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Outcomes of Neonatal Cardiac Surgery in a Tertiary Neonatal Intensive Care Unit in Cairo, a Retrospective Study

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ABSTRACT

Background: Congenital heart disease (CHD) in neonatal population remains a major health problem that requires more attention. Currently, most of the data came from high income countries which can't represent the situation in low-income countries.

Objectives: The aim of the current work was to evaluate in-hospital outcomes of neonates who were admitted to neonatal intensive care unit, Ain Shams University Specialized Hospital (ASUSH) with a cardiac anomaly requiring intervention as their main cause of admission.

Methodology: Electronic medical records of enrolled neonates were retrieved, reviewed, and analyzed over a period of 18 months. The outcomes of in-hospital mortality, length of stay, duration of mechanical ventilation, and postoperative complications were evaluated.

Results: Twenty-nine patients were identified; 10 females (34.5%) and 19 males (65.5%). 82.8% were full terms, with median admission age of 60 days. 65.5% (19/29) patients had coarctation of the aorta (COA). Twenty-eight patients (96.6%) underwent cardiac surgery. 100% of patients with Fallot tetralogy and double outlet right ventricle (DORV) received palliative surgery, while 94.7% (18/19) of patients with COA had corrective surgery. Overall mortality was 6.9% (2/29). Twenty-four patients required postoperative mechanical ventilation (range 1-41 days). 24/29 (82%) had uncomplicated stay, one patient had pneumothorax and four patients (13.8%) had sepsis.

Conclusion: It could be concluded that early outcomes of cardiac surgery in the Intensive Care Unit of Ain Shams University Specialized Hospital (ASUSH) appear to be satisfactory.

Key words: Neonatal cardiology- Coarctation- Neonatal surgery- Developing countries- neonatal ventilation

INTRODUCTION

Congenital heart disease (CHD) in neonatal population remains a major health problem that requires more attention. Globally, the gap in the developed and the developing world is strikingly wide. While CHD is the second most common cause of childhood mortality in high-income countries (HIC), it is the sixth in Low- and middle-income countries (LMIC) as other problems (e.g., infection and malnutrition) still hold a larger share in childhood mortality [1].

Middle-income countries (MICs) from the Latin America, Middle East and South Asia have impressively augmented their cardiac surgical capacity in the last twenty years but lagging remarkably behind what their populations need [2] and still providing very different qualities of cardiac surgical services for their populations when compared to developed countries [3].

Most of the HIC can maintain an excellent outcome, in spite performing corrective operations early - even during the neonatal period [4]. This has become possible because of continued improvement of surgical techniques, inputs from multidisciplinary teams, and the better understanding of the underlying pathophysiology of diseases [5].

On the other side, and although surgical and postoperative care for CHD is improving, and early mortality has markedly dropped in LMICs, the management of neonates with CHD there remains challenging [6]. Approximately <1.5% of children with CHD receive appropriate interventions for their life-threatening conditions [7].

International humanitarian efforts to improve cardiac care in LMICs have chronically faced frustration by lack of funding, compromised infrastructure of local healthcare systems, inadequate neonatal transport schemes, overwhelming healthcare priorities and critical shortage of medical professionals [8] .Several recent publications and professional associations have started raising awareness about the high prevalence, the cumulation of yet untreated cases and the poor access to cardiac care in developing countries [9].

The sad fact is that 30% of children with complex CHD either die before being diagnosed or remain trapped in a level of care lower than the required and waiting for referral to a highly specialized centre that might never happen [10]. Moreover, simple defects (e.g., atrial septal defects (ASDs), ventricular septal defects (VSDs) are the only realistic pathologies to be considered for treatment [11].

As cardiac surgeries are provided more in HIC, most of the data presents their outcomes, which can't be replicated to LMIC. Currently, there are databases in Europe, Asia and North America, but not in Africa [12].

The aim of the current study was to evaluate the outcomes of neonates who were admitted to neonatal intensive care unit (NICU) of Ain Shams University specialized Hospital (ASUSH), with a cardiac anomaly requiring intervention as their main cause of admission.

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It is important for developing countries to present their results to know the strengths and weaknesses aiming to improve the health service.

