ORIGINAL RESEARCH

The Impact of De-escalation of Antianginal Medications on Health Status After Percutaneous Coronary Intervention

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***Background*—**Antianginal medications (AAMs) can be perceived to be less important after percutaneous coronary intervention (PCI) and may be de-escalated after revascularization. We examined the frequency of AAM de-escalation at discharge post-PCI and its association with follow-up health status.

***Methods and Results*—**In a 10-center PCI registry, the Seattle Angina Questionnaire was assessed before and 6 months post-PCI. AAM de-escalation was defined as fewer AAMs at discharge versus admission or >25% absolute dose decrease. Of 2743 PCI patients (70% male), AAM were de-escalated, escalated, and unchanged in 299 (11%), 714 (26%), and 1730 (63%) patients, respectively. Patients whose AAM were de-escalated were more likely to report angina at 6 months, compared with unchanged or escalated AAM (34% versus 24% versus 21%; $P<0.001$). The association of AAM de-escalation with health status was examined using multivariable models adjusting for the predicted risk of post-PCI angina, completeness of revascularization, and the interaction of AAM de-escalation×completeness of revascularization. There was a significant interaction between AAM de-escalation and completeness of revascularization ($P<0.001$), suggesting that AAM de-escalation was associated with greater impairment of health status among patients with incomplete revascularization. In patients with incomplete revascularization, de-escalation of AAM at discharge was associated with 43% increased angina risk (relative risk, 1.43; 95% confidence interval, 1.26–1.63) and worse angina-related health status at 6 months post-PCI.

***Conclusions*—**De-escalation of AAM occurs in 1 in 10 patients post-PCI, and it is associated with an increased risk of angina and worse health status, particularly among those with incomplete revascularization. **(*J Am Heart Assoc*. 2017;6:e006405. DOI: 10.1161/JAHA.117.006405.)**

Key Words: angina • anti-anginal medications • de-escalation • health status • health-related quality of life • medical therapy • quality of life

Antianginal medications (AAMs) provide substantial angina relief[1] and can be used along with percutaneous coronary intervention (PCI) to optimally treat the symptoms of ischemic heart disease.[2] Current guidelines recommend initial treatment of stable angina with AAM (for the majority of patients) followed by revascularization, if AAMs are insufficient at effectively managing symptoms.[3] However, in patients eventually treated with PCI, there is little guidance on how to manage AAM after revascularization. Whereas PCI can be markedly effective in providing substantial symptom relief,[4] ongoing and recurrent angina remains a residual issue for many patients, with 20% to 40% of patients reporting angina at 6 months post-PCI.[5–7]

After revascularization, physicians may elect to de-escalate AAM, because they may no longer be necessary for symptom management. Because AAMs are not associated with reduction in morbidity or mortality[6–8] (with the exception of beta-blockers after myocardial infarction or with heart failure), de-escalation may be a reasonable treatment strategy, but the optimal timing of de-escalation is not known. Because angina is associated with impairment in quality of life[9] and increased healthcare costs,[10] understanding factors (especially modifiable ones) associated with angina post-PCI is paramount. We used a multicenter US PCI registry that collected detailed health status data before and after PCI to examine the

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Accompanying Tables S1 through S3 are available at http://jaha.ahajournals.org/content/6/10/e006405/DC1/embed/inline-supplementary-material-1.pdf

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Clinical Perspective

What Is New?

- The frequency of antianginal medications (AAMs) de-escalation at discharge after percutaneous coronary intervention and its association with follow-up health status have not been reported before.
- We report that de-escalation of AAMs occurs in 1 in 10 patients post-PCI, and it is associated with an increased risk of angina and worse health status, particularly among those with incomplete revascularization.

What Are the Clinical Implications?

- De-escalation of AAMs after percutaneous coronary intervention can be tempting, especially in patients who become asymptomatic.
- Although de-escalation of AAMs makes sense, a subset of patients (ie, incomplete revascularization) are at high risk for recurrent angina and may benefit from continued AAMs or a more-cautious de-escalation.
- Having a systematic method for de-escalation may be of benefit—1 strategy could be to de-escalate AAM in patients with low risk of residual angina and complete revascularization at discharge followed by symptom-guided de-escalation of other patients over time during follow-up.

frequency of de-escalation of AAM at discharge after PCI and the association of early de-escalation with long-term angina and health status.

