distance between the inflow edge of the TAVR frame and the aortic annulus at the noncoronary cusp defined the implant depth, which allowed for better appreciation of the position of the MS with more control of the depth at the non-right commissure.

However measured, patients with shorter MS length and ultimately smaller remaining presumably uncovered portion of the MS (septum length minus implantation depth) were found to be at greater risk for CDs. Yet, the methods used to obtain these more-sophisticated measurements seemingly mattered not nearly as much as the final depth of implantation in successfully mitigating the high rates of CD often seen with self-expanding valves. The key message then from this elegant work by Chen and colleagues seems simply to be to land the valve as high as safely possible.

See Article page 42.

Commentary: Landing high, but not too high, yields fewer pacemakers after transcatheter aortic valve replacement

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Transcatheter aortic valve replacement (TAVR) is now commercially available for the treatment of severe aortic stenosis for all risk groups. Therefore, it is more important than ever to optimize clinical outcomes, considering the longevity of younger patients receiving TAVR. Conduction abnormalities including permanent pacemaker (PPM) and left bundle

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CENTRAL MESSAGE

Implanting the TAVR prosthesis higher (aortic) may reduce the need for permanent pacemaker, and preoperative imaging may guide us in certain patients more vulnerable for complete heart block.

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branch block are associated with increased hospitalization for heart failure, lack of improvement in left ventricular ejection fraction, longer intensive care stay, and mortality.^{1,2} The incidence of new PPM comparing the balloon-expandable SAPIEN 3 valve (Edwards Lifesciences, Irvine, Calif) was similar to surgery in the PARTNER 3 randomized trial.³ In

contrast, PPM was significantly greater than surgery in the Evolut low-risk randomized clinical trial using the self-expanding valve at 17.4%.⁴ With the staggering increase in TAVR valve implantation in the United States, there remains an immense interest in finding potential techniques to lower this incidence, especially in those with an increased risk for a PPM. These patient populations include those with a baseline right bundle branch block, presence of coronary artery disease, greater Society of Thoracic Surgeons score, and self-expanding valve.¹ Most recently, the depth of TAVR valve implant and length of membranous septum are also emerging as a strong predictors of high-grade atrioventricular block (odds ratio [OR], 1.4; 95% confidence interval [CI], 1.2-1.7; $P < .001$) and the need for new PPM (OR, 1.43; 95% CI, 1.1-1.8; $P = .002$).⁵

In this issue of the *Journal*, Chen and colleagues⁶ retrospectively analyzed computed tomography (CT) scans of 195 high surgical risk patients who underwent TAVR. Length of membranous septum (MS) was measured in coronal view and infra-annular MS in the stretched view. Implant depth (ID) of transcatheter heart valve was calculated from fluoroscopy. Subtracting this ID from MS gave the “coronal Δ MSID” and from infra-annular MS gave the “infra-annular Δ MSID.” Essentially, these were the “residual septum length” after the transcatheter heart valve was implanted. As expected, deeper valve implants along with shorter MS were a predictor of conduction abnormalities. The authors were also able to demonstrate thresholds or optimal cut-off points for coronal Δ MSID ≤ 3.2 mm and infra-annular Δ MSID ≤ -0.2 mm, beyond which conduction abnormalities increase. This raised an interesting practical usability where preprocedure CT analysis may help guide the operators on desired implant depths. A similar concept was studied by Jilaihawi and colleagues⁷ on 248 patients who underwent TAVR with a self-expanding valve and found implant depth $>$ membranous septum length as a predictor of PPM (OR, 8.04; 95% CI, 2.58-25.04; $P < .001$). They took this a step further and studied 100 consecutive patients prospectively using MIDAS approach—Minimizing Depth According to the membranous Septum. Whenever possible, the operators positioned the device at a depth of $<$ MS length

(as measured on CT) and were able to reduce the new PPM rate from 9.7% in the standard cohort to 3.0% ($P = .035$), and the rate of new left bundle branch block from 25.8% to 9% ($P < .001$).

These studies demonstrate that thoughtful preprocedure planning and meticulous valve implantation technique could result in a very low PPM rate with not only self-expanding, but also balloon-expandable, valves. In addition, it remains to be seen whether the imager's CT reading reproducibility and implanter's technique can be reproduced in low-volume or inexperienced centers. However, operators run a risk of placing the valve to aortic, leading to increased paravalvular regurgitation or embolization. The concept by Chen and colleagues is definitely provocative but needs validation in a larger cohort before becoming the standard of care. If it is validated, this innovative technique could be used in patient education in regards to the specific individual “patient pacemaker risk,” allowing operators to navigate between treatment choices with equipoise.

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