Accuracy of transesophageal echocardiography in the identification of postoperative intramural ventricular septal defects

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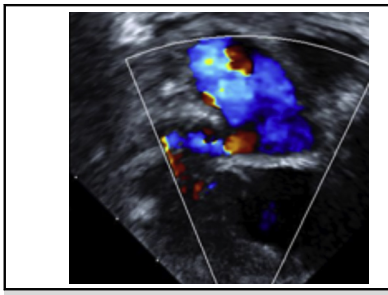
ABSTRACT

Background: Intramural ventricular septal defects (VSDs), residual interventricular communications occurring after repair of conotruncal defects, are associated with poor postoperative outcomes. The ability of intraoperative transesophageal echocardiography (TEE) to identify intramural VSDs has not yet been evaluated.

Methods: Intraoperative TEE and postoperative transthoracic echocardiography (TTE) data in all patients undergoing all biventricular repair of conotruncal anomalies in our hospital between January 1, 2006, and June 30, 2013, were reviewed. The ability of TEE to accurately identify residual defects was assessed using postoperative TTE as the reference imaging modality.

Results: Intramural VSDs occurred in 34 of 337 patients evaluated; 19 were identified by both TTE and TEE, and 15 were identified by TTE only. Sensitivity was 56% and specificity was 100% for TEE to identify intramural VSDs. Peripatch VSDs were identified in 90 patients by both TTE and TEE, in 53 by TTE only, and in 15 by TEE only, yielding a sensitivity of 63% and specificity of 92%. Of the VSDs requiring catheterization or surgical reintervention, 6 of 7 intramural VSDs and all 5 peripatch VSDs were identified by intraoperative TEE. TEE guided the intraoperative decision to return to cardiopulmonary bypass (CPB) in an attempt to close residual defects in 12 patients with intramural VSDs and in 4 patients with peripatch VSDs seen after initial CPB; of these, 10 intramural VSDs and all 4 peripatch VSDs resolved or became smaller on final intraoperative TEE.

Conclusions: TEE has modest sensitivity but high specificity for identifying intramural VSDs and can detect most defects requiring reintervention. Repeat attempts at closure in the index operation may successfully correct intramural VSDs identified by TEE. (J Thorac Cardiovasc Surg 2016;152:688-95)



Echocardiographic image of an intramural VSD.

Central Message

Intraoperative TEE has modest sensitivity but high specificity for identifying intramural VSDs after repair of conotruncal anomalies.

Perspective

Intramural ventricular septal defects (VSDs), residual defects that can occur after repair of conotruncal anomalies, are associated with increased morbidity and mortality. Transesophageal echocardiography is useful for identifying most clinically relevant intramural VSDs. Identification of these defects is important because they can often be repaired during the index operation.

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Intramural ventricular septal defect (VSD) is a distinct type of residual VSD that may occur after surgical repair of conotruncal defects involving patch closure of a VSD from the left ventricle to a great artery. VSDs are tunnel-like communications that occur when the VSD patch is not anchored to the right ventricular free wall but rather is attached to right ventricular trabeculations, such that blood can flow around the VSD patch and into the right ventricular cavity (Figure 1, Video 1). We have previously reported that children with intramural VSDs identified by postoperative transthoracic echocardiography (TTE) have

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Abbreviations and Acronyms
CI = confidence interval
CPB = cardiopulmonary bypass
IQR = interquartile range
TEE = transesophageal echocardiography
TTE = transthoracic echocardiography
VSD = ventricular septal defect

higher mortality, morbidity, and longer length of stay compared with those with nonintramural (peripatch) VSDs or no residual VSDs[1,2]; however, the ability of intraoperative transesophageal echocardiography (TEE) to accurately identify intramural defects had not been investigated previously.

METHODS

We performed a retrospective cohort study of all children aged 0 to 18 years at our institution who underwent biventricular repair of a conotruncal anomaly involving baffle closure of a VSD to a great artery (ie, VSD baffle to the aortic valve or a truncal valve, or VSD baffle to the pulmonary valve with an arterial switch operation or Damus–Kaye–Stansel procedure) at our hospital between January 1, 2006, and June 30, 2013. Our hospital's Institutional Review Board approved the study and waived the requirement for informed consent.