Methods

Study Design and Population

The PRISM (Personalized Risk Information Services Manager™) study was a prospective study that tested the benefits of providing individualized, evidence-based estimates of the procedural risks before PCI.[11,12] Briefly, between 2009 and 2011, consecutive patients undergoing PCI at 10 US hospitals were invited to enroll in this study at the time of their PCI. Because the question of AAM discontinuation is most relevant after nonemergent PCI, we excluded patients who underwent PCI for an ST-elevation myocardial infarction. Baseline data were collected through a combination of chart review and structured patient interview after the patient underwent PCI and was clinically stable. Medication data on admission and discharge were obtained directly from the medical record. Angiogram reports were used to determine complete revascularization, which was defined as anatomical completeness of revascularization with successful intervention to all significant stenoses in epicardial vessels (defined as coronary stenosis ≥70% in any reported coronary artery vessel or ≥50% in left main artery). A central follow-up center attempted detailed phone follow-up on all surviving patients at 6 months post-PCI. Each participating hospital obtained Institutional Research Board approval, and all patients provided written informed consent for baseline and follow-up assessments.

Health Status Assessment

The Seattle Angina Questionnaire (SAQ) was used to assess angina and angina-related health status at baseline and 6 months post-PCI. The SAQ is a reliable and valid 19-item questionnaire with a 4-week recall period that measures 5 domains of health in patients with CAD: angina frequency (SAQ AF); angina stability; quality of life (SAQ QoL); physical limitation (SAQ PL); and treatment satisfaction.[13,14] Additionally, the SAQ Summary Scale integrates the SAQ AF, SAQ QoL, and SAQ PL into a single summary score.[15] Domain and summary scores range from 0 to 100, with higher scores indicating fewer symptoms and better quality of life, and a ≈5-point mean change is considered clinically meaningful. The primary outcome for this study was the presence of angina at 6 months post-PCI, which was defined as a SAQ AF score <100 (versus no angina, defined as SAQ AF=100).[16] The SAQ AF domain correlates closely with daily angina diaries[17] and is associated with long-term survival,[18] hospitalization for acute coronary syndromes, and healthcare utilization among patients with chronic coronary artery disease.[19] We also examined the SAQ AF, SAQ QoL, SAQ PL, and SAQ Summary Scale scores as continuous variables.

Definition of De-Escalation and Escalation of AAM

For this analysis, we focused on changes in medications between hospital admission and discharge for PCI, given that these changes would be expected to be primarily done empirically (ie, because the patient was revascularized) as opposed to in response to residual symptoms post-PCI. Medication data, including doses, were collected at admission and discharge post-PCI. AAMs included beta-blockers, calcium-channel blockers, long-acting nitrate, and ranolazine. AAM de-escalation/escalation was defined as: (1) being on fewer/more AAMs at discharge versus admission or (2) clinically relevant decrease/increase in AAM doses (if same number of AAMs). Each AAM class of medication was assumed to similarly treat angina, per past literature.[20,21] To define a clinically relevant change in AAM dose, we determined the maximum recommended dose of each AAM for treating angina (Table S1) and then calculated the patient's % of maximum dose. The % of maximum dose was compared at admission and discharge for each patient, and a >25% absolute decrease/increase in AAM was considered a clinically relevant change (see Table S2 for examples). As a

sensitivity analysis, we also used a 50% absolute decrease/increase as a cut-off point for % maximum change. Further sensitivity analyses by PCI indication (stable coronary artery disease, unstable angina, non-ST-elevation myocardial infarction, and other indications) were performed. Results were qualitatively similar, and thus only the main analyses are shown.

Statistical Analysis

Demographic and clinical characteristics were compared among patients whose AAM were de-escalated, unchanged, and escalated at hospital discharge using 1-way ANOVA for continuous variables and chi-square tests for categorical variables. The percentage of patients who reported angina and the unadjusted health status scores at baseline and 6 months post-PCI were compared among groups using chi-square tests and 1-way ANOVA. To examine the independent association of change in AAM (de-escalation versus no change versus escalation) with angina at 6 months post-PCI, we constructed a multivariable, hierarchical modified Poisson regression model that included the patient's predicted risk of post-PCI angina based on preprocedural factors (using a previously published model that includes age, self-reported avoidance of care attributed to cost, depression, number of AAMs at admission, self-reported pain or discomfort [question from the EuroQol-5D], stable angina versus unstable angina versus non-ST-elevation myocardial infarction, SAQ AF, and SAQ QoL),[6] completeness of revascularization, and the interaction of AAM change×completeness of revascularization. Because angina was a common outcome, modified Poisson regression allowed us to estimate relative risks directly and avoid overestimating the effect size (as opposed to logistic regression).[22,23] Site was included as a random effect to account for clustering of patients within sites. Similarly, we constructed multivariable, hierarchical linear regression models (using the same covariates for adjustment as above) to examine the association of AAM de-escalation with 6-month SAQ AF, SAQ QoL, SAQ PL, and SAQ Summary Scale scores.

