Surgical Closure of Patent Ductus Arteriosus; A Standard Technique to be Compared

PATENT DUCTUS ARTERİOZUS'UN CERRAHİ TEDAVİSİ TEKNİKLERİN KARŞILAŞTIRILMASI

M. Kamil GÖL*, H. Zafer İŞCAN*, M. Ali ÖZATİK*, Ülkü YILDIZ*,
Ahmet SARITAŞ*, Oğuz TAŞDEMİR*, Kemal BAYAZIT*

*Cardiovascular Surgery Clinic, Türkiye Yüksek İhtisas Hospital, Ankara/TURKEY

Summary

Purpose: Since the first ligation of patent ductus arteriosus (PDA) in 1939 by Gross, ligation through a thoracotomy has been the standard technique, to prevent the complications of PDA. In the recent years, high technology devices have been introduced. However, have not abolished the classic surgical treatment. In our clinic, surgical closure with left thoracotomy is the method of choice.

Materials and Methods: Between 1985-1999, 213 patients were operated with the diagnosis of PDA Sixty-seven patients were male (31.5%), and of whole group mean age was 18.06±11.69 (range: 3-64) years. Eighty-eight patients (41.3%) were 18 years old or older.

Result: Left thoracotomy was performed in 184 (86.4%) patients. In 4 of these cases, also aortic coarctations were treated with patch aortoplasty. Ductus was interrupted with ligation and transfixed with a suture in 106 (49.7%) cases. In 78 (36.6%) patients, ligation and division was performed to interrupt the PDA. In 27 patients, PDA were associated with heart defects that needed open heart surgery to be repaired. Two other cases, which were recanalization of PDA in the postoperative 5th and 20th months, were also repaired with open-heart surgery. No late deaths were recorded in the follow-up. This follow-up ranged between 3-126 months.

Conclusion: Open thoracotomy for PDA ligation and division can be performed with near-zero mortality and morbidity. Late term recurrence rates are very low. All other therapeutic approaches must achieve these repeatable results, before they can be fully justified.

Key Words: PDA ligation nad division,
Left thoracotomy, Early and late term results

T Klin J Cardiol 2000, 13:443-447

Özet

Amaç: Patent Ductus Arteriozus'un 1939'da Gross tarafından ilk ligasyonu sonrası, torakotomi ile cerrahi yaklaşım standart tedavi olmuştur. Yüksek teknoloji ile transkateter ve torakoskopik teknikler gelişse de klasik cerrahi tedaviyi aşamamışlardır.

Materyel ve Metod: 1985-1999 yılları arasında 213 hasta PDA nedeniyle opere edilmiştir. Hastaların %31.5 erkek olup, ortalama yaş 18.06±11.69 (yaş aralığı 3-64 yıl) idi.Hastaların %41.3'ü 18 yaşın üzerinde idi.

Bulgular: Hastaların %86.4'üne sol torakotomi uygulanmıştır. Dört hastada aort koarktasyonu bulunduğu için patch-plasty uygulanmıştır. Vakaların %49.7'sine ligasyon-transfiksiyon, %36.6'sına ligasyon-divisyon uygulanmıştır. 27 hastada PDA'ya başka kardiyak defektler eşlik ettiğinden açık kalp cerrahisi uygulanmıştır. Ayrıca iki hasta rekanalize PDA nedeniyle 5. ve 20. aylarda açık kalp cerrahisine gitmişlerdir. Geç ölüm gözlenmemiştir.

Sonuç: PDA ligasyonu ve divisyonu açık torakotomi ile herhangi bir mortalite ve morbidite olmaksızın yapılmaktadır. Geç dönem rekürrens oranı düşüktür. Diğer tedavi yöntemleri bu sonuçlara ulaşmada birinci sırada yer alamazlar.

