Utility of Intraoperative Transesophageal Echocardiogram in Congenital Heart Disease

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Abstract

Intraoperative transesophageal echocardiogram (TEE) has improved the perioperative outcome in adult patients. The purpose of the current study was to assess the benefit of intraoperative TEE in patients with congenital heart disease undergoing surgical correction (repair). The results of the patients who had consecutively undergone intraoperative TEE during their congenital heart surgery between January 1998 to June 2000 were reviewed. There were 104 patients (whose ages ranged from one week old to 50 years old (median 5 years old) and their weights from 3 kg to 79 kg (median 15 kg). A significant impact was said to have occurred if these findings prompted a change in surgical procedure following a prebypass study or rebypass for repair of a residual defect. Prebypass TEE had a significant impact in seven patients (6.7%). TEE could be used as a guide to help repair in three patients. The postbypass TEE examination had a significant impact in 15 patients (14.4%). Of these 15 patients, eight were detected primarily by TEE examination. The group of patients in whom TEE had the most significant impact was in patients who had surgery related to the repair of the atrioventricular valve (complete or partial atrioventricular (AV) canal repair, Ebstein's anomaly; 9 out of 22 patients; 41%). A less significant impact was found in surgery for other complex congenital defects (single ventricle or complete transposition of great arteries; eight out of 46 patients; 17.4%). TEE had limited impact in simple congenital lesion. Intraoperative TEE is valuable in the perioperative care of patients with congenital heart defects. We found the most benefit in patients with complete or partial AV canal and Ebstein's anomaly.

Key words : Intraoperative Transesophageal Echocardiogram, Congenital Heart Disease

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BACKGROUND

The use of echocardiogram during repair of congenital heart defects has been well established since the 1980s[1-7]. Initial attempts at epicardial imaging, using the same probe for transthoracic imaging, produced some effect on the outcome of surgery[3]. However, epicardial imaging is somewhat cumbersome and interrupts the surgical procedure. Intraoperative transesophageal echocardiogram (TEE) has eliminated many problems with epicardial imaging and is now well established in adults and children. The impact of intraoperative TEE can be largely classified into two areas. Preoperative TEE could alter the planned procedure in patients in whom new information is obtained prior to the bypass procedure. Postbypass scanning could lead to immediate revision of the initial repair in patients. This may also decrease the chance of subsequent reoperation as has been shown by other investigators[7-12]. The anatomical and hemodynamic data obtained can also be used to improve the postoperative care of patients. Intraoperative TEE has been performed in our hospital since 1995[13]. Initial results in adult patients were encouraging. However, the pediatric biplane probe was not available in our hospital until 1997. The purpose of the current study was to assess the accuracy, safety, and value of intraoperative TEE in patients with congenital heart disease. Both the preoperative and postoperative influences of the technique were determined.

PATIENTS AND METHOD

Patients

Results of the patients who consecutively had intraoperative TEE during their operation between January 1998 and June 2000 were reviewed. All of the patients were diagnosed as having congenital heart disease and were scheduled for surgical repair at our weekly cardiac-surgical conference. The indications for transesophageal echocardiogram were in those patients with congenital heart defect in whom the surgeon thought that TEE would yield important information. We were not able to pass the TEE probe in two patients. All of them were below 5 kg in weight. There were 104 patients who had the operation with a TEE examination during the study period. The age of the patients ranged from one week to 50 years old (median age 5 years old). The patients weighed between 3 kg to 79 kg (median weight 15 kg). The congenital heart defects found in our patients are listed in Table 1. The primary surgical procedures performed are listed in Table 2. Many patients had more than one surgical procedure.

Table 1. Primary type of congenital heart defects that were operated on (VSD=ventricular septal defect).

Single ventricle	17
Tetralogy of Fallot	14
Ventricular septal defect	12
Complete atrioventricular canal	11
Complete transposition of great arteries (± VSD)	9
Partial atrioventricular canal	7
Pulmonary atresia with intact ventricular septum	6
Ventricular septal defect with aortic regurgitation	6
Ebstein's Anomaly	4
Atrial septal defect	4
Anomalous pulmonary venous connection	4
Pulmonary atresia with ventricular septal defect	3
Others	7

Table 2. Surgical procedures performed primarily in 104 patients (AV = atrioventricular; VSD = ventricular septal defect, RVOT = right ventricular outlflow tract, ASD = atrial septal defect).

