Video-assisted thoracoscopic versus open surgery for persistent ductus arteriosus: report of 10 years' experience

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Abstract: Video–assisted thoracoscopic surgery (VATS) has been applied as a less invasive procedure for closing Patent ductus arteriosus (PDA). The purpose of this study was to compare the -hospital outcomes between VATS PDA ligation and conventional thoracotomy. The hospital records of 135 children who underwent isolated PDA ligation (VATS=83, posterolateral thoracotomy =52) in 2003- 2012 in Mashhad, Iran were assessed. Collected data were evaluated for characteristics of patients, length of hospital and ICU stay, and also in-hospital outcomes included mortality, residual shunt, conversion rate, successful rate, pulmonary complications, chylothorax, and laryngeal nerve dysfunction. In this study we used the Student T-test for continuous variables and Chi-square or Fisher's exact test by SPSS software version 18.0,P value less than 0.05 were considered statistically significant. Patients' demographic characteristics were similar in two groups. Conversion rate was 3.6% in VATS group; therefore immediate thoracotomy was performed in operating room. Overall successful rate for complete PDA closure was 95.1% in VATS and 98% in thoracotomy group. although there was no significant difference in successful rate between two groups (p=0.85). Postoperative pulmonary complications were not significantly different between VATS and thoracotomy group (p=0.15). In VATS group 2 patients had laryngeal nerve dysfunction versus nobody in other group. The intubation time, ICU and hospital stay in VATS group were significantly shorter than other group (p< 0.001). In pediatric VATS technique can be an effective and safe approach than open thoracotomy for closing PDA. Shorter hospital stay, closing of PDA completely and better patient recovery in post operative period were the significant advantages of VATS technique.

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1. Introduction

Patent ductus arteriosus (PDA) includes 5% to 10% of all congenital heart disease [1]. Patients with PDA may be asymptomatic, but it can cause heart failure, failure to thrive, recurrent pulmonary infection, endocarditis, pulmonary hypertension, and also long-standing left-to-right shunt of PDA may predispose patient to Eisenmenger syndrome [1]. Although surgical ligation or division of ductus arteriosus via open thoracotomy has traditionally carried out since 1939 as gold standard treatment of PDA [2,3], Video-assisted thoracoscopic surgery (VATS) and Percutaneous transcatheter coil or device have introduced as less invasive procedures over the past several years. [4,5] Improvements in endoscopic instruments and camera technology have increased using VATS procedures in children. In addition, VATS for PDA ligation is feasible in pediatric group which is frequently applied even in very-low birth weight premature infants [6-10]. Moreover, VATS is performing to manage clinical pathways for process quality, outcome quality and cost containment in thoracic surgeries [11]. Minimal invasive surgical procedures have decreased chest wall injury and shorten postoperative period of recovery [11]. It is assumed that there are potential advantages for VATS

in comparison with open thoracotomy which include shorter hospital stay, reduced postoperative pain, and decreased incidence of chest wall deformity, and also better cosmetic results [10, 12]. Despite all these advantages there are few publication for comparing VATS with open thoracotomy in PDA ligation. The aim of this study is to analyze length of hospital stay and in-hospital outcome of PDA ligation using VATS versus open thoracotomy.

2. Material and Methods

In this cross sectional study the data of 135 pediatric patients undergoing isolated PDA ligation in Ghaem hospital of Mashhad, Iran from February 2003 to March 2012 were collected prospectively. This study was performed in accordance with the declaration of Helsinki and approved by ethic committee at Mashhad University of Medical Sciences.

All patients were referred by pediatric cardiologist and the PDA was diagnosed by color Doppler and 2-dimensional echocardiography.

The inclusion criteria were under 12 years old age, and admition for isolated PDA closure. The data of children with PDA associated with any other congenital anomalies that needed to correct simultaneously, patients who had right-to-left shunting due to severe pulmonary hypertension, and also in VATS group cases with a PDA diameter larger than 10 mm was excluded.

