Intraoperative aortic root pressure study for quantitative assessment of aortic regurgitation during valve-sparing root replacement: A preliminary report

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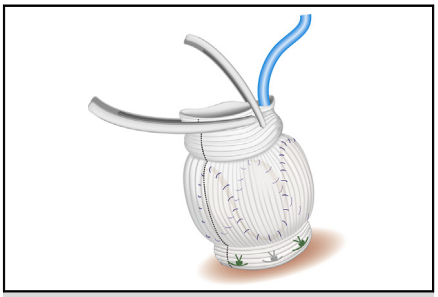


Depiction of pressurizing neosinus and circuit pressure monitoring.

Central Message

An aortic root pressure test that is based on the mean pressure buildup had a high diagnostic accuracy for evaluating aortic regurgitation.

See Editorial Commentaries pages 1402 and 1404.

Supplemental material is available online.

Video clip is available online.

Residual aortic regurgitation (AR) after valve-sparing root replacement (VSRR) is an important complication.[1] Assessment of the repair quality, however, largely depends on intraoperative visual inspection and transesophageal echocardiography (TEE). We previously reported a reproducible method of detecting AR with a videoscope[2]; however, this technique does not provide a quantitative estimate. This study aimed to analyze the diagnostic accuracy of an aortic root pressure test in evaluating AR during VSRR.

PATIENTS AND METHODS

Forty-five patients underwent VSRR with a reimplantation technique between July 2015 and March 2017. The intraoperative pressure test was used in 32 cases, and the clinical data were analyzed retrospectively. The study protocol was approved by the institutional review board, with informed consent waived because of the design of the study.

The algorithm of assessment is shown in Figure E1. Even in cases of suboptimal results of the pressure test, the surgeon determined whether to proceed to TEE assessment on the basis of visual inspection and aortic clamping time. AR was graded according to the American Society of Echocardiography recommendations as none, trace, mild, moderate, or severe.[3]

Technical details of the assessment are shown in Video 1. The aortic root was replaced with a Valsalva graft (Terumo Medical, Somerset, NJ). Before coronary implantation, the distal edge of the Valsalva graft was clamped, with great care taken to avoid inducing deformation, and the neosinus was pressurized with the crystalloid cardioplegic solution by means of a roller pump at the rate of 200 mL/min, as measured by the circuit pressure (CP) monitoring at the cardiopulmonary bypass machine (Figure E2). CP was plotted every 0.5 seconds to capture the trend graph (Figure 1, *A*). Implantation of the coronary arteries and distal anastomoses were completed after confirming the aortic cusp competency. After weaning from cardiopulmonary bypass, residual AR was determined by TEE.

Definition of the Mean Pressure Buildup

We set the CP assessment in the range of 50 mm Hg (the nadir of the pressure curve, P_{min}) to 200 mm Hg (the maximum of the pressure curve, P_{max}). Thereafter, the scope of assessment of time was set between the time corresponding to P_{min} (T_{min}) and P_{max} (T_{max}). Mean pressure buildup (*mPB*, in mm Hg/s) was defined as the pressure change during pressurization divided by the pressurization time (Figure 1, *B*):

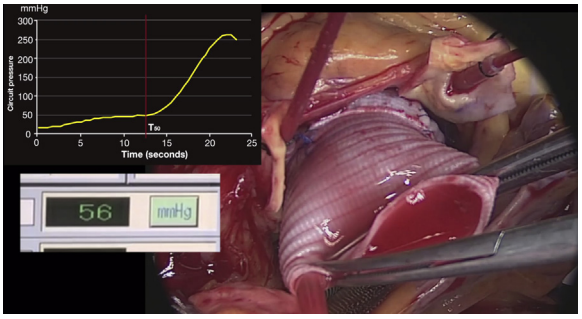
$$mPB\ (\text{mm Hg/s}) = (P_{max} - P_{min}) \div (T_{max} - T_{min})$$

Statistical Analyses

All continuous variables were expressed as the median with the interquartile range (IQR; 25th-75th percentile). The mPB values across the AR grade were assessed with the Kruskal-Wallis test. The Wilcoxon rank sum test was used for post hoc analysis. A P value of less than .05 was considered statistically significant. All data analyses were performed with JMP 11.0 (SAS Institute Inc, Cary, NC).

RESULTS

Patient characteristics are shown in Table 1. Eight patients underwent the pressure test at least 2 times (median,



VIDEO 1. After the second row suture and cusp repair (central plication of right coronary cusp) under cardiac arrest, we inspected the coaptation of the aortic cusp. Then, the aortic root pressure was assessed by administering crystalloid cardioplegia solution with the help of a roller pump (at the rate of 200 mL/min). The distal edge of the Valsalva graft was clamped with 2 forceps. After the clamping, the neosinus was pressurized, as measured by the circuit pressure monitoring at the cardiopulmonary bypass machine. In this patient, the circuit pressure showed a rapid rise beyond 200 mmHg. The mean pressure buildup (*mPB*) was calculated by the following equation:

$$mPB\ (\text{mm Hg/s}) = (P_{max} - P_{min}) \div (T_{max} - T_{min})$$
$$= (200\ \text{mm Hg} - 50\ \text{mm Hg}) \div (19.5\ \text{s} - 13.0\ \text{s})$$
$$= 23.1\ \text{mm Hg/s}$$

where P_{max} is maximum circuit pressure (cutoff of 200 mm Hg), P_{min} is minimum circuit pressure (cutoff of 50 mm Hg), T_{min} is time at minimum circuit pressure, and T_{max} is time at maximum circuit pressure. Postprocedural transesophageal echocardiography (*TEE*) showed no aortic regurgitation. Video available at: https://www.jtcvs.org/article/S0022-5223(18)31021-3/fulltext.