Ventricular septal defect closure	18
Tetralogy of Fallot repair	14
Modified Fontan operation	13
Complete AV canal repair	9
Partial AV canal repair with cleft left AV valve repair	7
Pulmonary atresia with VSD repair with conduit	6
Pulmonary valvuloplasty with RVOT reconstruction	6
Arterial switch operation	5
Aortic valve repair	5
Repair of mitral valve	5
Ebstein's anomaly repair	4
ASD closure	4
Mustard operation	3
Bidirectional cavopulmonary anastomosis	2
Truncus arteriosus repair	2
Rastelli procedure	2
Others	7

Intraoperative TEE technique

We used the commercially available echocardiographic system from Hewlett-Packard Corporation (Sonos 1000) with Pediatric bi-plane probe (9 mm in diameter) for children smaller than 20 kg, and an adult multiplane probe in larger patients. The TEE probe was inserted into the esophagus

after patients had been anesthesized and intubated. A complete TEE examination was performed in a standard image orientation[14-17]. TEE examination was performed before and after cardiopulmonary bypass by one of the two pediatric cardiologists (KD and JS). The examination included two-dimensional scanning, color-flow imaging, pulse- and continuous- wave Doppler imaging. The studies were reviewed with the surgeon in real time. The echocardiographic machine was turned off during cardiopulmonary bypass to minimize the potential heat production. Then, the tip of the probe was advanced into the stomach while it was not in use.

Data acquisition and interpretation

Initially, the medical records including previous diagnostic studies were reviewed. The accuracy of prebypass TEE was compared with the results of previous diagnostic studies (echocardiogram or cardiac catheterization) and surgical findings. New findings obtained from prebypass TEE were recorded. However, significant impact of prebypass TEE was classified as the findings that revealed new information that altered the previously planned surgical procedure. Additional information obtained immediately after the surgical procedure, such as the presence of a residual defect on the post-bypass TEE, was defined as "limited impact". However, "significant impact" was said to have occurred if this finding prompted a surgical repair (rebypass) of residual defects.

RESULTS

Preoperative result

Prebypass TEE showed new findings in 29 out of 104 patients (27.8%). Prebypass TEE had a significant impact in only seven patients. The specific detail of the findings that altered the surgical plan are listed in Table 3. All of them, except patients who had Ebstein's anomaly, had cardiac catheterization before surgery. None of them had TEE performed before surgery. Their ages were not significantly different from patients in whom TEE did not have a significant impact. In three patients, TEE did not reveal any new findings. However, TEE could be used in real time for guided repair. One patient, a 2-year-old girl (previously who had had a repair of Tetralogy of Fallot (TOF) using a right ventricular outflow patch) showed residual leakage. We were able to demonstrate the position of this leakage simultaneously with the surgeon's finger pushing on the outflow of the right ventricle to stop the flow through the leaking patch. The repair was carried out in that specific area. In a six-year-old boy who had complete transposition of great arteries with ventricular septal defect and pulmonary stenosis (D-TGA/VSD/PS), we identified a VSD with a band of conus muscle that obstructed the intracardiac VSD tunnel. The incision was extended in this area to eliminate the potential obstruction. The last patient was another six year old boy with a coronary fistula from the right coronary artery to the right ventricular apex. The open-

Table 3. Prebypass transesophageal echocardiographic findings with significant impact (D-TGA=complete transposition of great arteries; PS = pulmonary stenosis; VSD = ventricular septal defect; TR = tricuspid regurgitation; TV = tricuspid valve; AV = atrioventricular; RV = right ventricle; TOF = tetralogy of Fallot).

