Paediatric Cardiac Anaesthesia Perspective in Komfo Anokye Teaching Hospital Kumasi: A 10-year Review

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Abstract

Background: Infant mortality due to congenital malformations has an incident rate of 8 cases per 1000 live births. Due to Africa's inadequate health-care systems, congenital cardiac disease (CCD) remains a paediatric health-care issue. CCD patients undergo an open-heart operation (OHO) at the Komfo Anokye Teaching Hospital (KATH) in Kumasi. **Aim:** This study aimed to compare trends of cardiac anaesthesia protocols before and after 2014 and to assess the efficiency and quality of surgical care provided to children with CCD following the implementation of new cardiac anaesthesia protocols in 2014. **Materials and Methods:** Groups A and B were represented by the years before and after 2014. This was a retrospective study involving 118 patients who underwent OHO under general anaesthesia from 2007 to 2016 after obtaining Institutional ethical approval. **Results:** In Groups A and B, the mean length of hospitalization in days and cardiac care unit stay in days were (6.87 ± 3.51 and 4.20 ± 3.66) ($P = 0.046$) and (3.14 ± 2.37 and 1.96 ± 2.85) ($P = 0.382$), respectively. In Group B, ultrafast track extubations increased from 7.25% to 39.71% ($P = 0.021$), while patients mean mechanically ventilation time decreased by 82.34 ± 11.70–23.48 ± 7.94 h ($P = 0.018$). In the first 48 h, the chest tube's postoperative drainage reduced by 133 ± 28.46–95 ± 20.38 ml ($P = 0.018$) and haemorrhage leading to re-exploration decreased 11.77%–1.50% ($P = 0.019$). After 2014, postoperative haemorrhage, the chest tube's drainage, and re-exploration were statistically significantly reduced by tranexamic acid. **Conclusions:** This ten-year program primarily focused on selecting simple cases and simplifying anaesthesia protocols after 2014. Given the success of our OHO program at KATH Kumasi, there is a need for a paradigm shift to sustain OHO programs in other parts of Africa.

Keywords: Africa, anaesthesia, congenital cardiac disease, open-heart operation

Introduction

Congenital cardiac disease (CCD) is a condition with one or more structural problems in the heart since birth. In the United States (US), CCD affects about 1% or about forty thousand live births per year, with slight variation between many population-based studies. However, the incidence of CCD is as high as 7–13/1000 live births in the Sub-Saharan region of Africa.[1] Whereas in Ghana, the estimated prevalence of CCD is three hundred and seventy-two per million of the population.[2]

Besides CCD, acquired rheumatic heart disease (RHD), is also of great concern among children due to its high prevalence in developing and undeveloped countries. As per the World Health Organization (WHO) report, RHD attacks about 4 million children every year and leads to ninety thousand deaths, different from the developing world. In developing countries, the prevalence of RHD ranges from 4.7/1000 among toddlers to 21/1000 among adolescents.[3] During the next 25–30 years, the low and middle-income countries will confront the RHD due to a flawed health-care system to diagnose and treat streptococcal infection in children early. CCD and RHD together make cardiac care even more

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complex for children in developing countries. According to the current United Nations Development Program data, around seventy million toddlers died before reaching their fifth birth anniversary, most of whom were from Sub-Saharan Africa.[4] With the development in the health-care system, there has been a 50% reduction in the global incidence of preventable child fatalities since 1990. Despite this, noncommunicable diseases such as the CCD mortality rate have not changed in the African continent. Although, as visible from the WHO data, one million three hundred thousand children are born with CCD annually, over 90% do not have any access to medical or surgical cardiac care in Africa.[5]

Four countries in West Africa regularly run open-heart surgeries; these are Ghana (National Cardiothoracic Center [NCTC]–Accra), Nigeria (Obafemi Awolowo University Teaching and Babcock University Hospitals), Cote d'Ivoire (Abidjan Heart Institute–Abidjan), and Senegal (Centre Cardio-Paediatric Cuomo-Dakar). Other West African countries such as Cape Verde, Gambia, Guinea, Burkina Faso, Liberia, Guinea-Bissau, Niger, Togo, and Sierra Leone rely entirely on these four countries for cardiac operations. However, trained health-care professionals and insufficient health-care infrastructure are the main obstacles in the way of open-heart operation (OHO) programs in Africa. Europe and US have one cardiac surgery infrastructure per one million one hundred and fifty thousand inhabitants, but Africa has one cardiac facility for fifty million inhabitants.[6] NCTC in Accra is the only officially accredited center for OHO in Ghana. The Komfo Anokye Teaching Hospital (KATH) has sustained an OHO program for over a decade and moving toward an independent cardiothoracic center.