Missing Data

To evaluate for potential bias related to missing follow-up data, we first compared baseline characteristics of patients alive but missing 6-month angina data (n=443) with those in the analytic cohort (Table S3). We then constructed a multivariable logistic regression model among patients eligible for 6-month follow-up to determine the probability of having missing follow-up angina data. The model included all baseline demographic, clinical, and treatment variables. We then weighted each of the patients in the analytic cohort by the inverse probability of the likelihood of having follow-up angina data to better reflect the overall PCI population[24] and repeated all analyses. Results of these inverse propensity-weighted analyses were similar to the nonweighted analyses, and thus only the nonweighted analyses are shown.

Moreover, we compared baseline characteristics of patients that did not survive to 6 months (n=37) with those in the analytic cohort. Data are not shown because no differences were observed in the baseline characteristics and, more important, in the AAM escalation/de-escalation rates.

All statistical analyses were performed with SAS software (version 9.4; SAS Institute, Inc, Cary, NC).

Results

Patient Characteristics

Among 3299 patients from 10 US centers who underwent PCI and were enrolled in PRISM, we excluded 76 patients who presented with an ST-elevation myocardial infarction and 37 who did not survive 6 months and were therefore ineligible for follow-up. Of the remaining 3186 eligible patients, we further excluded 134 patients because of incomplete AAM data and 309 (9.7%) patients because of incomplete SAQ AF data. As such, our analytic cohort included 2743 patients (Figure 1). Mean age of patients was 65.2 years, 70.3% were men, and 92.0% were white (Table S3). Cardiac and noncardiac comorbidities were common, with past PCI in 43.2%, past bypass graft surgery in 21.8%, past myocardial infarction 28.1%, and diabetes mellitus in 34.4%. The most common indication for PCI was stable angina in 36.6% followed by unstable angina in 35.0% and non-ST-elevation myocardial infarction in 17.8%. Complete revascularization was achieved in 68.7% of patients. Compared with patients whose AAMs were unchanged or escalated, patients whose AAMs were de-escalated were more likely to be older and to have a history of past coronary revascularization (Table 1).

Baseline Angina and AAM

At admission, the mean SAQ AF score was 71.6±25.0 (Table S3). Pre-PCI, 74.2% of patients were on at least 1 AAM with a mean (±SD) of 1.0±0.8 AAM per patient. Beta-blockers, calcium-channel blockers, long-acting nitrates, and ranolazine were used in 64.6%, 23.8%, 14.1%, and 2.4% of patients, respectively (Table 2). At discharge, 88.4% of patients were on an AAMs with a mean (±SD) of 1.2±0.7 AAMs. From admission to discharge, AAM were de-escalated in 299 patients (10.9%), unchanged in 1730 (63.1%), and escalated in 714 (26.0%). Patients whose AAMs were de-escalated were more likely to have a greater burden of angina and worse health status at the time of PCI and had a higher predicted risk of residual angina at 6 months post-PCI.