Case	Planned procedure	Additional TEE	Effect on procedure
D-TGA/PS/VSD	Rastelli	restrictive VSD	extend VSD by cut through conus muscle
D-TGA	Mustard	severe TR	TV annuloplasty
Asplenia	Fontan, intracardiac Baffle	potential obstruction of pulmonary vein drainage	extracardiac conduit Fontan
D-TGA/VSD/ straddle AV valve	Fontan	position of chordae attachment	Arterial switch operation
Ebstein's anomaly	Repair	clot in right atrial appendage	remove clot
Coronary arterio-venous fistula	Repair	position of fistula enter RV	guided repair
TOF s/p repair with patch leakage	Repair	position of patch leakage	guided repair

ing of the fistula into the right ventricular cavity could be identified by TEE and compared with the surface anatomy.

Postoperative result

The postbypass TEE examination had a significant impact, which resulted in the immediate revision of these findings in 15 patients (14.4%). The specific residual lesions are shown in Table 4. Of these 15 patients, eight were detected primarily by TEE examination. The findings were discussed with the surgeon before a decision to rebypass was made. All of them were confirmed by surgical findings and the residual defects were repaired. The other seven patients were suspected by the surgeon as a result of : desaturation in oxygenation after Fontan operation; elevated left atrial pressure after repair of the left atrioventricular valve, or a residual thrill in the infundibular area by surgical inspection after repair of TOF.

Outcome of the surgical procedure

There was no intraoperative mortality in any of the 104 patients. No complication was found related to TEE probe insertion. One patient, who was a 3 kg neonate with an obstructed pulmonary vein, required prompt removal of the TEE probe postbypass because of hemodynamic instability. Compression of the descending aorta by the TEE probe was suspected. Two patients died during the early postoperative period. Both of them had a Fontan operation. One of them had an obstructed pulmonary vein and the other had leakage of the baffle. Both of them had a TEE examination which prompted an immediate rebypass. However, during the early postoperative period, they expired due to low cardiac output and renal failure. One late death was noted in one eight-month old girl who had a complete AV canal. Postbypass TEE identified moderate to severe left atrioventricular valve (AV valve) regurgitation which required rebypass for repair of the valve. However, she was brought back for a 2nd operation to repair her left AV valve a few days later. Prebypass TEE identified a dehisence of the patch closure of VSD with severe regurgitation of the left AV valve. Unfortunately, after the repair, she stayed in intensive care unit for another five months and expired due to severe fun-

Table 4. Postbypass transesophageal echocardiographic findings with significant impact (CAVC = complete atrioventricular canal; AVV = atrioventricular valve; VSD = ventricular septal defect; AR = aortic regurgitation; TOF = tetralogy of Fallot; RVOT = right ventricular outflow tract; UVH = univentricular heart; PA/IVS = pulmonary atresia with intact ventricular septum).

Case	Surgical performed	TEE findings	Immediate revision
CAVC	complete repair	patch leakage	rebypass-repair of patch leakage
CAVC	complete repair	left AVV regurgitation	rebypass-repair of left AVV
VSD/AR	VSD closure with aortic regurgitation	moderate AR	rebypass-repair of aortic valve
Ebstein's anomaly	Tricuspid valve replacement	prosthesis obstruction	rebypass-reposition of prosthesis
TOF	repair	patch leakage, RVOT obstruction	rebypass-closure of VSD, resection of infundibulum
Asplenia	Fontan	patch leakage	rebypass-suture of patch leakage
UVH	Fontan	pulmonary vein obstruction	rebypass-redo of Fontan tunnel
CAVC	complete repair	left AVVR	rebypass-repair of LAVV
Ebstein/VSD	complete repair	residual VSD	rebypass VSD closure
CAVC	complete repair	patch leakage	rebypass-closure of VSD
PA/IVS	RVOT reconstruction	severe PR	rebypass-homograft insertion
CAVC	complete repair	LAVV stenosis	rebypass-repair of LAVV
VSD	complete repair	patch leakage	rebypass-closure of VSD
CAVC	complete repair	LAVV regurgitation	rebypass-repair of LAVV
CAVC	complete repair	LAVV regurgitation	rebypass-repair of LAVV

gal infection. One late morbidity, which required reoperation, was noted in an eight month old girl who had a repair of the complete AV canal with mild or residual left AV valve regurgitation. However, during the follow-up, she developed severe left AV valve regurgitation and is now scheduled for another attempt at repair.

