Appropriate Use Criteria for Coronary Revascularization and Trends in Utilization, Patient Selection and Appropriateness of Percutaneous Coronary Intervention:

Trends in Appropriateness of PCI

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Abstract

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Importance—Appropriate Use Criteria for coronary revascularization were developed to critically evaluate and improve patient selection for percutaneous coronary intervention (PCI). National trends in the appropriateness of PCI have not been examined.

Objective—To examine trends in PCI utilization, patient selection, and procedural appropriateness following the introduction of Appropriate Use Criteria.

Design, Setting, Participants—Multi-center, longitudinal, cross-sectional analysis of patients undergoing PCI between July 1, 2009 and December 31, 2014 at hospitals continuously participating in NCDR-CathPCI Registry over the study period.

Main Outcome Measures—Proportion of non-acute PCIs classified as inappropriate at the patient- and hospital-level using the 2012 Appropriate Use Criteria for Coronary Revascularization.

Results—A total of 2.7 million PCI procedures from 766 hospitals were included. Annual PCI volume for acute indications was consistent over the study period (2010: 377,540; 2014: 374,543), but the volume for non-acute PCIs decreased from 89,704 in 2010 to 59,375 in 2014. Among patients undergoing non-acute PCI, there were significant increases in angina severity (CCS III/IV angina, 15.8% and 38.4% in 2010 and 2014 respectively), use of anti-anginal medications prior to PCI (at least 2 anti-anginal medication, 22.3% and 35.1% in 2010 and 2014 respectively), and high-risk findings on non-invasive testing (22.2% and 33.2% in 2010 and 2014 respectively) (p<0.001 for all), but only modest increases in multivessel CAD (43.7% and 47.5% in 2010 and 2014 respectively, p<0.001). The proportion (95% CI) of non-acute PCIs classified as inappropriate decreased from 26.2% (95% CI, 25.8%–26.6%) to 13.3% (95% CI, 13.1%–13.6%) and the absolute number of inappropriate PCIs decreased from 21,781 to 7,921. Hospital-level variation in the proportion of PCIs classified as inappropriate was persistent over the study period (median 12.6%, IQR 5.9%–22.9% in 2014).

Conclusions and Relevance—Since the publication of the Appropriate Use Criteria for Coronary Revascularization in 2009, there have been significant reductions in non-acute PCI volume. The proportion of non-acute PCIs classified as inappropriate has declined though hospital-level variation in inappropriate PCI persists.

Introduction

In 2009, the American College of Cardiology, the American Heart Association, along with other professional societies released Appropriate Use Criteria for Coronary Revascularization to critically examine and improve patient selection for PCI as well as address concerns about potential overuse.[1,2] Prior studies demonstrated that 1 in 6 non-acute PCIs were classified as inappropriate (new Appropriate Use Criteria documents use the term 'rarely appropriate'), indicating that the benefits of the procedure were unlikely to outweigh the risks.[3,4] Furthermore, there was substantial variation in the proportion of non-acute PCI considered inappropriate across hospitals.[3,4] These findings received considerable attention in both the academic literature and media[5,6], prompting numerous efforts to improve the appropriateness of PCI.

In 2011, the National Cardiovascular Data Registry's CathPCI Registry (NCDR CathPCI) began providing hospitals information about their performance on PCI appropriateness, which were benchmarked against other participating hospitals. Simultaneously, national quality improvement campaigns such as the American Board of Internal Medicine's Choosing Wisely Initiative, identified PCI appropriateness as a key area for intervention,[7] insurers incorporated measures of PCI appropriateness into pay-for-performance programs,[8] and some payers declined reimbursement for certain PCIs classified as inappropriate.[9]

Despite the attention the appropriateness of PCI has received, there has been no comprehensive, national examination of trends in the indications, patient characteristics, and appropriateness of PCI procedures following the introduction of the Appropriate Use Criteria. Similarly, the extent of hospital-level variation in the proportion of non-acute PCI considered inappropriate has not been systematically examined over time. To address these gaps in knowledge, we examined national trends in patient selection for PCI, changes in PCI appropriateness, and hospital variation in inappropriate PCI using the registry.

Methods

Data Source and Appropriate Use Criteria

Details of the registry have been described previously.[10,11] In brief, NCDR CathPCI is the largest national registry of diagnostic cardiac catheterization and PCI with more than 1500 participating institutions. Detailed information on clinical characteristics, cardiac testing, angiographic findings, as well as in-hospital management and clinical outcomes are collected by trained staff at participating hospitals using a standardized data collection form (http://cvquality.acc.org/en/NCDR-Home/Data-Collection/What-Each-Registry-Collects.aspx). All data submissions must meet specified quality standards and randomly identified sites are monitored through annual audits. The Human Investigation Committee of the Yale University School of Medicine approved the use of a limited dataset from the registry for research without requiring informed consent.

The methodology used to develop the Appropriate Use Criteria for Coronary Revascularization has been previously described (see Box for additional details).[1,12,13] The registry has developed validated algorithms mapping data collected using version 4 of the data collection form (beginning July 2009) to the Appropriate Use Criteria.[3] The initial Appropriate Use Criteria for Coronary Revascularization were revised in 2012 to provide greater specificity in defining non-acute indications.[12] For this analysis, we exclusively used the 2012 Appropriate Use Criteria.

An overview of the 2012 Appropriate Use Criteria for Coronary Revascularization and methodology for determination of the appropriateness of PCI

The methodology for developing the Appropriate Use Criteria for coronary revascularization, which are based upon the modified RAND methodology and reflect a synthesis of contemporary clinical trial evidence, clinical practice guidelines, and expert opinion, has been previously described[14] Using a modified Delphi approach, a 17-member expert panel adjudicated the appropriateness of coronary revascularization,

compared with medical therapy, for 198 distinct clinical indications, which were categorized by the clinical indication, angiographic severity, magnitude of ischemia, severity of angina symptoms and intensity of medical therapy. From the individual ratings of the technical panel members, each clinical indication was classified as appropriate, uncertain, or inappropriate. An 'Appropriate' rating denotes that coronary revascularization, as compared with medical therapy, would likely improve a patient's health status (symptoms, function, or quality of life) or survival, an 'Uncertain' rating implies that more research and/or patient information is needed to further classify the indication, and an 'Inappropriate' rating suggests that the benefits of coronary revascularization are unlikely to outweigh the risks.

