Composite graft aortic root reconstruction: Reproducible, durable, and uncomplicated

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There are several general rules when novel surgical procedures are introduced. Good therapies find their way, once clinical feasibility has been proved; first implementation and then modification are inevitable; and reproducibility requires simplicity. There are few better examples than the Bentall operation.

The Bentall procedure series presented in this issue of the *Journal* by Di Marco and colleagues¹ spans 33 years, covering almost exactly two-thirds of the time since the introduction of the operation 48 years ago by Bentall and de Bono.² This is a truly evolutionary series, and there is value in these lengthy retrospective looks. Although the initial concept of the operation has remained the same, modifications have been introduced to target specific weakness related to bleeding and pseudoaneurysm development. This series started with the classic Bentall inclusion technique, and as in other series, changes were incorporated as the benefits of change were proved. At inception of the Bentall procedure, the graft material was porous, and hemostasis required an inclusion technique to manage bleeding. Kouchoukos and colleagues³ introduced albumin impregnation, allowing an open technique and dramatically decreasing both immediate reoperation for bleeding and later reoperation. Intraoperative fabrication of the composite graft was required before the introduction of prefabricated valve conduits, first with mechanical valves and most recently with tissue valves. These measures have reduced operative time. Arguably, the most important contribution to aortic root surgery was the coronary button technique introduced by Kouchoukos and associates.⁴ This modification has nearly eliminated the occurrence of coronary anastomotic bleeding, coronary compromise, and coronary anastomotic pseudoaneurysms. An initial trepidation to mobilize difficult coronary artery buttons is evidenced by the use of the Cabrol technique in the experience of Di Marco and colleagues.¹ The use of the Cabrol technique, however, has allowed Di Marco and colleagues¹ to examine this subgroup and therefore to advise caution in using this technique. Despite the fairly radical improvements to the

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Central Message

The modified Bentall operation has proved to be reproducible, durable, and relatively uncomplicated.

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classic Bentall procedure during the last 48 years, early and long-term mortalities have remained low, particularly for patients undergoing elective surgery. This series reports an operative mortality of 5.3% (4.4% elective and 12% emergency) and a 20-year survival of 40.7% $\pm$ 4.6%, and there was a minimal era effect on the results. Other comparable series have shown similar results across several decades. Gott and colleagues⁵ reported on 675 patients with Marfan syndrome undergoing the Bentall procedure at 10 experienced centers. Operative mortalities were 1.5%, 2.6%, and 11.7% for elective, urgent, and emergency procedures, respectively, and the 20-year survival was 59%. The Mayo Clinic reported a 4% operative mortality and a 20-year survival of 52% for 149 patients undergoing a Bentall operation for pure annuloaortic ectasia during a 30-year period.⁶ In a series of 597 Bentall procedures, Etz and coworkers⁷ reported a 30-day mortality of 3.9%, with comparable survival curves. In addition, Svensson and colleagues⁸ reported a 1% in-hospital mortality for 493 patients undergoing the Bentall procedure at the Cleveland Clinic. Survival in their study was 90% at 15 years for 297 patients undergoing a mechanical composite graft reconstruction. These data are the strongest evidence that the operation is sound and results are reproducible and durable. The modifications

introduced have simplified the procedure, and the results are reproducible.

What of the Bentall procedure being uncomplicated? The series of Di Marco and colleagues¹ confirms very low complication rates, with 20-year freedoms from thromboembolism, bleeding, and endocarditis of 93.7%, 90.3%, and 98.4%, respectively. Freedom from aortic reoperation at 20 years was 91%. It is almost counterintuitive that the complication rates were so low with such a high proportion of mechanical valves. Among 802 surviving patients at follow-up, 586 (73.1%) were receiving warfarin sodium (INN warfarin). Of these 542 had mechanical valve conduits. There are several reasons that can be postulated for such low rates of thromboembolism, endocarditis, and reoperation in patients with composite grafts. All suture material and pledgets are on the outside of the aorta, and there is no internal cuff or aortotomy. This reduces potential surfaces and irregularities for platelet aggregation and thrombus deposition. There is a smoother transition from the left ventricular outflow tract to the ascending aorta, reducing turbulent flow. As a case in point, Urbanski and associates⁹ reported a case-matched study of 79 pairs comparing a bio-Bentall procedure with a routine aortic valve replacement. In their experience, early and 10-year survivals were similar, but thromboembolic events were 0.2% events/y in the bio-Bentall group and 1.4% events/y in the aortic valve group. There is no proximal suture line; rather, there is a proximal robust connection of the fibrous skeleton of the heart to the composite graft's sewing cuff. This makes reoperation for proximal root problems rare.

Despite these low complication rates specifically with a mechanical valve composite graft, current surgical trends are in favor of bio-Bentall procedures in younger and younger patients. There have been recent reports comparing the bio-Bentall procedure with a mechanical valve composite graft, but most are limited by midterm follow-up. Desai and colleagues¹⁰ compared 128 propensity-matched patients and found nearly identical 8-year survivals and complication rates between the 2 groups, with the exception of significantly more minor bleeding episodes in the mechanical Bentall group. The conclusion that a bio-Bentall procedure is appealing for this reason neglects the fact that reoperations are unlikely within 8 years of follow-up in a patient who has undergone a bio-Bentall procedure. Etz and associate¹¹ compared 77 patients between 50 and 60 years of age receiving a stentless bioprosthesis with 127 undergoing a mechanical valve Bentall operation. Freedom from complications was nearly identical at 12 years (porcine 94.9% vs mechanical 96.1%), and survival at 10 years was as well (porcine 80% $\pm$ 7% vs mechanical 75% $\pm$ 5%). Again, however, follow-up was insufficient to see the inevitable valve failures in the tissue valve group. The unproven prospect of receiving a valve-in-valve

transcatheter procedure after tissue valve failure seems an unclear trade-off for the published low complication rates from large series like this one. In addition, it is often ignored that many patients undergoing bio-Bentall procedures have indications for anticoagulation during the follow-up period. In this series, 17% of patients with a bio-Bentall procedure were receiving warfarin for other reasons. It remains to be seen whether the increased use of the bio-Bentall procedure proves a valid strategy for young patients wishing to avoid anticoagulation. There is a bias that there is a reduced quality of life associated with a mechanical valve, and surgeons often use this to justify the use of a bio-Bentall composite graft in a young patient. Repack and colleagues,¹² however, showed that receiving either a bio-Bentall or mechanical valve Bentall did not affect postoperative quality of life. They concluded, "prior concerns with mechanical valves do not affect patients in the commonly anticipated negative manner."

There are several limitations to the series presented by Di Marco and colleagues.¹ The last time this series was queried for follow-up was 5 years before presentation for publication. Of the 1045 patients, 781 were operated on between 2001 and 2010. Thus 75% of the series had relatively short-term follow-up. The statistical power of risks for late mortality and reoperation would be greatly enhanced by the additional 3905 years of patient follow-up. In particular, the yearly incidence of thromboembolism and endocarditis could have been determined more precisely. The series does not include any internal comparisons with valve-sparing aortic root procedures. The question of whether the proven durability of the Bentall procedure in the series of Di Marco and colleagues¹ and the low (but real) risk of thromboembolism offset the risk for reoperation associated with the learning curve of valve-sparing procedures in their own institution remains unanswered. Despite these limitations, this series of 1045 patients with excellent long-term survival and very low reoperative and complication rates will remain a benchmark for comparison for decades to come.

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