Transoesophageal echocardiography detects residual ductal flow during video-assisted thoracoscopic patent ductus arteriosus interruption

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This report describes transoesophageal echocardiographic (TEE) monitoring in a one-year-old boy undergoing patent ductus arteriosus (PDA) interruption. After application of a first vascular clip, echocardiographic monitoring detected incomplete interruption of ductal flow, prompting the surgeon to add a second clip to the ductus. The procedure was performed via a new surgical technique: video-assisted thoracoscopic surgery (VATS). This innovative approach offers many advantages to patient care including reduced postoperative pain and better preservation of pulmonary function. We conclude that the use of TEE monitoring during PDA interruption via the VATS procedure may improve the surgical result, and eliminate reintervention and the complications associated with residual ductal flow.

Nous décrivons l'utilisation de l'échocardiographie transoesophagienne (ETO) comme instrument de monitoring chez un enfant d'un an opéré pour fermeture de canal artériel. L'échocardiographie nous a permis de démontrer la persistance de flux à travers le du canal après l'application d'un premier clip vasculaire. Le chirurgien a alors appliqué un second clip et

a réussi à abolir tout flux résiduel. L'intervention fut accomplie grâce à une nouvelle technique chirurgicale: la chirurgie thoracoscopique assistée par vidéo. Cette nouvelle approche offre plusieurs avantages au patient: la douleur postopératoire est moindre et les fonctions respiratoires sont très peu perturbées. Nous concluons que le monitoring par ETO durant la fermeture thoracoscopique du canal artériel persistant peut améliorer les résultats chirurgicaux, prévenir une réintervention et éliminer les complications associées à la persistance du canal artériel.

Key words

SURGERY: cardiovascular, thoracoscopy;
ANAESTHESIA: cardiovascular, paediatric;
MONITORING: transoesophageal echocardiography.

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Transoesophageal echocardiography (TEE) is being utilized with increasing frequency in the operating room both as a monitor and as a diagnostic tool. Although TEE is seldom used to diagnose patent ductus arteriosus (PDA) the specificity and sensitivity of its transthoracic counterpart in diagnosing PDA are well described.¹⁻⁴ Colour-flow mapping and Doppler technology have facilitated the diagnosis and follow-up of PDA. Patent ductus arteriosus diagnosis is also possible with TEE⁵ but its use as a monitor to ascertain complete ductal interruption intraoperatively has not been described previously.

Video-assisted thoracoscopic surgery has emerged as an innovative new approach to various surgical procedures, including PDA interruption. However, assessing the efficacy of surgical closure by palpating the duct is impossible through diminutive thoracoscopic windows. We report the use of intraoperative TEE to demonstrate the complete interruption of ductal flow in real time during a video-assisted PDA procedure.

Case report

A one-year-old, 10 kg boy was admitted to Children's Hospital for video-assisted thoracoscopic PDA interrup-

tion. The patient was asymptomatic and the past medical history and physical examination were remarkable only for the presence of a restrictive PDA.

The patient was taken to the operating room without premedication and monitored with a five-lead ECG, non-invasive arterial blood pressure, and pulse oximetry. Following preoxygenation and induction of general anaesthesia, a 4.0 mm ID endotracheal tube was placed through the right nostril and into the patient's trachea. Endotracheal tube position was confirmed by the presence of bilateral breath sounds and an end tidal CO₂ waveform on capnography. A leak around the endotracheal tube was audible at 15 cm H₂O airway pressure. Anaesthesia was induced and maintained with fentanyl, pancuronium, isoflurane and oxygen. A 22-gauge catheter was placed in the right radial artery and an orogastric tube was inserted to evacuate the stomach. The patient was then placed in the right lateral decubitus position, and prepared for surgery. He tolerated the induction of anaesthesia and repositioning without haemodynamic changes or oxygen desaturation. A Hewlett-Packard paediatric biplane colour Doppler TEE probe was easily inserted. The paediatric probe has a frequency of 7.5 MHz and each transducer contains 64 elements. Care was taken to protect the endotracheal tube during placement of the probe and the airway was reassessed. The initial intraoperative TEE evaluation revealed normal cardiac anatomy and function except for the presence of a small PDA. Colour-flow mapping demonstrated left-to-right shunting across the PDA. Both horizontal and vertical planes were used to image the ductus arteriosus although, in this case, imaging in the vertical plane allowed better visualization of the PDA in its entirety.