For additional details see: 2012 Appropriate Use Criteria for Coronary Revascularization.[12]

Study Population and Definitions

The study cohort included all PCIs in the NCDR registry between July 1st, 2009 and December 31st, 2014. To accurately assess trends in appropriateness, we restricted our cohort to PCIs performed at hospitals that participated continuously in the registry during the entire study period. For patients undergoing multiple PCIs in a single visit, only the first PCI was included. We excluded hospitals that performed an average of fewer than 10 non-acute PCIs in each calendar year to provide more robust estimates of hospital performance.

Each PCI in our study cohort was initially classified as acute, non-acute, or non-mappable. Acute PCI were defined as those performed in the setting of an acute coronary syndrome. Non-mappable PCIs were PCIs which could not be classified because of missing data elements (typically because non-invasive testing was not performed or not available). All other PCIs were considered non-acute. Each mappable PCI was then assigned a rating of procedural appropriateness (appropriate, uncertain, or inappropriate) based upon the 2012 Appropriate Use Criteria for Coronary Revascularization.[12]

Statistical Analysis

All analyses were performed at either the patient-level, using all PCIs to calculate an estimate, or at the hospital-level, aggregating each hospitals' data to calculate a hospital specific estimate.

PCI volume and the relative proportions of acute, non-acute, and non-mappable PCIs were examined at the patient-level by year. Hospital-level variation in the proportions of PCIs for acute, non-acute, and non-mappable indications was examined across calendar year. Median hospital-level proportions with interquartile ranges (IQRs) were used to characterize the distribution and are displayed using box plots.

Baseline demographic and clinical characteristics as well as clinical presentation, background medical therapy, and results from non-invasive and angiographic studies were compared over time for all patients undergoing PCI and among those undergoing non-acute PCI. The proportions of appropriate, inappropriate, and uncertain PCIs at the patient-level

were calculated for each 6-month interval and compared over time. The proportion of non-acute PCIs considered inappropriate at the hospital level was calculated by aggregating all non-acute PCIs in the calendar year and displayed using box plots.

To identify the presence of different subgroups of hospital-level change in proportion of inappropriate PCI, we performed a latent growth curve analysis.[15,16] Latent class growth curve analysis, employing growth mixture modeling, serves to identify distinct patterns of change over time using each hospital's observed trajectory of the proportion of non-acute PCIs classified as inappropriate. Hospitals with similar patterns over time are grouped together and considered to form a latent class. The use of growth mixture modeling estimates a mean growth curve for each latent class while allowing for individual variation around the growth curve within each class. We fit 4 models: 2 group, 3 group, 4 group, and 5 group. For each model we evaluated the change in the BIC and calculated the approximated Bayes factor. We also plotted the observed verse the predicted values to evaluate model fit. The average posterior probabilities were used to ensure that the model adequately distinguished between identified groups. We chose the 4 group model because it performed best on these criteria. We performed this secondary analysis among hospitals in the highest quartile of proportion of inappropriate PCI between July 2009 and December 2010 to understand the trajectories of hospitals with the greatest opportunity for improvement. For each hospital, we then examined the proportion of inappropriate non-acute PCI from January 2011 to December 2014, grouping hospitals with similar patterns over time together. Finally, we compared hospital characteristics across groups to identify hospital features associated with various patterns.

Statistical testing of trends was performed using Cochran-Armitage Test[17,18] for binary variables and Jonckheere-Terpstra Test[19] for categorical variables. Further to assess sensitivity of hospital-level results to the aggregation of estimates within hospitals, we confirmed all test results using weighted general linear models, weighting estimates by hospital volume. Absolute changes in PCI volume and patient characteristics were calculated using 2010 and 2014 data as the study interval began July 1, 2009. All tests for statistical significance were 2-tailed and evaluated at a significance level of 0.05 corrected for multiple comparisons using the Šidák correction.[20] All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc, Cary, North Carolina).

Results

There were more than 3.5 million PCIs performed at 1,561 hospitals between July 2009 and December 2014. We excluded 550,836 patients treated at 583 hospitals that did not participate continuously in the registry during the study period and an additional 273,167 cases performed at 212 facilities who performed an average of fewer than 10 non-acute PCIs in each calendar year, leaving 2,685,683 PCI procedures from 766 hospitals as the primary study cohort. Characteristics of the hospitals in the primary study cohort are shown in eTable 1.

PCI indication over time

Of the PCI procedures included in our analysis, 76.3% (95% CI, 76.2%–76.3%) were for acute indications, 14.8% (95% CI, 14.8%–14.9%) for non-acute indications, and 8.9% (95% CI, 8.9%–9.0%) were non-mappable (Table 1). Annual PCI volume declined over the study period from 538,076 in 2010 to 456,507 in 2014. The volume of acute PCI was relatively stable over time (2010: 377,540; 2014: 374,543), but there were significant declines in the volume of non-acute PCI (2010: 89,704; 2014: 59,375; p<0.001) and non-mappable PCI (2010: 70,832; 2014: 22,589; p<0.001). As a consequence, the proportion (95% CI) of PCIs performed for acute indications rose from 69.1% (95% CI, 68.8%–69.3%) in 2009 to 82.0% (95% CI, 81.9%–82.2%) in 2014. The proportion of PCIs for non-acute indications declined from 16.8% (95% CI, 16.7%–17.0%) to 13.0% (95% CI, 12.9%–13.1%) while the proportion of non-mappable PCIs declined from 14.0% (95% CI, 13.9%–14.2%) in 2009 to 4.9% (95% CI, 4.9%–5.0%) in 2014. Similar findings were noted at the hospital-level (Figure 1).

