

JAMA Performance Improvement

β-Blockers in Myocardial Infarction

Issues With Standard Admission Order Sets

Arjun Gupta, MD; Sandeep R. Das, MD; Ambarish Pandey, MD

Case Summary

A 58-year-old man with untreated hypertension, type 2 diabetes mellitus, and tobacco use was admitted with crushing left-sided chest pain and shortness of breath. He was diagnosed as having an ST-elevation myocardial infarction (STEMI). Emergency percutaneous coronary intervention (PCI) of the right coronary artery was successful. During the procedure, he was noted to have elevated left ventricular filling pressure. After PCI, he was free of chest pain but was bradycardic (heart rate, 53/min) with normal blood pressure (143/82 mm Hg). An electrocardiogram demonstrated atrial fibrillation and complete heart block with a junctional escape at 54/min. The admitting physician placed orders via the electronic medical record using the "STEMI admission order set" and the patient was admitted to the coronary care unit. There, the patient received medications including atorvastatin, 80 mg, and carvedilol, 3.125 mg, within an hour of admission. Over the next few hours, he developed worsening shortness of breath, bradycardia (lowest heart rate, 40/min), and hypotension (lowest blood pressure, 93/63 mm Hg), with crackles noted on auscultation of the lung fields consistent with developing cardiogenic shock.

What Should Be Done Next?

1. Activate the catheterization laboratory for repeat angiography.
2. Perform electrical cardioversion to restore sinus rhythm.
3. Stop β-blocker, provide inotropic support, and start diuretics and transvenous pacing.
4. Provide mechanical circulatory support through placement of an intra-aortic balloon pump.

Consider the Options

In this patient, the initial complete heart block likely resulted from myocardial infarction in the right coronary artery region. The patient also had acute heart failure as reflected by the elevated left ventricular filling pressure. In the setting of complete heart block and acute heart failure, β-blocker therapy is contraindicated, and its administration contributed to the development of cardiogenic shock.¹ The best course of action would be to stop β-blocker therapy and provide inotropic support, transvenous pacing, and diuretic therapy (option 3). The patient was free of chest pain after PCI, and his post-catheterization electrocardiogram did not show ischemic changes, arguing strongly against reinfarction. Thus, activating the catheterization laboratory (option 1) would be inappropriate. In the setting of complete heart block, restoration of sinus rhythm with cardioversion is unlikely to improve hemodynamic instability. Thus, cardioversion (option 2) would not have been indicated at this time. Finally, placement of a mechanical circulatory support device can be

considered in patients with STEMI and refractory shock who do not quickly stabilize with pharmacologic therapy.² In this patient, cardiac output augmentation achieved by pacing and inotropes would be much greater than that achieved by high-risk placement of an intra-aortic balloon pump (option 4).¹

Analysis of the Case

Review of this case initially revealed individual error as an important cause of prescription of β-blockers. Ideally, the physician would have recognized the contraindications to β-blocker therapy. However, it is important to recognize that interaction between an individual and a system creates challenges in delivering optimal care (Audio).³ Systems, such as the order set in this scenario, are designed to facilitate appropriate care and reduce the potential for error. In this instance, it may have contributed to suboptimal care. Review of the previous 12 months of STEMI cases at this institution found that 3 other patients had similarly received β-blockers despite the presence of contraindications but had not experienced clinical decompensation.

At this institution, the STEMI admission order set had been created 5 years previously and has been reviewed and updated annually. The order set included nursing instructions, multiple medication classes (antiplatelet agents, nitroglycerin, β-blockers, statins, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers), laboratory tests, and imaging procedures with the intention of providing optimal care to patients with STEMI. House staff were encouraged to use this "opt-in" order set to admit post-PCI patients with STEMI. The order set had a section on β-blocker therapy that included a clinical decision support (CDS) message that stated that administering β-blockers was a performance measure at both hospital arrival and discharge. Within the β-blocker ordering window, no particular medication was preselected—the admitting physician was required to select one of a few options to proceed: carvedilol, metoprolol succinate, metoprolol tartrate, other β-blocker, β-blocker already administered via medication reconciliation, or contraindication to β-blocker. The first option was for administering 3.125 mg of oral carvedilol. The admitting physician's admission note stated the intention to "hold β-blocker therapy" given complete heart block and heart failure, yet the "carvedilol" option had been selected while putting in orders because it was the first and most visible option. When interviewed, the admitting physician reported that he was also influenced by the CDS stating that administration of β-blockers was a performance measure.

