JACC: CARDIOVASCULAR INTERVENTIONS VOL. 11, NO. 4, 2018

PUBLISHED BY ELSEVIER

EDITORIAL COMMENT

Efficiency Improvements in the Catheterization Laboratory

It's All About the Team*

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In the United States alone, someone experiences a heart attack every 40 s, and it is estimated that approximately 695,000 Americans will have new coronary events and 325,000 will have recurrent events this year alone (1). Given the prevalence of acute coronary events, in addition to the many other indications for patients to require cardiac catheterization, a large number of procedures are ultimately performed. At a time when the economics of medical care are shifting from quantity to quality, and health care systems are being pressured financially with decreases in reimbursement, one of the valuable tools available to practitioners and hospitals alike is improvements in efficiency (2). One of the areas most vulnerable to system inefficiencies is the cardiac catheterization laboratory, with its inherent high acuity, complexity, and often unpredictable schedule.

Cardiac catheterization laboratory inefficiencies are nearly universal, and most laboratories face various challenges while striving to increase throughput. There is a necessary balance among patient safety and satisfaction, employee fulfillment and retention, and overall quality of care. This becomes even more challenging as we work through increases in case complexity with unpredictable days and potential urgent add-on cases requiring prompt attention at any time. Although we all may experience similar sources of delay, our approaches must be unique and tailored to our specific programs.

There is a paucity of data regarding methods of improving efficiency in the catheterization laboratory. This is by its very nature a process that evolves over time. Agarwal et al. (3) described borrowing tools from industry to help with process efficiency. They used a technique called Lean Six Sigma, first used by Motorola, relying on a collaborative team effort to improve catheterization laboratory performance by systematically removing waste and reducing variation. A key component of Lean Six Sigma is *kaizen*, Japanese for "continuous improvement," suggesting that no process is perfect and that improvement is a continuous evolution rather than a single fix. Agarwal et al. (3) reported that over 3 years, improvements in turnaround time, physician downtime, on-time patient arrival, start times, and sheath pulls were achieved.

SEE PAGE 329

In this issue of *JACC: Cardiovascular Interventions*, Reed et al. (4) continue their improvement process. Perhaps the most important component of this evolution was establishing a group of stakeholders who dissected the catheterization laboratory work-flow process to identify areas for improvement. This is not very different from the guideline recommendations for a multidisciplinary approach to the treatment of patients with valve disease (5). Inclusion of all members of the team is important, as it provides an opportunity to be heard and to take ownership of the shared goal. After a thorough analysis of the issues, the leadership team then focused on a few areas of concern. They then continuously used plan, do, study, act cycles to make and track iterative changes. This technique was first described by

*Editorials published in *JACC: Cardiovascular Interventions* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Interventions* or the American College of Cardiology.

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ISSN 1936-8798/$36.00 https://doi.org/10.1016/j.jcin.2017.10.031

Dr. W. Edwards Deming, considered by many to be the father of modern quality control (6).

The investigators used several strategies to implement changes in process, including a pyramidal nursing schedule allowing extra staffing earlier in the day. They began using an electronic notification system whereby stakeholders were notified immediately of all stages of patient flow through the laboratory, also facilitating earlier transport of patients after procedures. Other simple changes were made, such as limiting sheath pulls in the catheterization laboratory, having an alternative destination for patients post-catheterization if their final rooms were not ready, and creation of a central supply system to reduce staff time searching for equipment. Importantly, physicians were notified the day before of patient scheduling and expected start times. There was a potential loss of future scheduling priority if cases were not begun within 15 to 30 min of an attending physician's being paged.

Reed et al. (4) report significant improvements in 4 domains, areas in which most would agree that change would be welcome (Table 4). They were able to achieve a 7:45 AM start time in 81.7% of cases, compared with 61.8% before process improvement ($p = 0.0024$). Room turnaround time, the bane of many if not most catheterization laboratories, was decreased from 20.6 ± 0.8 min before to 17.1 ± 1.8 min after the program ($p = 0.044$). Finding an extra 3.5 min between each case when 8 to 10 cases per day are scheduled is not insignificant when multiplied by the number of laboratories at the investigators' institution. Finally, they were able to improve overall use rates for all their laboratories from a mere 7.7% before the program to 77.3% after implementation ($p < 0.00001$). Impressively, this was all accomplished with fewer employees and no apparent decrement in employee satisfaction.

Reed et al. (4) are to be congratulated for tackling some of the issues of inefficiency most catheterization laboratories deal with and approaching the task with scientific rigor. Although published research does exist to help guide good clinical practice in the catheterization laboratory, there is little available to help with improvements in process and efficiency (7). The investigators have demonstrated several improvements over time, not just in the present study but also for some time leading up to this point, embodying the *kaizen* concept. One of the most significant achievements of this work is the assembly of stakeholders across the spectrum of care for patients who interact with the catheterization laboratory. The importance of this type of teamwork should not be underestimated, perhaps now more than ever. This in fact may be the part of their work most easily translated to other institutions.

In the next iteration of the investigators' process improvement, readers might be interested in additional metrics of quality as their process continues to be refined. It would be valuable to know if there were any changes in catheterization laboratory complication rates before, compared with after, the changes in their program. Were there any differences in the rates of hematomas, pseudoaneurysms, bleeding, or other procedure-related complications concomitant with improvements in efficiency? An additional quality measure of importance would be patient satisfaction. It would certainly be reassuring to know that patients treated after the implementation of any changes to improve efficiency did not have a less robust experience, and this could easily be tracked with patient satisfaction surveys. It might also be of interest, particularly to other teaching institutions, to know if the investigators placed any practical limits on the time taken by trainees for vascular access, catheter manipulation, lesion treatment, or other portions of the catheterization procedure.

Every catheterization laboratory in the country has its own unique efficiency challenges, which in fact highlights the importance of the local "team" approach to collectively decide where the "biggest bang for the buck" might be. Although the changes made by these investigators worked well at a large facility with a closed laboratory system, some of them may be harder to replicate at smaller institutions and those with an open catheterization laboratory format. It be may also harder to find the needed flexibility in programs with fewer operators. Differences in staffing levels at other institutions may make it more challenging to shift to a pyramidal-type scheme. There may even be differences in the physical plants of other facilities that limit the applicability of the investigators' domain changes to other programs. In addition, academic and private practice models are likely to each have their own process idiosyncrasies. Nonetheless, the investigators' data are encouraging: by using a team approach to quality improvement, engaging in not just a single but a continuous attempt at change, and with a constant revision of process, the results can lead to improvements important to each institution.

We are all stakeholders at the table of catheterization laboratory efficiency. There are no members of

the health care team who are exempt from the ubiquitous pressure to do more with less. While some of the quality improvements studied by Reed et al. (4) may be applicable to many or most institutions, the concept of creating a team from those who deliver the care daily can certainly be universally applied. Most or all institutions will have to come to terms with their own versions of quality or process improvement. It is certainly more desirable that the stakeholders drive the process before an outside entity does it for us.

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KEY WORDS cardiac catheterization, health economics, health care efficiency, quality improvement