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Case Series

Outcomes of Surgical Management for Patent Ductus Arteriosus in Infants in Nigeria

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Background: *Patent ductus arteriosus is a common cardiac anomaly in infants that, if untreated, is associated with high morbidity and mortality rates. In lower-middle-income countries, such as Nigeria, obtaining cardiovascular surgical care for infants remains difficult. In recent years, especially with the assistance of international voluntary cardiac organizations, efforts have increased to provide cardiac surgical services to this underserved population.*

Methods: *In this case series, the authors describe outcomes in 30 infants surgically treated for patent ductus arteriosus between 2013 and 2019 at an emerging cardiac center in Nigeria (9 male [30%] and 21 female [70%]; mean [SD] age, 8.2 [3.01] months; mean [SD] weight, 5.3 [1.52] kg; mean [range] weight deficit, 34.5% [15%-60%]).*

Results: *All the infants presented with patent ductus arteriosus as the main cardiac lesion, and 4 (13%) were syndromic. The mean (SD) patent ductus arteriosus diameter was 4.73 (1.46) mm. Surgical closure was completed in 29 infants; 1 died before surgery. No procedure-related deaths occurred, but 2 cases of trivial residual patent ductus arteriosus were recorded.*

Conclusion: *Overall, surgical outcomes were excellent, with acceptable mortality rates. Perioperative care will continue to improve as the center is built to a self-sustaining capacity. Findings of this research at this emerging cardiac center in a developing country are a testament to the positive contribution made by international voluntary cardiac missions.* ***(Tex Heart Inst J. 2022;49(6):e217633)***

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Patent ductus arteriosus (PDA) constitutes between 10% and 15% of all congenital cardiac lesions among children, making it the second or third most common.[1-6] The effects of PDA on infants and young children vary. When the lesion is large, its hemodynamic effects lead to presentation in infancy, recurrent respiratory tract infections, frequent hospitalizations, delayed developmental milestones, failure to thrive, and a high risk of mortality if untreated.[7] Despite tremendous advances in the management of PDA—from Gross'[8,9] previous work in the early 20th century to the emergence of video-assisted thoracoscopic surgical closure, device closure, and robotic surgery[10-13]—cardiovascular surgical services in many developing countries such as Nigeria remain underdeveloped, particularly for children.

In recent years, with the help of international voluntary cardiac organizations, efforts have increased to provide cardiac surgical services to children in lower- to middle-income countries,[14-16] with the goal of building self-sustaining centers.[17] At major centers worldwide, using a percutaneous device or video-assisted thoracoscopic surgical closure has become the standard method for obliterating the patent arterial duct, particularly in older children and infants weighing more than 5 kg. Open surgical closure is reserved for infants of lower-weight and preterm neonates.[18-20] With the refinement of device types, successful percutaneous device closure has been achieved in preterm infants and infants with very low birth weight.[21-23] However, neither patent arterial duct closure method is readily available in most developing countries. In some locations

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where device closure has been attempted, the overhead cost was found to be high. However, the cost was often canceled out by other advantages specific to device closure.[24,25] As a result, the open surgical technique is used in most lower- and middle-income countries where such services are available.[26,27] No substantial difference has been observed between open surgical closure or other methods in the successful obliteration of the patent arterial duct.[28-30]

This case series reports on the researchers' experience with the surgical treatment of PDA in term infants at an emerging cardiac center in Nigeria. Although the surgical closure of PDA was performed for several years prior at the center that was studied, most of those cases involved older children and young adults.[31]

