

EDITORIAL COMMENT

Still Working on Our Short Game

Technique and Accuracy of Stent Placement in Congenital Heart Disease*

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As our colleagues in cardiac surgery have begun to develop scores for the technical performance of an operation (1), we pediatric interventional cardiologists have similarly begun to review technical outcomes in addition to clinical ones. Operators and patients will no doubt benefit from efforts to improve practice with regard not only to the desired clinical result, but also with attention to the specific technical components of a “successful” procedure. In this single-center review of stent implantation in patients with congenital heart disease, Meadows et al. (2) effectively refine our understanding of a successful procedure into one that appreciates the subtle distinctions in stent placement that distinguish a perfect result from a merely adequate one.

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Since the first large series describing stent implantation for vascular obstructions in congenital heart disease patients, excellent long-term clinical results have been described in terms of relief of obstruction, as measured by decreased pressure gradients, increased luminal diameter, or decreased right ventricular pressure (3,4). Stent malposition, occurring as a result of equipment failure or misjudgment of the anatomy, was considered a complication, and grouped with clinical adverse events ranging from stent thrombosis to retroperitoneal hemorrhage.

This study of procedures performed between 1999 and 2009 delves into the previously undiscussed factors that influence our technical success in achieving the ultimate result. The operator’s evaluation of the procedure goes beyond “Did the gradient go down?” or “Did the lumen size increase?” This paper asks “Was the anatomy well understood?” “Could the stent have been placed more accurately?”

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“Could 1 perfect stent have done the job of the first 2?” Furthermore, the role of the operator, as opposed to the equipment, is emphasized. In the current era, relatively recent improvements in catheterization tools have practically eliminated some types of equipment failure that previously contributed to failed stent implantation. Advanced-material balloons have made balloon rupture during stent expansion a relatively rare and manageable event, and the availability of premounted stents has addressed the problem of undercrimping and stent slippage on the implanting balloon. Less-than-perfect stent implantations are now more likely than in the past to be related to operator experience and technique.

Reviewing 399 stents implanted during 322 procedures, Meadows et al. (2) found 33 implantation failures, either malposition or embolization. Of successfully implanted stents, 205 were judged to be perfectly implanted, a combination of ideal position and relief of the obstruction. Successful implantations resulting in suboptimal position and/or incomplete relief of obstruction were categorized as adequate. The designation of suboptimal positioning was angiographically based and relied on the stent’s relation to the lesion, to side branches or bifurcations, and to adjacent structures. Occurrences of “avoidable” jailing were considered adequate, rather than perfect, implantations. To facilitate analysis of risk factors for implantation failure, a novel categorization system for target vascular lesions was described. Lesions were divided into 4 categories, including discrete obstruction, diffuse obstruction, “compliant” lesions (a category that included compression or kinking), and, finally, previously stented vessels. Univariate predictors of stent implantation failure included compliant lesion type and vessel predilatation.

First, we consider the risk posed by compliant lesions. Importantly, Meadows et al. (2) note that these lesions are rare (4% in this series) and difficult to diagnose. In fact, these lesions can be extremely difficult to understand anatomically when working from biplane imaging. Kinked vessels, by definition, will not have a single long axis, and rapid restoration of lumen caliber beyond the kink makes it a challenge to profile the site of most severe obstruction. External compression can be equally difficult to comprehend, particularly when compressing structures are nonvascular and cannot be integrated into an overall angiographic landscape, for example, when large airways are involved. Often the suspicion of a kink, fold, or compression is raised precisely when there is measurable hemodynamic obstruction in the *absence* of a more recognizable lesion on routine angiography. Establishing a clear anatomic understanding of these lesions requires excellent angiographic technique, using multiple selected views, rather than routine orthogonal biplane imaging. Precatheterization imaging, whether by computed tomography or magnetic resonance imaging, may be useful in understanding the anatomy and, in the near

future, procedural magnetic resonance imaging may guide clinical intervention.

Thus, anatomic complexity contributing to an association between compliant lesions and unsuccessful stent placement is credible and argues for a more rigorous angiographic technique before stent placement. The risk associated with predilation is more problematic. In our laboratory, “predilation” is often used as a technique to gauge the balloon-vessel interaction that occurs with balloon inflation, particularly when the anatomy is difficult. Using such a practice, “predilation” will be associated with, but not the cause of, less than ideal stent placement in some cases. Due to the retrospective manner in which the data in this series were collected, we cannot know whether predilation actually changed/enlarged lesions in a manner that predisposed to malposition or embolization, as the authors propose. With information on the relative size and degree of balloon expansion during predilation, the inflation pressure, and the waist characteristics, this issue could be explored further.

All good papers point to areas of future study. In addition to further elucidating the role of predilation, subsequent work on stent placement in congenital heart disease should continue to define optimal stent positioning. In 1 recent long-term follow-up report, jailed vessels were sought on late angiographic review, and a remarkable 50% of stent implantations resulted in at least partial jailing of a side branch (5). If jailing is truly a mark of an “adequate” procedure, as the current paper proposes, the long-term clinical effects would need to be shown to be minor ones. If

jailing has significant, potentially harmful, clinical effects, then the techniques necessary to prevent “avoidable” jailing should be described. Despite these unanswered questions, the authors of the current study have done the field a great service by defining the standards of technical excellence for a procedure much in need.

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