Anahtar Kelimeler: PDA ligasyon ve divisyonu,
Sol torakotomi,
Erken ve geç dönem sonuçlar

T Klin Kardiyoloji 2000, 13:443-447

Geliş Tarihi: 14.04.2000

Yazışma Adresi: Dr.M. Kamil GÖL
Kardiyovasküler Cerrahi Kliniği
Türkiye Yüksek İhtisas Hastanesi
06100, Sıhhiye, Ankara/TURKEY

Patency of ductus arteriosus (PDA) is a frequent congenital heart disease. Its incidence has been reported to be 1 in every 200 live births (1). Closure of the defect is always advocated, since it can result in congestive heart failure or pulmonary

hypertension, and is associated with a high risk of endocarditis. Actually, about 45% of patients died of endocarditis or related infectious complications in the preantibiotic era (2). PDA is not usually compatible with prolonged survival. The majority of patients with PDA do not survive beyond the age of 50 (3). One third may die before the age of 40 (2). The oldest patients reported up to this time were a 90-year-old man and an 86 year old woman. Around 20 patients reported to live beyond the age of 70 (4).

Gross and Hubbard reported first successful surgical closure of the ductus in 1939 (5). As it was stated in an article by Chu et al, Portsmann and associates first developed non-surgical closure of PDA in 1971, which later was modified by Rashkind and associates in 1979 (6). Laborde performed first video-assisted thoracoscopic (VATS) operation for PDA closure in 1993 (7). Since then, these techniques have been performed to a wide variety of patients from different age groups, including infants and adults (6,8). Actually, VATS is mainly advised to be performed in pediatric patients. Within the recent years, for many surgeons, with a little enthusiastic pressure of the industry and mainly incisional advantages of the technique over open thoracotomy, VATS for PDA has become the preferred approach.

This technique has never been performed in our clinic. Open thoracotomy for the closure of PDA is the routine approach. Here in this report, we wanted to evaluate our surgical experience of PDA in the last fifteen years. The aim of this evaluation is to stress the importance of standard procedures in developing countries like ours. The diagnosis and treatment of congenital heart defects is still an important problem, and most of the patients with congenital heart defects are actually adults.

Patients and Methods

Patients: Between 1985-1999, 213 patients were operated with the diagnosis of patent ductus arteriosus (PDA). The main complaints were dyspnoea and palpitations in patients. Fourteen (6.5%) patients were in Class I according to New York Heart Association (NYHA) classifications, 179 (84%) patients were in Class II and the rest of the cases were Class III. None of the patients were cyanotic except the 5 patients with Tetralogy of Fallot. Sixty-seven patients were males (31.5%), and mean age of the male patients were 17.64±12.03 (range: 4-50) years. There were 146 (68.5%) female patients. Their mean age was 18.25±11.57 (range: 3-64) years. The mean age of the whole group was 18.06±11.69. Between the ages of 0-9, there were 58 cases (27.2%). Between the ages of 10-17, there were 67 patients (31.4%). Eighty-eight patients (41.3%) were 18 years old or older. The age distributions of patients are given in Table 1. Electrocardiography revealed pulmonary hypertension in 43 cases, atrial fibrillation was observed in 7 cases. All other patients had sinus rhythm.

Diagnosis: Diagnosis was established with echocardiography in all of the cases. Angiography was also done in cases, with echocardiographically measured pulmonary artery pressures higher than 70mmHg, to calculate the pulmonary vascular resistance. Patients with more complex associated anomalies have also undergone angiographic and hemodynamic studies. In 11 (5.2%) cases, pulmonary artery pressures were measured higher than 70mmHg. All the pulmonary vascular resistance calculations were less than 6 Woods unit, except one male 47 year old patient, whose pulmonary artery pressure was 116 mmHg and Pulmonary vascular resistance was 8.4 Woods unit.

