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Surgery for patent ductus arteriosus in infants with very low birth weight

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ABSTRACT

Objectives: We aimed to present our institutional experience on the surgical management of low birth weight infants with patent ductus arteriosus.

Patients and methods: In this retrospective study, 14 low birth-weight infants with a mean birth weight of 1201±252 g (range, 640 to 1500 g), mean age of 19.71±9.55 days (4 to 38 days), mean gestational age of 29.14±2.07 weeks (25 to 34 weeks) operated for isolated patent ductus arteriosus (mean weight on operation of 1377 g) between January 2008 and November 2012 were included. At baseline, all patients received indomethacin and three were also given ibuprofen. None achieved closure of the duct. Standard surgical protocol consisting of suture closure of patent ductus arteriosus through posterolateral thoracotomy approach was performed in all patients.

Results: The mean operation time was 70.4±18.8 min, the mean mechanical ventilation time was 10.6±7.4 h, the mean intensive care unit stay was 7.4 days (range, 1 to 38 days), and the mean hospital stay was 12.8±11.5 days (range, 4 to 44 days). There was no complication, mortality or morbidity related to surgery. Reintubation rate was 14.28% and this complication resolved with surfactant therapy.

Conclusion: Early intervention for closure of isolated patent ductus arteriosus is acceptable in very low birth weight infants who are unresponsive to medical treatment provided that no other abnormality is present and the surgical protocol is well standardized.

Keywords: Cardiac surgery; infant; patent ductus arteriosus; prematurity; very low birth weight.

Patent ductus arteriosus (PDA) is abnormal persistence of the communication between the descending aorta and the pulmonary artery.[1] It is more common in premature infants (about 8 of every 1,000 births) compared to those in full-term (2 of every 1,000 births) and is also more common in girls.[2] Genetic factors seem to play a role in persistence of ductus arteriosus.[1] The disease is characterized by a substantial decrease in peripheral blood circulation and oxygen delivery in small neonates, particularly, if the shunt of blood from systemic to pulmonary circulation is extremely high. If left uncorrected, PDA may cause systemic disturbances including feeding intolerance, necrotizing enterocolitis, intracranial hemorrhage, decreased glomerular filtration rate, and bronchopulmonary dysplasia.[1,2]

Very low birth weight infants (500 to 1500 g) comprise about 1% of all live births; however, more than 60% of all neonatal deaths are very low birth weighted ones.[3] The incidence of PDA was reported to be as high as 30% in premature neonates.[2] The main reason of high incidence in preterm infants is likely reduced sensitivity for oxygen and increased sensitivity to prostaglandin E2 (PGE2), nitric oxide (NO), and endothelin.[4] Clinical severity of symptoms depends on the degree of the left-to-right shunting and the level of increase in the pulmonary blood flow. Treatment approach for the PDA, either medical or surgical, may also be influenced by coexistence of other congenital abnormalities requiring further diagnostic effort and also implementation of an individual approach for selected patients.[5]

Surgery may be delayed in asymptomatic patients and in those whose symptoms are able to be controlled by medical treatment. However, surgical closure is usually indicated in infants with congestive heart failure unresponsive to medical therapy. In asymptomatic patients, elective closure of the duct may be done at any age or when the patient becomes symptomatic.[6,7]

Although surgery for isolated PDA is often easy to perform, the operation may be more challenging when performed on a low birth weight infant due

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to the comorbidites which mainly arise from the immaturity of organs and systems. Depending on the patients' overall clinical or hemodynamic status and also morphological features of the lesion, there have been several options for closure of a patent ductus arteriosus including conventional surgical banding or ligation and catheter-based interventions using various devices. Recently, a number of minimally invasive procedures have also been successful.[8,9]

In this study, we present our institutional experience on the surgical management of low birth weight infants operated for isolated patent ductus arteriosus.

PATIENTS AND METHODS

A parental informed consent was obtained for each patient. This was a retrospective cohort study performed in a tertiary university hospital and consisted of infants operated for isolated PDA between January 2008 and November 2012. Very low birth weight infants (birth weight of lower than 1500 g) with a PDA were considered to be eligible. Exclusion criteria were as follows: concomitant congenital cardiac abnormalities including atrial septal defect, ventricular septal defect, tetralogy of Fallot, atrioventricular septal defect, transposition of great arteries or interruption of the aorta. Between the dates given, a total of 36 infants underwent surgical closure of isolated PDA in our facility. Among them, 14 infants (8 boys, 6 girls; mean age 19.7±9.6 days; range, 4 to 38 days) with a mean birth weight of 1201±252 g (640 to 1500 g), and a mean gestational age of 29.14±2.07 weeks (range, 25 to 34 weeks) were considered to be eligible for the present study (Table 1).

Preoperative echocardiographic findings included a mean LA/Ao ratio of 1.37±0.16 and a mean PDA size of 2.12±0.35 mm. In patients with severe symptoms and contraindications to medical treatment or in those in whom medical therapy failed, surgical closure was performed. Prophylactic closure was also another indication which we used for one patient.

