The Heart Surgery Forum #2001-6301
5 (1):57–59, 2002

Online address: www.hsforum.com/vol5/issue1/2001-6301.html

Video-Assisted Thoracoscopic Surgical (VATS) Closure of Patent Ductus Arteriosus: Report of Three-Hundred Cases

(#2001-6301 … June 27, 2001)

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SUMMARY

Background: Video-Assisted Thoracoscopic Surgery (VATS) has recently been used for Patent Ductus Arteriosus (PDA) closure on a routine basis. Our experience with this technique is supporting its efficacy. The results and advantages of VATS are the same as when thoracotomy is being performed.

Methods: From June 1997 to October 2000, there were 300 consecutive patients (mean age: 6 years old) with PDA recognized by echocardiography and/or cardiac catheterization, on whom VATS were studied. With the patients under general anesthesia, three 5 mm holes were made through the left thoracic wall. A video camera and specialized surgical devices were introduced. The ductus was dissected, and two titanium clips were applied for complete closure of the ductus. Exclusion criteria were: 1) Diameter of the ductus > 9 mm, 2) Complicated PDA such as aneurysm formation, endocarditis, and calcification, 3) Pleural adhesion and/or left sided thoracic operation in the past.

Results: All cases were re-assessed immediately after the procedure, and followed up by control echocardiography. No significant complication and residual shunt was recorded during the observation period. The procedure was changed to thoracotomy in three adult patients due to an inappropriately dilated canal (>9mm). Moreover, two other patients developed transient recurrent laryngeal nerve dysfunction. Mean procedure time was about 20 ± 2 minutes. All patients were discharged shortly after the procedure (~20 hours).

Conclusion: Our results suggest that VATS compared to other techniques for PDA closure is rapid, cost-effective, painless and more cosmetic.

Presented at the Fourth Annual Scientific Meeting of the International Society for Minimally Invasive Cardiac Surgery, June 27-30, 2001, Munich, Germany.

Reprinted from The Heart Surgery Forum, Volume 5, Supplement 1, 2001.

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INTRODUCTION

Surgical interruption of Patent Ductus Arteriosus (PDA) using a left posterolateral thoracotomy was the only available technique until 1971. Portsman et al. [Portsman 1971] described a technique for nonsurgical closure of PDA by a catheter-delivered device. In 1979, Rashkind and his associates developed a completely different, smaller device for the transcatheter approach which was introduced into clinical trials in 1981. However, this technique is not performed in infants weighing less than 7 or 8 Kg. [Rashkind 1979, Mullins 1990, Hosking 1991].

In 1991, Laborde and associates in Paris applied the Video-Assisted Thoracoscopic Surgery (VATS) for PDA closure technique, which is a rapidly progressing era in the new field of minimally invasive surgery on 39 infants and children [Laborde 1993]. Since then, Laborde has used this technique on more than 500 cases [Laborde 1995, Laborde 1997).

Since June 1997, we have performed the VATS technique for PDA closure at Mashhad University of Medical Sciences, in Mashhad, which is the referral center for PDA closure by this technique in Iran. The aim of our study was to assess different aspects of the technique with special regards to its safety and efficacy.

METHODS AND MATERIALS

Between June 1997 and October 2000, 300 consecutive patients with PDA, recognized by color Doppler and 2D- echo and/or catheterization, were referred to us for PDA closure by the VATS technique.

Our exclusion criteria for VATS procedure were:

1) Diameter of the ductus > 9mm
2) Complicated PDA such as true ductal aneurysm, endocarditis and calcification.
3) Pleural adhesion and/or left sided thoracic operation in the past.

Specialized surgical instruments necessary for the VATS technique included: electrocautery hook, clip-applier, lung retractor, trocar, suction device and videoscope (Table 1, ◉).

Management of general anesthesia included insertion of a large intravenous catheter, three-lead EKG monitoring and pulse-oximetry pre-induction. General anesthesia was induced

Table 1. VATS instruments.

