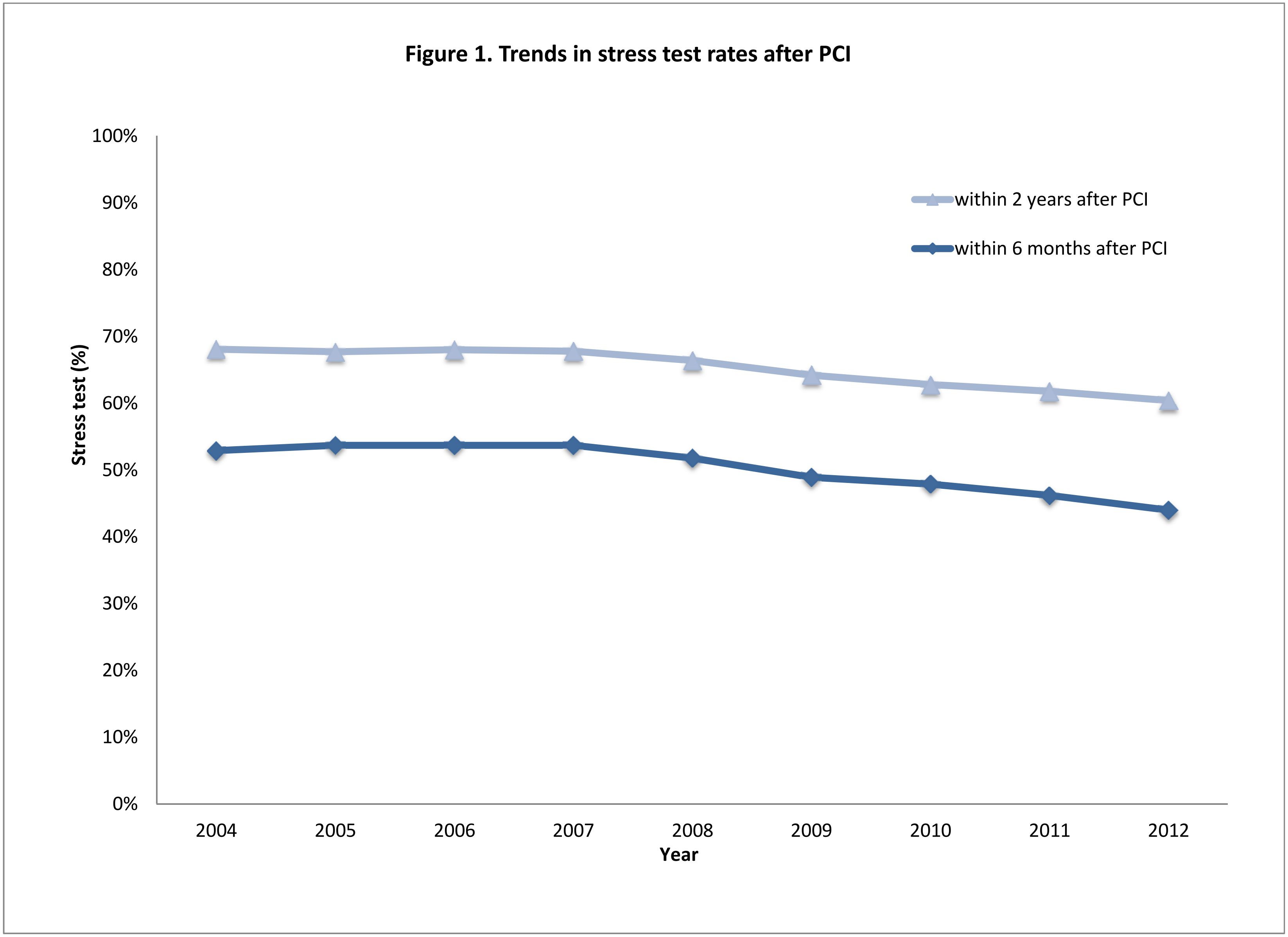


Figure 1. Trends in stress test rates after PCI
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Stress test (%)
within 2 years after PCI
within 6 months after PCI
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

