Original Article

Morbidity and Mortality Conference for Percutaneous Coronary Intervention

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Background—Morbidity and mortality conference is a common educational and quality improvement activity performed in cardiac catheterization laboratories, but best practices for case selection and for maximizing the effectiveness of peer review have not been determined.

Methods and Results—We reviewed the 10-year percutaneous coronary intervention morbidity and mortality conference experience of an academic medical center. Cases were triggered for review by the occurrence of prespecified procedural events. Summary reports from morbidity and mortality conference discussions were linked to clinical data from the Duke Databank for Cardiovascular Disease to compare baseline and procedural characteristics and to assess postdischarge outcomes. Of 11 786 procedures, from 2004 to 2013, 157 (1.3%) were triggered for review. The most frequent triggering events were cardioversion/defibrillation (72, 0.6%), unplanned use of mechanical circulatory support (64, 0.5%), and major dissection (41, 0.3%). Selected procedures were more likely to include high-risk features, such as ST-segment–elevation myocardial infarction, cardiogenic shock, and multivessel disease, and were associated with higher mortality at 30 days. Only a minority of triggering events were caused by controversial or unacceptable physician behavior.

Conclusions—This 10-year experience outlines the processes for conduct of an effective percutaneous coronary intervention morbidity and mortality conference, including a novel approach to case selection and structured peer review leading to actionable quality interventions. The prespecified clinical triggers, captured in the natural workflow by laboratory staff, identified complex cases that were associated with poor patient outcomes. **(*Circ Cardiovasc Qual Outcomes*. 2017;10:e003538. DOI: 10.1161/CIRCOUTCOMES.116.003538.)**

Key Words: cardiac catheterization ■ morbidity ■ peer review ■ percutaneous coronary intervention ■ workflow

The morbidity and mortality (M&M) conference is a forum for hospitals and clinicians to examine adverse outcomes for the purposes of performance improvement, systems change, and education. M&M conference is a common form of peer review used by percutaneous coronary intervention (PCI) programs and a potential method of accomplishing continuous quality improvement, ongoing professional practice evaluation, and case review.[1–5] Although the modern M&M conference dates from the mid-20th century and is familiar to most clinicians,[6] there is little consensus on strategies for effective case selection and review.[7] Previous description of M&M conference in the catheterization laboratory is limited to a single case report.[8]

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Objective and transparent methods for case selection and review are required to facilitate effective discussion of serious adverse outcomes in a supportive environment. Reliance on physician self-report for case selection may result in underreporting of cases, whereas random case selection may fail to identify cases with poor outcomes. Unclear methods of case review and performance evaluation could lead to defensiveness and resentment. Studies of effective PCI M&M conference processes are needed.

We therefore report the 10-year experience of PCI M&M conference case selection and review at a large academic medical center. Our objectives are to (1) describe M&M conference procedures, including an objective method of case selection using prespecified clinical triggers; (2) compare outcomes of patients selected versus not selected for review; and (3) present the results of physician, staff, and hospital system performance assessment and interventions.

Methods

The Duke University Hospital cardiac catheterization laboratory performs monthly M&M conference for peer review and education as recommended by consensus statements.[5] The M&M process is led by the Director of Cardiovascular Medicine Performance Improvement (an interventional cardiologist) and the Administrative Director of the Cardiac Catheterization Laboratory. Administrative support (screening of cases, assembly of the case list, conference coordination, and

Received December 30, 2016; accepted June 9, 2017.

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WHAT IS KNOWN

- M&M conference is a common method of quality improvement for PCI programs.
- Guidelines recommend peer review processes for all PCI programs, but do not specify best practices for implementation.

WHAT THE STUDY ADDS

- This study presents an example of a sustainable PCI M&M conference.
- Prespecified clinical triggers, captured by procedural data systems, select complex cases for review.
- A standardized peer review methodology leads to actionable quality interventions.