Baseline Characteristics

Baseline demographic and clinical characteristics as well as the presence and severity of angina symptoms, background anti-anginal medical therapy, results of non-invasive testing, and angiographic findings for the entire study cohort are included in eTable 2 and for patients undergoing non-acute PCI in Table 2.

Among patients in the overall study cohort, the absolute number and relative proportion of patients undergoing PCI with CCS 1 or 2 angina decreased over time while the absolute number and relative proportion of patients with CCS 4 angina increased over the study period. The numbers of patients undergoing PCI in the setting of an acute coronary syndrome (ACS) (unstable angina, NSTEMI, and STEMI) were stable (367,253 in 2010 to 368,574 in 2014) with increases in the number of NSTEMI patients (94,097 in 2010 to 107,225 in 2014) and decreases in the number of unstable angina patients (194,008 in 2010 to 183,735 in 2014). Use of anti-anginal therapy increased over the study period while use of non-invasive testing remained stable. The number and relative proportion of patients with unavailable or low-risk results on stress testing declined while there was an increase in the number and relative proportion of patients with intermediate and high-risk findings. The burden of coronary artery disease on angiography was similar over the study period.

Among patients undergoing non-acute PCI, the absolute number and relative proportion of patients without symptoms or with CCS 1 or 2 angina decreased over time. There was an increase in both the absolute number and relative proportion of patients undergoing non-acute PCI with CCS 3 angina (13,442 and 15.0% in 2010 to 20,727 and 34.9% in 2014). There was an increase in the use of anti-anginal therapy with 80.6% of patients undergoing non-acute PCI in 2014 reported to be on at least 1 anti-anginal medication and 35.1% receiving 2 or more anti-anginal medications as compared with 69.8% and 22.3% respectively in 2010. Performance of non-invasive testing and fractional flow reserve testing increased over the study interval from 64.6% and 8.1% in 2010 to 72.5% and 30.8% in 2014. Moreover, the extent of ischemia with non-invasive testing changed over time with 64.7% of patients having intermediate or high-risk findings in 2010 as compared with 78.1% in 2014.

The proportion of patients with multi-vessel coronary artery disease was 43.7% in 2010 and 47.5% in 2014.

Trends in Inappropriate PCI

Between July 2009 and December 2014, the proportion (95% CI) of non-acute PCIs classified as inappropriate decreased from 26.2% (95% CI, 25.8%–26.6%) to 13.3% (95% CI, 13.1%–13.6%), p<0.001, Figure 2A). The absolute number of inappropriate PCIs decreased from 21,781 in 2010 to 7,921 in 2014. The percentage (95% CI) of non-acute PCIs classified as appropriate increased from 30.1% (95% CI, 29.7%–30.6%) to 53.6% (95% CI, 53.2%-54.0%) and those considered uncertain decreased from 43.7% (95% CI, 43.2%–44.2%) to 33.0% (95% CI, 32.6%–33.4%) (Figure 2A). Hospital-level trends in the proportion of inappropriate non-acute PCIs are shown in Figure 2B. The median hospital proportion of non-acute PCIs considered inappropriate decreased from 25.8% in 2009 to 12.6% in 2014. There was persistent variation in hospital level proportion of non-acute PCIs classified as inappropriate over the study interval (IQR 16.7% to 37.1% in 2009; IQR 5.9% to 22.9% in 2014).

Temporal Patterns Across Hospitals

Among hospitals in the highest quartile for proportion of non-acute PCI deemed inappropriate from July 2009 to December 2010 (n=191), we observed 4 distinct trajectories in changes in rates of inappropriate PCI from January 2011 to December 2014 (Figure 3). Hospitals in groups 1, 2 and 4 had similar baseline rates of inappropriate PCI, however, hospitals in group 4 (n=108) demonstrated immediate and steady declines in inappropriate PCI rates from 43.9% (95% CI, 42.4%–45.3%) in 2009–10 to 15.5% (95% CI, 14.0%–17.0%) in 2014. In contrast, hospitals in group 1 (n=18) had minimal change in the first two years, but demonstrated lower rates of inappropriate PCI in the last two years of the study period. Hospitals in group 2 (n=50) demonstrated steady but smaller absolute declines in inappropriate PCI over the study period than groups 1 and 4, with the proportion of inappropriate non-acute PCIs decreasing from 40.9% (95% CI, 39.7%–42.1%) in 2009–10 to 32.2% (95% CI, 30.4%–34.1%) in 2014. Finally, hospitals in group 3 (n=15) had the highest initial rates of inappropriate PCI, but also the largest absolute decline over the study period from 70.6% (95% CI, 68.5%–72.7%) in 2009–10 to 9.4% (95% CI, 7.6%–11.1%) in 2014. There were no systematic differences in hospital characteristics, geographic location, financial status, or teaching status across hospital groups (eTable 3).

Discussion

Among patients undergoing PCI between July 2009 and December 2014, we found that volumes of non-acute PCIs declined significantly from 89,704 in 2010 to 59,375 in 2014 while the volume of acute PCIs remained stable, 377,540 in 2010 to 374,543 in 2014. In addition, we observed significant reductions in the proportion of non-acute PCIs classified as inappropriate from 26.2% in 2009 to 13.3% in 2014. However, there was persistent hospital-level variation in the rate of inappropriate PCIs with an IQR of 5.9% to 22.9% in 2014. Collectively these findings suggest that the practice of interventional cardiology has evolved since the introduction of Appropriate Use Criteria in 2009.

Our analysis provides details about changes in the clinical profiles of patients undergoing PCI and suggests that the observed reductions in inappropriate PCI in part reflect improvements in patient selection and clinical decision-making as well as better documentation of the key elements used to determine procedural appropriateness. Trends consistent with improvements in patient selection include the reduction in non-acute PCI volume and changes in the clinical profile of patients undergoing non-acute PCI. We observed significant declines in the proportions of non-acute PCI patients who were asymptomatic or had minimal symptoms; who were not receiving or only receiving minimal anti-anginal therapy; and who had low or intermediate risk findings on non-invasive testing. We identified increased use of FFR among patients with intermediate stenosis. These findings may indicate that clinicians are doing a better job of identifying and limiting non-acute PCI procedures to those patients most likely to benefit from revascularization.

