CLINICAL STUDY

Improving Inferior Vena Cava Filter Retrieval Rates with the Define, Measure, Analyze, Improve, Control Methodology

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ABSTRACT

Purpose: To design a sustainable process to improve optional inferior vena cava (IVC) filter retrieval rates based on the DMAIC methodology of the Six Sigma process improvement paradigm.

Materials and Methods: DMAIC, an acronym for Define, Measure, Analyze, Improve, and Control, was employed to design and implement a quality improvement project to increase IVC filter retrieval rates at a tertiary academic hospital. Retrievable IVC filters were placed in 139 patients over a 2-year period. The baseline IVC filter retrieval rate (n = 51) was reviewed through a retrospective analysis, and two strategies were devised to improve the filter retrieval rate: (*a*) mailing of letters to clinicians and patients for patients who had filters placed within 8 months of implementation of the project (n = 43) and (*b*) a prospective automated scheduling of a clinic visit at 4 weeks after filter placement for all new patients (n = 45). The effectiveness of these strategies was assessed by measuring the filter retrieval rates and estimated increase in revenue to interventional radiology.

Results: IVC filter retrieval rates increased from a baseline of 8% to 40% with the mailing of letters and to 52% with the automated scheduling of a clinic visit 4 weeks after IVC filter placement. The estimated revenue per 100 IVC filters placed increased from $2,249 to $10,518 with the mailing of letters and to $17,022 with the automated scheduling of a clinic visit.

Conclusions: Using the DMAIC methodology, a simple and sustainable quality improvement intervention was devised that markedly improved IVC filter retrieval rates in eligible patients.

ABBREVIATIONS

CPT = Current Procedural Terminology, DMAIC = Define, Measure, Analyze, Improve, Control, FDA = Food and Drug Administration, IVC = inferior vena cava, PDSA = Plan, Do, Study, Act, QI = quality improvement, RVU = relative value unit

In August 2010, the U.S. Food and Drug Administration (FDA) released a communication on the removal of retrievable inferior vena cava (IVC) filters and issued the following recommendation: "FDA recommends that implanting physicians and clinicians responsible for the ongoing care of patients with retrievable IVC filters consider removing the filter as soon as protection from PE [pulmonary embolism] is no longer needed" (1). In May 2014, the FDA updated the communication to include reference to a mathematical model that suggests if the patient's risk of pulmonary embolism has resolved, the risk/benefit profile begins to favor removal of the IVC filter between 29 and 54 days after IVC filter placement (2,3).

A systematic literature review of retrievable IVC filters by Angel et al (4) confirmed that most (93%) complications associated with retrievable IVC filters occurred with long-term use (> 30 d). Several reports have found high rates of IVC penetration with Celect (Cook, Inc, Bloomington, Indiana) (22%–93%) and Günther Tulip (Cook, Inc) (22%–78%) IVC filters (5–7) associated with longer dwell times. IVC filter fractures are the most common complication reported in the Manufacturer and

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Appendices A and B are available online at *www.jvir.org*

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User Facility Device Experience database with a rate up to 16% in the literature (6,8–11). A Kaplan-Meier survival analysis by Tam et al (9) estimated a 40% fracture rate at 5.5 years for the Bard Recovery filter (Bard Peripheral Vascular, Tempe, Arizona).

IVC filter retrieval rates are heterogeneous across institutions and patient populations. Estimated IVC filter retrieval rates in the Medicare population were 1.2%–5.1% for the 65,041 filters placed in 2008 (12). A systematic review of the literature reported retrieval rates of 12%–45% with a mean of 34% and an average retrieval time of 72 days (4). Retrieval rates with dedicated follow-up have been reported to approach 60% (13,14). Given the risk of adverse events with the long-term use of retrievable IVC filters and the FDA recommendations, we initiated a quality improvement (QI) project with a goal to increase the retrieval rate in eligible patients at our institution to 35% within 1 year of placement.

The design of the QI project was based on the DMAIC methodology. DMAIC is an acronym for Define, Measure, Analyze, Improve, and Control. DMAIC is a core tool in the Six Sigma paradigm developed in industry for process improvement with the aim to reach a level of quality 6 SDs above the average, equivalent to 3.4 defects of per 1 million opportunities. DMAIC has been successfully implemented over a wide range of disciplines and has previously been adopted in the health care setting (15–18).