Figure 2a. Trends of stress tests after PCI by risk of in stent restenosis

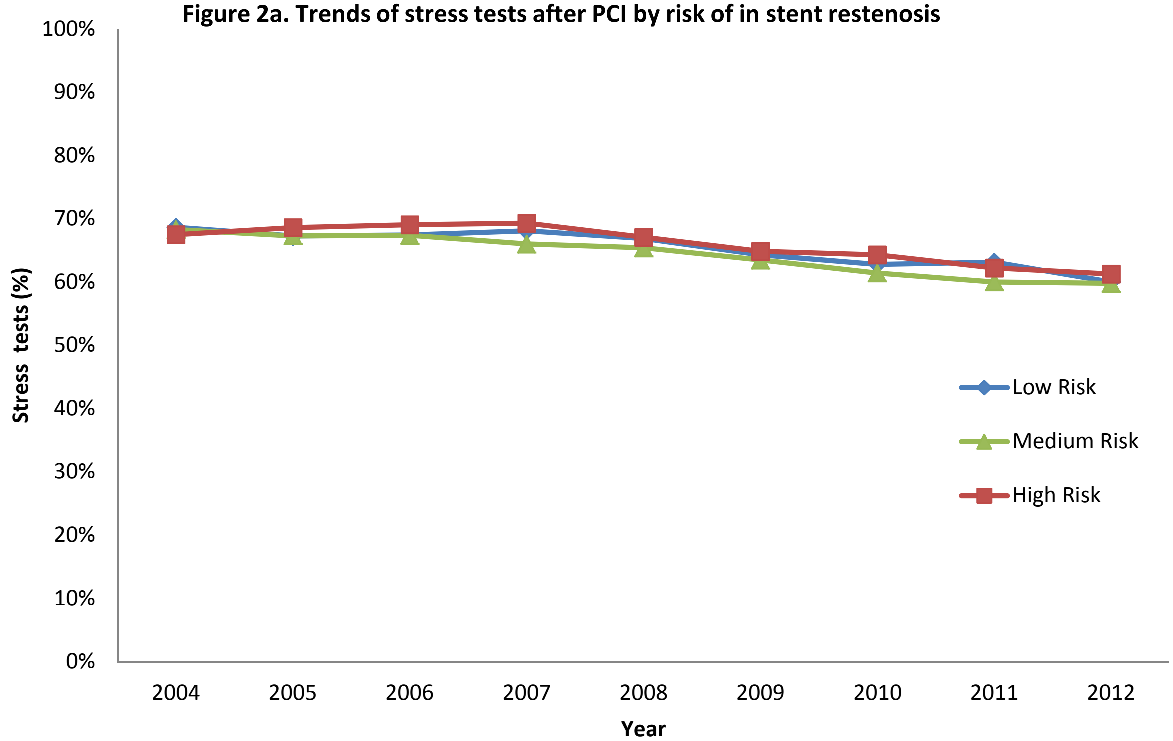
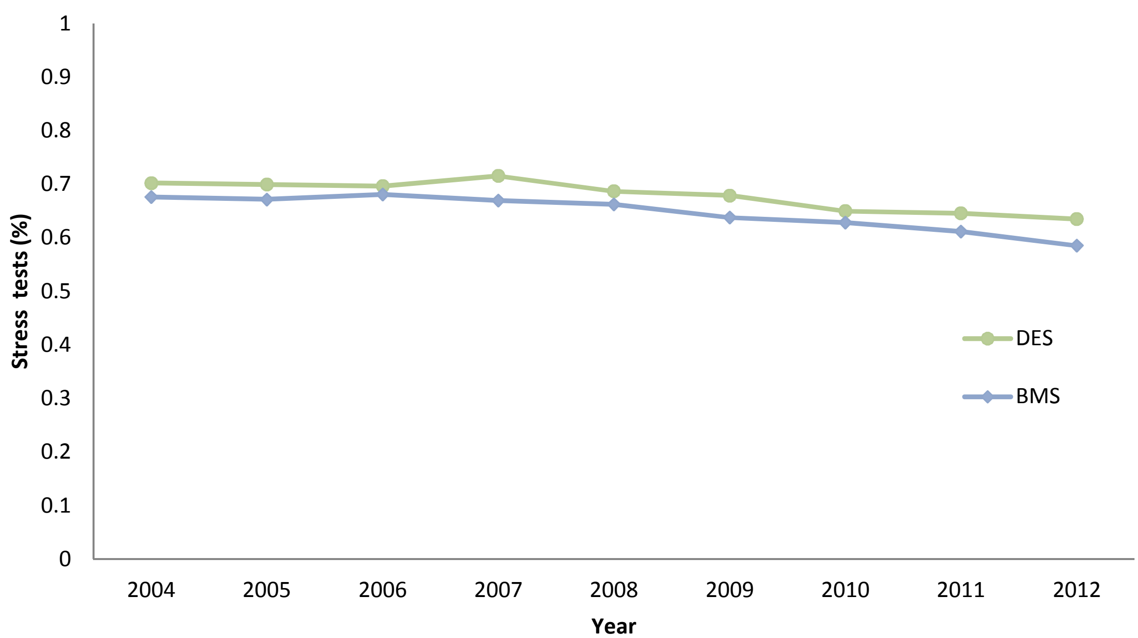


Figure 2b. Trends of stress tests after PCI in patients by stent type



Appendix Table 1. Trends in the demographic and clinical characteristics of patients who underwent stress tests within 2 years of having PCI