We cannot exclude the possibility that reductions in inappropriate PCI may reflect changes in documentation or even intentional up-coding, particularly of subjective data elements such as symptom severity. Temporal trends in anginal symptom burden raise the possibility that this data element, which is largely subjective, may be overstated. Specifically, despite significant reductions in the volume of non-acute PCI, we observed increases in the numbers and proportions of patients reported to have CCS 3 and 4 angina but minimal change in extent of CAD. Nevertheless, we did not see evidence that patients were being systematically shifted from non-acute to acute indications for PCI. The number of acute PCIs were stable over time, and the proportion of acute PCI patients reported to have unstable angina decreased.

The appropriateness of PCI has garnered attention from clinicians, insurers, and policymakers. It has been the subject of national quality improvement initiatives and incorporated into pay-for-performance programs. In our analysis, the observed reductions in inappropriate PCI appeared to accelerate in 2011, which coincided with the publication of a high profile paper on PCI appropriateness, the NCDR's inclusion of procedural appropriateness in its benchmarking reports, and the launch of national performance improvement campaigns.[3,7] Our findings are consistent with an analysis of PCI appropriateness in Washington State.[21] However, because the registry was not configured to characterize PCI appropriateness until July 2009, our analyses are limited to cases performed after the release of the Appropriate Use Criteria. As such we could not evaluate the impact of the Appropriate Use Criteria, and our findings are best considered a description of changes in patterns of care and procedural appropriateness over this period. It is likely that many factors such as the publication of the COURAGE and BARI2D trials influenced clinical practice during this timeframe.[22,23]

We observed persistent variation in hospital-level performance of inappropriate PCI. Among better performing hospitals (lowest quartile), fewer than 5% of non-acute PCIs in 2014 were classified as inappropriate. In contrast, among worse performing hospitals (highest quartile), more than 25% of non-acute PCIs were classified as inappropriate. These findings suggest the need for ongoing performance improvement initiatives and hospital benchmarking. Among hospitals with the highest rates of inappropriate non-acute PCI from July 2009 and December 2010, we observed distinct trajectories from January 2011 to December 2014.

Although the majority of hospitals with the highest baseline rates of inappropriate PCI demonstrated large reductions in the proportion of PCIs classified as inappropriate, we identified a group of hospitals with less than 10% absolute reduction in the performance of inappropriate PCI over the study period. The observed differences in timing and pace of change suggest both that Appropriate Use Criteria-related quality metrics are actionable and that the specific approach adopted by a hospital impacts its performance. Identifying the organizational strategies and enabling structures most strongly associated lower rates of inappropriate PCI remain a potentially important area for future research.

There are several limitations to our analysis. First, not all hospitals that perform PCI in the United States participate in the registry. Furthermore, we excluded hospitals that did not participate in the registry throughout the entire study period and these hospitals may have different rates of inappropriate PCI. Regardless, our analysis included nearly 2.7 million procedures performed across 766 facilities and represents the most comprehensive examination of PCI appropriateness to date. In addition, only including hospitals participating in the registry over the entire study period enabled us to more rigorously investigate temporal changes in PCI utilization, clinical characteristics, and appropriateness. Second, our analysis focused mostly on trends in potential overuse (i.e. inappropriate) PCI. Understanding whether Appropriate Use Criteria have introduced new barriers to the performance of medically necessary procedures remains an important topic that could not be addressed in our study. Relatedly, we only have information on patients undergoing PCI, rather than the larger population of patients with CAD who might be considered for revascularization. As such, we cannot determine whether the observed changes truly reflect improved patient selection or overestimation of patient symptoms. The integration of more objective assessments of patient-reported health status into routine clinical care may provide a way to reduce the chances of misclassifying symptom burden.[24]