In open thoracotomy group, after general anesthesia, the PDA was closed by 2no absorbable ligatures via 4th intercostals space with standard posterolateral thoracotomy. Before closing the chest, a chest tube was inserted. In VATS group, after general anesthesia an esophageal stethoscope was inserted to determine the position of the point of maximal intensity (PMI) of the murmur; then patients were positioned right side lateral decubitus, and right-lung ventilation was performed [13]. Just around scapula, three 5mm incisions were made for inserting access ports in left hemithorax. Video-camera and surgical instruments were applied through the access ports. Then, mediastinal pleura on the aorta and both sides of PDA were dissected carefully by hook shape electerocautery; finally the ductus was ligated by two Titanum clips (Ligaclip LT 400; Ethicon Endoscosurery). After inflation the left lung and deairing left hemithorax with a small pleural catheter, the small incisions were sutured without inserting chest tube in thorax cavity. An Intraesophageal stethoscope was applied for monitoring the PDA closure to confirm absence of ductal flow during operation of both groups by anesthesiologist [14]. Routinly patients were extubated base on their status in the operating room and the drain was removed when the absence of a chylous leak could find out. In addition, Color flow Doppler echocardiography was conducted to roll out residual shunt on next day.

Physical examination and a chest x-ray were performed immediately after surgery in the intensive care unit or cardiac surgery ward depending on the clinical status and age of the patients to exclude pneumothorax and other pulmonary morbidity by one observer.

In this study, in-hospital outcomes include successful PDA closure using controlled transthoracic echocardiography, extubation in operating room, length of stay in ICU and hospital, post operative intubation time, conversion VATS procedure to open thoracotomy and also surgery complications such as pulmonary problems, transient laryngeal nerve dysfunction, and residual shunt of PDA were assessed. Conversion VATS procedure to open thoracotomy was occurred based on the surgeon descion. Pulmonary complications were evaluated based on the physical examination and chest radiography, and finally the laryngeal nerve dysfuntion was detected if the patients were dysphonic and it confirmed by laryngoscope view. The way of residual shunt of PDA detection was by asculation of mumrur at the end of the surgery and also the next day echocardiography.

The unpaired Student's t test was used where appropriate for continuous data, and Pearson's chi-square test or Fisher's exact test was used to evaluate differences in non-continuous variables. P value less than 0.05was considered statistically significant. SPSS software version 18.0 for Windows was used for all statistical analyses.

3. Results

One-hundred thirty five children (40 males, median of age=24 m, inter quartile range 8-60 m) younger than 12 years old who underwent PDA surgical ligation were studied. The PDA was closed in 83 cases with VATS technique and 52 cases were operated with open thoracotomy. Mean weight of all patients at the time of surgery was 12 ± 6.8kg median of weight=10 Kg, inter quartile range 7-16 Kg. Table 1 reports patients' characteristics of the two groups. The demographic data of participants in VATS and thoracotomy groups were not significantly different.

Associated cardiac anomalies such as PFO, small ASD, small aneurysmal VSD, were present in 16 (11.9%) of patients, but all defects were mild and none of them required treatment when indication for PDA closure was done. Down's syndrome comprised 6.6% (9/135) of all participants.

Table 1. Patient characteristics based on surgical technique

Family	VATS (n=83)	Open P-value (n=52)	
Median age, years±SD	3.17±3	3.27 ±3	0.62
Median weight, kg (range)	11 (7-16)	10 (6-15)	0.27
Gender (M/F)	28/55	12/40	0.13
Patients with symptoms, n (%)	10 (%12)	7 (13%)	0.32
Patient with cardiac signs (%)	24 (30%)	17 (33%)	0.41
Other cardiac anomalies, n (%)	13 (9.6%)	3 (2.2%)	0.08
Down's Syndrome, n (%)	6 (7.2%)	3 (5.7%)	0.7

The outcomes of two surgical procedures is presented in Table 2. Results showed that length of ICU and hospital stay were significantly shorter in the VATS group ($p<0.001$). All patients with thoracotomy had a chest tube drain, but in 4 cases of VATS procedure the surgeon decided to insert the drain at the end of operation. Postoperative Pneumonia, left lung collapse and pneumothorax occurred in 3 patients who underwent thoracotomy; however, in VATS group just one patient complicated with pneumothorax and subcutaneous emphysema. There were no Chylothorax in both groups. Residual shunt was detected in 1 patient of each group by postoperative echocardiogheraphy and the PDA was reclosed via open thoracotomy at the same admission. Immediate conversion to open thoracotomy was necessary for three patients (3.6%) in VATS group; Ductal laceration, incomplete clips ligation and inappropriate expose were causes of conversion. Another specific complication with the VATS was dysphonia due to transient recurrent laryngeal nerve dysfunction which was reported in 2 patients (2.4%) which was not significantly different. Just one death occurred due to sever heart failure which was in thoracotomy group.

