

Ligation of patent ductus arteriosus through left anterior mini-thoracotomy in preterm infants

Yiğit Kılıç¹, Ahmet İrdem¹, Onur Doyurgan¹, Özlem Gül¹, Hasan Balık¹, Esra Aktiz Bıçak¹, Fikret Salik², and Bedri Aldudak¹

¹Diyarbakir SBU Gazi Yasargil Eğitim Ve Arastirma Hastanesi

²Dicle Universitesi Tıp Fakultesi

April 15, 2022

Abstract

Objective Patent ductus arteriosus (PDA) is an important cause of morbidity and mortality, especially in very-low-birth-weight infants. The aim of the study is to report our single-center short-term results of preterm patients who underwent patent ductus arteriosus ligation through left anterior mini-thoracotomy. **Methods** Data of 27 preterm infants operated by the same surgeon who underwent PDA closure with left anterior minithoracotomy technique between November 2020 and January 2022 at a single institution were reviewed. The patients were divided into two groups according to their weight at the time of surgery. Data on early postoperative outcomes and survival rates after discharge were collected. **Results** Twenty-seven patients with a mean (\pm SD) gestational age of 25.8 (\pm 2.0) weeks and a mean birth weight of 1027 (\pm 423) g were operated using left anterior mini-thoracotomy technique. The lowest body weight was 480 g. Complications such as bleeding, abnormal healing of incision or pneumothorax were not seen. There were 8 mortalities after the operation (29,6 %). There was no internal thoracic artery injury or no need for conversion to thoracotomy or sternotomy. there were 6 (22%) deaths in the postoperative first 30 days and 4 (14,8%) deaths between the postoperative first month and first year. The cause of the deaths were sepsis, NEC, hydrops fetalis, hepatoblastoma and intracranial bleeding. Left diaphragmatic elevation developed in 1 patient, and plication was performed. There was no statistically significant difference in the rates of morbidity, and complication between the groups. **Conclusions** PDA closure with the left anterior mini-thoracotomy method is advantageous in terms of reducing damage to the already congested lung, shortening the hypothermia time of the baby by shortening the procedure time, and has good cosmetic results, especially in very low birth weight preterm babies.

Ligation of patent ductus arteriosus through left anterior mini-thoracotomy in preterm infants

¹Yiğit Kılıç, ¹Ahmet Kuddusi İrdem, ¹Onur Doyurgan, ²Özlem Gül, ²Hasan Balık, ³Esra Aktiz Bıçak, ⁴Fikret Salik, ²Bedri Aldudak

¹Department of Pediatric Cardiac Surgery, Dr. Gazi Yasargil Training and Research Hospital, Diyarbakir, Turkey

²Department of Pediatric Cardiology, Dr. Gazi Yasargil Training and Research Hospital, Diyarbakir, Turkey

³ Department of Anesthesiology and Reanimation, Dr. Gazi Yasargil Training and Research Hospital, Diyarbakir, Turkey

⁴ Department of Anesthesiology and Reanimation, Dicle University Medical Faculty, Diyarbakir, Turkey

Objective

Patent ductus arteriosus (PDA) is an important cause of morbidity and mortality, especially in very-low-birth-weight infants. The aim of the study is to report our single-center short-term results of preterm patients who underwent patent ductus arteriosus ligation through left anterior mini-thoracotomy .

Methods

Data of 27 preterm infants operated by the same surgeon who underwent PDA closure with left anterior minithoracotomy technique between November 2020 and January 2022 at a single institution were reviewed. The patients were divided into two groups according to their weight at the time of surgery. Data on early postoperative outcomes and survival rates after discharge were collected.