MATERIALS AND METHODS

DMAIC Methodology as Applied to the Current Project

This institutional review board–approved, Health Insurance Portability and Accountability Act–compliant QI project with retrospective and prospective components was conducted as part of a clinical safety and effectiveness project. The core team included a lead interventional radiologist, nurse coordinator, internal medicine nurse navigator, and QI facilitator. Additional members of the multidisciplinary team included interventional radiologists, interventional radiology physician assistants, a pulmonologist, and a hematologist. The DMAIC methodology set a framework for process improvement, and it was applied sequentially as detailed subsequently and in Fig 1.

Define the Problem. IVC filter complications occur with long-term use often after the risk of pulmonary embolus has subsided. The presence of an IVC filter after the indication for placement has resolved was defined as the problem. In addition, after initiating the improvement process, it was recognized that poor clinical follow-up of patients with IVC filters was a major contributing factor and was defined as a secondary problem.

Measure the Problem. The IVC filter retrieval rate in eligible patients was the measure that ultimately determined the success of the program. Secondarily, the percentage of patients seen in the clinic after filter placement was used as a measure of patient follow-up.

Analyze the Process. The existing filter placement and retrieval process was evaluated (Fig 2). The IVC filter placement process began with a request from the referring physician. An IVC filter was subsequently placed, and instructions on how to arrange for IVC filter removal were placed at the end of the dictation if the filter was retrievable (Fig 2). The multidisciplinary team reviewed the process and discussed the strengths and weaknesses and brainstormed to identify barriers to IVC filter removal over multiple sessions. The barriers to removal were grouped into four categories: provider, patient, clinical, and systems. The barriers were further classified into controllable (Fig 3a) and uncontrollable

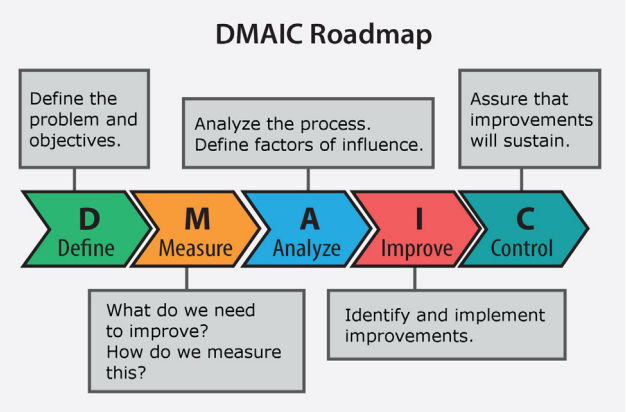

Figure 1. DMAIC methodology. Graphic representation of the DMAIC model of process improvement. (Available in color online at *www.jvir.org*.)

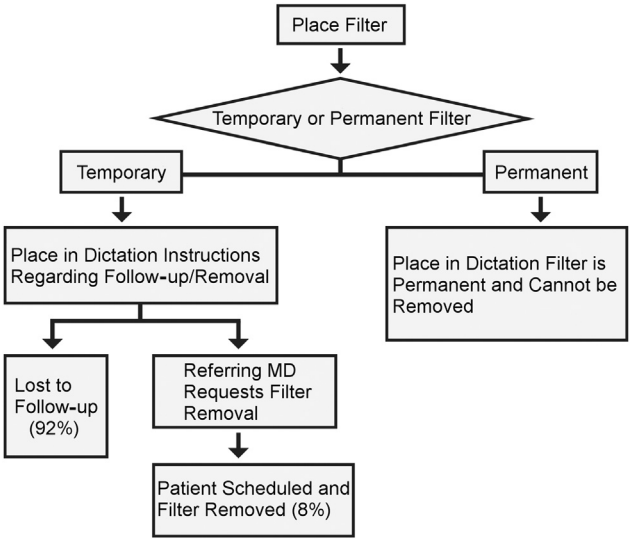

Figure 2. Existing IVC filter placement process. Flow diagram of the existing filter placement process reveals that the referring physician (*MD*) determines when the filter is no longer indicated and requests filter removal.