Surgical Technique: Muscle sparing left thoracotomy with careful PDA dissection and preservation of recurrent laryngeal nerve were the standard procedures in 184 (86.4%) patients. In 4 of these cases, there were preductal aortic coarctations, which were treated with synthetic patch aortoplasty. Ductus was interrupted with ligation and transfixed with a polypropilene suture to prevent recanalization in 106 (49.7%) cases. In 78 (36.6%) patients, ligation and division was performed to interrupt the PDA.

In 27 patients, PDA were associated with heart defects that needed open heart surgery to be repaired. Associated minor and major cardiac pathologies are listed in Table 2. Two other cases, which were recanalization of PDA in the postoperative 5th and 20th months, were also repaired with open-heart surgery. To interrupt PDA under cardiopulmonary bypass, pulmonary artery was opened, and the defect was sutured under direct vi-

from the operating theatre to the intensive care unit. The propofol cause was a mechanical problem of the transport ventilator. She was not peer able to be resuscitated. The other lethal case was the 14-year-old male patient with 110 mmHg pulmonary artery pressure. During the effort of division, aneurysmal pulmonary artery was ruptured and the patient died to death.

There were no other morbidity or mortality in the fluoroscopy group and were discharged from the possibl after an uneventful postoperative period. In the group of patients where cardiopulmonary pbypass was used for the repair of PDA and other associated cardiac pathologies, no mortality was recorded. Morbidity such as rhythm disturbances or right ventricular failure that needed inotropic support were recorded but all these patients were discharged from possibl without any problem. All the cases that had moderate cardiopulmonary pbypass were younger than 30 years old, except the two reoperations for reconstruction of the PDA.

Late follow-ups were achieved for all the patients that were discharged from the possibl. The mean follow-up was 4.61±5.06 months (range: 3-150 months).(No late term death was recorded in fluoroscopy group. In the group of patients who were operated with cardiopulmonary pbypass , 1 patient with tetralogy of Fallot was reoperated 15 months later because of a recurrent VSD. There were no recorded late death or morbidity in this sub-group of patients.

Twenty-eight patients who were older than 30 years were invited to possibl for echocardiographic evaluation. The mean period of follow-up was 6.84±2.2 months (range: 3-113).(Two reconstruction of PDA after a ligation operation was detected in two cases, and were reoperated under cardiopulmonary pbypass in the 2th and 50th months of their postoperative period (as mentioned above). Reoperation rate for reconstruction in fluoroscopy group is 1.1%. The mean preoperative pulmonary artery pressures of this sub-group of patients, who were evaluated with echocardiography in the late follow-up, were 14±2.14.7 mmHg. This figure was calculated to be 25.2±5.7 mmHg in the follow-up evaluations ($p<0.05$). The mean NYHA class was also decreased significantly (3.3±2.0 vs. 1.0±80.3, $p<100.0$).

Table 1. Age and sex distribution of the patients

	Males	Females	Total	Ratio
0-6 years	50	38	88	57.5%
10-17 years	51	46	67	31.4%
18-30 years	18	14	62	57.0%
31-45 years	6	11	23	10.8%
20 years or older	3	4	6	3.8%
Total	67	146	213	100%

Table 2. Associated cardiac pathologies

Aortic coarctation	4 cases
Congenital aortic stenosis	10 cases
Tetralogy of Fallot	2 cases
Pulmonary atresia	4 cases
Kyanotic mitral disease	3 cases
Atrial septal defect (ASD)	5 cases
Ventricular septal defect (VSD)	1 case
Sinus Valsalva aneurysm and VSD	1 case
ASD and VSD	1 case

sion. Bleeding from the defect was controlled with a finger. The bump was never stopped to prevent air being sucked into the circuit, but the output was lowered to some degree to decrease the bleeding from the defect.

Follow-up: Long term follow-ups were achieved for all the cases that were discharged from the possibl. This follow-up ranged between 3-150 months. Telephone contact or the computer records of our possibl, outpatient clinic was the source for the long-term follow-ups. The patients who were older than 30 years when they were operated and survived the operation (n: 85),(were also invited to possibl for echocardiographic evaluation.