METHODS

We conducted a retrospective review of data of all patients (29 babies) admitted to NICU of ASUSH with a cardiac anomaly requiring cardiothoracic consultation and possible intervention as their main cause of admission over a period of 18 months between March 2012 till September 2022.

NICU of Ain Shams University Specialized Hospital (ASUSH) is a tertiary neonatal unit with annual admissions of approximately 150 patients. It offers specialized medical and surgical neonatal services (e.g., access to catheter lab, point of care ultrasound and MRI). It provides pre and post operative surgical care in variable specialties (cardiothoracic, neurosurgery, general neonatal surgery, and orthopedic surgery).

Electronic medical records and registration data of enrolled neonates were retrieved retrospectively and analyzed. Lab and radiology results including echo cardiography, multi slice CTs were reviewed. These data included:

A. Personal and perinatal history (weight, gender, gestational age, maternal illness or medication, age of presentation, referral circumstances).
B. Cardiac surgery: Diagnosis, surgical intervention (conservative or operation), type of operation, Echo findings, multi slice CT findings, timing of surgery, preoperative medications e.g., prostacyclin
C. Outcomes: Mortality before and after surgery, length of NICU stay, any complication, need for mechanical ventilation.

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Inclusion criteria:

Only patients who had a congenital heart disease were included in the study.

Exclusion criteria:

Neonates who have missing key clinical data (e.g., type of surgical intervention, surgical diagnosis, outcome) from their notes will be excluded.

Ethical consideration:

The study approved by the ethical committee of Ain Shams University before the start of the study. Informed consent was taken from the patient's caregivers. All patients' identifying information were sealed and coded to preserve confidentiality. The study was concordant with the code of ethics for human studies "Declaration of Helsinki".

Statistical Analysis

Statistical Package used was Social Science (IBM SPSS) version 23. For quantitative data, mean, standard deviations and ranges were used when parametric, and median and inter-quartile range (IQR) when non-parametric. For presenting qualitative variables, as number and percentages were used. The comparison between groups with qualitative data was done using Chi-square test. The comparison between two groups with quantitative data and parametric distribution was performed using independent t-test. Mann-Whitney test was used to compare two groups with quantitative data and non-parametric distribution. Kruskal-Wallis test was used to compare two or more independent samples of equal or different sample sizes using ranks. Spearman correlation coefficients to compare two quantitative parameters in the same group. Receiver operating characteristic curve (ROC) was used in to determine negative predictive value (NPV), sensitivity, positive predictive value (PPV), specificity and area under curve (AUC) for the studied parameters.

The confidence interval was set to 95% (error accepted was 5%). P-value was considered significant if < 0.05 and: non-significant if p> 0.05.

RESULTS

During the study period, 29 patients were admitted to the unit with a primary cardiac diagnosis as the main cause for admission. Five patients had cyanotic heart disease and 24 had acyanotic heart disease. Results of analysis are displayed in the next figures (1-3) and tables (1-7).

Table (1) shows the demographic data of enrolled patients. Ten patients (34.5%) were females and 19 (65.5%) were males. The majority of patients were full terms (82.8%) and their median admission age was 60 days (ranging from 1- 240 days).

Table (1): Patients demographic data:

		n= 29
Gender	**Male**	19 (65.5%)
	Female	10 (34.5%)
Gestational age (weeks)	**Mean ± SD**	37.28 ± 1.07
	Range	34 – 39
Term	**Preterm**	5 (17.2%)
	Full term	24 (82.8%)
Weight (Kg)	**Mean ± SD**	4.04 ± 1.21
	Range	2.3 – 6.3
Admission age (days)	**Median (IQR)**	60 (36 – 90)
	Range	1 – 240

IQR: interquartile range

Figure (1) shows that 65.5% (19/29) patients had coarctation of the aorta which was the most common cause of admission while the least were vascular ring and tricuspid atresia (3.4% each).

