What Every Surgeon Should Know About Intraoperative Evaluation of Paravalvular Leaks

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Central Message

Transprosthetic cuff leak is an avoidable, infrequent cause of early transvalvular leak after surgical aortic valve replacement. Whatever the mechanism, successful decision-making requires a sophisticated understanding of the risks-benefit ratio posed to the patient by a second clamp time, and also a clear and shared understanding of the limitations and language of intraoperative imaging.

In this issue of *Seminars*, Hiraoka et al describe an underrecognized cause of aortic insufficiency immediately after surgical aortic valve implantation.[1] First described in 2015 by Tokunada et al,[2] the authors show how suture placement at the struts of the Carpentier Edwards Magna Ease can contribute to the formation of a gap associated with a characteristic regurgitant jet arising from the sewing ring most commonly at the right-left commissure and directed parallel to the annular plane. The risk of a second clamp time to address this defect must be weighed against the sequelae of paravalvular leaks: the authors conclude that mild cuff leaks may resolve with protamine administration and can safely be left alone whereas moderate leaks may warrant a second clamp time for surgical repair—where attention should be directed to fixing defects in the cuff, rather than gaps between the cuff and annulus.

This case series contributes to a body of knowledge on paravalvular leaks that has recently expanded, thanks in part to interest and data driven by the very high rates initially associated with transcatheter aortic valve replacement, improvements in imaging, emerging percutaneous repair options, and new data on the outcomes of intervening on paravalvular leaks vs conservative management. We know that the prevalence of surgical aortic paravalvular leaks ranges between 2% and 17%, with around a quarter identified at the time of surgery.[3] Predictors of early paravalvular leaks include patient factors such as annular calcium, steroid use, and active endocarditis; technical factors including continuous vs pledgetted interrupted sutures; and prosthesis factors—with mechanical and sutureless bioprostheses (relative risk 2.32, 95% confidence interval 1.5−3.5) associated with higher rates than conventional bioprosthesis.[4]

When a paravalvular leak is identified on intraoperative transesophageal echocardiogram, accurate assessment is essential for effective management: surgeons can participate effectively in decision-making only if they understand the echocardiographic grading system being used, and appreciate the limitations of imaging. There are 3 things every surgeon needs to know about echocardiographic findings when deciding whether to give protamine, or to reclamp.

1) Echocardiographic assessment of aortic paravalvular leaks is difficult. Consensus guidance emphasizes that for optimal evaluation of aortic valve prostheses, both transthoracic and transesophageal echocardiography is needed because acoustic shadowing prevents imaging of the anterior sewing ring from transesophageal midesophageal views (and the posterior annulus from transthoracic parasternal views). Additionally, there may be "considerable overlap of mild and moderate" paravalvular leak, such that grading can be very challenging, mandating an approach that integrates qualitative and quantitative evaluation and more than one modality.[3] Given transthoracic echocardiography is not feasible intraoperatively, 3D transesophageal echocardiography is described as an essential tool for intraprocedural guidance.
2) Essential information includes the location of the regurgitant jet (central vs paravalvular), orientation in relation to the sewing ring, and quantification of the jet size.
3) Clinicians, consensus guidelines, and studies have used a variety of grading schemes with little consistency, including 3-class schemes (mild, moderate, and severe); 4-class

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Table 1. Echocardiographic Assessment of Paravalvular Leak Severity in Prosthetic Aortic Valves (Modified From Ref. 3)

Increasing need for intervention

3-class grading scheme	None/trace	Mild		Moderate		Severe
4-class grading scheme	1	1	2	2	3	4
5-class grading scheme	Trace	Mild	Mild to mod	Moderate	Mod to severe	Severe
Doppler echocardiography structural parameters						
Sewing ring motion	Normal	Normal	Either	Either	Abnormal	Abnormal
Doppler parameters (qualitative or semiquantitative)						
Wide jet origin	No	No	No	Yes	Yes	Yes
Multiple jets	Possible	Possible	Common	Common	Usually	Usually
Flow convergence	No	No	No	Possible	Common	Common
Vena contracts (mm)	–	<2	2–4	4 to <5	5 to <6	>6
Jet width (% LVOT)	<5	5 to <15	15 to <30	30 to <45	45 to <60	>60
Jet deceleration (ms)	>500	>500	200–500	200–500	200–500	<200
Diastolic flow reversal in aorta	Absent	Early diastolic	Intermediate	Intermediate	Holodiastolic	Holodiastolic
Circumferential extent (%)	–	<5	5 to <10	10 to <20	20 to <30	>30
Regurgitant volume (mL/beat)	<10	<15	15 to <30	30 to <45	45 to <60	>60
Regurgitant fraction (%)	<15	<15	15 to <30	30 to <40	40 to <50	>50
Effective regurgitant orifice area (mm^2)	<5	<5	5 to <10	10 to <20	20 to <30	>30

schemes (grade 1, 2, 3, or 4), and 5-class schemes allowing description of intermediate grades. The proliferation of grading schemes, combined with the uncertainties of imaging can contribute to significant discrepancies in reporting and unreliable decision-making. For example, when an anesthesiologist describes a paravalvular leak as "1 to 2+," a category which does not exist in any standardized scheme does this translate as "the leak isn't mild, it isn't mild to moderate, but it's probably inbetween" or "the leak could be mild or moderate"? Further, discordance of one grade or more between 2 clinicians evaluating the same images has been reported in up to 21% of echocardiograms.[5] So how can we reliably determine which paravalvular leaks need a second clamp time to address? Facility with 3D transesophageal echocardiography is essential in the operating room to assess the circumferential extent of a paravalvular leak, exclude artifacts of imaging, and perform direct measurement of color Doppler vena contracta and dimensions.[3] Primary criteria for a mild aortic valve paravalvular leak (which may not need intervention) vs greater grades are listed in Table 1.

Paravalvular leaks are associated with worse survival, although it remains unclear whether this is due to the poorer patient substrate contributing to increased risk of paravalvular leak and prohibitive risk for surgical correction; or the associated burden of aortic insufficiency, hemolysis, and late endocarditis. A recent series comparing 595 patients with paravalvular leaks including 105 (21%) with endocarditis managed either operatively ($n = 351$, 71%) or conservatively reported 3% in-hospital mortality with operative intervention, and after initially worse survival, superior outcomes at 5-year follow-up.[6] Percutaneous repair is an emerging alternative with procedural success rates in large series reported at 77–87%, and clinical success rates of 67–77%.[3] Improvement in heart failure symptoms after percutaneous closure is typically only seen in patients left with less than mild regurgitation, whereas hemolysis may not improve—and may worsen in up to a third of patients after percutaneous closure.[3] Consequently, indications for percutaneous closure include symptomatic heart failure and hemolytic anemia with suitable anatomic features, but there are no data for percutaneous closure of transprosthetic cuff leaks.

In conclusion, Hiraoka et al describe an avoidable, infrequent cause of early transvalvular leak after surgical aortic valve replacement. Whatever the mechanism, successful decision-making requires a sophisticated understanding of the risks-benefit ratio posed to the patient by a second clamp time, and also a clear and shared understanding of the limitations and language of intraoperative imaging.

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