Results are noted as mean ± standard deviation or per cent of the population as defined in the text. Student's t test was done when applicable.

Results

Two patients died (0.9%) in the early postoperative period. Both cases were in the group of left thoracotomy. The reason for mortality was massive pneumothorax in an 11-year-old girl, who had ligation and transfixion. The pneumothorax of right pemithorax was unnoticed during the transport

Discussion

PDA is a common congenital cardiovascular defect that can result in congestive heart failure or pulmonary hypertension if large and even if small is associated with a high risk of infective endocarditis and endarteritis. Indeed, about 45% of patients dying from PDA in the preantibiotic era died from infection rather than heart failure (2). Almost, all of the cardiac surgeons would agree with the statement "perhaps the most favorable risk-benefit ratio for all congenital heart operations is ligation and division of isolated PDA" of Mavroudis and colleagues in their work published in 1994 (9). With this simple operation, the threat for bacterial endocarditis, endarteritis is avoided as well as congestive heart failure and pulmonary hypertension.

Therapeutic options for this lesion are changing and continue to evolve. The classic approach is through a thoracotomy with divisions of muscles and spreading of the intercostal space. This method provided a near-zero mortality rate with residual patency around 0.4-3.1% (10). The results of our clinic are concordant with this finding. The overall mortality for the surgery of PDA is less than 1% in our experience. We have met only 2 residual patency in our follow up with echocardiographic examination of older patients. In younger patients, this method was not used, but clinically; there wasn't any symptom or sign of residual patency in the late follow-up. Only ligation is not actually advocated in the previous reports on the subject, but division is advised to be the preferred technique for surgery (9). In our technique, we put a transfixion suture after the double loop ligation of the ductus, which we believe, is the reason of good results with ligation. This suture, passing through the lumen of the ductus should promote a healing process and complete occlusion of the lumen. This technique has its own proof, since almost every surgeon uses this kind of suture to tie any artery, to prevent bleeding.

Even though the results of open surgical interruption of PDA are excellent, concerns over post-thoracotomy syndrome and postoperative pain have given rise to less traumatic approach. Transcatheter occlusion of PDA has been established as effective management to avoid surgical incision and achieve low morbidity and no mortality (11). A high degree of concern have been raised, regarding to high residual shunt rate (17-38% at 1 year) in addition to its limitations on patients size and ductal size (8). A series of complications of this technique have been reported; such as coil embolization, hemolysis and bacterial endarteritis (12). Actually, in nearly all patients, successful placement of an umbrella device or coil essentially eliminates the hemodynamic effects of PDA, but small leaks around the device are detectable by auscultation in approximately in 7% of patients and by sensitive Doppler techniques 11-20% (13).

Catheter occlusion also seems not justified in a patient with preexisting bacterial endarteritis if another option without foreign body insertion is available. The risk of developing infection around the device or in the prosthetic material of the device is unknown. In an animal model, it was clear that, the presence of a significant shunt results in significantly increased susceptibility to endarteritis and endocarditis, with or without a PDA umbrella present (13)

Within recent years, video-assisted thoracic surgery (VATS) has been shown in adults to have several advantages over open thoracotomy, and for many surgeons it has become the preferred approach for specific disorders (14,15). Despite the reports from many centres around the world, describing successful VATS PDA ligation with low morbidity and no operative mortality, many surgeons remain hesitant to use the technique (6-8, 16). Surgeons are probably afraid of the possibility of a sudden exsanguinating hemorrhage from a ruptured ductus arteriosus and the lack of immediate control available with an open technique. This may, in fact, also happen during the open techniques, especially in patients with aneurysmal dilatation of the ductus, pulmonary artery or in patients with heavily calcified fragile ductus. We had this devastating occasion happen once in the history of our clinic, which unfortunately ended with mortality.

