Editorial

Reflections on valve-sparing operations utilizing straight tube versus Valsalva grafts

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Introduction

The development of the aortic root starts with a tube and ends up with three units, each consisting of a semilunar valve and the corresponding sinus connected by three straight, cylindrical interleaflet triangles/commissures—the remnants of the original tube. All these elements provide the optimal anatomical and functional solution for the aortic root and are indispensable for lifelong durability—a real miracle.

Discussion

Accumulated knowledge indicates sinuses and the inherent vortices to be mandatory for valve closure and that in a valve without sinuses, the cusps align themselves with the vessel wall and only close after 23% of forward flow has reversed (1). Thus, the David reimplantation technique (2) using a straight tube without sinuses theoretically would result in considerable aortic regurgitation. But this is not the case. Why? After the David operation, the preoperatively dilated annulus is constricted by the prosthesis and additionally by the aortic annulus that is placed inside the graft. We studied this condition using a mock circulation with fresh porcine aortic leaflets in a correspondingly sized Perspex® tube or porcine root with and without sinuses. A 2.5-mm thick nozzle ring at the annulus level simulates a David-operation-like situs. This setup caused a considerable (25% without versus 65% with the nozzle ring) increase in systolic valve closure motion independent of the presence of a sinus. This mechanism is based on Bernoulli's principle: the annulus constriction leads to flow acceleration which increases the kinetic energy at the cost of potential energy, generating a centripetal suction effect on the leaflets (Venturi effect). Although less pronounced, this effect also occurs physiologically whereby the annulus and flow constriction are induced by the conical shape of the left ventricle outflow tract and the cyclic contraction of the bulbospiral muscles (3). Furthermore, the downsized root diameters potentially lead to leaflet redundancy and leaflet folds often requiring surgical adaptation. How much correction of the leaflets in a non-distensible prosthesis is necessary? Together these factors prevent the leaflets from completely aligning and adhering to the wall but do not prevent the intermittent wall contact of the leaflets that was reported as a constant echocardiographic finding after the David operation with a straight tube (4), but not when a sinus was present (5). Magnetic resonance imaging confirmed these results and additionally found malrotated vortices behind the leaflets in a straight tube with unknown sequelae (3). In our experiments also, but rarely, complete leaflet alignment to the wall occurred in the straight tube without sinuses.

In summary some essential advantages of sinuses are:

(I) Prevention of complete leaflet wall adhesion with significant regurgitation;
(II) Prevention of intermittent leaflet wall contact with yet unknown sequelae;
(III) Minimizing stress on the leaflets by normalizing leaflet motion (4) and preventing malrotation of

vortices (3);
(IV) Promoting coronary flow;
(V) Warranting sinus washout;
(VI) Facilitating coronary button anastomosis by reducing the coronary orifice to prosthesis distances.

Benefiting from these advantages necessitates anatomically correct grafts with three separate sinuses and straight positions of the interleaflet triangles/commissures which provide the additional option of anastomosing the patients' commissures to the wall of the cylindrical tube at any height. All these features are best realized in the Uni-Graft W SINUS prosthesis (Aesculap, B. Braun Melsungen AG, Germany) (2,5). However, the company Aesculap has stopped the production of the prosthesis due to the high expenses necessary to fulfill the requirements of the new European medical device regulations). The importance of the straight cylindrical position of the commissures was recently reported by Paulsen *et al.* (6), which highlighted that it results in preserved leaflet coaptation, decreased regurgitation and lower forces on the leaflets, potentially improving durability in contrast to Valsalva grafts (Vascutek Terumo, Vascutek Deutschland GmbH, Hamburg, Germany) with radially displaced commissures (6). These results once again confirm the paradigm that nature provides the best solution for any task, a concept that in my experience was also beneficial for other procedures: the bicaval heart transplantation (7), the direct anatomical anastomoses of the great arteries during correction of the transposition of the great arteries (8), the subcoronary Ross operation and even a novel anticoagulation-free mechanical heart valve with three wing-shaped leaflets (9). But not only an anatomically correct prosthesis, but also adequate surgery is decisive for success, and the David procedure is challenging. For example, complete dissection down to the annulus is desirable but sometimes easier said than done, particularly at the septum. Should it be enforced in every case or should the graft be adapted by short incisions at the level of the interleaflet triangles next to the right coronary sinus when dissection seems to become too extensive, as I do. In this case, oblique subannular sutures are unavoidably necessary and need careful, gentle knotting to prevent distortion and prolapse of the right coronary leaflet. Furthermore, surgically achieving absolute parallelism of leaflets, adequate leaflet adjusted coaptation area, good quality and postoperative mobility of the leaflets are key elements for success. Due to all these variables, analyzing the results and judgement, especially of the different prostheses, is difficult and requires presentation of all degrees of valve function, and over time, at least 95% follow-up and comprehensive description of the situs and surgery. This would also help further research to design imaging programs to preoperatively predict the best operative procedure (quality of the leaflets, precise surgical technique, size of the graft) (10) to develop physiological distensible prosthetic material and to increase understanding of morphology and function of the aortic root for improving the ingenious concept of the David procedure.

Conclusions

During millions of years of evolution nature has developed optimal results in design and function for any task, the best blueprint for reconstructive surgery. That holds also true for an anatomically accurate prosthesis with three separate sinuses and three straight, cylindrical interleaflet triangles/commissures. From a medical point of view, there are no reasonable arguments not to preserve and imitate nature accurately combined with a pursuit of surgical perfection for optimal results in cardiovascular surgery and therefore for patients.

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Footnote

Conflicts of Interest: HHS formerly received royalties from B. Braun, Braun, Melsungen. The other author has no conflicts of interest to declare.

References

1. Bellhouse BJ, Bellhouse FH. Mechanism of closure of the

aortic valve. Nature 1968;217:86-7.
2. David TE. On sinuses and vortices. J Thorac Cardiovasc Surg 2017;154:791-3.
3. Oechtering TH, Frydrychowicz A, Sievers HH. Malrotated sinus vortices in straight graft valve-sparing aortic root treatment: A matter of concern?. J Thorac Cardiovasc Surg 2017;154:794-7.
4. Leyh RG, Schmidtke C, Sievers HH, et al. Opening and closing characteristics of the aortic valve after different types of valve-preserving surgery. Circulation 1999;100:2153-60.
5. Schmidtke C, Sievers HH, Frydrychowicz A, et al. First clinical results with the new sinus prosthesis used for valve-sparing aortic root replacement. Eur J Cardiothorac Surg 2013;43:585-90.
6. Paulsen MJ, Kasinpila P, Imbrie-Moore AM, et al. Modeling conduit choice for valve-sparing aortic root replacement on biomechanics with a 3-dimensional-printed heart simulator. J Thorac Cardiovasc Surg 2019;158:392-403.
7. Hunt SA, Haddad F. The changing face of heart transplantation. J Am Coll Cardiol 2008;52:587-98.
8. Rickers C, Kheradvar A, Sievers HH, et al. Is the Lecompte technique the last word on transposition of the great arteries repair for all patients? A magnetic resonance imaging study including a spiral technique two decades postoperatively. Interact Cardiovasc Thorac Surg 2016;22:817-25.
9. Schaller T, Scharfschwerdt M, Schubert K, et al. Aortic valve replacement in sheep with a novel trileaflet mechanical heart valve prosthesis without anticoagulation. JTCVS Open 2021;7:76-88.
10. Sievers HH. Advanced imaging unveils aortic valve secrets: What is next, theoretic biology? J Thorac Cardiovasc Surg 2018;156:963-4.

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