The Ashanti Region is Ghana's third-largest administrative region, with an estimated 2.3 million population.[7] KATH provides surgical cardiac care to patients from the Ashanti region, other parts of Ghana, and the Economic Community of West African States. This study aimed to compare the efficiency and quality of care provided to OHO patients in KATH before and after 2014. Before 2014, Group A cardiac anaesthesia protocols were compared with new cardiac anaesthesia protocols of Group B. after 2014 protocols, the main focus of our team was to reduce complications and mortalities. We primarily focused on selecting simple cases with a life expectancy of <1–2 years without any corrective procedure. In 2014 protocols, more emphasis was on patients' ultrafast track (UFT) extubation to reduce ventilator-associated complications. In addition, the administration of tranexamic acid (TXA) was recommended in most cases to minimize postoperative haemorrhage. Although insufficient evidence supports tight glycemic control is better for paediatric patients, dextrose was used liberally in the perioperative period after 2014. With new protocols, we decided not to start inotropes in all cases while coming off cardiopulmonary bypass (CPB), and we started using inotropes as per patients' requirements. Expectedly, practicing cardiothoracic anaesthesia in such a resource-constrained environment has unique challenges. We managed our cardiac surgery program for more than a decade despite economic and human challenges. This study aims to characterize the types of cardiac procedures conducted from May 2007 to October 2016, analyze trends before and after 2014, and evaluate the efficiency and quality of health care delivered by cardiac anaesthesiologists in limited-resource settings. We discussed how low and middle-income African countries with limited resources could continue their cardiac surgery program. We believe that a paradigm shift is required to ensure the long-term viability of OHO programs in Africa.

Materials and Methods

This study was a single-center, retrospective chart evaluation of 121 cardiac operations performed from May 2007 to October 2016 at KATH. Institutional approval was obtained from the Research and Development Unit KATH, registration No. RD/CR16/275. KATH is the second-largest teaching hospital in Ghana, having 1264 beds (KATH Annual Report, 2019-20).

This study included 121 paediatric cardiac surgeries performed between May 2007 and October 2016. Patients' records with insufficient information or data were excluded from this study. Each OHO case was given a unique computer-generated code for research purposes. All precautions were taken not to reveal patients' identities and information. The KATH ethics committee waived the need for individual written consent. Instead, permission was taken from the Directorates of Anaesthesia and Intensive Care and Surgery, KATH, Kumasi, to review patient records for anaesthesia and surgical information.

The study aimed to characterize the cardiac operations performed in the last decade and analyzed trends before and after 2014. We compared cardiac anaesthesia protocols used before and after 2014 in a low-resource setting. In new protocols, we focused on reducing anaesthesia-related mortalities and complications. Early extubation of patients to prevent ventilator-associated complications, TXA use for reducing postoperative haemorrhage, moving from tight glycemic control to avoid hypoglycemia, and rational use of inotropes as per patients' requirement to prevent arrhythmias. Routine perioperative data with 32 clinical variables were collected and analyzed. The Shapiro–Wilk test was used to assess the normal distribution of data. Continuous variables were expressed as means, standard deviation, or standard error of the mean in both groups and compared using Student's *t*-test and Mann–Whitney tests, as appropriate. Fisher's exact and Chi-square tests were conducted to compare categorical data. A $P < 0.05$ was considered statistically significant in our study. SPSS (IBM SPSS Statistics for Windows, version 23.0; IBM, Armonk, NY, USA) was utilized as the statistics program.

Results

Overall, 121 patient charts were evaluated, and 118 patients with complete information were included in the final analysis. As described in Table 1, the demographic profiles of the cohort study were comparable. The patients' median age (years), weight (kg), body surface area (m^2) were 5.61 ± 1.05 and 5.69 ± 1.01 ($P = 0.272$), 16.38 ± 0.65

Table 1: Demographic profile

Parameter	Mean±SEM		*P*
	Group A (*n*=51)	Group B (*n*=67)	
Average patient age (years)	5.61±1.05	5.69±1.01	0.272
Average patient weight (kg)	16.38±0.65	17.46±0.69	0.531
BSA (m^2)	0.56±0.11	0.58±0.15	0.349
Sex, *n* (%)			
Male	1 (35.29)	1 (37.31)	0.127
Female	1.83 (64.71)	1.68 (62.69)	

Data presented as means±SEM, a $P<0.05$, was considered statistically significant. BSA: Body surface area, SEM: Standard error of the mean

and 17.46 ± 0.69 (P = 0.531), and 0.56 ± 0.11 and 0.58 ± 0.15 (P = 0.349), whereas gender ratio of male to female in Groups A and B was 1:1.83 and 1:1.68 (P = 0.127), respectively.