Results

Twenty-seven patients with a mean (\pm SD) gestational age of 25.8 (\pm 2.0) weeks and a mean birth weight of 1027 (\pm 423) g were operated using left anterior mini-thoracotomy technique. The lowest body weight was 480 g. Complications such as bleeding, abnormal healing of incision or pneumothorax were not seen. There were 8 mortalities after the operation (29,6 %). There was no internal thoracic artery injury or no need for conversion to thoracotomy or sternotomy. there were 6 (22%) deaths in the postoperative first 30 days and 4 (14,8%) deaths between the postoperative first month and first year. The cause of the deaths were sepsis, NEC, hydrops fetalis, hepatoblastoma and intracranial bleeding. Left diaphragmatic elevation developed in 1 patient, and plication was performed. There was no statistically significant difference in the rates of morbidity, and complication between the groups.

Conclusions

PDA closure with the left anterior mini-thoracotomy method is advantageous in terms of reducing damage to the already congested lung, shortening the hypothermia time of the baby by shortening the procedure time, and has good cosmetic results, especially in very low birth weight preterm babies.

Keywords: Patent ductus arteriosus, premature, minimally invasive surgery

Introduction

Patent ductus arteriosus (PDA) is a persistent communication between the pulmonary artery and the descending thoracic aorta. In term infants, it closes physiologically within 72 hours after birth. Especially this closure is delayed in preterm infants. PDA is one of the most common congenital anomalies of these neonates (1-3). Persistence of this fetal connection leads to left ventricular volume overload, pulmonary hypertension, increased mechanical ventilatory support, hypotension requiring inotropic support, oliguria/renal failure, or feeding intolerance/failure to gain weight. Surgical closure is considered when medical therapy fails. In preterm infants surgical closure technique is especially important as you deal with congested lungs. Minimally invasive techniques are more and more used in this manner (4,5). Among different minimally invasive strategies that have emerged in the last decades left anterior minithoracotomy has been recognized as a safe, efficient and less expensive technique (6-9). In this study, we tried to evaluate the effects of the less invasive left anterior mini thoracotomy technique and share our results.

Materials and Methods

This study involved a retrospective review of the clinical and operative records of 27 preterm infants (gestational age < 37 weeks) who had surgical closure of PDA with left anterior minithoracotomy technique between November 2020 and January 2022 at a single institution. 27 patients underwent PDA closure with this technique (9 male, 18 female). Same pediatric surgeon operated all the patients. PDA was closed in premature infants who had congestive heart failure despite medical treatment or showed a large left to right shunt on echocardiogram causing increased mechanical ventilatory support, hypotension requiring inotropic support, oliguria/renal failure or feeding intolerance/failure to gain weight. The range of the weight at operation was 480–2700 g. Preoperatively, 26 infants were ventilator-dependent.

Data on early postoperative outcomes and survival rates after discharge were collected. Baseline information

of patients are shown in Table 1. The data collected include medical treatment time, preoperative mechanical ventilation (MV) support(days), PDA closure with clip or ligation, operation time, intraoperative blood loss, conversion to sternotomy or thoracotomy, use of inotropic agents, surgery related complications, postoperative length of stay(days), hospital length of stay(days), transfer to another hospital, postoperative MV time(days), complications in the intensive care unit, hospital mortality and number of patients still alive. All operations were performed in the operating room of our hospital.

Surgical Technique

In the operating room, three-lead electrocardiography and pulse oximetry were used for routine monitoring. The patient was under a heater until the operation started. Central venous catheter or invasive arterial monitoring were not used routinely. Adrenalin infusion was started routinely. In left anterior mini-thoracotomy technique, approximately 2-3 cm incision was made through the second intercostal space. The incision was limited to left internal mammarian artery. The lung was retracted with a small rolled gauze gently. A longitudinal incision 1cm above the phrenic nerve was made. Then a stay suture was placed at pericardium to visualize the ductus and the pulmonary arteries. After the dissection of the lateral surfaces of the ductus was completed a clip was placed on the PDA or the PDA was ligated with a 2-0 silk suture. Especially in the case of fragile and thin-walled PDAs, single clip was preferred. The surgical incision was closed with interrupted 4/0 prolene sutures without a chest tube (Figure 1). The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the ethics committee. Permission for this study was granted by the Dr. Gazi Yasargil Training and Research Hospital Ethical Committee of Clinical Researches with the decision number 26 and date 11.02.2022.