Instruments	Company
Camera Head (Telecom ®)	STORZ –Germany
Camera Control Unit	STORZ – Germany
Monitor	SONY – England
Electrocautery Hooks	
Electro Surgical Generator (Autocon ®)	STORZ – Germany
Forward-oblique Telescope 30°, 10mm,4mm	STORZ – Germany
Trocar 5mm	STORZ – Germany
Light Source	STORZ – Germany
2-3 Right Angle –Hooks	
Clip-Applier 8mm	MICROFANCE – France
Clips (Ligaclips®) , LT 400,	ETHICON – USA

with thiopental 5-7 mg/kg, Atracurium 0.5 mg/kg and Fentanyl 5 mg/kg. For better surgical vision, single lung ventilation was used by selective right bronchial intubation with Murphy-eye tracheal tube. In order to reduce bronchial damage, we selected a tracheal tube with the half size expected for appropriate age. Pulse-oximeter and capnograph (Capnosat, Dräger) monitored arterial oxygenation and end-tidal CO_2. Oxygen-saturation was maintained over 92% by FiO_2 100%, and in difficult cases in which Oxygen-saturation dropped below 90%, PEEP (2.5-5 cmH_2O) was included. Blood pressure was controlled and monitored through a 20G catheter inserted in the right radial artery. General anesthesia was maintained with Halothane 0.5% plus O_2 100% without nitrous-oxide.

All patients were positioned on their right sides in the classic posterolateral thoracotomy approach. Three 5-mm holes were made in the left hemithorax. The first incision was made in the third intercostal space on the left axillary line for the videoscope (4 mm). The next hole was made in the third intercostal space in the middle axillary line for the introduction of two right-angled hooks for lung retraction. The last hole was made in the fourth intercostal space beneath the angle of the scapula for insertion of the clip-applier and electrocautery hook.

The surgical field was viewed on a video screen. After identification of PDA, the posterior pleura was opened, and the ductus was dissected free from surrounding tissues. The pericardium was also dissected on the pulmonary side to protect the easily identifiable recurrent laryngeal nerve from injury. It should be stressed that both sides of the ductus were dissected for appropriate placement of clips.

The first titanium clip was fixed at the junction of the aorta and PDA, and the other one at the pulmonic side. After visual confirmation that both clips were well in place, the trocars were removed. A small pleural catheter was placed and the lung was expanded. After closure of the access ports, the pleural catheter was removed.

Immediately after extubation in OR, the vocal cords were directly evaluated by an anesthesiologist. A chest X-ray and echocardiogram were also followed to exclude the pneumothorax and residual shunt, respectively. (Figures 1 and 2, ◉)

All patients were discharged after about 20 hours. Mean procedure time was approximately 20 ± 2 minutes. It should be emphasized that there was a "Learning Curve Phenomenon" in our series; that means, the operation time was gradually shortened after the first hundred cases.

RESULTS

As noted above, the mean age was 6 years old (range: 3 months to 35 years), and mean weight was 11 Kg (range: 6 to 65 Kg). Sixty percent of patients were female. All of our patients were full-term. All cases were reassessed by echocardiography immediately before discharge and followed up monthly for three months, and every six-months for one year, and then annually until now. There was no significant complication requiring thoracotomy, such as hemorrhage (which is usually caused by ductal rupture or laceration) and residual shunt. The procedure was changed to thoracotomy in three adult patients due to inappropriately dilated canal (>9mm). Two patients (from our first 50 cases) developed transient laryngeal nerve dysfunction, but recovered completely in three and five weeks respectively (Table 2, ◉).

DISCUSSION

The anatomical presence of PDA is usually considered as a significant and sufficient indication for closure at any time and at any age, regardless of with or without symptoms [Friedman 1997]. A variety of approaches have been described for non-surgical transcatheter closure of ductus via a relatively large-diameter femoral sheath, such as coils, buttons, plugs, and umbrellas [Moore 1994, Moore 1995]. This approach is especially feasible in cases with more than 10 kg of body weight and in adults with calcified ducts who have higher operative risk. In experienced hands, initial occlusion is successful in 85-90% of patients. At the six months follow-up during 205 procedures, Ali Khan et al. reported that 22% of the small residual shunts following transcatheter closure of ductus were greater than 6 mm, and residual flow was recorded in 59% of cases [Ali Khan 1992]. Disadvantages of this method which had been described elsewhere, include its cost, availability of limited size, rather bulky delivery apparatus making it unsuitable for most infants, potential proximal left pulmonary artery narrowing developed in small subjects, occasional hemolysis after implantation and relatively high incidence of color doppler detected residual duct flow of 10-20%, device embolization and late endarteritis [Sullivan 1998].

Table 2. Results of VATS

Patients	N = 300
Mortality %	0
Conversion to Thoracotomy	3 (1%)
Recurrent Laryngeal Dysfunction (Transient)	2 (0.6%)
Extubation in OR	300 (100%)
Length of Hospitalization (hr)	~20
Procedure Time (min)	20 ± 2

Although the traditional thoracotomy is still the "Gold Standard" for PDA closure with a success rate of 77-100%, it requires larger incisions and is associated with late complications such as scoliosis, wing scapula, breast disfigurement and rib fusion with respiratory compromise in 22-33% of cases, recurrent laryngeal nerve dysfunction in 1.1-4.2%, and residual shunt flow after the PDA ligation but not division in 5-23%. Its other relative disadvantages include longer hospitalization, less cost-effectiveness and more painful postoperative course [Yale University School of Medicine 2000].