Patients and Methods

This case series included each consecutive term infant who presented with PDA and underwent surgical closure of the duct at the National Cardiothoracic Center of Excellence at the University of Nigeria Teaching Hospital, Ituku/Ozalla, Enugu, Nigeria, between June 1, 2013, and May 31, 2019. Information was gathered using a structured form and included the patient's age at presentation (in months), birth weight, sex, weight at presentation, weight deficit percentage (based on the predicted weight corresponding to the 50th percentile for age, with the obtained weight being subtracted from the expected weight and the deficit expressed as a percentage of the expected weight),[32] PDA diameter, associated noncardiac anomalies, and surgical outcome. The inclusion criteria were term gestation and a primary presentation of isolated PDA. Infants with PDA and associated noncardiac anomalies were included. The exclusion criteria were PDA in all other children older than 12 months, PDA in association with a more predominant cardiac lesion, and PDA closure as an associated procedure or as part of a staged procedure in infants with other cardiac lesions. Preterm infants with PDA were excluded.

Diagnosis

The diagnosis of PDA was confirmed in each patient via transthoracic echocardiography using the SONOS 2000 cardiac ultrasound imaging machine (Hewlett Packard). Images of 2-dimensional echocardiography, color Doppler, continuous and pulsed-wave Doppler, and M-mode for cardiac measurements were taken in diastole. The machine used for this study had a transducer with multifrequency technology (range, 5.5-12 MHz) for children. Younger patients who were not cooperative in the presence of their caregivers or parents were pacified with toys or sedated with a mild short-acting sedative (chloral hydrate), as appropriate. The echocardiographic diagnosis of PDA was made during the study period based on a standard definition.[33] The center team was undergoing capacity and capability skills training for pediatric cardiac catheterization; none of the patients underwent this investigative procedure or had percutaneous device closure.

Medical Management

Preoperative medical optimization in infants included an antifailure regimen and antibiotics, and the patients were stabilized before surgery. Generally, if heart failure remained controlled, the child had no recurrent chest infection, and some appreciable weight gain was observed, surgery was delayed until the infant reached 6 months of age. If the infant continued to be experience intermittent heart failure, have frequent chest infections requiring hospital admission, and exhibit failure to thrive, surgical ligation of the PDA was performed as soon as possible when infection was controlled, even if the infant was younger than 6 months.

Surgical Technique

The operation was performed while the patient was under general anesthesia. In all patients, a central venous line was inserted. An arterial line was only inserted in very ill patients. A pulse oximetry probe was routinely placed on a lower limb in each patient. In all patients, PDA closure was performed via a left serratus-anterior-sparing thoracotomy entering the fourth intercostal space. After mobilization, the duct was temporarily occluded, and the oxygen saturation and blood pressure were monitored. The duct was then doubly ligated with silk suture with or without transfixion, as long as the oxygen saturation did not go below 95% and the diastolic blood pressure increased with a narrowing of the arterial pressure gap. The wound was closed in a standard fashion with or without a chest tube. After the procedure, the patient was admitted to the intensive care unit. As part of the discharge protocol, each patient underwent an echocardiographic reevaluation.

Statistical Analysis

Statistical analysis was performed using SPSS version 21 (SPSS, Inc). Data were presented as the mean (SD), a percentage, or median (range). Univariate analysis of categoric data was performed using the Fisher exact test. Continuous variables were analyzed using a Student *t* test.

Ethical Clearance

This research project was reviewed and approved by the University of Nigeria Teaching Hospital Health Research Ethics Committee (approval number: NHREC/05/01/2008B-

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FWA00002458–1RB00002323) on December 4, 2020.

Results

During the study period, 54 children presented with PDA at the center. Of those, 30 (56%) were infants ranging in age from 3 to 12 months; the other 24 children were excluded because of age. All infants had been delivered at term. Patient demographics are shown in Table I. Five (17%) of the 30 infants had other associated noncardiac congenital anomalies, of which 4 (80%) were syndromic, with congenital rubella syndrome accounting for 2 (40%) of those. Although delivered at term, 3 infants (10%) had a low birth weight. Six (20%) of the infants had hemodynamically insignificant non–duct-dependent cardiac anomalies, of which patent foramen ovale was predominant (Table I).