Routine Postoperative Care

We transferred all the preterms back to the neonatal intensive care unit. Fentanyl infusion was commenced. Epinephrine infusion was gradually decreased and stopped according to the mean arterial pressure (MAP). MAP of less than that for corrected gestational age was defined as hypotension. One hour after the procedure all preterms had a chest x-ray to exclude possible hemothorax or pneumothorax.

Statistical Analysis

Patient cohort was divided into two groups according to their weight at the time of surgery: Group 1 < 1000 g and Group 2 [?] 1000 g. The SPSS statistical programme for Windows, version 22 (SPSS, Inc., Chicago, IL, United States of America) was used for data analysis. The Shapiro–Wilk test was used for the analysis of compliance with normal distribution. Normally distributed continuous data are presented as a mean +- standard deviation together with its ranges in brackets and nominal variables are presented as counts and/or percentages. Non-normally distributed continuous data are presented as a mean +- standard deviation and the median parameters with their interquartile ranges in brackets. For statistical comparison of group data, Student's t-test was used for normally distributed continuous variables and Mann–Whitney U-test for non-normally distributed continuous variables. Complication and death incidences for both groups were tested for significance using the Ki-Kare ve Fisher's exact test. All statistical tests were two-sided. A p-value of < 0.05 was considered statistically significant

Results

Twenty-seven patients with a mean (+SD) gestational age of 25.8 (+2.0) weeks and a mean birth weight of 1027 (+423) g were operated using left anterior mini-thoracotomy technique. Eighteen were females (66 %), 9 were males (33 %). 17 (62 %) were born at [?]26 weeks and 17 were [?] 1000 g. According to their weight at the time of operation the patients were separated into two groups: Group 1[?] 1000 g (n: 13) and Group 2 > 1000 g (n: 14). Mean weight of all the patients on operation day was 1188 (+553) (480-2700 g). In Group 1 it was 822 (+169) g and in Group 2 it was 1528 (+573) g. Statistically difference was significant between Group 1 and 2 : 822 (+169) g, 1528 (+573) g, respectively(p: 0.000). Mean age of all the patients on operation day was 29,7 +- 16,1 days. In Group 1 it was 23 (+12) and in Group 2 it was 36 (+20) days, respectively (p: 0.079). Statistically difference was not significant between Group 1 and 2. Each group

had some limitations as all the patients in group 1 were very-low birth weight, 7 patients in group 2 were very-low birth weight. All of the cases were completed without cardiopulmonary bypass. There was no blood loss during the cases, no surgery related mortality or no significant difference in operation time between the cases. As the patients had no drainage tube, they had no drainage after the operation. Complications such as bleeding, abnormal healing of incision or pneumothorax were not seen. Patients' preoperative conditions were analyzed in Table 2. Additional comorbidities of the patients before the surgery were 8 bacterial sepsis (29,6 %), 3 necrotizing enterocolitis (11 %), 1 hydrocephalus (0,3 %), 4 intracranial hemorrhage (14,8%). All of the patients had congestive heart failure and five had a pulmonary infection. A clip was placed on the PDA in 16 patients and PDA was ligated with a 2-0 silk suture in 11 patients. Mean operation time was 18.7 (+5.5) minutes (range, 10-40 minutes). After a day of postoperative follow-up we sent the patients back to centers they came from. We transferred all the 13 patients back to centers they came from. The remaining patients' postoperative mean mechanical ventilatory support time was 29.5 (+42.6) days (range, 1-165 days), mean hospital stay was 71.5 (+56.0) days (range, 7-193 days) and the mean postoperative length of stay was 47.4 (+44.2) days (range, 6-165 days). There were 8 mortalities after the operation (29,6 %). Five were due to sepsis, one was due to necrotizing enterocolitis, one was due to hydrops fetalis and one was due to renal failure with hepatoblastoma. There was no internal thoracic artery injury or no need for conversion to thoracotomy or sternotomy. All patients except one were ventilator-dependent before surgery. That patient had rapidly progressive renal failure before the surgery. There were 16 (59%) postoperative complications (8 in Group 1 and 8 in Group 2) during intensive unit care stay. In addition, there were 6 (22%) deaths in the postoperative first 30 days and 4 (14,8%) deaths between the postoperative first month and first year. The cause of the deaths were sepsis, NEC, hydrops fetalis, hepatoblastoma and intracranial bleeding. Left diaphragmatic elevation developed in 1 patient, and plication was performed. Three percent (one patient) of all patients needed reoperation because of a significant residual patent ductus arteriosus. This patient was reoperated on postoperative day 1 through the same thoracotomy incision. Other residual shunt closed spontaneously. 17 of all patients are still alive (Table 3).