Conclusions

Since the publication of the Appropriate Use Criteria in 2009, there have been significant reductions in non-acute PCI volume. The proportion of non-acute PCIs classified as inappropriate has declined though hospital-level variation in inappropriate PCI persists, suggesting the need for ongoing quality improvement initiatives.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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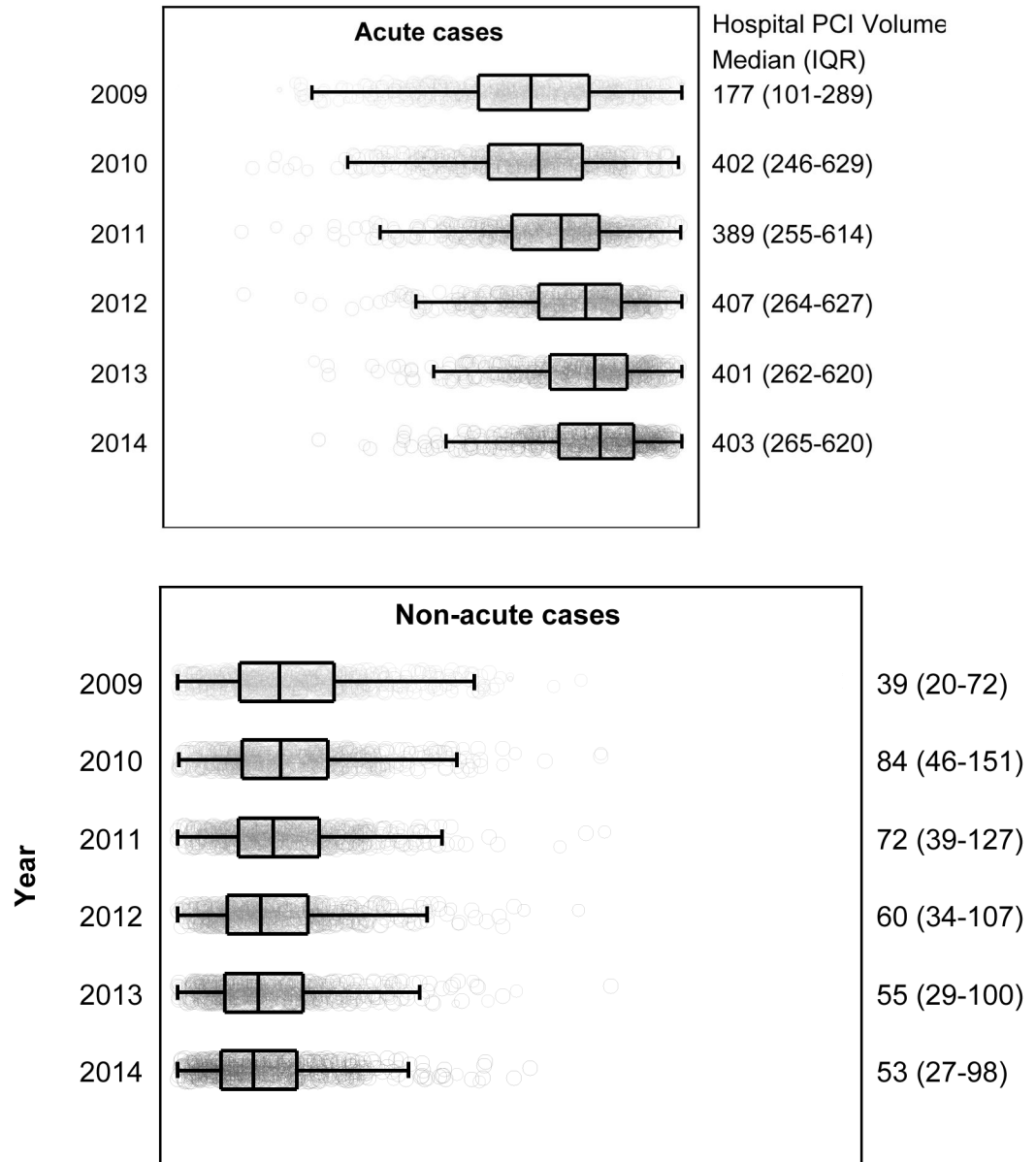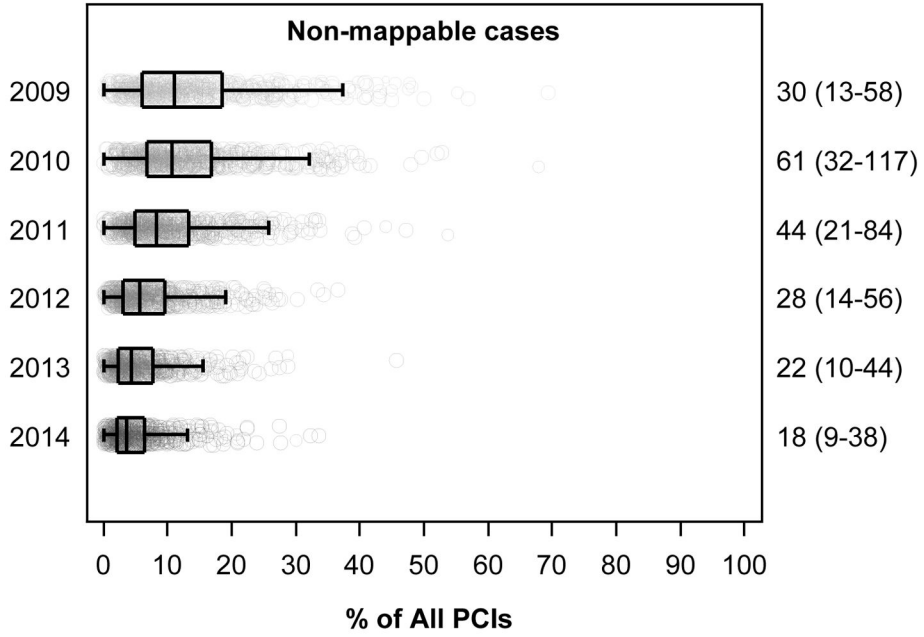
Figure 1. Proportion of PCI Performed for Acute, Non-acute, and Non-mappable Indications at the Hospital-level from 2009 to 2014

