ORIGINAL ARTICLE

Design-of-Experiments Approach to Improving Inferior Vena Cava Filter Retrieval Rates

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Abstract

Purpose: The association of retrievable inferior vena cava filters (IVCFs) with adverse events has led to increased interest in prompt retrieval, particularly in younger patients given the progressive nature of these complications over time. This study takes a design-of-experiments (DOE) approach to investigate methods to best improve filter retrieval rates, with a particular focus on younger (<60 years) patients.

Methods: A DOE approach was executed in which combinations of variables were tested to best improve retrieval rates. The impact of a virtual IVCF clinic, primary care physician (PCP) letters, and discharge instructions was investigated. The decision for filter retrieval in group 1 was determined solely by the referring physician. Group 2 included those patients prospectively followed in an IVCF virtual clinic in which filter retrieval was coordinated by the interventional radiologist when clinically appropriate. In group 3, in addition to being followed through the IVCF clinic, each patient's PCP was faxed a follow-up letter, and information regarding IVCF retrieval was added to the patient's discharge instructions.

Results: A total of 10 IVCFs (8.4%) were retrieved among 119 retrievable IVCFs placed in group 1. Implementation of the IVCF clinic in group 2 significantly improved the retrieval rate to 25.3% (23 of 91 retrievable IVCFs placed, $P < .05$). The addition of discharge instructions and PCP letters to the virtual clinic (group 3) resulted in a retrieval rate of 33.3% (17 of 51). The retrieval rates demonstrated more pronounced improvement when examining only younger patients, with retrieval rates of 11.3% (7 of 62), 29.5% (13 of 44, $P < .05$), and 45.2% (14 of 31) for groups 1, 2, and 3, respectively.

Conclusions: DOE methodology is not routinely executed in health care, but it is an effective approach to evaluating clinical practice behavior and patient quality measures. In this study, implementation of the combination of a virtual clinic, PCP letters, and discharge instructions improved retrieval rates compared with a virtual clinic alone. Quality improvement strategies such as these that augment patient and referring physician knowledge on interventional radiologic procedures may ultimately improve patient safety and personalized care.

Key Words: Inferior vena cava filters, filter retrieval, clinic, quality improvement

J Am Coll Radiol 2016;■:■-■. Copyright © 2016 American College of Radiology

INTRODUCTION

The use of retrievable inferior vena cava filters (IVCFs) for mechanical prevention of pulmonary embolism resulting from deep vein thrombosis has been steadily increasing over the past decade, ranging from 2,000 placements in 1979 to an estimated 259,000 in 2012 [1-3]. However, this increased utilization of retrievable IVCFs has coincided with an increased awareness of their potential long-term adverse effects. More than 900 documented adverse events have been reported since 2005, including caval perforation, strut fracture, occlusion, and migration [1,2,4,5]. Because these events may carry significant morbidity, the FDA, first in 2010 and then most recently in 2014, recommended prompt filter retrieval when no longer clinically indicated [6,7]. This is particularly important in younger patients given the progressive nature of these complications over time [1].

Published IVCF retrieval rates vary widely. Reported rates range between 12% and 45%, with a mean of 34%

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The authors have no conflicts of interest related to the material discussed in this article.

1546-1440/16/$36.00 ■ http://dx.doi.org/10.1016/j.jacr.2016.08.015

in the setting of a dedicated filter retrieval clinical initiative program and an average dwell time of 72 days [8]. The lowest retrieval rates have been reported in the Medicare population at 1.2% to 5.1% for the 65,041 filters placed in 2008 [9]. Furthermore, recent evidence supports that women may be at a higher risk for filter complications, including filter strut caval wall perforation [1]. Because strut perforation is progressive over time [1], these complications associated with long-term IVCF placement may make filter retrieval more challenging. This is particularly concerning for women of childbearing age given the associated risk from procedure-related radiation at filter retrieval [10]. Given the low reported rates of filter retrieval in the literature and the increased risk for adverse events associated with longer dwell times [2,8,11-13], our department implemented a quality improvement (QI) project in collaboration with a health care quality team with the goal of improving our institutional IVCF retrieval rates.

One new approach to improving IVCF retrieval rates is adopting a design-of-experiments (DOE) methodology to increase compliance. DOE is a process improvement method commonly used in industry, but it is also applicable to clinical practice. DOE helps determine and optimize the relationships between both controllable and uncontrollable factors and process outcomes (Fig. 1). This approach applies statistically based methods to test multiple process improvement ideas to optimize the output of a process by exploring cause-and-effect relationships [14-16]. Accordingly, the purpose of this study was to apply DOE methodology to improve filter retrieval rates, particularly in younger patients, who are more likely to experience IVCF-associated adverse events.

METHODS

Experimental Design

This prospective QI study was performed with institutional review board approval. The study team was composed of interventional radiologists, QI specialists, residents, nurse coordinators, and a medical student. Our QI goal was quantified as at least tripling our baseline retrieval rate after improvement interventions. The DOE methodology was adopted as the basis for process improvement, as outlined in Figure 2. The process for arranging IVCF retrievals was reviewed, and the contribution of controllable and uncontrollable factors was discussed over multiple sessions. The study stratified 261 patients into three groups testing combinations of controllable variables, including (1) the impact of a virtual IVCF clinic, (2) primary care physician (PCP) letters, and (3) discharge instructions. Uncontrollable factors were disregarded, including technical removal failure, provider change, and loss to follow-up.

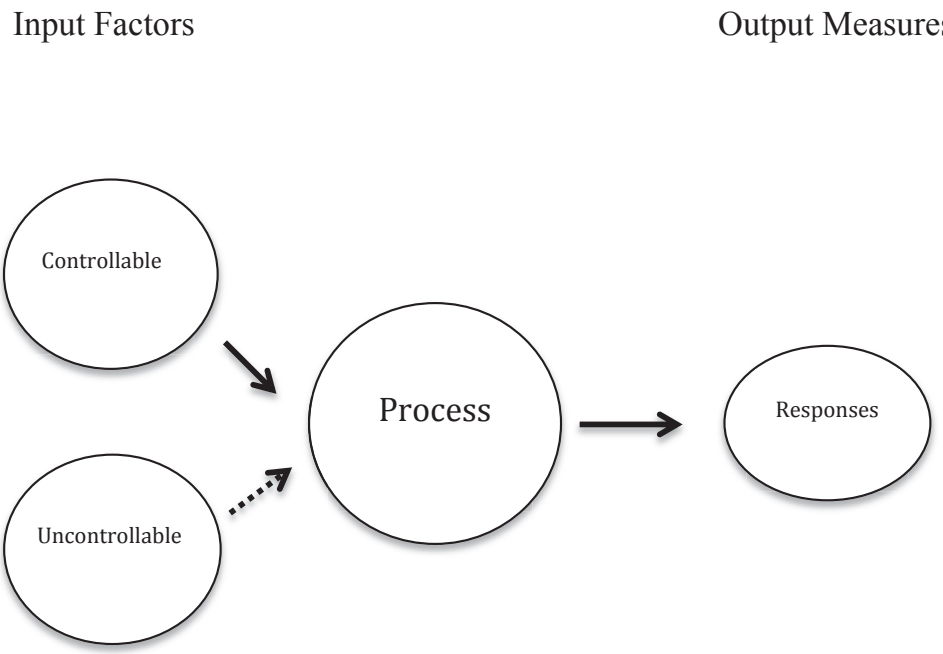

Fig 1. Design-of-experiments (DOE) optimization of process input parameters to improve outcomes. The DOE approach tests multiple process improvement ideas to optimize the output of a process by exploring cause-and-effect relationships.