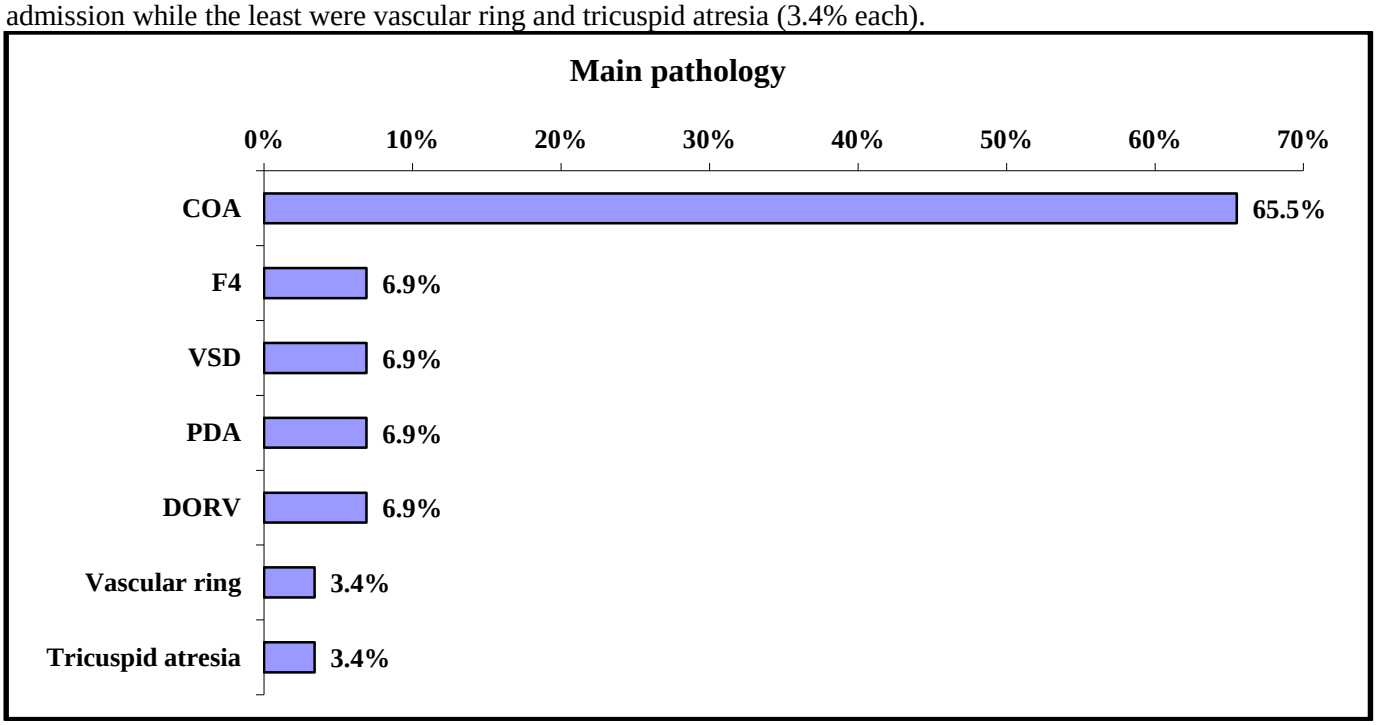

Figure 1: Most detected cardiac anomalies

VSD: ventricular septal defect, COA: coarctation of the Aorta, F4: Fallot tetralogy, DORV: double outlet right ventricle, PDA: patent ductus arteriosus

Table (2) shows that 14/29 patients (48.3%) suffered multiple cardiac anomalies. Twenty-eight patients (96.6%) underwent cardiac surgery, either corrective (21/29 -72.4%) or palliative (7/29-24.1%). Nine patients required preoperative mechanical ventilation (ranging between 1-23 days) while 24 patients required mechanical ventilation post operatively (range 1-41 days). As for complication during stay, 24/29 (82%) had uncomplicated stay, one patient had pneumothorax, four patients (13.8%) had sepsis, and two patients died before discharge, with overall mortality of 6.9% (2/29).

Table (2): Clinical status and data of hospital stay:

		Total no. = 29
Other cardiac anomalies	No Yes	15 (51.7%) 14 (48.3%)
Operation	No surgery Palliative Corrective	1 (3.4%) 7 (24.1%) 21 (72.4%)
Preoperative MV	Not Ventilated Ventilated	20 (69.0%) 9 (31.0%)
Duration of preoperative MV (days)	Median (IQR) Range	2 (1 – 6) 1 – 23
Postoperative MV	Not Ventilated Ventilated	5 (17.2%) 24 (82.8%)
Duration of postoperative MV (days)	Median (IQR) Range	4 (2 – 7) 1 – 41
Length of stay	Median (IQR)	10 (6 – 16)
	Range	4 – 55
Complications	No complication Sepsis Pneumothorax	24 (82.8%) 4 (13.8%) 1 (3.4%)
Outcome	Died Improved	2 (6.9%) 27 (93.1%)