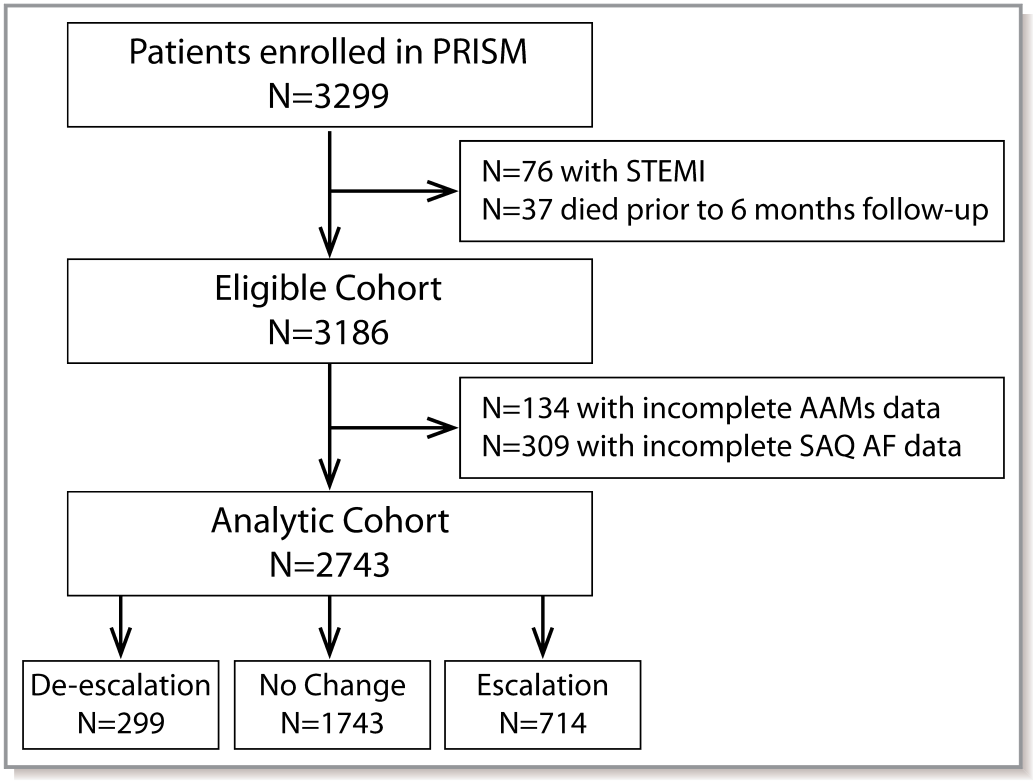

Figure 1. Patient population. Flow chart of patients in the study. AMM indicates antianginal medications; AF, angina frequency; STEMI, ST-elevation myocardial infarction; PRISM, the Platelet Receptor Inhibition in Ischemic Syndrome Management™ study; SAQ, Seattle Angina Questionnaire.

Six-Month Angina and Health Status

In unadjusted analysis, the proportion of patients who reported angina at 6 months post-PCI was higher in those whose AAM was de-escalated versus unchanged or increased (33.4% versus 23.3% versus 21.3%; $P<0.001$; Figure 2), and all SAQ domains were lower in patients who were de-escalated (Table 2). Among patients with complete revascularization (n=1884), there were no significant differences in angina (25.6% versus 21.9% versus 20.3%; de-escalation versus unchanged versus escalation with $P=0.30$; Figure 2) or health status (Table 3) regardless of the change in AAM at discharge. However, among those with incomplete revascularization (n=859), 48.1% of patients whose AAMs were de-escalated reported angina at 6 months post-PCI versus 26.3% and 23.6% of patients with unchanged or escalated AAM, respectively.

In the multivariable model that adjusted for the patient's preprocedural risk for post-PCI angina, there was a significant interaction between AAM change and completeness of revascularization ($P<0.001$), with the most significant impact on angina of AAM de-escalation in those with incomplete revascularization. In patients with complete revascularization, there was no significant association of de-escalation with risk of post-PCI angina (de-escalation versus no change: relative risk, 0.92, 95% confidence interval [CI], 0.78–1.09). However, among patients with incomplete revascularization, patients whose AAMs were de-escalated had a 43% increased risk of angina at 6-months post-PCI (relative risk, 1.43, 95% CI, 1.26–1.63) compared with those whose AAMs were unchanged (Figure 3). Similar risks of angina were observed among patients whose AAMs were unchanged versus escalated, regardless of completeness of revascularization.

Similar findings were observed when we examined the SAQ domains and summary score as continuous variables (Table 3). The interaction of completeness of revascularization by change in AAM was significant for all outcomes except SAQ QoL. For patients who had complete revascularization, there were no significant differences in 6-month health status for any of the SAQ domains or the summary score regardless of change in AAM. However, among patients with incomplete revascularization, AAM de-escalation was associated with a 4.7-point worse SAQ Summary Scale score (95% CI, −8.1 to −1.4) and a trend toward worse SAQ AF (−5.3; 95% CI, −11.0 to 0.5) and SAQ PL scores (−2.8; 95% CI, −5.8 to 0.1). De-escalation was not associated with a significant difference in SAQ QoL scores.

Discussion

In this large, multicenter study of patients undergoing PCI, we found that 1 in 10 patients had their AAM regimen de-

Table 1. Demographic and Clinical Characteristics of Patients Whose AAMs Were De-escalated, Unchanged or Escalated