Discussion

PDA is one of the most common congenital heart diseases. Excessive blood flow to the lungs caused by PDA results in pulmonary congestion, pulmonary edema and respiratory failure (10). This patency may also cause cerebral, renal or mesenteric hypoperfusion that leads to serious complications in intensive care unit (11). Medical management, surgical ligation or percutaneous closure of PDA are treatment methods used currently for preterm infants. Percutaneous closure of PDA has really limited place among the treatment methods although transcatheter technology advances (12-15).

Indomethacin or ibuprofen is used for the medical treatment of PDA. If medical treatment is unsuccessful surgical closure is performed. These drugs have various side effects and may cause thrombocytopenia, necrotizing enterocolitis, pulmonary edema and bleeding, renal failure (16). There are even publications suggesting early surgery instead of medical therapy to save the patients from complications of PDA and medications. (17,18)

In 1938, Gross was first to ligate PDA successfully (19). With the improvement in cardiovascular surgery better cosmetic results and less harm to lung tissue became more important. For this purpose, several minimally invasive techniques have been tried by surgeons instead of the conventional methods without affecting the operative results (19,20).

Another choice is transcatheter closure of PDA. With the rapid development of science and technology new occlusion devices serve to close PDA in appropriately selected preterms. However, it is still not routinely occluded in very small infants with birth weight ≥ 2 kg and still there is a lack of experience (12). As it is safe and successful transcatheter closure of PDA receives more attention; but there are some concerns about vascular access, risk of residual shunt, providing the suitable device, possibility of device migration or embolization and contrast administration in preterm infants (21,22).

Lateral thoracotomy has been procedure of choice for PDA closure in preterm infants for over five decades;

but it doesn't have the qualities that left anterior mini-thoracotomy technique has. Lung injury and potential long-term spinal and chest wall deformities are potential risks of lateral thoracotomy (23,24)

Verhaegh et al compared lateral thoracotomy with sternotomy for PDA closure in preterm infants and they found that the postoperative pulmonary complication rate was significantly lower in the median sternotomy patients. This obviously shows that it is important not to touch lungs as much as possible during operation to avoid lung-related postoperative complications (23).

Technically, left anterior mini-thoracotomy technique requires short surgical times (< 20 minutes), offering direct visualization of the left recurrent laryngeal nerve, thus preventing complications secondary to its damage, guarantees good surgical exposure of the PDA (also in patients < 1.5 kg who are not routinely managed through catheterization). In addition, less trauma to lung tissue reduces the risk of pulmonary complications. This technique also has good aesthetical results. This is a simple technique and provides good exposure and the closest approach to the PDA when compared to the other thoracotomy incisions. The patient is in the supine position during the operation with the left chest elevated for anterior mini-thoracotomy. Supine position provides extra comfort for the surgeon and can be maintained easily in the operating room or in the intensive care unit. In case of emergency (for example; massive bleeding) you can easily convert to sternotomy.

We operated all of our patients in the operating room. Patient was under the heater till the start of the operation. Sometimes even gentle traction of pulmonary artery for PDA dissection for better view caused bradycardia and hypotension so adrenaline infusion was started all of the patients, preoperatively. Our operation time was generally under 20 minutes. Therefore, time under hypothermia was also not long. Our lightest baby was 480 g. Interestingly, we operated twins, two sisters, on the same day and discharged them to home one day apart.