Table 2. Patient characteristics based on surgical technique

Family	VATS (n=83)	Open P-value (n=52)	
Median Intubation period, hour (IQR)	0.5 (0.10-4)	2 (1.2-4)	<0.001
Median ICU stay, hour (IQR)	2.90 (0-4)	2.4 (1.6-2)	<0.001
Mean hospital stay, day (SD)	1.7± 0.5	4.6±1.8	<0.001
Operating room Extubation, n (%)	62 (74.6%)	8 (15.3%)	<0.001
Inserting chest tube drain, n	4	53	<0.001
Pulmonary complication, n	1	3	0.15
Ductal residual shunt, n	1	1	0.62
Hospital Mortality, n	0	1	0.86
Successful rate, n (%)	79 (95.2%)	51 (98.1%)	0.64

4. Discussions

In this study, we compare length of hospital stay and in-hospital outcome between VATS PDA ligation and conventional thoracotomy, our finding showed that in overall successful rate in thoracotomy technique was better than in VATS technique.

it's assumed that patients who treat with minimal invasive surgical processes have a better convalescence and recovery period following operation, in this study a better and faster patient recovery after VATS PDA ligation were seen. Different studies have illustrated that the most advantages of VATS compared to open thoracotomy are lesser chest wall injuries because of avoiding rib spreading and detachment of the intercostals muscles, minimizing risk of nerve intercostals damage, no need to cut latissimus dorsi muscle and also, no stretching in paraspinal muscles [6]. Also this lesser injuries in VATS method may lead to better and faster patient recovery after PDA ligation.

Majority (74.6%) of our participants in VATS group and 15.3% in thoracotomy group were extubated in operating room in which was similar to other studies. Different authors reported early extubation for all VATS patients at the end of operation. Also, the mean hospitalization time was 20 hours [8] which confirmed our results; length of hospital stay in our VATS patients was significantly shorter than thoracotomy group (1.7 versus 4.6 days). In two other studies which VATS PDA ligation compared to coil technique, the mean length of hospital stay were 1.6 and 1.4 day [15, 16]. Significant shorter intubation time, ICU and hospital stay in our VATS patients may corroborate better recovery versus open thoracotomy group.

Residual shunt for VATS PDA ligation was occurred in 0% to 12% of cases in previous studies. [17, 18] However, in recent studies it has been reported less than 2% [8.12, 14, 19]. These results are is similar to our findings that incomplete closure's PDA was happened in 1 patient of both VATS (1.2%) and thoracotomy (1.9%) groups. Residual ductal patency was confirmed in postoperative period with Doppler echocardiography.

In addition, we had 3 conversion phenomena (3.6%) in VATS group to thoracotomy. Inadequate visualizing of PDA due to inappropriate one-lung ventilation in one patient was the reason of conversion, another cause was ductal bleeding after PDA clipping, and the third converted patient had an audible murmur and incomplete PDA closure that needed re-clipping under open thoracotomy. Changing thoracoscopic procedure to an open surgery may be necessary for a safe and more successful PDA ligation. Conversion rate depends on shape and size of the PDA, adequate single-lung ventilation and surgeon experience. In one report, this phenomenon was up to 15% of VATS patients [20], but in other recent studies it was occurred in 0 – 1% of cases [8,10,19].

Four patients in VATS group needed thoracotomy, in which three cases required for

immediate conversion and one other patient scheduled for the next day because of residual shunt. Therefore, overall successful rate for clipping PDA closure was 95.1% in VATS group. Moreover, in thoracotomy group with one residual shunt the successful rate was 98%. By the way no significant different was observed between two groups in successful rate for PDA closure completion (p=0.64).