DISCUSSION

Transesophageal echocardiogram has recently become widely accepted in the evaluation of congenital heart disease during surgery[7-12,18]. It provides more information and has a technical advantage over transthoracic echocardiogram. Our institute has used intra operative TEE since 1995 in adult patients[13] (multiplane probe from Hewlett Packard). Earlier, it was found that the advantages of TEE were in the area of monitoring ventricular function, detection of intracardiac free air, and valvular dysfunction with limited exposure to congenital heart disease patients. However, over the past two years, the newer and smaller biplane Pediatric Transesophageal Transducer with 7.5/5.5 MHz frequency (9.1 mm wide, 8.8 mm thick and 27 mm long) has allowed us to study patients as small as 3 kg.

The significant impact of TEE findings in our patients can be easily divided into three different categories. First, in simple congenital defect (atrial eptal defect (ASD), ventricular septal defect (VSD) repair and tetralogy of Fallot; total of 36 patients), TEE had little impact. Only one patient was found to have a VSD patch leakage that required rebypass for closure of the residual VSD. The second patient had residual aortic regurgitation, which required rebypass for repair of the aortic valve. In our institute, the majority of patients who had a tetralogy of Fallot repair had preoperative cardiac catheterization. A plan had already been made to perform infundibular resection or to extend the patch to the right ventricular outflow tract. From a postbypass TEE study, we found only one patient in whom we were able to identify the position of the patch leakage. Over all, a significant impact was found in four patients (11.1%). Second is the group of patients who had surgery which involved repair of atrioventricular (AV) valve (complete or partial AV canal repair, Ebstein's anomaly; total 22 patients). In this group, a significant impact was found in nine patients (41%). All of them had residual regurgitation of the atrioventricular valve and also patch leakage of the VSD. After rebypass to repair these lesions, only two patients had reoperation. Both of them had a complete AV canal. The third group is patients with complex congenital heart disease (single ventricle, complete transposition of great arteries with or without VSD; pulmonary atresia with intact ventricular septum, etc, total 46 patients). The TEE findings showed a significant impact in eight patients (17.4%), five for the prebypass study and three for the postbypass study. These impacts were specific to the individual lesions.

This study has been compared with a previous study from the Mayo Clinic[7] which showed the greatest benefit from TEE in patients who had a Fontan operation (40%), or patients with subaortic obstruction. However, in their study, one-third of the patients had this type of operations. Fontan operation represented only 13 patients in our study (12.5%). Many other studies have pointed out the impact of TEE on either pre- or postbypass varies from 10 to 20 per cent[9-12]. Our study demonstrated that the influence of TEE is especially high in patients who had attempted valve repair. We realize these findings may have been influenced by the selection of each type of surgical procedure. However, we felt that with such a high impact on this group of patients (41%), the TEE should be routinely performed during these procedures.

It is interesting to see that with all of the patients that had thorough investigation (echocardiogram or cardiac catheterization), the prebypass study still could show some impact which affects the surgical procedure. We agreed with the previous investigator[7] that TEE cannot replace preoperative diagnostic evaluation. It should be considered a complementary procedure that can frequently provide some additional information. It will certainly confirm the diagnosis and occasionally yield new and important data that alter the surgical management.

As reported in other studies[7,9,10,12,18] the frequency of complication associated with intraoperative TEE was low. Recently, a study using endoscopic evaluation of the esophagus in infants and children immediately following intraoperative use of TEE,[19] showed some mild mucosal injury in patients particularly these weighing less than 9 kg. However, no long term feeding or swallowing difficulties were noted. Generally, injuries to the

esophagus during insertion are most likely to occur at the level of the cricopharyngeal muscle. With careful technique and selection of the appropriate size of the probe, most patients would allow passage of the probe easily. Throughout our series of patients, TEE was performed after induction of general anesthesia with control of the airway by tracheal intubation. The use of muscle relaxants facilitated esophageal intubation and enhanced the safety of TEE insertion. Children with Down's syndrome may have intrinsic narrowing of their hypopharyngeal structures, which makes passing the probe difficult[19]. We could not pass the probe in two patients. Both of them weighed less than 5 kg. However, we did not encounter any significant complications related to the TEE probe insertion. Care must also be observed in infants in whom the compression of the adjacent structures such as trachea, bronchus, and descending aorta could occur. Any sign of sudden development of hemodynamic instability or breathing difficulty should prompt removal of the TEE probe.