Hospital-level proportion of acute, non-acute, and non-mappable indications for all PCIs performed from July 1, 2009 to December 31, 2014 at 766 hospitals participating continuously in the NCDR-CathPCI Registry over the study period. For each box-plot, the vertical line in the center of the rectangle represents the median, the left and right vertical lines of each rectangle represent the 25th and 75th percentiles respectively, and the vertical lines capping the horizontal lines extending from the rectangle represent 1.5-times the interquartile range. Each hospital is represented as a point in the box-plot, the size of the point reflects the hospital volume. Note: Results for 2009 include 6-months of data.
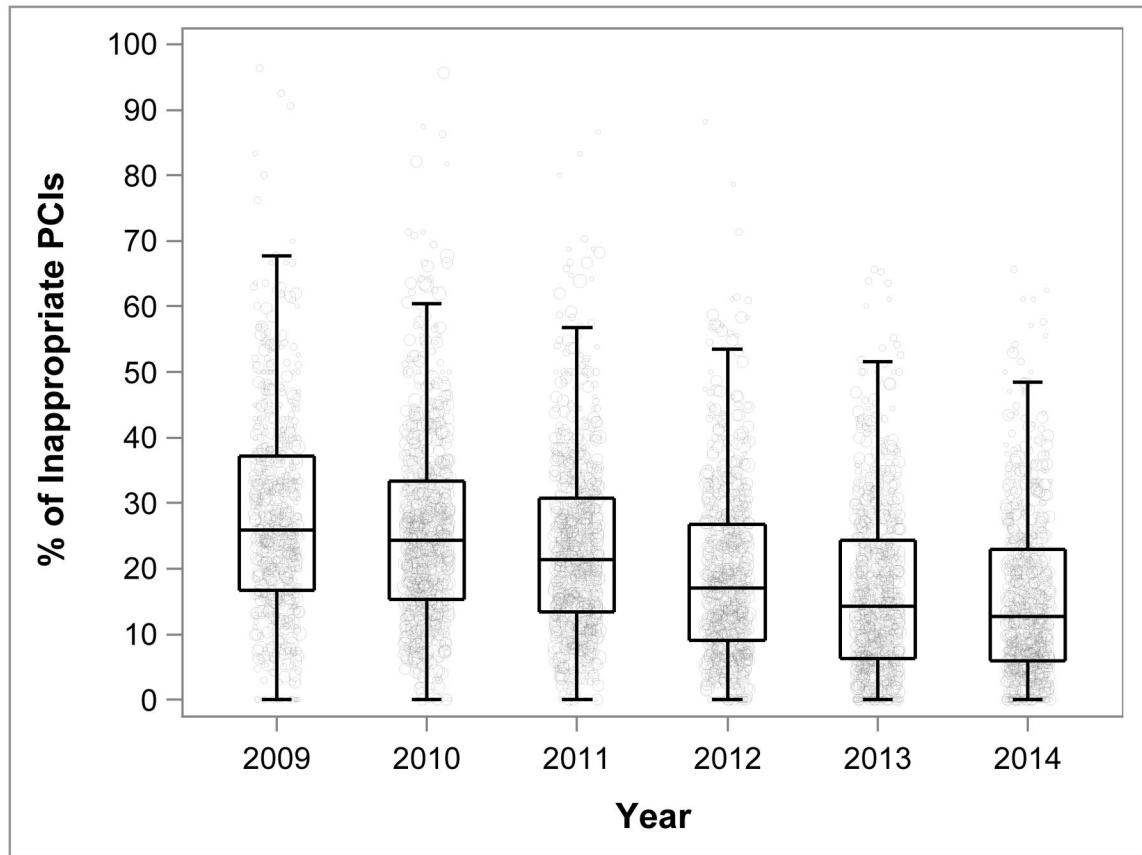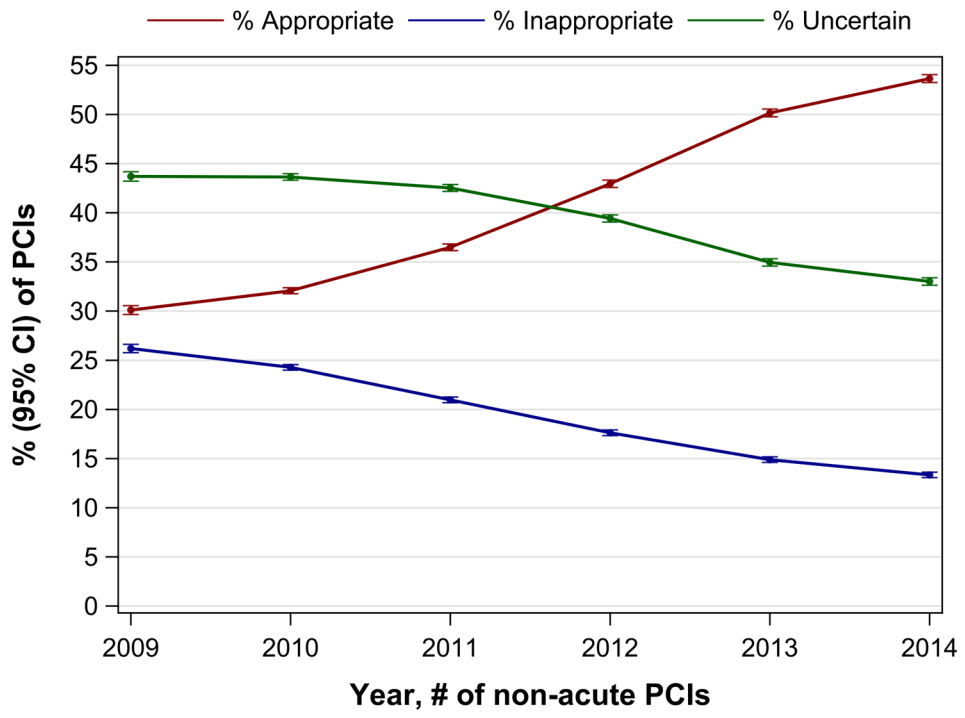
Figure 2. Proportions of Appropriate, Inappropriate, and Uncertain PCI at the Patient-level (A) and Proportions of Inappropriate PCI at the Hospital-level (B) among Non-acute PCIs from July 1, 2009 to December 31, 2014