In our study, we especially focused on advantages of the technique on time and lung related complications and possible surgical complications related with PDA closure. In our cohort, we didn't have any intraoperative bleeding, chylothorax and chylomediastinum; but we had one left diaphragma elevation. Left diaphragma was plicated and the patient was successfully discharged. Dissection of PDA for better view may be dangerous in some patients who have more fragile PDA tissue than the others. In these type of cases we prefer clip ligation. In these cases using a metallic vascular clip allows for limited dissection and safe occlusion. After the operation air was removed using the underwater drainage system, the thoracotomy was closed without placing a chest tube. This may have improved the comfort of the patient after the operation.

48% (13) of the patients were transferred to our center for PDA closure. After the operation we followed-up the patients for one day in our neonatal intensive care unit. The day after the operation all of the 13 patients were transferred back to their centers. Transfer of a preterm patient especially before the surgery is important. If the patient comes to the surgery in hypothermic condition with loss of intravenous lines or ventilation problems, this may increase the risk of the surgery.

Although there was no surgery related mortality, our hospital mortality rate was 29,6 %. This is higher than most of the prior studies related to PDA closure in preterms (23-25). As our cohort includes preterm patients with PDA and serious comorbidities these mortality rates are connected to complications associated with prematurity, infection and comorbidities. Five were due to sepsis, one was due to necrotizing enterocolitis, one was due to hydrops fetalis and one was due to renal failure with hepatoblastoma.

Of course we have several limitations. First of all a limited population was retrospectively studied. We only have early and mid-term results but not long term results. Also we can not compare the technique with another technique as we did not have another group operated by another surgical technique. All of these avoid us claiming the superiority of the technique over other techniques. Also, our short and mid term results with left anterior mini-thoracotomy technique in preterm infants are promising.

To conclude, PDA closure with the left anterior mini-thoracotomy method is advantageous in terms of reducing damage to the already congested lung, shortening the hypothermia time of the baby by shortening

the procedure time, and has good cosmetic results, especially in very low birth weight preterm babies. Prospective randomised studies are needed to compare the technique's safety and efficiency with other conventional techniques.

Declaration of conflicting interests: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