All infants were symptomatic at presentation. The main symptoms reported were recurrent respiratory tract infections with associated breathlessness, failure to thrive manifesting as poor weight gain and weight deficit for age, and delayed developmental milestones. The weight deficit was severe (ie, ≥40% deficit of expected weight) in 9 (30%) of the infants, particularly in those presenting before 6 months of age (42.9% in this age group). The smallest patient was a 3.5-month-old female infant delivered at term with a birth weight of 2.2 kg who weighed only 2.5 kg at presentation. This weight deficit, which is calculated from the expected 50th percentile weight of an age- and sex-matched population, was substantial in infants with PDA. Eight (27%) of the infants presented before 6 months of age, with the youngest being a 3-month-old female patient with recurrent chest infections and intractable heart failure. All of the infants had a moderate to large PDA with dilated left atrial and left ventricular chambers and dilatation of the main pulmonary artery and its branches (Fig. 1). Functional mitral regurgitation and occasional aortic regurgitation were also observed.

TABLE I. Demographics of Infants Presenting With PDA (n = 30)

Male, No. (%)	9 (30)
Female, No. (%)	21 (70)
Male:female ratio	1:2.3
Birth weight,[a] mean (SD), kg	3.03 (0.52)
Weight at presentation, mean (SD), kg	5.3 (1.52)
Weight deficit of expected, No. (%)	
≥40%	9 (30)
<40%	21 (70)
Age at presentation, mo	
Mean (SD)	8.2 (3.01)
≤6, No. (%)	8 (27)
>6, No. (%)	22 (73)
PDA diameter, mean (SD), mm	4.73 (1.46)
Associated noncardiac congenital anomalies, No. (%)	5 (17)
Syndromic[b]	4 (80)
Nonsyndromic	1 (20)
Associated non–duct-dependent minor cardiac anomalies, No. (%)	6 (20)
Patent foramen ovale	3 (50)
Hemodynamically insignificant ostium secundum ASD	2 (33)
Hemodynamically insignificant VSD	1 (17)

ASD, atrial septal defect; PDA, patent ductus arteriosus; VSD, ventricular septal defect

[a] 3 infants had low birth weight (2.2 kg, 2.26 kg, and 2.3 kg).

[b] These were 2 cases of congenital rubella syndrome, 1 trisomy 21, and 1 anomaly that could not be characterized.

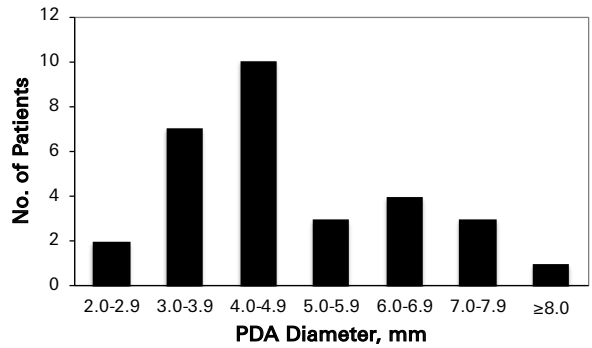

Fig. 1 *Echocardiographic estimation of PDA diameter in infants.*

PDA, patent ductus arteriosus

TABLE II. Outcomes of Surgery in Infants With PDA

No. (%) operated	**29 (97)**
Method of closure, No. (%)	
Ligation plus transfixion	17 (59)
Ligation alone	12 (41)
Blood transfusion, No. (%)	1 (3)
Chest tube insertion, No. (%)	
Yes	26 (90)
No	3 (10)
ICU stay, mean (SD), h	44 (30.13)
Postoperative residual PDA, No. (%)	2 (7)
Hospital stay, median (range), d	6 (4-38)
Mortality[a]	3 (10)

ICU, intensive care unit; PDA, patent ductus arteriosus

[a] There were no deaths related to the surgical procedure.