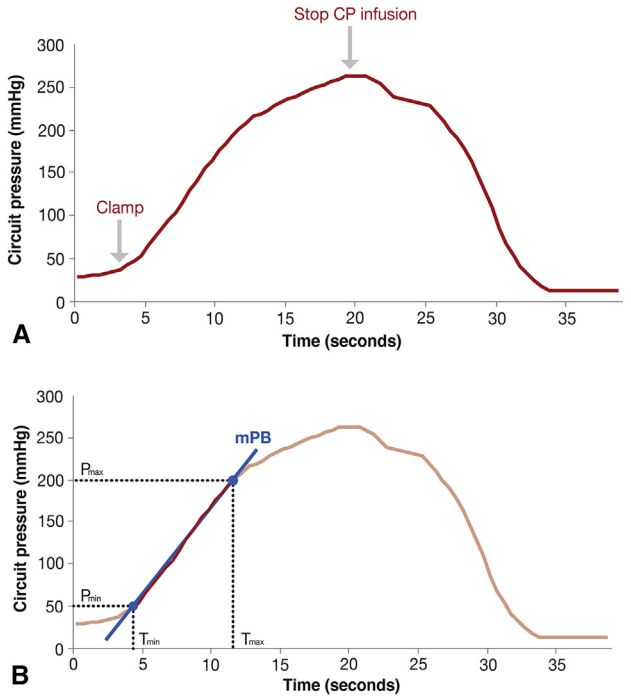


FIGURE 1. A, Trend graph of circuit pressure. B, Definition of mean pressure buildup (*mPB*). *CP*, Cardioplegia; P_{max}, maximum pressure (200 mm Hg); P_{min}, minimum pressure (50 mm Hg); T_{min}, time at minimum pressure; T_{max}, time at maximum pressure.

TABLE 1. Patient characteristics and operative variables (n = 32)

Variable	Value
Preoperative	
Age (y)	54.0 (45.3-65.5)
Male sex	27 (84.4%)
BSA (m^2)	1.69 (1.63-1.82)
Symptoms	
NYHA I	14 (43.8%)
NYHA II	16 (50.0%)
NYHA III	2 (6.2%)
Previous cardiac surgery	5 (15.6%)
Urgent operation	1 (3.1%)
Aortic valve morphology	
Quadricuspid	2 (6.2%)
Tricuspid	22 (68.8%)
Bicuspid	6 (18.8%)
Autograft	2 (6.2%)
AR grade	
None	1 (3.1%)
Trace	3 (12.5%)
Mild	1 (3.1%)
Moderate	2 (6.2%)
Severe	25 (78.1%)
Cusp prolapse	20 (62.5%)
LVEF (%)	55.8% (45.8%-63.4%)
LVDd (mm)	61.6 (56.7-67.7)
LVDs (mm)	43.7 (37.7-52.3)
AVJ (mm)	25.8 (23.5-27.6)
Valsalva sinus (mm)	44.1 (39.1-50.8)
STJ (mm)	34.9 (31.3-46.7)
Intraoperative and postoperative	
Implanted graft size	
24 mm	3 (9.4%)
26 mm	7 (21.9%)
28 mm	19 (59.4%)
30 mm	3 (9.4%)
Central plication	21 (65.6%)
Free margin reinforcement	11 (31.3%)
Patch repair	3 (9.4%)
Cusp decalcification	3 (9.4%)
Commissural plasty	4 (12.5%)
Cardiopulmonary bypass time (min)	220.5 (188.8-260.5)
Aortic clamping time (min)	180.0 (143.5-206.0)
Postprocedural AR grade	
None	12 (37.5%)
Trace	14 (43.8%)
Mild	5 (15.6%)
Moderate	0 (0%)
Severe	1 (3.1%)

Data are median with interquartile range or number of patients with percentage. *BSA*, Body surface area; *NYHA*, New York Heart Association functional class; *AR*, aortic regurgitation; *LVEF*, left ventricular ejection fraction; *LVDd*, left ventricular diameter, diastolic; *LVDs*, left ventricular diameter, systolic; *AVJ*, aortoventricular junction; *STJ*, sinotubular junction.

4.0 times; IQR, 2.5-6.3 times). The final value for mPB was 16.3 mm Hg/s (IQR, 12.-24.6 mm Hg/s). The mPB values were significantly lower in patients with mild or greater