The diagnoses by intraoperative TEE were accurate. Nevertheless, as pointed out by others, this technique was somewhat limited in its ability to image small ventricular septal defects and structures that were anterior to bronchus or to prosthetic material. Multiplane imaging devices for pediatric patients, which were developed later on for application with small children, will avoid some of the limitations of the biplane instruments[20].

SUMMARY

Intraoperative TEE is valuable in the perioperative care of patients who had surgical repair for their congenital heart defects. Although intraoperative TEE is not needed in all types of surgery for congenital heart disease, we found the most benefit in patients who had surgical procedure related to repair of either the atrioventricular or the semilunar valve. Less benefit was found in individuals with complex congenital heart defects. Limited benefit was found in simple congenital heart defects.

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ประโยชน์ของการใช้เครื่องตรวจคลื่นเสียงสะท้อนเสียงหัวใจความถี่สูงทางหลอดอาหารในการผ่าตัดโรคหัวใจพิการแต่กำเนิด

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การตรวจคลื่นเสียงสะท้อนหัวใจความถี่สูงทางหลอดอาหาร (transesophageal echo- cardiogram : TEE) ระหว่างการผ่าตัดเปิดหัวใจนั้น ช่วยให้ผลการรักษาในผู้ใหญ่ดีขึ้น การศึกษาครั้งนี้เพื่อดูผลของการตรวจ TEE ระหว่างการผ่าตัดภาวะหัวใจพิการแต่กำเนิด ได้ศึกษาผลการตรวจ TEE ระหว่างการผ่าตัดผู้ป่วยหัวใจพิการแต่กำเนิดระหว่างเดือนมกราคม พ.ศ. 2541 ถึง เดือนมิถุนายน พ.ศ. 2542 ผู้ป่วยจำนวน 104 ราย อายุตั้งแต่ 1 สัปดาห์ ถึง 50 ปี (ค่ามัธยฐาน 5 ปี) โดยมีน้ำหนักตั้งแต่ 3 – 79 กก. (ค่ามัธยฐาน 15 กก.) ประโยชน์ของ TEE ในการผ่าตัดนั้นจะพิจารณาจากการตรวจผู้ป่วยก่อนหัวใจหยุดเต้น (pre bypass study) โดยที่ผลการตรวจทำให้มีการเปลี่ยนแปลงแผนการผ่าตัด หรือในการตรวจหลังจากหัวใจกลับมาเต้นใหม่ เมื่อเสร็จสิ้นการผ่าตัด (post bypass study) โดยที่ผลการตรวจทำให้มีการกลับลงไปแก้ไขความผิดปกติที่เหลืออยู่ใหม่ TEE มีประโยชน์ในการศึกษา prebypass ร้อยละ 6.7 โดยช่วยในการหาตำแหน่งผิดปกติจำนวน 3 ราย การศึกษา postbypass พบประโยชน์ในผู้ป่วย 15 ราย (ร้อยละ 14.4) ประโยชน์ที่มากที่สุดในกลุ่มที่มีการซ่อม atrioventricular valve หรือ semilunar calve เช่นใน complete หรือ partial atrioventricular canal และ Ebstein's anomaly (9 ใน 22 ราย คือร้อยละ 41) ส่วนในกลุ่ม complex lesion พบน้อยกว่า (ร้อยละ 17.4) ประโยชน์พบน้อยที่สุดในกลุ่ม simple lesion การตรวจ TEE ระหว่างการผ่าตัดหัวใจพิการแต่กำเนิด มีผลช่วยในการรักษาผู้ป่วย โดยเฉพาะในกลุ่มที่เป็น complete atrioventricular canal หรือ Ebstein's anomaly

คำสำคัญ : การใช้เครื่องตรวจคลื่นเสียงสะท้อนเสียงหัวใจความถี่สูงทางหลอดอาหาร, โรคหัวใจพิการแต่กำเนิด

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