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One 6-month-old infant died of infective endocarditis before surgery. The outcomes for the 29 infants who underwent surgery are shown in Table II. One patient required an intraoperative blood transfusion as a result of injury to the pulmonary artery. No procedure-related deaths occurred, although 3 postoperative deaths were recorded in infants aged 6 months or younger. One of these patients died from a recurrent respiratory tract infection on postoperative day 19. The second of these patients died of asphyxiation after a laryngospasm 24 hours after endotracheal extubation; following a difficult intraoperative intubation and the laryngospasm, he could not be reintubated. The third of these patients died 24 hours postoperatively of possible aspiration. She had become breathless shortly after breastfeeding and died before she could be reintubated. Trivial residual PDA shunt was detected on an echocardiogram in 2 patients but resolved within 6 months of follow-up.

Discussion

Nearly 60% of children with PDA present within the first year of life. In this age group, the association between PDA and poor weight gain is so substantial that routine echocardiographic screening should be performed for all infants with failure to thrive, even in the absence of cardiac murmurs. The weight deficit in approximately 30% of the infants is so severe that delaying closure of the PDA, except in the presence of absolute contraindications, confers no benefit.

Regardless of PDA size, the presence of symptoms during infancy is an indication for closure after medical stabilization. Such PDAs do not spontaneously close. Notably, the infants in this study had moderate to large PDAs with substantial chamber dilatation, supporting the assertion that closure should not be delayed. Despite the fact that the deaths recorded in this study all occurred in infants aged 6 months or younger, the findings of this study showed that early presentation is an indicator of disease severity, advocating for early, expeditious closure. Moreover, the causes of death were postoperative, were not directly related to the surgical procedure, and could have happened at any age. If, however, the infant is not experiencing recurrent heart failure and has no recurrent chest infection or failure to thrive, a case may be made for delaying closure until the infant is aged 6 months. For emerging cardiac centers in low- and middle-income countries, the guidelines provided by the Indian Working Group on the closure of isolated PDA are useful.[34] Although the 10% hospital mortality rate recorded among those who received surgery in this study was high, this was not directly related to the surgical procedure but rather to the usual problems encountered in an emerging cardiac center, especially with infant care. Improvement in the perioperative care of infants is expected to continue, which should result in a drop in mortality rates.

Approximately 10% of infants with isolated PDA are syndromic; congenital rubella is the most common of those. Observations similar to those reported here have been noted by Otaigbe et al,[6] particularly with respect to the larger PDA diameter in the 2 infants with congenital rubella in the present study. Whether congenital rubella is associated with a larger PDA diameter remains undetermined. Congenital rubella is preventable with the routine immunization of girls before the age of childbearing potential. Unfortunately, although this vaccine is available in Nigeria, it is not part of the National Immunization Program, despite the nation's high serologic prevalence of rubella.[35,36] Because of the substantial burden of caring for a child with congenital rubella syndrome, a case may be made for routine immunization against rubella in girls before the age of childbearing potential as a preventive measure.

Limitations

A limitation of this study was the small number of cases. This was because only patients referred to and examined by pediatric cardiologists were enrolled. The authors believe that if more infants presenting with failure to thrive had been referred for echocardiographic investigation, more infants with PDA could have been identified and surgically treated.

Conclusion

Patent ductus arteriosus presenting in infants is associated with high morbidity and mortality rates if not surgically closed. This case series showed that surgical outcomes in infants treated with this procedure, even in a developing country, are excellent, with an acceptable mortality rate that will continue to improve as perioperative care advances. When properly performed, surgical ligation leads to excellent results, with trivial asymptomatic residual PDA occurring in only a small percentage of patients. This report from an emerging cardiac center in a developing country is a testament to the positive contribution made by international voluntary cardiac missions. If this practice is sustained and improved upon, it will greatly reduce the unacceptably high infant mortality rate attributable to congenital cardiac diseases in developing countries.

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