Figure 2A/B. Rates of Appropriate, Inappropriate, and Uncertain PCI at the Patient-level (A) and Rate of Inappropriate PCI at the Hospital-level (B) among non-acute PCIs from July 1, 2009 to December 31, 2014 at 766 hospitals participating continuously in the NCDR-CathPCI Registry over the study period. For each classification of procedural appropriateness, the point estimate and 95% CI are plotted in Figure 2A. For each box-plot in Figure 2B, the horizontal line in the center of the rectangle represents the median, the bottom and top horizontal lines of each rectangle represent the 25th and 75th percentiles respectively, and the horizontal lines capping the vertical lines extending from the rectangle represent 1.5-times the interquartile range. Each hospital is represented as a point in the box-plot, the size of the point reflects the hospital volume. Note: Results from 2009 include 6-months of data.
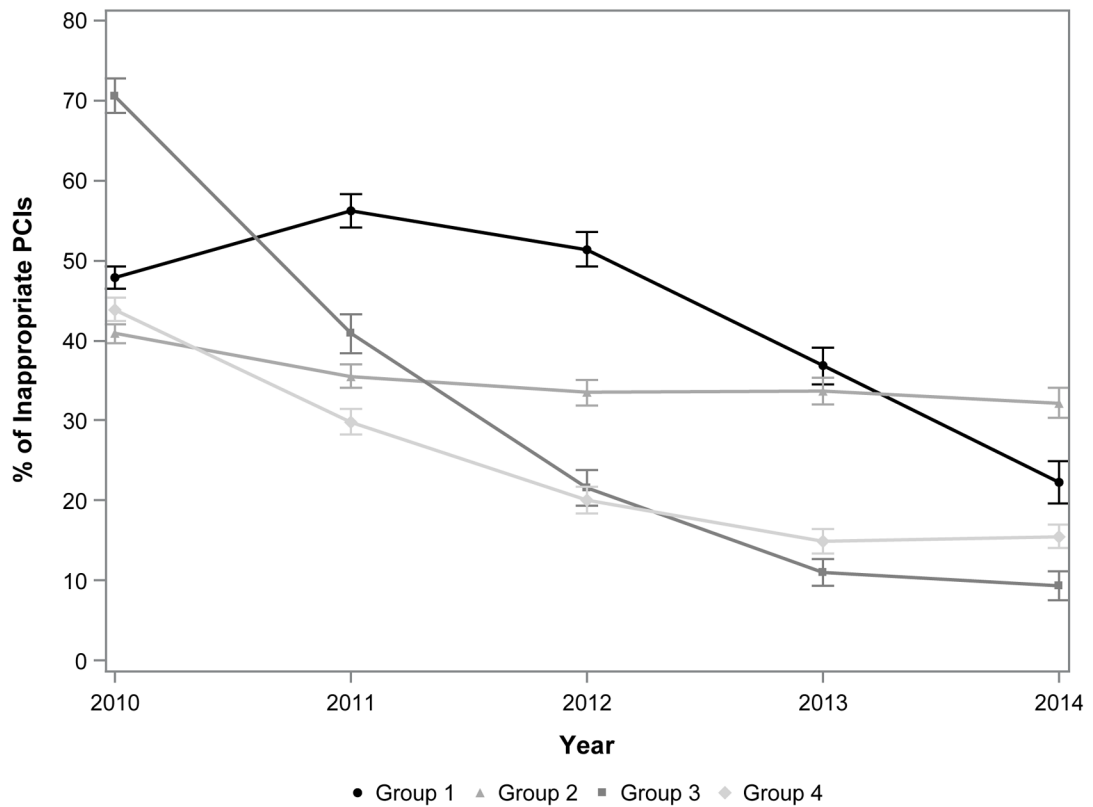
Figure 3. Trends in Inappropriate Non-Acute PCI at Hospitals with the Highest Initial Proportion of Inappropriate PCI (>34% from July 2009 to December 2010)

Observed Rates (95% CI) of Inappropriate non-acute PCI for 4 groups of hospitals identified by latent growth curve analysis. The analysis was restricted to hospitals with the highest initial rates of inappropriate non-acute PCI from July 2009 to December 2010 (>34%, n=191). Note: Results shown for 2010 include data for 2009 and 2010.

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Table 1

Number and percentage (95% CI) of acute, non-acute and non-mappable PCIs from July 1, 2009 to Decmeber 31, 2014.

PCI indication/Year	Total	2009*	2010	2011	2012	2013	2014
Overall, n	2,685,683	243,580	538,076	502,995	481,889	462,636	456,507
Acute, n (95% CI)	2,047,853 (76.2%–76.3%)	168,366 (68.9%–69.3%)	377,540 (70.0%–70.3%)	373,423 (74.1%–74.4%)	380,331 (78.8%–79.0%)	373,650 (80.7%–80.9%)	374,543 (81.9%–82.2%)
	76.3%	69.1%	70.2%	74.2%	78.9%	80.8%	82.0%
Non-acute, n (95% CI)	397,737 (14.8%–14.9%)	41,024 (16.7%–17.0%)	89,704 (16.6%–16.8%)	78,328 (15.5%–15.7%)	66,849 (13.8%–14.0%)	62,457 (13.4%–13.6%)	59,375 (12.9%–13.1%)
	14.8%	16.8%	16.7%	15.6%	13.9%	13.5%	13.0%
Non-mappable, n (95% CI)	240,093 (8.9%–9.0%)	34,190 (13.9%–14.2%)	70,832 (13.1%–13.3%)	51,244 (10.1%–10.3%)	34,709 (7.1%–7.3%)	26,529 (5.7%–5.8%)	22,589 (4.9%–5.0%)
	8.9%	14.0%	13.2%	10.2%	7.2%	5.7%	4.9%

*
Includes July 1, 2009 to December 31, 2009

Abbreviations: PCI, percutaneous coronary intervention.

Table 2

Baseline Characteristics of Patients Undergoing Non-Acute PCI from July 1, 2009 to December 31, 2014.

Patient Characteristics	Total		2009§		2010		2011		2012		2013		2014	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
N	397,737	100.0	41,024	10.3	89,704	22.6	78,328	19.7	66,849	16.8	62,457	15.7	59,375	14.9
Demographics														
Age - Mean (SD)	66.5	10.9	65.9	11.1	66.1	11.0	66.3	10.9	66.6	10.8	66.9	10.8	67.1	10.8
Sex: Male	275,469	69.3	27,574	67.2	60,902	67.9	53,801	68.7	46,433	69.5	44,457	71.2	42,302	71.3
Race: White	350,988	88.3	36,376	88.7	79,591	88.7	68,884	87.9	58,822	88.0	55,124	88.3	52,191	87.9
Insurance														
Private	278,236	70.1	27,640	67.5	61,789	69.0	54,489	69.7	47,129	70.7	44,514	71.4	42,675	72.0
Public Only	109,827	27.7	12,432	30.4	25,723	28.7	21,734	27.8	17,909	26.9	16,417	26.3	15,612	26.3
Non-US	266	0.1	33	0.1	57	0.1	46	0.1	37	0.1	40	0.1	53	0.1
None	8,607	2.2	854	2.1	2,004	2.2	1,872	2.4	1,600	2.4	1,349	2.7	928	1.6
Clinical Risk Factors and comorbidities														
Current/Recent Smoker(< 1 year)	77,355	19.5	8,528	21.0	18,437	20.6	15,522	19.8	12,822	19.2	11,352	18.2	10,694	18.0
Hypertension	344,698	86.7	34,932	85.2	77,378	86.3	67,532	86.3	58,262	87.2	54,656	87.5	51,938	87.5
Dyslipidemia	341,445	85.9	34,755	84.8	77,123	86.0	67,145	85.8	57,191	85.6	53,981	86.5	51,250	86.4
Family history of coronary artery disease	93,873	23.6	10,084	24.6	21,969	24.5	18,789	24.0	16,194	24.2	14,450	23.1	12,387	20.9
Prior PCI	173,734	43.7	17,075	41.6	38,785	43.2	34,273	43.8	29,323	43.9	27,794	44.5	26,484	44.6
Prior CABG surgery	57,394	14.4	5,096	12.4	11,615	13.0	10,877	13.9	9,986	14.9	10,116	16.2	9,704	16.3
Diabetes mellitus	156,865	39.5	15,505	37.8	34,023	37.9	30,794	39.3	26,627	39.8	25,467	40.8	24,449	41.2
Clinical Presentation														
Coronary artery disease presentation														
No symptoms, no angina	91,046	22.9	11,899	29.0	23,889	26.6	18,367	23.5	13,902	20.8	12,301	19.7	10,688	18.0
Symptoms unlikely to be ischemic	41,247	10.4	4,145	10.1	9,577	10.7	8,301	10.6	7,179	10.7	6,165	9.9	5,880	9.9
Stable angina	265,444	66.7	24,980	60.9	56,238	62.7	51,660	66.0	45,768	68.5	43,991	70.4	42,807	72.1