Another important morbidity of PDA operation is injury to recurrent laryngeal nerve. It can be a criticism point for VATS PDA ligation. Clip entrapments of nerve, thermal injury by electrocautery, stretching or traction of nerve are causes for nerve damage that present with dysphonia and hoarseness after operation; however, most of injuries are functional and transient. Mechanism of transient nerve injury is traction of the nerve while the mediastinal pleural flap is rotated medially by a retractor to expose the PDA; Moreover, clip or suture entrapment of recurrent nerve causes persistent nerve injury [10, 21]. The incidence of nerve injury in standard thoracotomy was reported 4.2% by Fan et al [22], while Bensky announced 2.5% nerve injury by using VATS procedure [23]. Results of other studies were reported this pit fault between 0-20% in VATS PDA ligation [12]. Although in our VATS group the transient recurrent laryngeal nerve dysfunction occurred in 2 patients (2.4%), the hoarseness of both patients was disappeared after 2 months. In addition, in thoracotomy group recurrence of this morbidity was not documented. We believe that recurrent nerve injury might be prevent by avoiding nerve traction, providing an excellent vision, not to cautery near the nerve, and also conversion from VATS to open thoracotomy while the nerve injury is probable.

Chylothorax is a rare complication following PDA surgery. In a large series of patients, incidence of chylothorax was 0.6% [10]. We had this morbidity neither in VATS patients nor in thoracotomy group. As pulmonary blood flow is increased in patients with PDA, recurrent pulmonary infection is common. Therefore, lymphatic of mediastinum are then activated and some large lymphadenopathies in hilum and periaortic area will be appearing. In this situation, during PDA surgery some accessory lymphatic ducts may be cut and lead to lymphatic leakage [12]. As the patients were fasted before surgery, the lymphatic leakage is clear with no milky color. We advise that, surgeon should wait for some minutes and recheck the operation field under magnification of optic at the end of VATS PDA ligation, and ligates the opened accessory lymphatic ducts.

Although more pulmonary complications happened in our thoracotomy patients, pulmonary morbidity was not significantly more than VATS group (p=0.15). Only one (1.2%) pneumothorax with subcutaneous emphysema was happened and needed to insert a chest tube after VATS operation, however 3 patients (3.6%) in thoracotomy group were scheduled for pulmonary complications, 1 pneumonia, 1 lung collapse and also 1 pneumothorax. postoperative pain and pulmonary impairment after open thoracotomy can cause more pulmonary morbidity. Villa reported incidence of pulmonary complication in 700 patients with VATS PDA ligation was 1.3% [10].

The way of sampling and study desing especially for the thoracotmy group which their data were collected retrospectively was a major limitation for our study. Also, we tried to overcome to this limitation by collecting data from just one major center in Mashhad. On the other hand thoracotomies were performed by three different surgeons and just the VATS was carried out by one surgeon.

We recommend a prospective study for both VATS and thoracotomies to evaluate and compare this two methods of PDA clipping and its long-term follow up. Moreover, we wish to provide a survey for comparing interventional coil / amplatzer and VATS PDA ligation.

VATS PDA clipping may be effective and safe approach in pediatric patients. Shorter hospital stay, compared to conventional thoracotomy, was the advantage of this technique and almost always PDA was closed completely

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References

1. Schneider DJ, Moore JW. Patent ductus arteriosus. Circulation. 2006; 114:1873–1882.
2. Gross R, Hubbard J. Surgical ligation of a patent ductus arteriosus: report of a first successful case. JAMA.1939; 112:729–731.
3. Mavroudis C, Backer CL, Gevitz M. Forty-six years of patent ductus arteriosus division at Children's Memorial Hospital of Chicago. Standards of comparison. Ann Surg. 1994; 220:402–9.
4. Laborde F, Noirhomme R, Karam J, Batisse A, Bourel P, Saint Maurice O.A new video-assisted