report management) is provided by a cardiac catheterization laboratory advanced practice provider. M&M conference is attended by interventional cardiology faculty and fellows, along with a laboratory staff and administrative representative. Faculty members are individually notified if they have a case under review and strongly encouraged to attend. For each case, a fellow presents a standardized clinical vignette followed by review of angiography. Subsequent discussion focuses on indications for the procedure, interventional technique, opportunities for practice improvement, alternative approaches, the environment of care, and other points of educational value. The review is retrospective, with cases from the preceding month being discussed. Cases in which the complication is unavoidable and effectively managed (ie, successful defibrillation of ventricular tachycardia after reperfusion during an intervention for acute ST-segment–elevation myocardial infarction) may be discussed for only minutes, whereas other cases may require up to an hour of discussion. Participants are encouraged to engage in frank conversation to identify variances in care delivery while describing opportunities to improve. At the conclusion of the case discussion, separate summative scores are assigned to the physician team, cath laboratory staff, and hospital systems by faculty consensus (Figure 1, peer review score). A review score of 3 to 5 (very controversial or unacceptable performance) prompts the creation of a formal plan for process improvement or corrective action. If no consensus is reached during M&M conference, the Director of Performance Improvement privately compiles opinions from participating faculty members, with majority vote determining the severity score. Documentation, including the case vignettes, discussion summaries, review scores, and action items are retained by the Chief of the Division of Cardiology and the hospital Performance Improvement Office to contribute to periodic practitioner performance assessment and as a reference for subsequent quality improvement activities. Discussions are protected from discovery or disclosure per statute applicable to peer review and quality improvement activities, and the confidentiality of M&M processes is emphasized.

Cases are selected for M&M review based on the occurrence of at least 1 of 9 prespecified clinical events or triggers. The occurrence of the event is captured in the procedure log by the catheterization laboratory staff responsible for monitoring and documentation (rather than the physician). Triggering events include in-laboratory death, cardiac arrest requiring cardiopulmonary resuscitation, defibrillation/cardioversion, intubation, coronary perforation, major coronary dissection, unplanned pericardiocentesis, unplanned use of mechanical circulatory support (intra-aortic balloon pump, left ventricular assist device, or extracorporeal membrane oxygenation), and unplanned placement of a temporary transvenous pacemaker. A monthly report run against the cardiac catheterization database identifies patients with a triggering event. Any disagreement about whether or not a case should be reviewed is adjudicated by the Director of Performance Improvement. In addition, cases not meeting one of these criteria can be reviewed by physician or staff request. These additional cases were assessed, but were not included in the cohort of M&M conference cases for analysis, to focus on cases triggered by prespecified clinical events.

We collected summary reports of all reviewed cases, including the indication(s) for review, clinical case vignettes, and severity scores assigned to physician, staff, and hospital systems performance. These clinical data, retained for quality improvement purposes, were then linked to the Duke Databank for Cardiovascular Disease to obtain demographic, procedural, and longitudinal outcomes data. The Duke Databank for Cardiovascular Disease is a prospective registry of all patients undergoing invasive and interventional cardiac catheterization procedures at the Duke University Hospital.[9] Clinical presentation and angiographic data are prospectively captured in the course of routine patient care and populate a clinical database that is used for both clinical report generation and research. Outcomes were determined by the Duke Databank for Cardiovascular Disease using previously described mechanisms, including a self-administered questionnaire and follow-up phone calls for nonresponders.[9,10] The National Death Index was used to assess vital status not available through the previous mechanisms. The Duke Institutional Review Board approved the study, and waiver of participant informed consent was obtained.

All PCI patients from January 1, 2004 to December 31, 2013 were eligible for review. PCI was defined as the placement and activation of any interventional treatment device in any coronary artery. Of 11 817 procedures during this period, we excluded 28 procedures because of a lack of diagnostic angiography data and 3 cases because of patient age <18 years.

We compared baseline and procedural characteristics of patients selected versus not selected for M&M conference review via the previously described clinical triggers. Continuous variables are described by median and interquartile range and compared using Wilcoxon rank-sum test. Categorical variables are described as percentages and compared using the χ^2 test for independence or Fisher mid-P for smaller sample sizes. Outcomes evaluated to 30 days include all-cause mortality, unplanned repeat revascularization, the composite of death or myocardial infarction, and the composite of death or rehospitalization. Outcomes are presented as raw percentages and compared with the χ^2 test.