	AAM De-escalation (n=299)	No Change (n=1730)	AAM Escalation (n=714)	*P* Value
Age, y	67.0±10.7	65.6±10.5	63.6±10.8	<0.001
Male sex	71.1%	72.2%	65.3%	0.003
White race	89.8%	93.5%	89.1%	<0.001
Self-reported avoidance of care attributed to cost	8.0%	11.6%	16.4%	<0.001
Current smoker	11.5%	14.2%	18.5%	0.006
Past myocardial infarction	34.1%	30.7%	19.2%	<0.001
Past PCI	51.2%	48.0%	28.3%	<0.001
Past CABG	30.4%	23.4%	14.6%	<0.001
Hypertension	94.6%	85.7%	79.6%	<0.001
Diabetes mellitus	36.8%	33.6%	35.3%	0.468
Creatinine, mg/dL	1.2±0.8	1.1±0.7	1.1±0.9	0.326
Chronic lung disease	14.7%	13.4%	13.0%	0.769
PCI indication				
Stable CAD	29.8%	41.1%	28.6%	<0.001
Unstable angina	36.5%	36.0%	31.9%	
NSTEMI	23.1%	11.6%	30.8%	
Other	10.7%	11.4%	8.7%	
Predicted risk of residual angina (%)	30.7±18.4	23.9±16.3	21.7±14.5	<0.001
Complete revascularization	65.2%	68.8%	69.7%	0.356
Ejection fraction <40%	13.7%	11.5%	8.7%	0.105

AMM indicates antianginal medications; CABG, coronary artery bypass graft; CAD, coronary artery disease; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention.

escalated at discharge post-PCI. Patients whose AAMs were de-escalated at discharge were more likely to report residual angina and worse overall health status at 6 months postdischarge. In a model that adjusted for the patient's preprocedural predicted risk of residual angina, we found that the impact of de-escalation on subsequent angina was essentially isolated to patients with incomplete revascularization. Among these patients, nearly half reported angina at 6 months post-PCI if their AAMs were de-escalated compared with only one quarter of those with unchanged or escalated AAM. Although we are unable to examine de-escalation over time and its impact on long-term health status, these findings suggest that AAMs, when possible, should not be de-escalated in the immediate post-PCI period, especially in patients with incomplete revascularization.

Previous Studies

There have been a number of studies that have examined factors associated with angina or health status post-PCI and other cardiac events.[4,12,25,26] In these studies, 1 of the strongest predictors of post-PCI angina is the severity of ischemic symptoms pre-PCI. In addition, in our past work in PRISM, we found that patients who were on more AAMs at admission were at higher risk for residual angina post-PCI (presumably as an additional marker of more symptoms pre-PCI). However, scarce data are available on the association of post-PCI factors (especially medication changes) with subsequent health status. In the RIVER-PCI (Ranolazine in patients with incomplete revascularization after percutaneous coronary intervention) trial, the addition of ranolazine to standard medical regimen in patients with incomplete revascularization did not result in less angina or better health status.[27] Similarly, we did not find an association of AAM escalation immediately post-PCI with less angina or better quality of life at follow-up. Our data, however, confirm the challenge presented by this group of patients. Patients with incomplete revascularization (particularly those with high-risk features, such as high burden of pre-PCI angina, poor quality of life, depression, or low socioeconomic status) are at high risk for residual angina that could be worsened by early de-escalation of AAM post-PCI. Whereas there may not be a role for empiric escalation post-PCI, a more-cautious de-escalation that is based on symptoms and not anatomy may be prudent.

Table 2. Baseline Angina and Health Status and AAM

	AAM De-escalation (n=299)	No Change (n=1730)	AAM Escalation (n=714)	*P* Value
AAM on admission				
Any AAM	100.0%	85.2%	36.7%	<0.001
No. of AAM	1.8±0.7	1.2±0.7	0.5±0.7	<0.001
Beta-blocker	82.3%	77.9%	25.1%	<0.001
Calcium-channel blocker	52.5%	22.1%	16.1%	<0.001
Long-acting nitrate	35.8%	13.3%	7.1%	<0.001
Ranolazine	8.7%	2.0%	0.8%	<0.001
AAM on discharge				
Any AAM	79.6%	85.2%	100.0%	<0.001
No. of AAM	1.1±0.8	1.2±0.7	1.4±0.6	<0.001
Beta-blocker	72.9%	78.7%	95.5%	<0.001
Calcium-channel blocker	17.1%	21.2%	27.0%	<0.001
Long-acting nitrate	17.4%	13.2%	18.2%	0.003
Ranolazine	3.3%	2.1%	2.5%	0.380
SAQ at baseline				
Angina frequency	64.4±28.3	72.3±24.5	73.1±24.1	<0.001
Quality of life	51.9±4.8	56.4±25.7	55.7±26.0	0.01
Physical limitation	70.9±26.0	76.1±24.1	79.4±23.4	<0.001
Summary score	61.5±21.4	68.3±20.3	69.6±20.2	<0.001
SAQ at 6 mo				
Angina frequency	88.8±19.6	92.9±16.2	93.6±14.9	<0.001
Quality of life	76.4±22.0	80.3±20.0	80.3±20.4	0.008
Physical limitation	93.6±15.4	95.4±13.9	96.5±11.1	0.02
Summary score	86.0±15.9	90.3±13.2	91.0±12.4	<0.001

AAM indicates antianginal medications; SAQ, Seattle Angina Questionnaire.