As indicated in Table 2 and Figure 1, the types of operations performed at KATH between May 2007 and October 2016 included the closure of atrial septal defect (ASD), ligation of patent ductus arteriosus (PDA), closure of ventricular septal defect (VSD), and repair of double outlet right ventricle (DORV).

2.54% mortalities were reported in paediatric cardiac operations in the last decade. All deaths occurred in group A, representing a mortality rate of 5.88%. The first death was due to cerebral malaria, and the other two were due to ventilator failure, as depicted in Figure 2.

To compare complexity levels of cardiothoracic procedures between both the groups, the Ross preoperative functional classification/NYHA class and Aristotle's comprehensive complexity (ACC) level were employed as described in Table 3. The last decade's mean complexity level of cardiac procedures performed was 7.1, whereas, in Groups A and B, ACC means were 6.9 ± 0.35 and 7.3 ± 0.32, respectively. All operated cases were ACC level 2 (range between 6.0 and 7.9). With the Mann–Whitney test, obtained Z for ACC level, NYHA I, NYHA II, and NYHA III were 1.47, 1.361, 1.483, and 1.362, respectively, showing no difference in the complexity of cases between the two groups (P > 0.05).

Table 4 describes the duration, number, and percentage of inotropes administered in Groups A and B. In Groups A and B, adrenaline was the most frequently infused inotrope (84% and 62%, respectively), while milrinone was the rarely infused inotrope (6% and 4%, respectively). The critical value was 1.645 at α = 0.05, and the observed Z values for adrenalin, milrinone, and dopamine were 2.471, 1.374, and 1.925, respectively, showing significantly less use of adrenaline and dopamine in Group B (P < 0.05). For none inotrope variable, the CL – 95%, Z critical value –1.96, the observed Z values were 2.151, showed a difference between two groups (P < 0.05), but in 1 inotrope and two or more inotropes variables, the observed Z values were 1.248 and

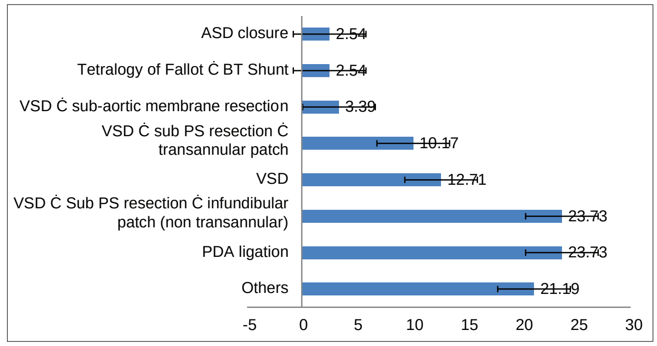

Figure 1: Percentage of cardiothoracic operations performed in the last decade

1.572, respectively, showed no difference between Groups A and B (P > 0.05).

As per UFT protocol, early extubations in Groups A and B were 7.85% and 38.81%, which statistically significantly increased after 2014 in Group B. In the Mann–Whitney test with CL – 95%, the observed Z values for mean postoperative mechanical ventilator support, drainage of a chest tube (first 48 h), and length of hospitalization in days were 2.528, 2.731, and 2.015, respectively, showed a significant difference between Groups A and B (P < 0.05) as described in Table 5. The patients who had re-exploration showed Fisher's exact test, X^2 = 0.0416, P = 0.019, but patients who developed central line infection showed Fisher's exact test, X^2 = 0.577, P = 0.427.

Discussion

In many African countries, cardiac anaesthesia is a subspecialty with a severe shortage, and anaesthesia services are undeveloped.[8] Anaesthesia is a high-tech specialty that relies significantly on monitoring devices and drugs. Many operation theaters in this part of the globe lack essential equipment such as pulse oximeters and medications, which makes providing anaesthesia in such low-resource settings extremely challenging.[6,9]

In Group A, mortality rate was very high (5.88%), forcing us to evaluate our cardiac anaesthesia protocols in 2014. As a result, we adopted new protocols in 2014. The focus of our anaesthesia team was to reduce anaesthesia-related perioperative complications and mortalities with the help of evidence-based medicine (EBM). The critical factor for the success of our OHO program was the selection of appropriate cases as per our experience.[9] Therefore, we selected patients with uncomplicated cardiac abnormalities at the initial stages of our program. As a result, our ACC level was two and mortality rate was 2.5% for the past decade.