Patient Selection

The institutional surgical database was queried for all surgical procedures during the study period in patients with a conotruncal anomaly, defined as tetralogy of Fallot, d-transposition of the great arteries, truncus arteriosus, double-outlet right ventricle, l-transposition of the great arteries, anterior malalignment (Eisenmenger type) VSD, posterior malalignment VSD, double-outlet left ventricle, and aorta arising from the right ventricle with pulmonary atresia. The clinical outcomes of this cohort based on VSD type identified by TTE have been reported previously.[1] In the present study, patients were included if they had an adequate intraoperative TEE and postoperative TTE that evaluated for residual VSD (sweeps of the interventricular septum in 2-dimensional [2D] and color Doppler TTE performed in 2 or more views).

Echocardiographic Evaluation

It is institutional protocol to perform intraoperative TEE to assess the repair of conotruncal defects whenever patient size is adequate to allow for probe placement and there are no contraindications to the use of TEE. The intraoperative TEE protocol included full 2D and color Doppler sweeps along the VSD patch in the midesophageal 4-chamber, midesophageal long-axis, midesophageal short-axis, and left ventricular outflow tract views. Transgastric views of the outflow tracts were also obtained when possible. Postoperative TTE was deemed adequate if evaluation for residual VSD was performed with sweeps of the interventricular septum in 2D and color Doppler in 2 or more views. Sedation was administered for performing TTE if patient agitation prevented interpretable images from being obtained but generally was not required.

Images were acquired with a Philips T6207 Mini-Multi TEE probe (Philips Corp, Andover, Mass) in the majority of patients. For patients in whom this probe would not pass (generally those weighing <3 kg), the Philips S8-3T Multi-Mini TEE probe was used, and the Philips T6H or X7-2T probe was used for patients weighing approximately >25 kg. All images were acquired on a Philips iE33 ultrasound machine.

The intraoperative TEE images obtained after all cardiopulmonary bypass (CPB) runs and the first adequate postoperative TTEs were reviewed by a single experienced echocardiographer (MSC), and the presence and type of residual VSDs were noted. As described previously,[1] an intramural VSD was defined as a communication located anterior to the VSD patch between the great artery and the right ventricular trabeculations; to meet the definition, the VSD patch had to be seen attached to the right ventricular trabeculations rather than anchored to the right ventricular free wall adjacent to the annulus of the semilunar valve. Residual VSDs that did not meet this definition were considered nonintramural, or peripatch, defects. VSDs were measured and categorized as <2 mm or ≥2 mm, based on previous studies reporting that most residual VSDs <2 mm close spontaneously and/or do not typically require reintervention.[3,4]

Chart Review

Both inpatient and outpatient medical records were queried to abstract demographic data, medical and surgical history, cardiac history, and perioperative hospital course. Operative notes were reviewed for any repeated attempts to close a VSD during the index operation. The institutional surgical database was queried to determine CPB times and the Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery mortality categories[5] for each operation. The medical record was reviewed to assess for mortality or additional surgical or catheter-based procedures performed to close a VSD in the 30 days after initial operation or during hospitalization for the initial operation if longer than 30 days.

Statistical Methods

Descriptive statistics, expressed as count (percentage) or median (interquartile range [IQR]), were used. Test characteristics (sensitivity, specificity, and negative and positive predictive values) for TEE were determined using TTE as the reference imaging modality. The χ^2 test and Wilcoxon rank-sum test were used to evaluate categorical and continuous variables between patients with correct or incorrect diagnoses of VSD by TEE as compared with TTE (ie, those with concordant findings of a VSD on TEE and TTE vs those with discordant findings). The χ^2 and Wilcoxon rank-sum tests were also used to evaluate categorical and continuous variables between the patients included in this analysis and those excluded because of a lack of adequate TTE or TEE imaging. Significant P values were determined a priori as <.05. All statistical analyses were performed with Stata version 12.1 (StataCorp, College Station, Tex).

RESULTS

Patient Selection and Demographic Data

A total of 903 surgical procedures were performed in patients with conotruncal defects over the 7-year study period. Of these, 462 were biventricular repairs of conotruncal defects involving baffle closure of a VSD from the left ventricle to a great artery. One patient aged >18 years was excluded. Nineteen patients were excluded because they did not have a postoperative TTE that adequately evaluated for residual VSD, and 105 patients were excluded because of inadequate intraoperative TEE (ie, no intraoperative TEE performed in 29, TEE truncated owing to interference with respiration in 15, inadequate TEE images in 20, and inability to access TEE images in