VATS technique, as a natural evolution of minimally invasive surgery, allows ductal closure with minimal chest wall trauma and with a success rate of 88-98%, laryngeal nerve dysfunction in 0.6-3.4%, residual shunt in 0-5.9% without other potential limitations of the two other methods.

Our experience in 300 cases also supported the advantages of this method. The technique is feasible, even in low-weight infants, with no need for blood transfusion, in contrast to the transcatheter endovascular closure, which is usually more dependent on transfusion. VATS could be considered as a cost-effective method (at least in our country), which is about one-fifth of the cost of the traditional thoracotomy. The only complication in our patients was transient laryngeal nerve dysfunction manifested as dysphonia, mainly caused by thermal and traumatic injury. Precise and gentle dissection and avoidance of cautery near the nerve may usually mitigate this problem. The most significant limitation in the VATS technique is its inability to close wide ductus (> 9mm) due to unavailability of clips greater than 9 mm. In an effort to overcome this problem, Kim et al. used a self-made endoscopic loop ligation in 10 patients by using only a small window with successful ligation of ductus in all cases without residual shunt [Kim 2000].

We conclude that in comparison with the traditional thoracotomy approach, the VATS technique for PDA closure is simple, rapid, cost-effective, more comfortable, less painful, and of more cosmetic benefit.

REFERENCES

1. Ali Khan MA, al Yousef S, Mullins CE, Sawyer W. Experience with 205 procedures of transcatheter closure of ductus arteriosus in 182 patients, with special reference to residual shunts and longterm follow up. J Thoracic and Cardiovasc Surg 104:1721-7, 1992.
2. Friedman WF. Congenital heart disease in infancy and childhood in E. Braunwald Heart Disease. A textbook of cardiovascular medcine, 5th ed.: 906, 1997.
3. Hosking MCK, Benson LN, Musewe N. Transcatheter occlusion of the persistently patent ductus arteriosus: Forty month follow-up and prevalence of residual shunting. Circulation 84:2313-7, 1991.
4. Kim BY, Choi HH, Park YB, Yu BS, Oh BS. Video assisted thoracoscopic ligation of patent ductus arteriosus. Technique of sliding loop ligation. J Cardiovasc Surg (Torino) 41:69-72, 2000.
5. Laborde F, Noirhomme P, Karem J, Batisse A, Bourel Pard Saint Maurice O. A new video assisted thoracoscopic surgical technique for Interruption of patent ductus arteriosus in infants and children. J Thorac Cardiovasc Surg 105:278-80, 1993.
6. Laborde F, Folliguet T, Batisse A, Dibie A, Da Cruze, Carbognani D. Video assisted thoracoscopic surgical interruption, The technique of choice for PDA closure. Routine experience in 300 pediatric cases. J Thorac Cardiovasc Surg 110:1681-5, 1995.
7. Laborde F, Folliguet T, Etienne P, Carbognani D, Batisse A, Petrie J. Video assisted thoracoscopic surgical interruption of PDA. Routine experience in 332 cases. Europ J Cardiothoracic Surg 11: 1052-5, 1997.
8. Moore TW, George L. et al. Percutaneous closure of the small PDA using occluding spring coils. J Am Coll Cardiol 23:759, 1994.
9. Moore TW, Cambier PA. Transcatheter occlusion of PDA. J Intervent Cardiol 8:517, 1995.
10. Mullins CE. Patent ductus arteriosus, in: Garson A.Jr. et al. The science and practice of pediatric cardiology, 1st ed. Philadelphia Lea & Febiger 1055-69, 1990.
11. Patent Ductus Arterosus, Non-cyanotic Disease; Yale University School of Medicine, Yale Manual of Adult Congenital Heart disease, 2000.
12. Portsman W et al. Catheter closure of patent ductus arteriosus: 62 cases treated without thoracotomy. Radiol Clin North Am 9: 203-18, 1971.
13. Rashkind WJ, Cuasco CC et al. Closure of PDA in infants and small children without thoracotomy. Proceedings of the Association of European Pediatrc Cardiologist, Seventh Annual Meeting, Madrid, Spain, May 8-11, 17, 1979.
14. Sullivan Ian D. Patent ductus arteriosus: When should it be closed? Arch Dis Child 78:285-7, 1998.