MV: mechanical ventilation

Table (3) shows the possible role of the type of cardiac anomaly in determining the surgical intervention. 100% of patients with cyanotic heart disease (Fallot tetralogy (2/2), DORV (2/2), Tricuspid atresia 1/1) received palliative surgery, while 94.7% (18/19) of patients with coarctation of the aorta underwent corrective surgery. All other diagnoses showed no statistical significance (p>0.05).

Table 3: Correlation between type of surgery and cardiac anomaly:

Main pathology	Surgical intervention		Test value*	P-value
	Palliative	Corrective		
	No. = 7	No. = 21		
COA	1 (14.3%)	18 (85.7%)	12.281*	0.**000**
F4	2 (28.6%)	0 (0.0%)	6.462*	**0.011**
VSD	1 (14.3%)	0 (0.0%)	3.111*	0.078
PDA	0 (0.0%)	2 (9.5%)	0.718*	0.397
DORV	2 (28.6%)	0 (0.0%)	6.462*	**0.011**
Vascular ring	0 (0.0%)	1 (4.8%)	0.346*	0.556
Tricuspid atresia	1 (14.3%)	0 (0.0%)	3.111*	0.078

COA: coarctation of the Aorta, VSD: ventricular septal defect, F4: Fallot tetralogy,; DORV: double outlet right ventricle, PDA: patent ductus arteriosus *: Chi-square test

Table (4) shows a non-significant statistical correlation between admission age and main cardiac pathology (p=0.73).

Table (4): Correlation between age on admission and main pathology:

		Admission age (days)		Test value	P-value
		Median (IQR)	Range		
Main pathology	**COA**	53 (30 – 67)	10 – 210	3.608≠	0.730
	F4	45.5 (1 – 90)	1 – 90		
	VSD	85 (80 – 90)	80 – 90		
	PDA	172.5 (135 – 210)	135 – 210		
	DORV	157.5 (75 – 240)	75 – 240		
	Vascular ring	73 (73 – 73)	73 – 73		
	Tricuspid atresia	180 (180 – 180)	180 – 180		

DORV: double outlet right ventricle ,COA: coarctation of the Aorta, VSD: ventricular septal defect, F4: Fallot tetralogy, PDA: patent ductus arteriosus, ≠: Kruskal-Wallis test

Table (5) shows that neither age on admission, weight or length of hospital stay were correlated to the decision of appropriate surgery either palliative or corrective (p=0.111, p= 0.236 & p=0,150 respectively)

Table 5: Correlation between length of hospital stay, weight and age on admission in determining type of surgical intervention

		Surgical intervention		Test value	P-value
		Palliative	Corrective		
		n: 7	n: 21		
Length of stay (days)	Median (IQR)	15 (8 − 46)	9 (5 − 15)	-1.439≠	0.150
	Range	4 – 55	4 – 30		
Admission age (days)	Median (IQR)	90 (60 − 180)	56 (30 − 73)	-1.594≠	0.111
	Range	1 – 240	10 – 210		
Weight (kgs)	Mean ± SD	4.53 ± 1.50	3.88 ± 1.13	1.212•	0.236
	Range	2.5 – 6.3	2.3 – 6.1		

≠: Mann-Whitney test, •: Inde
pendent t-test, IQR: interquartile range, SD: standard deviation

Using Spearman correlation**, table 6** and **figure 2** show the significant correlation between postoperative MV and length of hospital stay (p=0.000).