Patients diagnosed as having STEMI in the emergency department were transferred to the catheterization laboratory, where PCI was performed by the interventional cardiology team. The inpatient cardiology team, who would be responsible for post-PCI care, would often not be alerted about the patient until PCI was complete. The inpatient cardiology team might place admission orders without knowing all of the patient's clinical information.

Correct the Errors

1. **Optimize the order set.** Order sets are comprehensive sets of preformed “quick orders” to address certain clinical situations such as venous thromboembolism prophylaxis, sepsis, and STEMI. Order sets are intended to increase consistent evidence-based practice, prevent errors of omission, provide CDS, and enhance clinicians' ordering efficiency. However, these tools have limitations and should not be viewed as a replacement for clinical judgment. Default options in order sets can influence the behavior of decision makers; in one study, the ordering of posttransfusion platelet counts increased from 7.0% to 59.4% when the default was changed from “optional” to “preselected.”⁴ Opt-out defaults result in a greater number of items ordered and specifically increased commission errors (overordering) compared with opt-in defaults, which result in fewer orders but also more omission errors (underordering).⁵ Despite its opt-in nature, the format and contents of the order set influenced prescribing in this case, as reported by the ordering physician. A CDS stating that “β-blockers can be started orally, in the absence of contraindications (eg, heart failure, hypotension, bradycardia)” was introduced in the β-blocker ordering window. A force function, a means of preventing undesirable user input, was instituted by the introduction of hard stops; the physician had to review and click “no contraindications present” when attempting to order β-blockers. Anticipating physician needs, corollary information (last set of vital signs) were pulled up into the β-blocker ordering window. The order of options was modified such that contraindications was listed first, followed by metoprolol tartrate and carvedilol.
2. **Reevaluate quality measures for STEMI.** Quality metrics are tools that reflect consensus standards and are intended to benchmark health care processes to facilitate system-level improvements in the ability to provide high-quality health care.⁶ However, attempts to better adhere to quality metrics can lead to overtesting and overtreatment, especially in scenarios in which patients have contraindications to guideline-indicated therapies.⁷ This patient's initial care demonstrated underuse of clinically indicated diuretic therapy that was not part of STEMI quality metrics. At the same time, β-blocker therapy, which in the past was a STEMI quality metric, was inappropriately given despite clinical contraindication. This disconnect between the putative “quality of care” as measured by metrics and the

true quality of clinical care provided is stark and offers an instructive example to physicians and policy makers.

When “solutions” are put in place to address underuse, a consequence may be worsening overuse or inappropriate use. Moreover, when the process of care that is underused is made a performance measure, the resulting pressure increases the risk of overuse unless there is a balancing measure (or more informal assessment) of overuse.

On review of the American College of Cardiology/American Heart Association guidelines, it emerged that β-blockers on arrival had been removed as a performance measure in 2008 “due to increased complexity of decision making and controversy about the magnitude of net benefit.”⁸ This metric had stopped being tracked by the hospital since then but had continued to be listed as a performance measure in the STEMI order set. The CDS regarding β-blocker administration as a quality metric was removed from the STEMI order set.

3. **Improve communication.** Arrival of a patient with STEMI triggered a consultation to the inpatient cardiology team in addition to the interventional cardiology team. A formal process was introduced in which the interventional cardiology physician team, consisting of an attending physician and a senior fellow, had to discuss admission medications with the inpatient cardiology team, which is composed of more junior house staff.

Outcome

The patient received inotropic support, diuretics, and transvenous pacing and had discontinuation of β-blockers. His heart block resolved and he was discharged in good condition 5 days later. In the 3 months since the changes in the STEMI admission order set, no instances of iatrogenic harm from β-blockers have been observed.

Bottom Line

1. Attention should be paid to the development, components, default settings, and applications of order sets. End users should be involved in all aspects of developing and modifying order sets.
2. An order set, or “guideline-based care,” has its own set of limitations and does not replace clinical judgment.

ARTICLE INFORMATION

Author Affiliations: Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas (Gupta, Das, Pandey); Division of Cardiology, University of Texas Southwestern Medical Center, Dallas (Das, Pandey).

Corresponding Author: Ambarish Pandey, MD, Division of Cardiology, Department of Internal Medicine, University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd, Dallas, TX 75390-8830 (ambarish.pandey@outlook.com).

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