In Group A, two patients died due to ventilator failure. However, many studies supported UFT anaesthesia with early extubation for minimizing ventilator-related complications.[10,11] Therefore, we adopted UFT anaesthesia with early extubation protocols from 2014, which resulted in zero mortality in

Table 2: Operations performed in the past 10 years

Type of operation performed	Total number
PDA ligation	28
VSD Ċ sub PS resection Ċ infundibular patch (which was nontransannular)	28
VSD	15
VSD Ċ sub PS resection Ċ transannular patch	12
VSD Ċ sub-aortic membrane resection	4
ASD closure	3
Tetralogy of Fallot Ċ BT Shunt	3
ASD closure Ċ PDA ligation	2
ASD Ċ pulmonary valvulotomy	2
VSD Ċ PFO	2
VSD Ċ Sub pulmonic stenosis Ċ pulmonary valve replacement	2
VSD Ċ DORV repair	2
AP window resection	1
VSD Ċ PDA	1
VSD Ċ ASD	1
VSD Ċ ASD Ċ Sub PS Ċ infundibular patch (nontransannular)	1
VSD Ċ ASD Ċ mitral valve annuloplasty	1
VSD Ċ PFO Ċ PDA	1
VSD Ċ sub-aortic membrane resection Ċ mitral valvuloplasty	1
VSD Ċ pulmonary valve commissurotomy	1
VSD Ċ aortic valve reconstruction	1
Subaortic membrane takedown	1
DORV repair	1
Posterior mitral valve annuloplasty (cosgrove band Ċ closure of mitral valve cleft)	1
Sub pulmonic stenosis resection+transannular patch	1
Partial anomalous pulmonary venous return repair Ċ ASD repair	1
Pulmonary valve commissurotomy Ċ PFO closure	1

Ċ: With, ASD: Atrial septal defect, DORV: *Double outlet right ventricle*, PDA: Patent ductus arteriosus, PFO: *Patent foramen ovale*, PS: Pulmonary stenosis, VSD: Ventricular septal defect, BT: Blalock-Taussig

Table 3: Complexity level of surgeries

Classifications	Group A (n=51)	Group B (n=67)	Z
ACC level (mean±SME)	6.9±0.35	7.3±0.32	1.472
NYHA/ross preoperative functional class (%)			
I	44	37.5	1.361
II	49	57.5	1.483
III	7	5	1.362

*P<0.05 significant, CL-95%, Z critical value-1.96. ACC: Aristotle comprehensive complexity, NYHA: New York Heart Association, SEM: Standard error of the mean

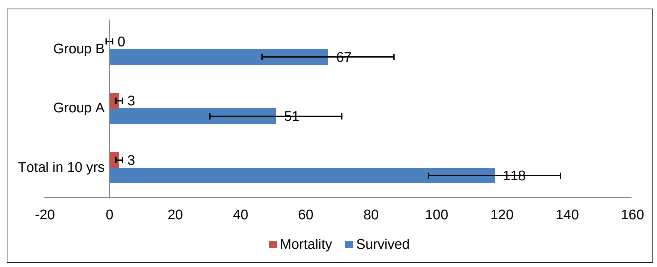

Figure 2: Cardiothoracic surgery mortality rate

Group B compared to a mortality rate of 3.92% in Group A due to ventilator failure.

Blood glucose levels increase during cardiac surgery due to surgery stress or CPB. This hyperglycemia results from insulin resistance and increased hepatic glucose production.[12] Before 2014, we followed tight glycemic control in cardiac surgery patients. When we administered exogenous glucose intraoperatively during paediatric cardiac surgery, there was a rise in blood glucose. However, hypoglycemia occurs when glucose is excluded.[12] About 2% of patients had hypoglycemia due to tight glycemic control in Group A. However, insufficient literature supports that tight glycemic control is better for paediatric patients. Hence, giving a small amount of dextrose-containing solutions in the pre-CPB period seems prudent to evade hypoglycemia without tight glycemic control. As a result, no incidence of hypoglycemia was reported in Group B.