Table 6: Spearman correlation between postoperative duration of mechanical ventilation and length of hospital stay

	Length of stay	
	r	P-value
Duration of postoperative ventilation	0.759**	0.000

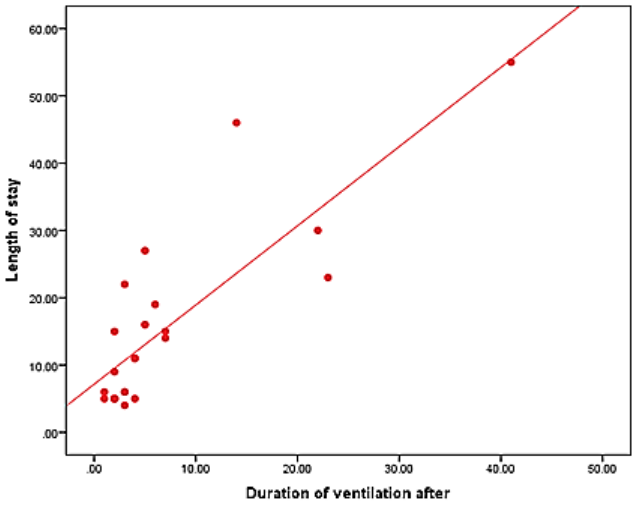

Figure (2): Correlation between postoperative duration of mechanical ventilation and length of hospital stay

Table (7) and **figure (3)** illustrate that for babies enrolled in the current study group, >4 days on mechanical ventilation postoperatively would predict a hospital stay for at least 2 weeks, with 92.3% specificity and 80% sensitivity.

Table (7): Receiver operating characteristic curve (ROC) for the cut-off point of length of hospital stay and post operative duration of ventilatory support

Cut off point	AUC	Sensitivity	Specificity	+PV	-PV
>4	0.862	80.00	92.31	88.9	85.7

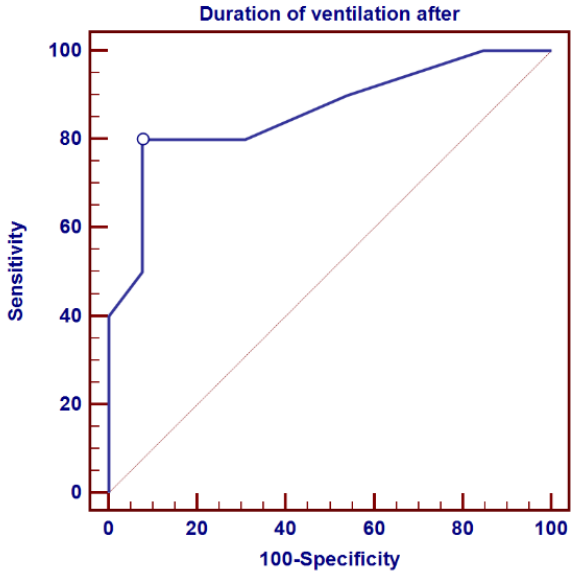

Figure (3): Receiver operating characteristic (ROC) curve for predicting length of hospital stay from duration of mechanical ventilation

DISCUSSION

The current study was aimed to review the early outcomes from cardiac surgeries in neonates and infants, admitted with CDH requiring surgical intervention, over a period of 18 months in a single tertiary neonatal centre in Cairo, Egypt. The study included 29 patients admitted to the unit with a primary cardiac diagnosis as the main cause for admission.

In the current study, the in-hospital mortality was 6.9%, a relatively low number when compared to the usual figures from developed countries.

On the same line, ***Hu et al.*** [13] conducted a retrospective cohort study in large single Chinese centre over a period of 15 years. They reviewed the outcomes of 1,078 neonates who underwent cardiac surgeries. Their overall in-hospital mortality was 16.3% but was notably reduced in the more recent years of the study. They attributed the high mortality to low weight at time of surgery, poor general condition, need for complex surgical intervention, and limited surgeon experience.

Furthermore, ***Bakashi et al.*** [14] reviewed the records of 330 babies who received a cardiac surgery for their CHD in large tertiary paediatric cardiac facility in India, between 1999 and 2006. They reported a drop of the overall mortality from 21.4% before 2002 to 4.3% after 2002 with an overall mortality 8.8%.

In the current study, 65.5% (19/29) patients had coarctation of the aorta (COA), while the least common were vascular ring and tricuspid atresia (3.4% each). 100% of patients with cyanotic heart diseases received palliative surgery, while 94.7% (18/19) of patients with COA underwent corrective surgery.

Likewise, ***McElhinney et al.*** [15] reported that corrective cardiac surgery couldn't be provided safely in the neonatal period and even in the first year of life. For that reason, palliative procedures are widely accepted as the treatment of choice despite being imperfect and having high risk of mortality.