Clinical Implications

AAMs effectively treat angina[28–31] and are recommended as first-line therapy in most patients with stable coronary artery disease. Management of these medications after revascularization can be challenging. AAMs are not associated with a decrease in morbidity or mortality in the majority of patients and therefore should be used only for symptom relief. As such, after revascularization, it makes sense to try to de-escalate AAMs. It is not uncommon for patients to be angina free for several months and yet remain on intensive AAM. This therapeutic inertia can contribute to polypharmacy and side effects from medications that are not providing any therapeutic benefit. However, it is important to recognize that PCI does not eliminate angina in all patients, and there are a subset of patients at high risk for recurrent angina that may benefit from continued AAM or at least a more-cautious de-escalation. Examples of this include patients who have functional mechanisms for angina, such as microvascular dysfunction and coronary spasms, which are not impacted by revascularization and best treated with AAMs. Thus, having a systematic method for de-escalation may be of benefit—1 strategy could be to de-escalate AAM in patients with low risk of residual angina and complete revascularization at discharge followed by symptom-guided de-escalation of other patients over time during follow-up. De-escalation should occur in the majority of patients, but we have shown that doing this too early in high-risk patients may have adverse consequences on long-term angina and health status. Interestingly, we found a paradoxical pattern in the patients whose AAMs were reduced, with this occurring more often in those with more baseline angina and in those predicted to have more angina at 6 months. This suggests that a more-formal method for identifying patients whose AAM can be reduced is needed, perhaps by utilizing a risk model before discharge.[12]

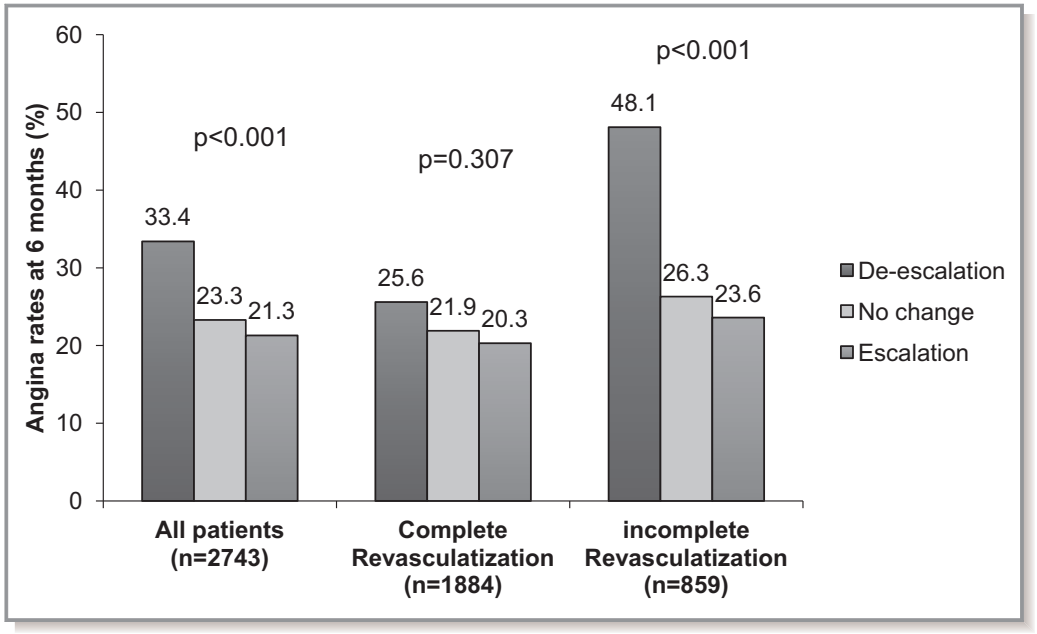

Figure 2. Angina rates at 6 months post–percutaneous coronary intervention (PCI). Unadjusted rates of patient-reported angina at 6 months post-PCI, stratified by change in antianginal medications (AAM) at discharge and completeness of revascularization.