All of the operations were performed under general anesthesia (inhalated sevoflurane and intravenous fentanyl protocol with neuromuscular blockade) by a single surgical team with the participation of an experienced senior pediatric cardiac surgeon. The infant was placed in right lateral decubitus position. Surgical anti-sepsis and appropriate dressing were performed. A left posterolateral thoracotomy was performed and the left lung was retracted. Patent ductus arteriosus was easily able to be visualized in all cases and closed by double ligation by using thick ligature of plaited silk in nine patients by Ligaclip (Ethicon Endo-Surgery, Cincinnati, OH, USA) in two and by division of the duct with double ligation in three (Table 2). A single chest tube of 12 or 16 Fr was placed before skin closure. Patients were transferred to pediatric cardiac surgery intensive care after the operation. There was no specific medication after surgery except antibiotherapy.

The primary outcome measure was in-hospital death from any cause and included procedural failure (i.e. unsuccessful closure), bleeding, hemothorax, pneuomothorax, respiratory distress, need for prolonged mechanical ventilation, revision surgery, low cardiac output syndrome, acute renal failure (serum creatinin >35 μmol/L or urine output <1 mL/kg/h), chylothorax, phrenic nerve paralysis and neurological complications. All patients underwent echocardiographic examination following the operation and the outcome data were collected by an independent pediatric cardiologist.

Continuous parameters were expressed in the mean (min.-max. values) and categorical variables were represented in number/total number.

RESULTS

The mean operation time was 70.4±18.8 min, the mean mechanical ventilation time was 10.6±7.4 h, the

Table 1
Demographic data of the patients (n=14)

	Mean±SD	Range
Birth weight (g)	1201±252	640 to 1500
Gestational age (weeks)	29.1±2.1	25 to 34
Operation day after birth (days)	19.7±9.6	4 to 38

SD: Standard deviation.

Table 2
Surgical procedures

Procedure	n	%
Double ligation	9	64.28
Ligaclip	2	14.28
Division + double ligation	3	21.42

Table 3
Pre- and posttreatment complications

	n	%
Pretreatment complication		
Acute renal failure	3	21.42
Necrotizing enterocolitis	3	21.42
Thrombocytopenia	2	14.28
Intraventricular hemorrhage	1	7.14
Posttreatment complication		
Surgical complication	0	0
Reintubation	2	14.28

mean intensive care unit stay was 7.4 (range, 1 to 38) days, and the mean hospital stay was 12.8±11.5 days.

At baseline, all patients received indomethacin as a standard three dose regimen (0.2 mg/kg in 12 h intervals during 48 h period) by intravenous route and three were also given ibuprofen (10 mg/kg in 12 h intervals during 48 h period) by peroral route; however, none achieved closure of the duct. Before the operation, three patients had acute renal impairment, one patient had intracranial hemorrhage, and two patients had thrombocytopenia (Table 3).

There was no in-hospital death. Secondary outcome measures were those related to surgery. Reintubation rate was 14.28% (n=2) and these two patients were extubated after one and seven days of reintubation, respectively. This complication was likely resulted from the immature respiratory system of the patients. The mean amount of 24 h bleeding was 12.5±7.5 mL and the mean blood transfusion amount was 0.048±0.014 units. Postoperative echocardiography revealed no residual flow of PDA.

DISCUSSION

We achieved satisfactory surgical outcomes in low birth weight infants operated for isolated PDA. Fragility of the tissues and also duct is a challenge on a low birth weight infant compared to a normal weight one. We paid attention to this severe complication, although we did not use ligation technique when the duct appeared fragile and hard to ligate.

In preterm infants, PDA can be challenging to manage and definitive treatment is either achieved by pharmacological means or surgery. Traditionally, intravenous indomethacin has been considered and a variety of dosing regimens have been proposed.[5] Additionally, ibuprofen, another cyclo-oxygenase inhibitor, can be as effective as indomethacin with fewer side effects.[10,11] In our institution, we used indomethacin preoperatively. As intravenous form of ibuprofen was not easily accessible, peroral administration was applied in three patients. When medical therapy fails or congestive heart failure occurs, surgical closure of PDA may be necessary.

If hemodynamically significant PDA is unable to be closed or becomes significantly smaller despite medical therapy, surgical closure is often considered.[12,13] Surgery is also performed, if there are contraindications to pharmacological treatment.[14]

Patent ductus arteriosus can be closed via thoracotomy, sternotomy or minimally invasive techniques.[15] Minimally invasive procedures may be feasible in even premature babies[16] which seems to be equally safe, although it is more time-consuming. However, left thoracotomy, if applicable, is the most common approach for isolated PDA in particular. We perform posterolateral thoracotomy in all our patients with isolated PDA.

Surgical closure of PDA can be achieved through left posterolateral thoracotomy, left anterolateral thoracotomy or midline sternotomy. Closure technique of PDA includes ligation, division, closure from inside the pulmonary artery or patch closure under cardiopulmonary bypass, ligaclip occlusion, transcatheter closure or video-assisted thoracoscopic surgery.[8]

Prophylactic surgical ligation is a method particularly in extremely low birth weight infants for the prevention of mortality and morbidity; however, this procedure remains an area of controversy. We used this technique for only one patient who was on fourth day of birth.

Furthermore, minimally dissection is recommended to preserve intact tissues. After careful evaluation we preferred double ligation in our institution. On the other hand, surgical complications including bleeding, recanalization, recurrent laryngeal nerve injury, chylothorax, and pneumothorax are uncommon.

In conclusion, despite the shortcomings of retrospective design, we suggest that surgery may be well-tolerated for isolated PDA in very low birth weight infants with good results if the first-line treatment by indomethacin or ibuprofen fails.

Declaration of conflicting interests

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