Additionally, ***Jacobs, et al.*** [16] reported that the severity of cardiac defects together with the complexity of surgical procedures are considered a more significant predictors of early deaths following cardiac surgery in neonates when compared with other risk factors like low birth weight and gestational age.

Furthermore, ***Ashraf et al.*** [17] in their systematic review reported that uncorrected coarctation shrinks life expectancy to 30-40 years, with causes of death including aortic rupture, heart failure, intracranial bleeding, and bacterial endocarditis.

Moreover, in a retrospective study from India, ***Shukla et al.*** [18] included 200 neonates to evaluate early outcomes from neonatal cardiac surgery. They found the most common diagnoses were total anomalous pulmonary venous circulation (TAPVC), aortic malformations and transposition of great arteries (TGA). Their overall mortality rate was 13.5% with significant association with shock, number of needed inotropes, and deep hypothermic circulatory arrest time. Further logistic regression analysis showed that duration of invasive ventilation and residual cardiac defect were independent predictors of mortality.

In the current study, the majority of patients were full terms (82.8%) and their median admission age was 60 days (ranging from 1- 240 days). The correlation between admission age or patient's weight and main cardiac pathology was shown non to be non-significant ($p=0.111$ & $p=0.236$ respectively).

Additionally, ***Alradi*** [19] reported that neither age or weight were significant predictors of death before discharge or prolonged hospital stay in patients with CHD unless they have genetic abnormality.

However, ***Costello et al.*** [20] found that incidence of complications and duration of postoperative hospital and ICU stay were significantly higher for babies born at 37- and 38-weeks' gestation compared to those born at 39.5 weeks. Late-preterm (34–36 weeks' gestation) also had higher mortality and longer postoperative duration of stay.

Additionally, ***Anagnostopoulos*** [21] reported that patients with lower birth weight had a higher odd of palliation and lower probability to use of cardiopulmonary bypass (CPB). They mentioned also that they are more prone to longer postoperative ventilation, and hospital stay.

In the current study, 24/29 (82%) had an uncomplicated stay. One patient had pneumothorax, four patients (13.8%) had sepsis, and two patients died before discharge 6.9% (2/29). The median hospital stay was 10 days ranging from 4- 55 days. It was estimated that more than 4 days on mechanical ventilation postoperatively would predict a hospital stay for at least 2 weeks, with 92.3% specificity and 80% sensitivity.

Along the same line, in their 10 years retrospective study -in a large tertiary centre from Saudi Arabia-, ***Alassal et al.*** [22] reviewed 1155 cardiac surgeries in children; of which, 136 were performed in neonatal period. Among the post operative complications, they reported the need for post operative extra corporeal membrane oxygenation in 11 (8.1%) patients, 4 (2.9%) patients had complete heart block and overall mortality was 11%. The median postoperative duration of assisted ventilation, and length of hospital stay were 6 and 24 days, respectively.

Furthermore, ***Wheeler* et al.** [23] found that prematurity, respiratory distress, sepsis, preoperative inotropic support, and postoperative infection were all among the predictors of prolonged hospital stay for babies recovering from arterial switch operation.

Additionally, ***Bakashi et al.*** [14] found that predictors of early outcomes were age less than 7 days at time of operation, postoperative infection, reintubation, need for cardiopulmonary bypass and hospital stay of more than 10 days.

On the other hand, ***Tabib et al.*** [24] enrolled 300 paediatric patients recovering from cardiac surgeries in Iran to assess the possible predictors of post operative mechanical ventilation. They concluded that postoperative mechanical ventilation data can't be

generalized and that mechanical ventilation as predictor to outcomes are mostly specific for each centre, opening the door for quality improvement studies.

Study limitations:

This study has the limitations of observational studies, that correlation doesn't necessitate causation. Moreover, there was paucity of patients who had congenital cyanotic heart disease and long term follow up. However, all patients admitted were included in the analysis with no exclusion.

CONCLUSION

It could be concluded that early outcomes of cardiac surgery in the Intensive Care Unit of Ain Shams University Specialized Hospital (ASUSH) appear to be satisfactory. Studies enrolling larger number of patients with variable congenital heart defects would provide a better insight about the care of complex cardiac patients in developing countries.

Conflict of interesting:

Authors indicate no conflict of interesting.

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