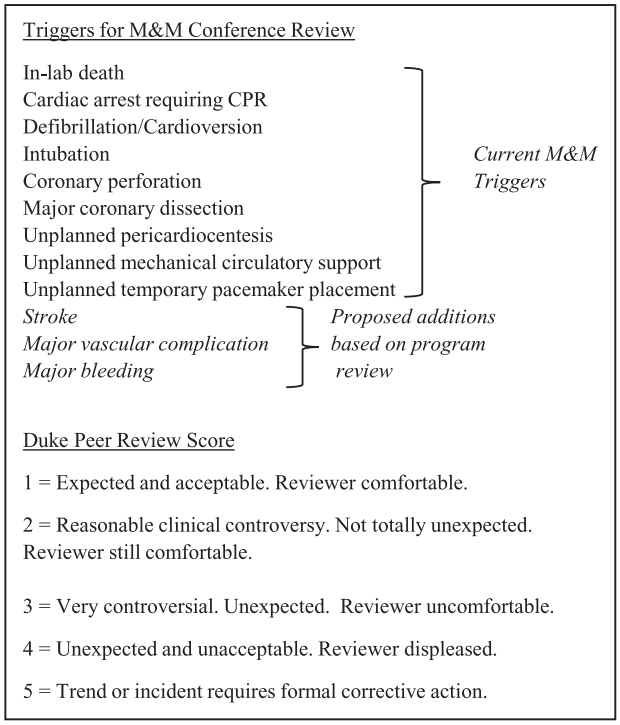

Figure 1. morbidity and mortality (M&M) conference processes for case selection and peer review. CPR indicates cardiopulmonary resuscitation.

All variables had <1% missing data with the exception of multivessel disease (10%). The data analysis was generated using SAS software, Version 9.4 (SAS Institute, Inc., Cary, NC). Statistical significance was attributed to comparisons with a P value ≤0.05, and no adjustments were made for multiple comparisons.

Results

From 2004 to 2013, we assessed 11 786 PCI procedures performed in the Duke University Medical Center adult cardiac catheterization laboratory. Of these, 157 (1.3%) were selected for peer review because of the occurrence of one or more of the prespecified clinical triggers. The most frequent triggering events were cardioversion/defibrillation (72, 0.6% of all cases), unplanned use of mechanical circulatory support (64, 0.5%), and major dissection (41, 0.3%). Death in the cath laboratory occurred in 6 cases (0.05%). Among cases selected for review, 82 cases (52.2%) were triggered by a single clinical event, 36 cases (22.9%) were triggered by 2 events, and 39 cases (24.8%) were triggered by ≥3 events (Figure 2).

Patients triggered for peer review were more likely to present with ST-segment–elevation myocardial infarction and cardiogenic shock and had a greater frequency of multivessel coronary artery disease and left main stenosis. Triggered cases were more likely to have had ≥2 stents implanted, less likely to have had a drug-eluting stent implanted, and had higher rates of in-hospital complications such as periprocedural myocardial infarction, cardiogenic shock, heart failure, and bleeding requiring blood transfusion (Table 1).

Compared with patients not triggered for peer review, selected patients had significantly higher 30-day rates of death (23.7% versus 1.9%, P<0.001), death/myocardial infarction (26.8% versus 3.4%, P<0.001), death/rehospitalization (31.2% versus 12.5%, P<0.001), and repeat revascularization (11.5% versus 4.4%, P<0.001; Table 2). Mortality increased in a stepwise manner as the number of clinical triggers increased (Figure 2).

At the time of peer review, all triggered cases were assigned review scores for physician, staff, and hospital systems performance. Physician performance was judged acceptable (severity score=1) in 107 cases (68.2%), controversial (severity score=2) in 41 cases (26.1%), and very

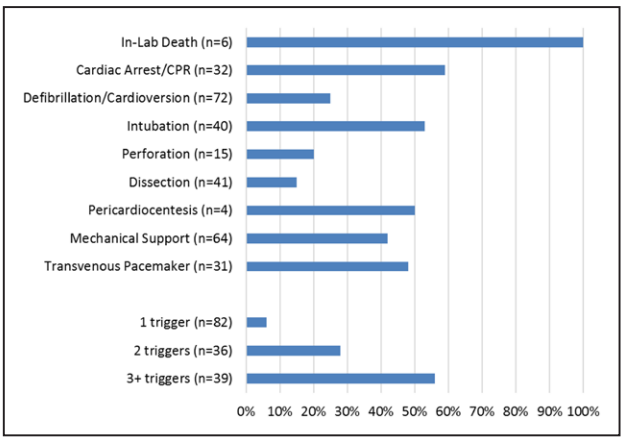

Figure 2. Mortality rates at 30 d for patients with each of 9 clinical triggers during the index percutaneous coronary intervention (PCI) procedure, and by number of clinical triggers. The 6 cases resulting in in-laboratory death all had at least 3 additional triggers. CPR indicates cardiopulmonary resuscitation.