Postoperative haemorrhage is common after cardiac surgery, and it is linked to a higher rate of surgical re-exploration to find the cause of the haemorrhage. These patients often require donated blood, resulting in serious complications such as arrhythmias, sepsis, renal failure, the prolonged need for ventilation, extended hospitalization, and higher mortality.[9] Our anesthetic team's primary goal was to prevent

Table 4: Inotropic drugs infused

Inotropes	Group A (*n*=51)	Group B (*n*=67)	*Z*
Adrenaline	56.72±10.46 h (84%)	22.63±5.72 h (62%)	2.471*
Milrinone	32.58±5.31 h (6%)	36.82±6.41 h (4%)	1.374
Dopamine	13.26±6.57 h (28%)	6.51±3.13 h (13%)	1.925*
None inotrope (%)	9.81	29.85	2.151*
1 inotrope (%)	37.25	38.81	1.248
2 or more inotroeps(%)	52.94	31.34	1.572

*P<0.05 significant, Data presented as means±SD and percentage. SD: Standard deviation

Table 5: Comparison of clinical variables

Clinical variables	Group A	Group B	*P*
UFT extubations (%)	7.85	38.81	0.021*
Mean duration of mechanical ventilator in postoperative period (h)	82.34±11.70	23.48±7.4	0.018*
Mean CCU stay (days)	3.14±2.37	1.96±2.85	0.382
Chest tube drainage (ml) in the first 48 h in the postoperative period	133±28.46	95±20.38	0.017*
Mean LOH (days)	6.87±3.51	4.20±3.66	0.046*
Re-exploration (%)	11.77	1.50	0.019*
Arrhythmia (%)	5.88	1.5	0.081
Central line infection (%)	3.93	1.50	0.427
Hypoglycemia (%)	1.99	0	-

*P<0.05 significant, Data presented as means±SD and percentages. CCU: Cardiac care unit, LOH: Length of hospitalization, SD: Standard deviation, UFT: Ultra-fast track

postoperative hemorrhage and re-exploration in cardiothoracic surgery patients. Several studies have demonstrated that the use of injection TXA in paediatric cardiothoracic surgery efficiently lowers blood loss.[13,14] Therefore, as per EBM, we used 20 mg/kg of TXA bolus after induction of anaesthesia and 20 mg/kg after protamine administration.[13] We started using TXA routinely for OHO in Group B, which resulted in reduced postoperative chest tube drainage from 133 ± 28.46 to 95 ± 20.38 ml (P = 0.17) in Groups A and B, respectively. The re-exploration rate decreased from 11.77% to 1.50% (P = 0.019) in Groups A and B, respectively.

The low cardiac output syndrome is a known complication of cardiac surgery.[15] Inotropic support usually starts while coming off CPB to improve post-CPB ventricular function. Myocardial contractility improves, but myocardial oxygen and energy consumption also increases after initiating inotropic support. Increased contractility of the hibernating viable myocardium in the presence of inotropes causes a mismatch between perfusion and contraction. Furthermore, anaerobe glycolysis activation causes myocardial ischemia and necrosis.[16] Many studies suggested that the aggressive usage of inotropes in the hibernating heart is associated with multiple adverse outcomes. These studies resulted in a debate on the usefulness of inotropes in OHO.[17-19] Therefore, the use of inotropic drugs per-patient with caution was in our 2014 protocol resulted in reduced cases of arrhythmias from 5.88% to 1.5% in Groups A and B, respectively. Furthermore, reduced inotropes number and duration of administration showed a reduction in arrhythmogenesis in Group B. As a result, inotrope management mainly depended on the individual patient and the anesthesiologist's preference.

Conclusions

The surgical procedures performed in the past ten years at KATH were the closure of ASD, ligation of PDA, closure of VSD, BT shunt, and repair of DORV. In this milieu, it provided good palliation for advanced congenital cardiac disorders. The cardiac anaesthesia team worked hard to avoid complications by carefully selecting uncomplicated cases, UFT early extubation, using inotropic drugs with caution on a per-patient basis, minimizing postoperative hemorrhage, and re-exploration by aggressive use of TXA. We brought these changes by revising cardiac anaesthesia protocols in 2014. All these factors contributed to our OHO program's success. Our experience serves as a prototype for others intending to run a program to provide palliative surgical care to children with congenital cardiac disease in low and middle-income countries.

Ethics consideration

This study was conducted after approval by the Research and Development Unit KATH, registration No. RD/CR16/275.

Consent for publication

The authors hereby give consent for the publication of this work under the Creative Commons CC Attribution. Noncommercial 4.0 license.

Availability of data and materials

The data used and analyzed during the current study are available from the corresponding author on reasonable request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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