Angina

Patient Characteristics	Total		2009§		2010		2011		2012		2013		2014	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
No symptoms	102,920	25.9	12,443	30.3	26,313	29.3	20,541	26.2	16,313	24.4	14,420	23.1	12,890	21.7
CCS I	44,889	11.3	6,297	15.4	12,752	14.2	10,070	12.9	6,484	9.7	4,934	7.9	4,352	7.3
CCS II	148,898	37.4	15,824	38.6	34,958	39.0	31,366	40.0	25,842	38.7	21,571	34.5	19,337	32.6
CCS III	89,909	22.6	5,575	13.6	13,442	15.0	14,454	18.5	16,299	24.4	19,412	31.1	20,727	34.9
CCS IV	11,121	2.8	885	2.2	2,239	2.5	1,897	2.4	1,911	2.9	2,120	3.4	2,069	3.5
No. of antianginal medications														
0	102,655	25.8	13,811	33.7	27,076	30.2	21,306	27.2	15,719	23.5	13,222	21.2	11,521	19.4
1	187,154	47.1	19,272	47.0	42,610	47.5	37,427	47.8	31,930	47.8	28,884	46.3	27,031	45.5
>=2	107,885	27.1	7,928	19.3	20,011	22.3	19,585	25.0	19,195	28.7	20,350	32.6	20,816	35.1
Stress or imaging test performed	273,237	68.7	26,720	65.1	57,942	64.6	53,045	67.7	47,420	70.9	45,041	72.1	43,069	72.5
Stress test results (among those with a test)														
Unavailable	40,046	15.1	5,053	19.6	10,328	18.4	8,373	16.3	6,442	14.0	5,142	11.7	4,708	11.2
Low risk *	37,316	14.0	4,272	16.5	9,548	17.0	7,855	15.2	5,953	12.9	5,171	11.8	4,517	10.7
Intermediate risk **	116,078	43.7	10,756	41.6	23,920	42.5	22,416	43.5	20,319	44.1	19,709	44.8	18,958	44.9
High risk #	72,463	27.3	5,759	22.3	12,460	22.2	12,893	25.0	13,373	29.0	13,960	31.7	14,018	33.2
Fractional flow reserve among patients with 40–70% lesion	14,636	18.0	706	8.1	1,987	10.2	2,285	13.8	2,824	21.6	3,369	28.2	3,465	30.8
No. of diseased vessels														
0	2,758	0.7	350	0.9	741	0.8	587	0.8	407	0.6	358	0.6	315	0.5
1	214,960	54.1	23,162	56.5	49,732	55.4	42,445	54.2	35,963	53.8	32,790	52.5	30,868	52.0
2	116,447	29.3	11,656	28.4	25,908	28.9	23,008	29.4	19,578	29.3	18,539	29.7	17,758	29.9
3	63,572	16.0	5,856	14.3	13,323	14.9	12,288	15.7	10,901	16.3	10,770	17.2	10,434	17.6

§ Includes July 1, 2009 to December 31, 2009.

Abbreviations: CABG, coronary artery bypass graft; CCS, Canadian Cardiovascular Society; PCI, percutaneous coronary intervention.

* Low-risk (<1% annual mortality rate) includes: low-risk treadmill score (score ≥ 5); normal or small myocardial perfusion defect at rest or with stress; normal stress echocardiographic wall motion or no change of limited resting wall motion abnormalities during stress.

**
Intermediate-risk (1% to 3% annual mortality rate) includes: mild/moderate resting left ventricular dysfunction (LVEF 35% to 49%); intermediate-risk treadmill score (score between −11 and <5); stress-induced moderate perfusion defect without LV dilation or increased lung intake (thallium-201); limited stress echocardiographic ischemia with a wall motion abnormality only at higher doses of dobutamine involving less than or equal to 2 segments.

#
High-risk (>3% annual mortality rate) includes: severe resting left ventricular dysfunction (LVEF <35%); high-risk treadmill score (score ≤ −11); severe exercise left ventricular dysfunction (exercise LVEF <35%); stress-induced large perfusion defect (particularly if anterior); stress-induced multiple perfusion defects of moderate size; large, fixed perfusion defect with LV dilation or increased lung uptake (thallium-201); stress-induced moderate perfusion defect with LV dilation or increased lung uptake (thallium-201); echocardiographic wall motion abnormality (involving >2 segments) developing at low dose of dobutamine (≤ 10 mg/kg/min) or at a low heart rate (<120 beats/min); stress echocardiographic evidence of extensive ischemia.