Table 1. Characteristics of Patients Selected Versus Not Selected for M&M conference Review After Percutaneous Coronary Intervention Based on Prespecified Clinical Triggers

	Selected for M&M, n=157	Not Selected for M&M, n=11 629	P Value
Demographics			
Age, y, median (IQR)	64 (56–73)	63 (55–72)	0.404
Male	65.6	68.1	0.507
Non-white race	26.1	27.0	0.283
Clinical history			
BMI, kg/m^2, median (IQR)	27 (25–32)	29 (25–33)	0.019
Current/recent smoker	40.1	46.6	0.105
Hypertension	65.6	72.4	0.059
Dyslipidemia	59.9	64.7	0.210
Diabetes mellitus	26.8	31.6	0.192
Kidney disease on dialysis	3.2	2.3	0.349
Previous myocardial infarction	70.1	54.4	<0.001
Previous heart failure	17.2	18.9	0.595
Previous PCI	23.6	33.0	0.013
Previous CABG	18.5	26.2	0.029
Previous stroke	13.4	9.1	0.062
Presentation and treatment			
Presentation of CAD			<0.001
Stable angina	13.4	31.0	
Unstable angina/NSTEMI	24.8	44.6	
STEMI	61.1	24.2	
Other	0.6	0.2	
Cardiogenic shock at presentation	17.8	0.7	<0.001
Procedure performed during daytime	84.1	92.8	<0.001
Procedure performed Monday–Friday	85.4	92.9	<0.001
Left main stenosis ≥50%	14.6	8.4	0.005
2 or 3 vessel CAD	64.2	52.5	0.005
Multivessel PCI	19.7	14.5	0.066
>1 stent used	52.2	35.8	<0.001
Graft intervention	3.8	10.2	0.008
DES used	45.2	64.0	<0.001
Postprocedural complications			
Cardiac arrest	4.5	0.1	<0.001
Cardiogenic shock	8.9	0.3	<0.001
Heart failure	5.7	1.4	<0.001
Transfusion	9.6	1.5	<0.001
Stroke/TIA	0.6	0.1	0.060

Reported numbers reflect percentages, unless noted otherwise. BMI indicates body mass index; CABG, coronary artery bypass graft; CAD, coronary artery disease; DES, drug-eluting stent; IQR, interquartile range; M&M, morbidity and mortality conference; NSTEMI, non–ST-segment–elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction; and TIA, transient ischemic attack.

Table 2. Outcomes at 30 Days Post-Procedure of Patients Selected Versus Not Selected for M&M conference Review Based on Prespecified Clinical Triggers

	Selected for M&M, n=157	Not Selected for M&M, n=11 629	*P* Value
Death	23.7	1.9	<0.001
Death/myocardial infarction	26.8	3.4	<0.001
Death/rehospitalization	31.2	12.5	<0.001
Repeat revascularization	11.5	4.4	<0.001

Reported numbers reflect percentages. M&M indicates morbidity and mortality conference.

controversial or unacceptable (severity score=3–5) in 9 cases (5.7%). Review occasionally identified concerns with catheterization laboratory staff performance or processes (1.9%) or hospital systems and infrastructure (2.5%; Table 3). Finally, further intervention was pursued in all cases where a physician was assigned a severity score of 3 to 5, or where a hospital system or process issue was identified. The interventions were context specific, ranging from working with individual physicians to eliminate knowledge gaps to adjusting the acute ST-segment–elevation myocardial infarction staff activation process.

Only 21 cases not triggered by the prespecified selection criteria were reviewed, all by physician request. These cases included the following periprocedural complications: groin hematoma or pseudoaneurysm (7), acute stent thrombosis (2), acute coronary thrombus/embolus (2), bradycardia requiring atropine (2), equipment failure (2), and one each of a kinked guide catheter, retroperitoneal bleed, femoral artery dissection, pulmonary edema, and stroke.