References

1. Kitterman JA, Edmunds LHF, Gregory GA, Heymann MA, Tooley WH, Rudolph AM. Patent ductus arteriosus in premature infants: incidence, relation to pulmonary disease and management. *N Engl J Med.* 1972;287: 473–7.
2. Van Overmeire B, Smets K, Lecoutere D, Van de Broek H, Weyler J, Degroote K, et al. A comparison of ibuprofen and indomethacin for closure of patent ductus arteriosus. *N Engl J Med.* 2000;343:674–81.
3. Lee et al. *Journal of Cardiothoracic Surgery* (2020) 15:144 Page 8 of 9 , Hoffman JI, Kaplan S. The incidence of congenital heart disease. *J Am Coll Cardiol.* 2002;39:1890–900.
4. Baruteau AE, Hascoet S, Baruteau J, Boudjemline Y, Lambert V, Angel CY, et al. 2014. Transcatheter closure of patent ductus arteriosus: past, present and future. *Archives of cardiovascular diseases.* 107(2):122-32.
5. Jin M, Liang YM, Wang XF, Guo BJ, Zheng K, Gu Y, et al. 2015. A Retrospective Study of 1,526 Cases of Transcatheter Occlusion of Patent Ductus Arteriosus. *Chinese medical journal.* 128(17):2284-9.
6. Leon-Wyss J, Vida VL, Veras O, Vides I, Gaitan G, O'Connell M, et al. Modified extrapleural ligation of patent ductus arteriosus: a convenient surgical approach in a developing country. *Ann Thorac Surg.* 2005;79(2):632-5.
7. Mazzer E, Brancaccio G, Feltri C, Michielon G, Di Donato R. Minimally invasive surgical closure of patent ductus arteriosus in premature infants: a novel approach. *J Card Surg.* 2002;17(4):292-4.
8. Vicente WV, Rodrigues AJ, Ribeiro PJ, Evora PR, Menardi AC, Ferreira CA, et al. Dorsal minithoracotomy for ductus arteriosus clip closure in premature neonates. *Ann Thorac Surg.* 2004;77(3):1105-6.
9. Demirturk O, Guvener M, Coşkun I, Tünel HA. Results from extrapleural clipping of a patent ductus arteriosus in seriously ill preterm infants. *Pediatr Cardiol.* 2011;32(8):1164-7. doi: 10.1007/s00246-011-0050-5.
10. Benitz WE. Treatment of persistent patent ductus arteriosus in preterm infants: time to accept the null hypothesis? *J Perinatol.* 2010;30:241-252.
11. Overmeire BV, Chemtob S. The pharmacologic closure of the patent ductus arteriosus. *Semin Fetal Neonat Med.* 2005;10:117-184.
12. Moore JW, Greene J, Palomares S, et al. Results of the combined U.S. multicenter pivotal study and the continuing access study of the Nit-Occlud PDA device for percutaneous closure of patent ductus arteriosus. *J Am Coll Cardiol Interv.* 2014;7:1430-1436.
13. Francis E, Singhi AK, Lakshmivenkateshaiah S, Kumar RK. Transcatheter occlusion of patent ductus arteriosus in preterm infants. *J Am Coll Cardiol Intv.* 2010;3:550-555.
14. Zahn EM, Nevin P, Simmons C, Garg R. A novel technique for transcatheter patent ductus arteriosus closure in extremely preterm infants using commercially available technology. *Catheter Cardiovasc Interv.* 2015;85:240-248.
15. Sathanandam S, Agrawal H, Chilakala S, et al. Can transcatheter PDA closure be performed in neonates [?]1000 grams The Memphis experience. *Congenit Heart Dis.* 2019;14:79-84.
16. Mercanti I, Boubred F, Simeoni U. Therapeutic closure of the ductus arteriosus: benefits and limitations. *J Matern Fetal Neonatal Med.* 2009;22:14-20.
17. Avsar MK, Demir T, Celiksular C, Zeybek C. Bedside PDA ligation in premature infants less than 28 weeks and 1000 grams. *J Cardiothorac Surg.* 2016;11:146-150.
18. Ko YC, Chang CI, Chiu IS, Chen YS, Huang SC, Hsieh WS. Surgical ligation of patent ductus arteriosus

in very-low-birth-weight premature infants in the neonatal intensive care unit. *J Formos Med Assoc.* 2009;108:69-71.

19. Susheel Kumar TK. 2019. Surgical management of patent ductus arteriosus. *Congenit Heart Dis.* 14(1):57-59.
20. Garcia AV, Lukish J. 2017. Minimally Invasive Patent Ductus Arteriosus Ligation. *Clin Perinatol.* 44(4):763-771.
21. Weisz DE, Giesinger RE. Surgical management of a patent ductus arteriosus: is this still an option? *Semin Fetal Neonatal Med.* 2018;23: 255-266.
22. Nealon E, Rivera BK, Cua CL, Ball MK, Stiver C, Boe BA, et al. Follow-up after Percutaneous Patent Ductus Arteriosus Occlusion in Lower Weight Infants. *J Pediatr.* 2019;212:144-150.
23. Verhaegh AJFP, Accord RE, Kooi EMW, et al. Thoracotomy versus sternotomy for patent ductus arteriosus closure in preterm neonates. *Ann Thorac Surg* 2020; 109: 171–177. 9.
24. Bal S, Elshershari H, Celiker R, Celiker A. Thoracic sequels after thoracotomies in children with congenital cardiac disease. *Cardiol Young* 2003; 13: 264–267.
25. Lehenbauer DG, Fraser CD, Crawford TC, et al. Surgical closure of patent ductus arteriosus in premature neonates weighing less than 1,000 g: contemporary outcomes. *World J Pediatr Congenit Heart Surg* 2018; 9: 419–423.