Four 4 mm thoracostomies were made for insertion of the videoscope, the dissection instrumentation, a lung retractor and the clip applier. Dissection of the descending aorta and aortic arch proceeded to define and expose clearly the underlying patent ductus arteriosus. The recurrent laryngeal nerve was identified and preserved. Preparations for rapid volume infusion and immediate thoracotomy were made prior to closing the clip in the event of bleeding from the duct. The patent ductus was then interrupted with a single vascular clip.

Transoesophageal echocardiography imaging and colour-flow mapping revealed residual flow across the ductus (Figure 1, left frame and Figure 2) prompting the surgeon to perform further dissection and add a second vascular clip to the duct. The additional clip abolished all residual flow across the ductus as confirmed by TEE (Figure 1, right frame).

Discussion

The intraoperative use of transoesophageal echocardi-

FIGURE 1 Both frames show a vertical (longitudinal) view of TEE imaging of the patent ductus arteriosus. *Left frame:* transoesophageal imaging demonstrates residual flow across the ductus arteriosus following application of first vascular clip. *Right frame:* demonstrates absence of flow after application of the second clip. *DAo:* Descending aorta. *MPA:* main pulmonary artery. *PDA:* patent ductus arteriosus.

FIGURE 2 Representation of the anatomic orientation of the vertical TEE image illustrated in Figure 1. The expanded view corresponds to Figure 1, left frame. *DAo:* Descending aorta. *MPA:* main pulmonary artery. *PDA:* patent ductus arteriosus.

graphy is expanding rapidly in cardiac operating suites and is becoming a useful addition to standard monitoring techniques. Transthoracic echocardiography with colour-flow mapping allows more sensitive and specific diagnosis of PDA and of residual flow than clinical evaluation alone.⁶ The intraoperative use of TEE is an extension of its transthoracic counterpart allowing real-time evaluation of ductal flow during the VATS procedure and detection of residual flow after ligation.

Video-assisted thoracic surgery is an innovation although it stems from thoracoscopy, a technique first introduced by Jacobaeus in 1910.⁷ The development of video technology and its incorporation into endoscopic methods as well as the creation of adapted instrumentation have given rise to VATS. The technique offers definite advantages to patient care including: reduced post-operative pain, shorter hospitalization, enhanced recovery times and better preservation of pulmonary function.⁸⁻⁹ This unique profile makes the procedure an attractive alternative, sparing the patient a rib spreading and muscle tearing manoeuvre that may degenerate into a post-

thoracotomy syndrome characterized by rib fusion, scoliosis, chest wall deformities and compromise of pulmonary function.¹⁰⁻¹³

Although TEE and VATS are accepted techniques in cardiac surgery, they are not without complication. Laryngeal and oesophageal damage have been known to occur with placement of the transoesophageal probe in adults.¹⁴ In children, arrhythmias have been reported as have isolated cases of bronchial and vascular obstruction.¹⁵⁻¹⁷ These complications occur infrequently and usually disappear with reduced antelexion of the probe or by its removal.

Echocardiographic findings of residual ductal flow have been reported to be as high as 23% after PDA ligation via thoracotomy.⁶ The incidence of residual ductal flow after a VATS procedure is reported to be 5.3% according to data taken from a single study of 38 patients.⁸ Clinical consequences of residual patency include haemodynamically significant left-to-right shunting that may result in congestive heart failure and pulmonary oedema, the continued need for antibiotic prophylaxis against subacute bacterial endocarditis and perhaps even reintervention. Furthermore high-flow velocity, as seen with residual patency, is associated with an increased risk of endocarditis.¹⁸

The sensitivity and specificity of transthoracic echocardiography (TTE) in diagnosing PDA are well established. However, the use of TTE intraoperatively has several disadvantages. The probe is cumbersome and may become a hindrance during the procedure as four thoracostomies are used to manipulate and dissect the anatomical structures. On a small child, these thoracostomies along with the inserted instrumentation do not leave sufficient room for the TTE probe. The probe may also compromise the sterility of the surgical field. Furthermore, the chest cavity is filled with air, as the ipsilateral lung is retracted, and this medium has little echogenicity. Thus intraoperative TTE imaging may be of lesser quality than the preoperative evaluation. Considering these restrictions, intraoperative TEE yields better results than TTE.

With good technique, intraoperative TEE can be a safe diagnostic tool during cardiac surgery. By demonstrating complete ductal interruption in the operating room, the incidence of residual patency may be minimized. This case report demonstrates that TEE monitoring during PDA interruption may improve the surgical result, eliminate reintervention and the complications associated with residual ductal flow.

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