Discussion

This 10-year experience from a large academic medical center catheterization laboratory describes processes for an effective PCI M&M conference, including a novel method of case selection and structured peer review guiding quality interventions. Prespecified clinical triggers, identified automatically through staff documentation, identify complex cases of educational value that are associated with poor patient outcomes. These methods use existing clinical procedure documentation systems to systematically capture data and thus reduce selection bias in the evaluation of opportunities to promote care quality.

Table 3. Results of Peer Review of morbidity and mortality conference Cases (n=157)

Peer Review Severity Score	Physician Team	Laboratory Staff	Systems
1=Expected and acceptable	107	154	153
2=Reasonable controversy, not totally unexpected	41	3	3
3=Very controversial, unexpected	8	0	1
4=Unexpected and unacceptable	1	0	0
5=Unacceptable and requires formal action	0	0	0

Reported numbers indicate number of procedures.

M&M conference was pioneered by the surgery and anesthesiology communities,[6] but is now used in most fields of medicine and is nearly ubiquitous among training programs.[11,12] Despite this popularity, few studies have examined the characteristics of effective M&M conference[13,14] or proposed a standardized method for case selection or review.[15] In many ways, the catheterization laboratory is an ideal setting for M&M conference. PCI is a technical procedure in which operator skill and decision-making may immediately and directly determine patient outcomes. PCI also produces a durable record of the delivered care (the angiographic images) that, in addition to clinical data, provides substrate for M&M conference discussion. Peer review of challenging and complicated cases is recommended for all PCI programs,[3] and M&M conference in particular is endorsed by the Society of Cardiovascular Angiography and Intervention.[2] Our study provides evidence that PCI M&M conference can be effective and sustainable.

One key goal of M&M conference is the investigation of adverse events to identify opportunities for care improvement. This is dependent on appropriate case selection. Our method, using prespecified triggering events identified from the procedure reporting system, selects complex PCI procedures and patients with high rates of short-term morbidity and mortality. Use of 9 clinical triggers selects a reasonable number of cases (1.3% of all PCIs, about 2 cases per month in our hospital) and focuses on cases that may be most amenable to quality improvement because of the occurrence of procedural complications. We found that triggering events were associated with adverse outcomes at 30 days, and that an increasing number of events correlated with worse outcomes. Other hospitals may choose alternative clinical triggers, and in fact we propose the inclusion of stroke, major vascular complication, and major bleeding as triggers of potential value based on our review.

Nearly, all hospitals in the United States report PCI data, including procedural complications, to the National Cardiovascular Data Registry or other quality improvement registries.[16] This study demonstrates a local, qualitative use of these registry data. Our method of M&M conference may be useful in other clinical fields as well, especially as electronic data systems and quality improvement registries become more prevalent.

Our review processes are predominantly focused on procedural care, and alternative methods for case selection and review may serve complementary purposes. For example, random case review may be valuable to assess procedural appropriateness and operator technique in uncomplicated cases. Review of in-hospital or postdischarge events such as periprocedural myocardial infarction, readmission, or repeat revascularization may identify opportunities for improvement not evident during the procedure. Some programs may choose to review all PCI procedures, with complicated or educational cases then prioritized for additional scrutiny. The potential advantages and disadvantages of these methods are described in Table 4. In our hospital, a multidisciplinary quality improvement committee reviews postdischarge outcomes

Table 4. Comparison of Potential Case Selection Methods for morbidity and mortality conference

Case Selection Method	Advantages	Disadvantages
Physician selected	Focus on cases of educational or QI value	Potential for cherry picking
	Promotes physician engagement	
Random sample	Assess care in normal or uncomplicated cases	May fail to select cases of high complexity or educational value
	Assess procedural appropriateness	
Universal	Comprehensive	Time and resource intensive
	Can generate quantitative data on outcomes	Lack of focus
Triggered by complication		
Procedural complication	Focus on procedural care	Misses postprocedural events and some systems issues
	Selects cases of high complexity and educational value	
30-d complication (ie, death, readmission, repeat revascularization)	Focus on outcomes	Misses procedural issues that do not result in downstream complications

QI represents quality improvement.

of PCI patients in a process that is separate from, but complementary to, the M&M conference.