Characteristics	2004 N= 9355	2005 N= 9685	2006 N= 9827	2007 N= 9040	2008 N= 9151	2009 N= 9176	2010 N= 9328	2011 N= 8974	2012 N= 9100	*P* -value for trend
Demographics										
Age, mean ± SD, years	60.2 ± 11.1	60.5 ± 11.2	60.6 ± 11.2	60.3 ± 11.2	60.5 ± 11.3	60.6 ± 11.3	60.9 ± 11.3	61.1 ± 11.4	61.5 ± 11.2	<0.001
Men	74.6%	75.4%	76.8%	75.4%	74.9%	73.7%	74.1%	74.5%	74.2%	<0.001
Residing in a rural area	14.1%	14.4%	13.8%	14.1%	13.2%	13.5%	14.7%	14.6%	14.5%	0.202
Income quintile										
1 (lowest)	18.4%	18.8%	18.9%	18.8%	18.1%	18.6%	18.7%	18.1%	18.5%	0.408
2	20.4%	20.5%	20.6%	19.8%	19.9%	20.0%	19.7%	19.3%	20.0%	0.031
3	19.6%	20.6%	18.9%	19.3%	20.4%	20.0%	20.2%	20.9%	20.6%	0.015
4	21.4%	20.2%	20.3%	21.1%	20.3%	20.8%	20.8%	2130.0%	20.8%	0.634
5 (highest)	19.9%	19.7%	20.9%	20.8%	20.9%	20.4%	20.1%	20.1%	19.8%	0.850
CCS angina classification										
0	6.4%	7.1%	6.1%	4.8%	5.0%	4.8%	5.0%	5.2%	6.0%	<0.001
1	5.2%	5.1%	5.0%	3.8%	3.9%	4.3%	5.0%	4.8%	5.2%	0.593
2	16.3%	16.1%	15.5%	13.5%	13.0%	13.9%	13.2%	13.7%	12.9%	<0.001
3	20.1%	19.3%	13.8%	13.0%	11.3%	9.8%	8.6%	8.5%	8.0%	<0.001
4+	44.6%	47.5%	58.0%	63.5%	65.7%	66.8%	68.0%	67.8%	66.0%	<0.001
Cardiac risk factors and comorbidities										
Diabetes	26.0%	27.0%	27.8%	27.6%	27.5%	27.6%	28.3%	28.0%	29.5%	<0.001
Hypertension	64.8%	66.5%	71.4%	70.2%	70.9%	70.7%	71.2%	70.2%	71.2%	<0.001
Hyperlipidemia	53.6%	54.0%	68.7%	67.5%	66.3%	65.4%	64.9%	63.3%	62.1%	<0.001
Myocardial Infarction	44.2%	42.0%	41.6%	44.2%	49.7%	56.4%	57.0%	54.7%	51.5%	<0.001
Congestive heart failure	3.7%	3.2%	5.1%	4.2%	3.6%	3.4%	3.6%	2.9%	3.4%	<0.001
History of stroke	1.3%	1.2%	1.0%	1.1%	1.0%	1.0%	1.1%	1.0%	1.1%	0.140
Peripheral vascular disease	4.4%	4.3%	4.4%	4.5%	3.9%	4.1%	4.0%	3.5%	3.5%	<0.001
Renal failure	2.0%	1.7%	1.9%	1.8%	1.3%	1.9%	1.9%	2.2%	1.9%	0.213
Chronic obstructive pulmonary disease	4.3%	3.9%	5.4%	5.3%	5.0%	5.2%	5.1%	5.0%	4.9%	0.003

Smoking history	49.4%	49.9%	55.0%	56.7%	55.1%	55.8%	54.3%	52.6%	50.4%	0.010
Charlson's comorbidity index (mean, SD)	0.55 ± 1.03	0.48 ± 1.01	0.50 ± 1.09	0.49 ± 1.09	0.44 ± 1.02	0.44 ± 1.05	0.44 ± 1.06	0.43 ± 1.05	0.45 ± 1.03	<0.001
PCI characteristics										
Stent type										
Drug eluting stent	46.2%	52.1%	47.5%	35.5%	38.4%	39.4%	39.3%	43.8%	51.6%	<0.001
Bare metal stent	49.7%	43.3%	49.0%	61.1%	57.3%	56.6%	57.2%	52.4%	44.7%	<0.001
Number of stented vessels										
1 stent	54.6%	52.0%	52.6%	54.6%	55.1%	57.4%	58.0%	58.8%	58.2%	<0.001
2 stents	25.2%	26.1%	26.2%	25.4%	25.9%	25.7%	25.8%	25.3%	25.5%	0.637
3 or more stents	16.1%	17.4%	17.8%	16.5%	14.8%	12.9%	12.7%	12.2%	12.6%	<0.001
Target vessel size										
≤3mm diameter	45.2%	48.7%	48.3%	44.7%	45.0%	45.3%	45.7%	47.6%	49.6%	0.028
>3mm diameter	50.7%	46.8%	48.2%	51.8%	50.6%	50.7%	50.7%	48.6%	46.5%	0.100
Target lesions length										
<20 mm	36.1%	33.4%	34.5%	37.8%	35.1%	35.1%	35.5%	34.9%	31.2%	<0.001
≥20 mm	59.9%	62.0%	62.0%	58.8%	60.5%	60.9%	60.9%	61.2%	64.9%	<0.001

*Abbreviations: CCS, Canadian Cardiovascular Society; SD, standard deviation