Limitations

Our study findings should be interpreted in light of the following potential limitations. First, reasons for de-escalating the AAMs were not available in the registry, which could have been physician driven (eg, deliberate de-escalation) or patient driven (eg, side effects). Moreover, these classes of medications could be used for other medical reasons other than angina (eg, hypertension), and reasons for use were not available. Whereas this would not impact the interpretation of our findings of the association of de-escalation on health status, data on reasons for its use and de-escalation (or escalation) could provide important insight. Second, when defining change in AAM, we assumed equal antianginal properties of all 4 AAM classes. Whereas this is supported by past literature,[20,21] it is certainly possible that individual

Table 3. Independent Association of Change in AAM With Long-Term Health Status*

	Complete Revascularization	Incomplete Revascularization	
	Estimate† (95% CI)	Estimate† (95% CI)	Interaction *P* Value‡
De-escalation vs unchanged			
SAQ angina frequency	0.2 (−0.9 to 1.3)	−5.3 (−11.0 to 0.5)	0.047
SAQ physical limitations	1.5 (−0.1 to 3.0)	−2.8 (−5.8 to 0.1)	0.003
SAQ quality of life	−0.2 (−2.9 to 2.6)	−1.2 (−6.1 to 3.7)	0.289
SAQ summary score	0.0 (−1.7 to 1.7)	−4.7 (−8.1 to −1.4)	0.009
Escalation vs unchanged			
SAQ angina frequency	−0.2 (−1.5 to 1.2)	0.6 (−1.1 to 2.4)	0.047
SAQ physical limitations	0.2 (−0.8 to 1.2)	1.1 (−0.3 to 2.6)	0.003
SAQ quality of life	−1.5 (−2.9 to −0.2)	1.1 (−2.9 to 2.6)	0.289
SAQ summary score	−0.3 (−1.3 to 0.7)	0.7 (−1.1 to 2.5)	0.009

CI indicates confidence interval; SAQ, Seattle Angina Questionnaire

*Adjusted for the patient's predicted risk of residual angina after percutaneous coronary intervention.

†Estimate is the adjusted difference in SAQ scores at 6 months between de-escalation vs unchanged and escalation vs unchanged.

‡*P* value for the interaction between the SAQ scores at 6 months and revascularization status (incomplete vs complete).

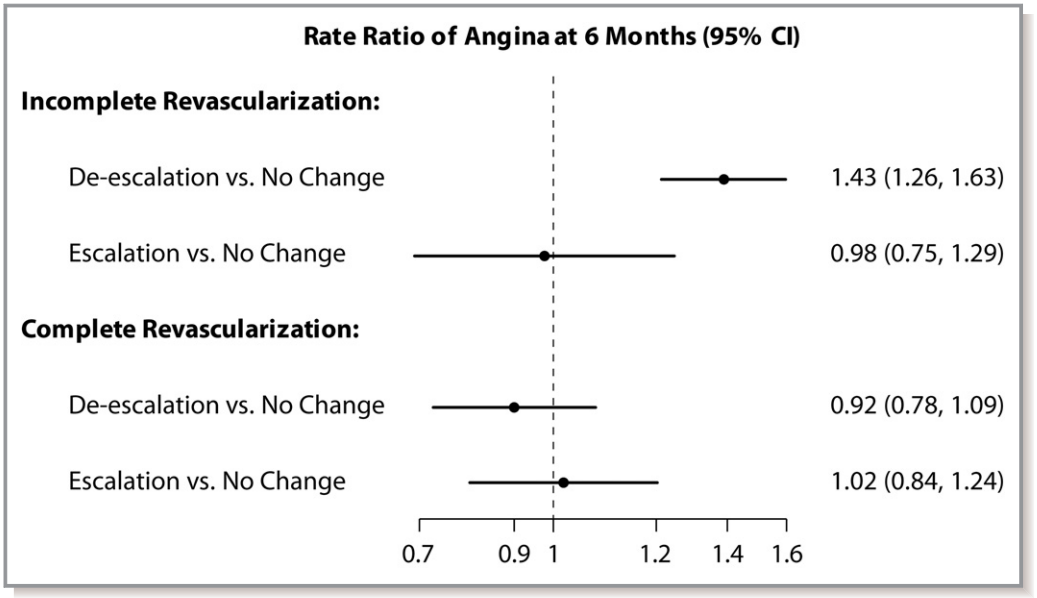

Figure 3. Independent association between antianginal medications (AAM) change and angina at 6 months after percutaneous coronary intervention (PCI). Adjusted for the pre-procedural risk of predicted residual angina and completeness of revascularization. CI indicates confidence interval.