thoracoscopic surgical technique for interruption of patent ductusarteriosus in infants and children. J ThoracCardiovasc Surg. 1993; 105:278–280.
5. Portsmann W, Wierny L, Warnake H, Gerstberger G, Romaniuk PA.Catheter closure of patent ductusarteriosus. 62 cases treated without thoracotomy. RadiolClin North Am.1971; 9:203–218.
6. Zamfir CR, Vernet M, and Vega MF, Sapin E. Patent Ductus Arteriosus Ligation: The Liga Sure System May Be Unreliable. Ann Thorac Surg. 2007; 83:2228–30.
7. Hines MH, Raines KH, Payne RM, Covitz W, Cnota JF, Smith TE, O'Brien JJ, Ririe DG. Video-assisted ductal ligation in premature infants. Ann Thorac Surg.2003; 76:1417–14.
8. Nezafati MH, Soltani G, Vedadian A. Video-assisted ductal closure with new modifications: minimally invasive, maximally effective, 1,300 cases. Ann ThoracSurg.2007; 841343–1348.
9. Jacobs JP, Giroud JM, Quintessenza JA, Morell VO, Botero LM, van Gelder HM, Badhwar V, Burke RP The modern approach to patent ductus arteriosus treatment: complementary roles of video-assisted thoracoscopic surgery and interventional cardiology coil occlusion. Ann Thorac Surg. 2003; 76:1421–1428.
10. Villa E, VandenEynden F, Le Bret E, Folliguet T, Laborde F Pediatric video-assisted thoracoscopic clipping of patent ductusarteriosus: experience in more than 700 cases. Eur J Cardiothorac Surg. 2004; 25:387–393.
11. Schwarz bach MH, Ronellen fitsch U, Wang Q, RössnerE D, DenzC, Post S, and Hohenberger P. Effects of a clinical pathway for video-assisted thoracoscopic surgery (VATS) on quality and cost of care. Langenbecks Arch Surg.2010; 395:333–340.
12. VanamoK, Berg E, Kokki H, Tikanoja T. Video-assisted thoracoscopic versus open surgery for persistent ductusarteriosus. J Pediatr Surg. 2006; 41, 1226– 122.
13. KagamiM, KouiK, HirotsuguO, Tai-ichi T, KuniyoshiO, HirokuniY. One-Lung Ventilation for Video- Assisted Thoracoscopic Interruption of Patent DuctusArteriosus. Surg Today.2004; 34:1006–1009.
14. Nezafati MH, Soltani G, Kahrom M. Esophageal stethoscope: an old tool with a new role, detection of residual flow during video-assisted thoracoscopic patent ductusarteriosus closure. J Pediatr Surg. 2010 Nov; 45(11):2141-5.
15. Dutta S, Mihailovic A, Benson L, KantorPF, Fitzgerald PG, Walton JM, et al. Thoracoscopic ligation versus coil occlusion for patent ductusarteriosus: a matched cohort study of outcomes and cost. Surg Endosc. 2008 Jul; 22(7):1643-8.
16. Jeffrey PJ, Jorge MG, James AQ, Victor M, Luis MB, Hugh MG, et al. The modern approach to patent ductus arteriosus treatment: complementary roles of video-assisted thoracoscopic surgery and interventional cardiology coil occlusion. Ann Thorac Surg. 2003; 76:1421-1428.
17. Hines MH, Bensky AS, HammonJr JW, et al. Video-assisted thoracoscopic ligation of patent ductusarteriosus: safe and outpatient. Ann ThoracSurg.1998; 66:853- 8.
18. Burke RP, Wernovsky G, van der Velde M, et al. Video-assisted thoracoscopic surgery for congenital heart disease. J Thorac Cardiovasc Surg. 1995; 109:499 - 507.
19. Chen H, Weng G,Chen Z, Wang H, Xie Q, Bao J, et al. Comparison of Long-Term Clinical Outcomes and Costs Between Video-Assisted Thoracoscopic Surgery and Trans catheter Amplatzer Occlusion of the Patent DuctusArteriosus. Pediatr Cardiol 2012; 33:316–321.
20. Lavoie J, Burrows FA, Hansen DD. Video-assisted thoracoscopic surgery for the treatment of congenital cardiac defects in the pediatric population. Anesth Analg. 1996; 82:563- 7.
21. Odegard KC, Kirse DJ, del Nido PJ, Laussen PC, Casta A, Booke J, Kenna MA, McGowan Jr. FX. Introperative recurrent laryngeal nerve monitoring during video-assisted thoracoscopic surgery for patent ductusarteriosus. J Cardiothorac Vasc Anesth. 2000; 14:562–4.
22. Fan LL, Campbell DN, Clarke DR, Washington RL, Fix EJ, White CV. Paralyzed left cord associated with ligation of patent ductusarteriosus. J Thorac Cardiovasc Surg. 1989; 98:611–3.
23. Bensky AS, Raines KH, Hines MH. Late follow-up after thoracoscopic ductal ligation. Am J Cardiol. 2000; 86:360–1.

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