We also describe a performance assessment method to identify potential opportunities for quality improvement for physicians, staff, and hospital systems. In most cases, performance was judged to be acceptable despite the adverse event, an acknowledgment that some risk is unavoidable when performing PCI, especially in the setting of high-risk conditions like myocardial infarction or cardiogenic shock. When concerning performance is identified, a collaborative and positive discussion is required to minimize negative attribution and instead identify opportunities for practice improvement. In some cases, this may require a formal plan for corrective action. In our M&M conference, a severity index of 3 to 5 (very controversial or unacceptable performance) creates the impetus for a clear quality improvement plan that may include additional training or remediation, as appropriate. This has led to multiple interventions led by physicians and staff. For example, to improve the rapidity of response to unstable cardiac rhythms, staff received specific training to recognize and immediately call out any rhythm changes. This is now incorporated into annual staff competency assessment. Prompted by several vascular access site complications, training was developed for all physicians focused on vascular access site technique (both femoral and radial approaches). Algorithms for the interventional management of spontaneous coronary dissection (including when not to intervene) were developed as a result of triggered events across several cases. Systems and processes were adjusted to reduce our door to device time in acute ST-segment–elevation myocardial infarction cases to substantially below national averages. A critical point is that these opportunities for improvement were approached in a constructive and collaborative manner. A punitive environment would likely have stifled discussion and led to defensiveness.

M&M conference is also commonly used as an educational tool and a means to address general competencies endorsed by the Accreditation Council for Graduate Medical Education.[13,17,18] M&M conference may be particularly effective at addressing the competencies Practice-based Learning and Improvement, and Systems-based Practice.[19,20] Active participation by trainees in M&M conference is recommended, not only in the presentation of cases but also in the development of quality improvement interventions. M&M conference should be 1 component of a comprehensive education program, including topic reviews, case reviews, and procedural training. Educational opportunities are not limited to trainees; experienced operators may also benefit from M&M conference via critical examination of their own practice and that of their colleagues.

We cannot determine if this method of M&M conference leads to improved patient outcomes or is superior to other methods of case review, which is a limitation of this retrospective study (and most published research on PCI quality improvement). Assessing the effectiveness of M&M conference, or differences between various case review methods, would require a prospective multicenter trial. However, previous studies have identified that audit and feedback interventions are most successful when feedback is personalized, actionable, repeated, timely, nonpunitive, and delivered by a respected colleague.[21,22] Our method of M&M meets these criteria. Other facilities may choose to adopt similar methods, but processes must be adapted to local circumstances and improved iteratively. Review of our program, for example, has led to the routine inclusion of staff and administrative representatives at M&M conference. In addition, fellows now present a report on a clinical topic identified in the preceding month's M&M conference, with the goal of maximizing educational value and following up quality improvement opportunities. Our M&M conference template has been successfully implemented in 8 affiliated hospitals in 3 states, indicating the potential to adapt this method to multiple practice models.

Although this study is the first to systematically describe the case selection and other methods applicable to an effective PCI M&M conference, it does have limitations. Our single-center experience may not be applicable to all cath laboratories, particularly those that do not have trainees or

electronic data systems. Our method focuses intentionally on procedural events and therefore may not identify other hospital or systems factors leading to poor patient outcomes after PCI. As an example, a subset of patients in our control group, not selected for M&M review, nonetheless died (1.9%) or were rehospitalized (10.6%) within 30 days. Procedural complications are implicated in only a small percentage of deaths after PCI,[23,24] and, therefore, a comprehensive PCI quality improvement program could consider review of all early adverse events, even if no complications are identified at the time of PCI.

Conclusions

We describe a cardiac catheterization M&M conference process that uses clinical data systems to systematically identify high complexity PCI cases for peer review where there is likely opportunity for quality improvement. These methods may be useful as a primary component of cardiac catheterization quality improvement programs and may be adapted to local needs and the specifics of individual programs.

Disclosures

Dr Patel reports research grants from AstraZeneca, CSL, HeartFlow, Janssen Research and Development, Johnson & Johnson, Maquet Cardiovascular, Medtronic, National Heart, Lung, and Blood Institute. He reports consulting services for AstraZeneca, Bayer, CSL, Genzyme, Janssen Research and Development, Medtronic, and Merck. The other authors report no conflicts.

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Circ Cardiovasc Qual Outcomes. 2017;10:
doi: 10.1161/CIRCOUTCOMES.116.003538
Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 1941-7705. Online ISSN: 1941-7713