patients can respond differently to different drugs. In addition, the >25% threshold for a clinically relevant change in AAM was selected based on clinical judgment. Although we did sensitivity analyses examining alternative thresholds and found similar associations with post-PCI angina (although with slightly different rates of de-escalation/escalation), because there is no established definition for AAM de-escalation, one could make an argument for a different threshold. Third, data on changes in AAM postdischarge were not available. Changes in AAM postdischarge, either de-escalation or escalation, certainly occur and would potentially impact our results. However, titration of medications based on symptoms postdischarge should, if anything, mitigate the observed association of discharge medications with long-term health status. Fourth, completeness of revascularization was determined on an anatomical basis through adjudication of the coronary angiogram reports. The lack of core lab adjudication of angiograms may have led to overestimation of complete revascularization (attributed to nonreporting of lesions not treated), and the lack of routine functional data (through stress imaging and fractional flow reserve) may have led to underestimation of complete revascularization. However, it would be expected that these issues would bias our result toward the null because of the decreased specificity of the complete revascularization definition. Last, PRISM was conducted between 2009 and 2011. Although the registry is a few years old, no noticeable changes in guideline recommendations regarding angina treatment or AAMs and thus results are unlikely to be confounded by the age of the cohort studied.

Conclusion

Approximately 1 in 10 patients who undergo PCI have their AAMs de-escalated at discharge. Patients whose AAMs were de-escalated, particularly those with incomplete revascularization, were more likely to report angina and worse health status at 6 months post-PCI. Because AAMs do not reduce morbidity or mortality in most patients, AAMs should be de-escalated over time in patients whose symptoms are effectively treated by the revascularization. However, our data suggest that this should be done more cautiously in patients at high risk for residual or recurrent angina. A systematic method for de-escalation based on risk of residual angina, completeness of revascularization, and symptoms over time could maximize health status while safely reducing medications over time. Future studies to evaluate causes for AAM discontinuation and to evaluate different strategies to adjust these medications post-PCI are needed.

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SUPPLEMENTAL MATERIAL

Table S1. Maximum daily dosages of antianginal medications

Drug Name	Maximum recommended daily dose (mg)*
Beta-blockers	
Atenolol	200
Acebutolol	400
Bisoprolol	20
Carvedilol	50
Labetalol	2400
Metoprolol	400
Nadolol	240
Nebivolol	40
Propranolol	320
Sotalol	320
Calcium channel blockers	
Amlodipine	10
Diltiazem	480
Felodipine	10
Isradipine	10
Nifedipine	180
Nisoldipine	40
Verapamil	480
Nitrates	
Isosorbide Dinitrate	160
Isosorbide Mononitrate	120
Nitroglycerin	26
Other	
Ranolazine	2000

*Data from Lexicomp online drug dictionary.

Table S2. Examples of AAM changes

Admission Medication	Total daily dose	% Max Dose	Discharge Medication	Total daily dose	% Max Dose	Absolute % Change	Definition of Change in AAM
Carvedilol	50 mg	100%	Metoprolol	25 mg	6.25%	-92.75%	De-escalation
Amlodipine	5 mg	50%	Amlodipine	10 mg	100%	+50%	Escalation
Carvedilol	12.5 mg	25%	Diltiazem	120 mg	25%	0%	No change

Table S3. Baseline characteristics of patients who are alive but missing 6-month angina data compared with the analytic cohort.

	Missing data n=443	Analytic cohort n=2743	P-value
Age (y)	57.9 ± 11.3	65.2 ± 10.6	<0.001
Male sex	76.5%	70.3%	0.007
White race	86.5%	92.0%	<0.001
Self-reported avoidance of care due to cost	20.8%	12.5%	<0.001
Current smoker	33.3%	15.0%	<0.001
Prior myocardial infarction	25.5%	28.1%	0.263
Prior PCI	33.6%	43.2%	<0.001
Prior CABG	12.9%	21.8%	<0.001
Hypertension	73.4%	85.1%	<0.001
Diabetes mellitus	30.0%	34.4%	0.072
Creatinine (mg/dL)	1.1 ± 1.3	1.1 ± 0.8	0.684
Chronic lung disease	11.1%	13.5%	0.167
PCI indication			<0.001
Stable angina	24.4%	36.6%	
Unstable angina	34.3%	35.0%	
NSTEMI	33.2%	17.8%	
Other	8.1%	10.6%	
Complete revascularization	65.2%	68.8%	0.356
EF < 40%	10.7%	11.0%	0.881
Antianginal medications on admission	74.1%	74.2%	0.978
Antianginal medications on discharge	89.9%	88.4%	0.362
SAQ Angina Frequency	70.8 ± 23.4	71.6 ± 25.0	0.482
SAQ Quality of Life	55.5 ± 26.6	55.7 ± 25.7	0.838
SAQ Physical Limitation	76.0 ± 25.0	76.4 ± 24.2	0.735