Editorial

Aortic valve-in-valve and hemodynamic outcomes: where are we?

Implante aórtico *valve-in-valve* e resultados hemodinâmicos: onde nós estamos?

The importance of valve-in-valve (VIV) has grown considerably over the last decade. Considering the evolving demographic profile of the Western world, this should come as no surprise. A few decades ago, while it was known that bioprosthetic valves had limited durability, surgeons everywhere were less concerned about what would happen when the devices became dysfunctional because most patients "failed" before their valves did.[1,2] However, with the massive increase in life expectancy[3] and a greater utilization of bioprostheses,[4] it became prudent to actively find alternatives for these patients.

In this issue of the *Revista Brasileira de Cardiologia Invasiva*, Meneguz-Moreno et al. present a series of seven cases of aortic VIV from two major tertiary hospitals. The patients were all male with a mean age of 72.6 ± 10 years and had elevated risk scores (Society of Thoracic Surgeons - STS 9.6 ± 10.5% and logistic EuroSCORE 22.7 ± 14.7%). Mixed failure was the most common type of failure in the cohort (three cases, 42.8%); stenosis and regurgitation were equally common (two cases each, 28.6%). Their experience was divided into two CoreValve (Medtronic, Minneapolis, USA) and five SAPIEN XT (Edwards Lifesciences, Irvine, USA) cases. Mean gradients post-procedure, albeit reduced, still remained worse than the Valve Academic Research Consortium (VARC)-2 cut-off (20.9 ± 5.9 mmHg). However, there was a clear improvement in the symptom status of the patients. Operators obtained successful results and further demonstrated the reproducibility and safety of VIV in diverse clinical settings.

VIV consists in the insertion of a transcatheter heart valve (THV) into a failed bioprosthetic valve.[5] The gold standard is still the conventional surgical replacement of the failed valve.[6] Surgical valves have proven long-term durability and outcomes,[2,7] and more evidence is needed to employ THV as the first therapeutic choice. Minimally invasive procedures certainly draw the attention of patients for obvious reasons. Replacing a valve without the risks of open-heart surgery, reduced discharge times, conscious sedation, and less post-operative pain is understandably attractive. However, physicians must be critical, judicious, and fully understand the shortcomings of VIV. The Valve-in-Valve International Data (VIVID) Registry, founded in 2010, intends to provide scientific insight on both the advantages and disadvantages of the procedure.[5]

A key problem faced by Meneguz-Moreno et al. was the elevated post-operative mean gradient in three out of seven cases of the series. Elevated post-procedural gradients are not a new concern. In the seminal 2012 VIVID analysis published in Circulation,[5] as well as in the 2014 Journal of the American Medical Association landmark paper,[8] the high incidence of elevated post-procedure gradients (≥ 20 mmHg by VARC-2 criteria) was noted as one of three unresolved problems in VIV.

Operators have good reasons to consider gradients as a potential enemy. Elevated post-procedural gradients are intrinsically associated with prosthesis-patient mismatch.[8] A large meta-analysis identified an association between moderate and severe prosthesis-patient mismatch with worse outcomes.[9,10] Some evidence also suggests that elevated gradients may further reduce leaflet durability, allowing for increased device degeneration,[11] demanding earlier replacement.

We previously reported that the average mean gradient in the VIVID Registry was 15.8 ± 8.9 mmHg.[8] However, transcatheter aortic valve replacement (TAVR) procedures in native valves have relatively low post-procedural mean gradients, in the range of 5 to 10 mmHg.[12] It could then be concluded that THV itself is not, on its own, responsible for this phenomenon. The accepted current explanation for the high incidence involves a combination of predictors: baseline surgical valve stenosis and type of THV.[13]

While biological tissues, such as the aortic root, are flexible, surgical valve rings are structurally rigid. As a consequence, THV does not expand the surgical valve with it. Conversely, a rigid surgical valve may not allow full expansion of the THV. This is compounded by the mechanism of failure encountered in the surgical device. A primarily stenotic device has less malleable leaflets that may also impair THV expansion. A regurgitant one, on the other hand, is more pliable and would not demonstrate the issue in the same magnitude.

Expansion of the THV is only important if it affects the functional area of the leaflets. This is the fundamental rationale behind the status of the THV model as a predictor of elevated mean gradients. THV are not built equally. The leaflet area may be built at the level of the aortic (or, in our case, surgical valve) annulus, which would make the device intraannular, or it can be assembled above the annulus, hence supraannular.[14] Examples of the former are the SAPIEN XT and the Portico (St. Jude Medical, St. Paul, USA) valves. The most important of the latter is the CoreValve. A supraannular device is less affected by the rigidity of the surgical valve. Better expansion of the device, with improved leaflet coaptation, would be expected in a supraannular position.

A natural next-step would be to involve THV positioning in this discussion. Theoretically, if an operator positions an intra-annular device high enough, it would eventually be "supra-annularified". In the same way, implanting a supra-annular device too low could potentially constrict the functional area of the THV. Obtaining greater insight on the importance of positioning was the objective of the currently in-press *in vivo* and *in vitro* depth of implantation analyses of the Registry.[13] We found, in the *in vitro* section, that higher implantation is associated with lower gradients and larger effective orifice area in SAPIEN XT, CoreValve, and Portico valves.

This was confirmed by a 292-patient analysis, which identified high positioning as the most important protector against high gradients, followed by CoreValve use. Baseline stenosis was, as expected, identified as a predictor of higher gradients. Optimal cutoffs for positioning were identified: zero to 5 mm depth for CoreValve cases and zero to 10% of frame length (~2 mm) for SAPIEN XT cases.[13] Ad-

DOI of original article: http://dx.doi.org/10.1016/j.rbci.2016.06.002

vances in the field are needed. While high positioning provides a clinically feasible manner of preventing poor hemodynamics, newer surgical valves could further improve VIV hemodynamic outcomes. Improvements in surgical valve technology, aiming for future VIV, are crucial: proper fluoroscopic markings, expandable annuli, and large internal diameters are features that could potentially improve procedural quality.

In conclusion, VIV is a promising, less invasive approach that may offer life-saving possibilities for many patients. There are still procedural challenges that may impair desired outcomes. However, there is a rich amount of experience in the field that allows operators to perform the procedure safely. We encourage newcomers into the field to learn about the procedure and enrich the present state of knowledge.

Conflicts of interest

Matheus Simonato and Ruhina Rana declare no conflicts of interest. Danny Dvir is a consultant for Edwards Lifesciences and Medtronic.

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