Table 1: Patient characteristics in all cases

	All cases (n = 27)	All cases (n = 27)
	Mean ± SD (minimum–maximum)	Median [interquartile range]
Gestational age (week)	25.8±2.0	26 (22-31)
Mean birth weight (gr)	1027±423	920 (550-2500)
Mean weight at surgery (g)	1188±553	1020 (480-2700)
Medical treatment time	2.0±1.1	2 (0-4)
Preoperative MV support	24.2±16.2	25 (0-77)
Operation time	18.7±5.5	20 (10-40)
Mean postop LOS	25.2±39.0	6 (0-165)
Mean hospital stay	38.5±52.7	7 (0-193)
Mean PDA size	2.85±0.72	3 (1.7-4.5)
Mean postoperative MV time	16.0±33.3	3 (0-165)

MV: Mechanical ventilation, LOS: Length of stay.

Table 2: Patient characteristics in both groups

	Group 1 (n = 13)	Group 1 (n = 13)	Group 2 (n = 14)	p Value
Sex (male/female)	5/8	4/10	4/10	0.586
Gestational age (week)	25.0±1.87	26.7±1.93	26.7±1.93	0.028*
Mean birth weight (g)	809±167	1229±491	1229±491	0.007*
Mean age at surgery (days)	23±12	36±20	36±20	0.079
Mean weight at surgery (g)	822±169	1528±573	1528±573	0.000*
Mean PDA size (mm)	2.64±0.61	3.04±0.79	3.04±0.79	0.162
Preoperative condition				

	Group 1 (n = 13)	Group 1 (n = 13)	Group 2 (n = 14)	p Value
NEC	2	1	1	0.496
CHF	13	14	14	1.000
ARF	6	3	3	0.173
RDS	12	12	12	0.586
ROP	2	3	3	0.686
Sepsis	4	4	4	0.901
Hydrops fetalis	0	1	1	0.326
Genetic syndrome	1	0	0	0.290
Post-resuscitation	0	0	0	1.000
Failed	0	0	0	1.000
percutaneous				
closure				
Hydrocephalus +	0	1	1	0.326
tracheostomy				
Bronchopneumonia	2	3	3	686
Preoperative MV	13	12	12	0.157
support				

NEC: Necrotising enterocolitis , CHF: Congestive heart failure , ARF: Acute renal failure, RDS: Respiratory distress syndrome, ROP: Retinopathy of prematurity, MV: Mechanical ventilation.

Table 3: Outcome data of both groups

	Grup 1 (n = 13)	Grup 1 (n = 13)	Grup 2 (n = 14)	p Value
Mean total procedure time (min)	18.7±2.1	18.7±7.5	18.7±7.5	0.980
Mean hospital LOS after surgery (days)	30.0±49.5	20.9±27.3	20.9±27.3	0.557
Mean postoperative MV time (days)	26.0±45.6	6.7±10.4	6.7±10.4	0.138
Mean operation time	18.7±2.1	18.7±7.5	18.7±7.5	0.980
Complications				
Intraoperative death	0	0	0	1.000
Atelectasia	0	0	0	1.000
Residual shunt	1	1	1	0.957
Left recurrent laryngeal nevre injury	0	0	0	1.000
Chylothorax	0	0	0	1.000
Pneumothorax	0	0	0	1.000
Eventionration of diaphragm left side	1	0	0	0.290
Blood transfusions	0	0	0	1.000
Surgical site complication	0	0	0	1.000
Transfer to another hospital	6	7	7	0.842
Complications in the intensive care unit	8	8	8	0.816
Hospital mortality	6	2	2	0.070
Stil alive	7	10	10	0.345

MV: Mechanical ventilation, LOS: Length of stay.



Fig1: Clips ligation of PDA in a 480 g preterm infant.Clips ligated PDA is shown with black arrow.