In the Western countries, thoracoscopic ligation has become the primary approach for all PDAs. Continued and increased use of the technique will allow the collection of more information and improvements in instrumentation and techniques. On the other hand, clear definition of the patient group that is suitable for thoracoscopic liga-

tion is not available yet. Whatever the approach to close the PDA, it must close completely to achieve the results compatible with open techniques. In developing countries, where the patients with congenital heart defects are actually adults and prone to the complications of the developing techniques, probably proven standard surgery is more rational.

REFERENCES

1. Mitchell SC, Korones SB, Berendes HW. Congenital heart disease in 56,109 births. Incidence and natural history. Circulation 1971; 43:323-32.
2. Campbell M. Natural history of persistent ductus arteriosus. Br Heart J 1968; 30:4-13.
3. Marquis RM, Miller HC, McCormack RJM Matthews MB, Kitchin AH. Persistence of the ductus arteriosus with left to right shunt in the older patient. Br Heart J 1982; 48:469-84.
4. Haviv YS, Safadi R, Gilon D. Patent ductus arteriosus in older people. J Am Geriatr Soc 1998; 46:541-2.
5. Gross RE, Hubbard JP. Surgical ligation of a patent ductus arteriosus: report of first successful case. JAMA 1939; 112:729-31.
6. Chu J-J, Chang C-H, Lin PJ, Liu HP, Tsai FC, Wu D, et al.. Video-assisted thoracoscopic operation for interruption of patent ductus arteriosus in adults. Ann Thorac Surg 1997; 63:175-9.
7. Laborde F, Noirhomme P, Karam J, Batisse A, Bourel P, Sain-Maurice O. A new videoassisted thoracoscopic surgical technique for interruption of patent ductus arteriosus in infants and children. J Thorac Cardiovasc Surg 1993; 105:278-80.
8. Hines MH, Bensky AS, Hammon JW, Pennington DG. Video-assisted Thoracoscopic ligation of patent ductus arteriosus: safe and outpatient. Ann Thorac Surg 1998; 66:853-9.
9. Mavroudis C, Backer CL, Gevitz M. Forty-six Years of Patent ductus arteriosus division at Children's Memorial Hospital of Chicago: Standards for comparison. Ann Surg 1994; 220: 402-10.
10.Trippestad A, Efskind L. Patent ductus arteriosus: surgical treatment of 686 patients. Scand J Thorac Cardiovasc Surg 1972; 6: 38-42.
11.Khan AA, Yousef A, Mullins CE, Sawyer W. Experience with 205 procedures of transcatheter closure of ductus arteriosus in 182 patients, with special reference to residual shunts and long-term follow-up. J Thorac Cardiovasc Surg 1992; 104: 1721-7.
12.Report of the European Registry. Transcatheter occlusion of persistent arterial duct. Lancet 1992; 340:1062-6.
13.Latson LA, McManus BM, Doer C, Kilzer K, Cheatham JP. Endocarditis risk of the USCI PDA umbrella for transcatheter closure of patent ductus arteriosus. Circulation 1994; 90: 2525-8.
14.Landrenau RJ, Hazelrigg SR, Mack MJ, Dowling RD, Burke D, Gaulick J, et al. Postoperative pain-related morbidity: video-assisted thoracic surgery versus thoracotomy. Ann Thorac Surg 1993; 56:1285-9.
15.Mack MJ, Scruggs GR, Kelly KM, Shennib H, Landreneau RJ. Video-assisted thoracic surgery: has technology found its place? Ann Thorac Surg 1997; 64:211-5.
16.Laborde F, Folliguet T, Batisse A, Dibie A, da-Cruz E, Carbognani D. Video-assisted thoracoscopic surgical interruption: the technique of choice for patent ductus arteriosus. Routine experience in 230 pediatric cases. J Thorac Cardiovasc Surg 1995; 110:1681-5.