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THE ROSS PROCEDURE: UNDERUSE OR UNDER-COMPREHENSION?

To the Editor:

Yacoub and colleagues¹ elegantly discussed the underuse of the Ross procedure in a recent comment in *The Lancet*. Technical difficulties and risks of the procedure, especially at issue if it is not performed by experienced practitioners, have conspired against the widespread use of this life-saving operation. Additionally, the advancing technologies of bioprosthesis manufacturing, the reports on their prolonged life, along with the increasingly available option of percutaneous valve-in-valve implantation, have discouraged the majority of surgeons from undertaking a technically challenging operation. The procedure carries augmented surgical risk, may negatively affect a surgeon's reputation, and potentially burdens cardiac units economically. We think that a miscomprehension of the intrinsic value of this procedure additionally played a role in its underutilization. In other words, we believe that in the face of the technical difficulties of the procedure, its biological significance and clinical advantage for the patient may have been overlooked in surgical practice.

As Yacoub and colleagues¹ point out, along with Ross himself, the inventor of the procedure,² its real keystone is the possibility of maintaining the viability of the aortic valve and preserving the biological activity of the valve leaflets. As pointed out recently, cells populating the

leaflets guarantee an adequate coagulative balance and favorable tissue homeostasis.³ Compared with the glutaraldehyde fixed bioprostheses, the active function of a living leaflet is reflected by the absence of calcific degeneration and anticoagulation.³ More importantly, when applied to pediatric or young adult cases, the Ross procedure's advantage is the possibility of providing an aortic root substitute that can be harmoniously integrated into the vascular system during progressive somatic growth of the aortic structures. However, reports of the need for reoperation for neoroot dilation must be taken into account and are another major deterrent to use of the procedure, especially with young patients.⁴ Such dilation is mainly a result of the anatomic and histologic features of the native pulmonary artery (PA), which is normally subjected to pulmonary pressures and behaves as a venous conduit. Horer and colleagues⁵ elegantly examined the hemodynamic loads on a PA autograft and reported the differential potential for dilation at the various regions of the neo-aorta: the annulus, the Valsalva sinuses (0.5 mm per year) and the sinutubular junction (0.7-0.9 mm per year). They point out that root enlargement may be a pivotal problem, affecting the reimplanted coronaries in the long term.

Attempts to reinforce PAs using synthetic materials such as polyethylene terephthalate and polytetrafluoroethylene have been performed, but though they are effective in preventing dilation, the poor elastomechanical properties and deleterious inflammatory reactions caused by the artificial nature of the materials undermined the effectiveness of this approach.⁶ The biological consequences of surgical procedures should not be neglected, and these 2 materials, which are normally used to reinforce the PA, fail to meet the demanding needs of growing tissue. The strong foreign-body reaction

associated with their use impairs PA viability, preventing any arterialization or vascular remodeling. The reaction eventually constrains the growing aorta and results in fibrous degeneration of the aortic wall. Impoverishment of vascular compliance and loss of the Windkessel effect have been shown to produce, in turn, detrimental effects on the aorta and the valve, leading to regurgitation.⁷

We therefore believe that respect for graft viability and its biological features needs to guide the surgical process, but strategies to improve the biomechanical properties of the autograft, at least in the early stages, leaving intact the biological function of the intima and the valve, could be a solution that allows patients to benefit fully from the biological and clinical advantages of the Ross procedure, while avoiding the drawback of autograft dilation. An understanding of the biological cascade of events triggered by the transposition of the PA in aortic position, and leading to vessel remodeling and wall modification, is fundamental in this context. In our group, we have explored the possibility of guiding and boosting the mentioned remodeling process, through the use of resorbable external meshes.⁶ A biocompatible device designed to minimize radial tension, based on the combination of a single-layer of polyglactin (early resorbability material), strengthened by an interlaced polydioxanone (late resorbability material), was used as reinforcement of the PA, bracing its outer aspect.

The device prevented aneurysmal dilation of the neo-aorta, while allowing compatible growth of the PA, in an experimental model of the Ross procedure in growing lambs.⁶ Surprisingly, the resorbable materials triggered a process of histoarchitectural rearrangement at the medial and adventitial side of the vessel without strong inflammatory infiltrates. Over time, new matrix

deposition was observed, along with a shift toward an elastic remodeling of the PA.⁶

We might reliably speculate that the temporary interaction between the bioresorbable reinforcement and the PA orchestrated a complex process of vascular remodeling, based on a balance between inflammation and extracellular matrix production, resulting, after biomaterial resorption, in a “neovessel” that exhibits characteristics similar to those of the aorta but is still biologically alive and capable of growth. This system would therefore allow induction of the in vivo creation of a PA with morphostructural features that enable it to both manage the hemodynamic load of the arterial system and harmoniously increase in size during somatic growth.⁸ Although this possibility needs to be confirmed with additional results, the use of biocompatible external reinforcements that are able to stimulate, guide, and improve the natural processes of graft biological remodeling and reaction to foreign materials, while accommodating tissue growth, may constitute an innovative avenue to solving some of the drawbacks of the Ross procedure. We believe that this potential could be key to increasing use of the Ross procedure in the immediate future and stimulating further research on the development of bioartificial vascular substitutes.

The surgical and medical community may need to “go back to biology,” as every procedure we perform may have a deep influence on the organism, and therefore their biological consequences should not be neglected. Understanding, ameliorating, or simply exploiting naturally occurring processes might constitute a key element of not only the Ross operation but also those for several other pathologies. Is there something more to understand about the Ross procedure before we abandon it just because of its technical difficulty? Sometimes solutions are

easier than expected when problems are fully understood.

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