

Review Articles

Establishing Pediatric Cardiac Intensive Care Unit in a Low Resource Setting: Bangladesh Perspective and Dhaka Shishu (Children) Hospital Paediatric Cardiac Intensive Care Unit Model

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Abstract

Advances in technology and training in paediatric cardiology have improved long-term outcome and promised better quality of life. Bangladesh is facing multitude of health problems and congenital heart disease is one of them. With facilities for accurate diagnosis and scope of complete correction, more and more children are undergoing cardiac intervention and surgical treatment for congenital heart diseases. So there is increasing demand for dedicated personnel for the specialized intensive care of these critically ill children. A dedicated team dictating specialized intensive care has translated into better outcomes in several centers. Over recent decades, specialized paediatric cardiac intensive care has emerged as a central component in the management of critically ill neonatal and paediatric patients with congenital and acquired heart disease worldwide. The majority of developed centers have dedicated paediatric cardiac intensive care units to care for paediatric cardiac patients. In developing countries with limited resources, pediatric cardiac intensive care is yet to take root as a distinctive discipline. Congenital heart surgery, together with transcatheter interventions, has resulted in marked improvement in cardiac care in Bangladesh. So, we need to establish more and more dedicated paediatric cardiac center and cardiac intensive care units to care for paediatric cardiac patients.

Introduction

Like other developing countries, Bangladesh is facing a multitude of health problems. Pediatric heart diseases are one of them. Congenital heart disease (CHD) occurs in 5-8 out of every 1000 live births.^{1,2} Without early recognition, diagnosis and treatment, a

majority of infants and children with CHD die in their first month of life in developing countries.³

The care of children with congenital heart disease has progressed by leaps and bounds in the last 60 years.⁴ With developments in perfusion technology and refinement of surgical techniques, most complex congenital heart malformations can be repaired in the present era. Parallel developments in pediatric cardiology, such as, early diagnosis and rapid stabilization, improvements in imaging, advanced interventional techniques, and newer treatment options for pulmonary artery hypertension and heart failure have also complemented the growth in this field.

Pediatric intensive care grew out of a need for increasingly complex postoperative management, in the face of advances in surgical and medical subspecialties, and the development of sophisticated

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life-support technology. Since the origin of the first dedicated pediatric intensive care units in 1950s, the field of pediatric intensive care has been expanding and sprouting new sub specialties.^{5,6} A number of factors led to the development of the subspecialty of pediatric critical care medicine. Rapid advancement of adult respiratory intensive care, neonatology and neonatal intensive care, pediatric general surgery, pediatric cardiac surgery, and pediatric anesthesiology during 1950s led to the emergence of pediatric critical care.⁷ Over the years hundreds of Paediatric ICU established in academic institution, children hospital and many community hospital worldwide. First dedicated Paediatric ICU of Bangladesh was established in 1994 in Dhaka Shishu (Children) Hospital.

The concept of dedicated pediatric cardiac intensive care units (PCICU) originated from the unique requirements for management of children after cardiac surgery. In the early years of development of congenital heart surgery, pediatric cardiac surgeons have been primarily responsible for postoperative intensive care. Over the past three decades, other pediatric cardiac professionals from cardiology, intervention cardiology, cardiac anesthesia, critical care nursing, respiratory therapy, and others have started to contribute increasingly to the care of these patients. Thus, pediatric cardiac intensive care emerged as a new subspecialty to cater to the unique needs of children with congenital and acquired heart disease.⁸

Though there are large numbers of paediatric cardiac centres worldwide, few papers have been published that describe the components that make up a dedicated cardiac intensive care service.^{9,10} The concept of a PCICU varies widely, ranging from units that are largely managed surgically, to those in which children with heart disease are cared for in a general intensive care environment.^{11,12} This study reviewed the necessity and different elements that seem to be important in the establishment of a PCICU in resource limited country like Bangladesh.

Models of Paediatric Cardiac Intensive Care Unit

In developing nations with limited infrastructure, human, and material resources, pediatric cardiac intensive care is yet to take root as a distinctive discipline. As a result, many models exist. Common model of pediatric cardiac intensive care, is through

a specialized pediatric cardiac intensive care facility located in a children's hospital. The services are provided by a multidisciplinary team that includes pediatric cardiologists, pediatric cardiac surgeons, intensivists, critical care nurses, respiratory therapists, and other support personnel.¹⁰ The second model may be where the pediatric cardiac critical care is a part of a general pediatric intensive care unit.¹³ These models are successfully used to deliver pediatric cardiac intensive care in several well established and large pediatric heart programs in United States, Canada, Europe, Australia and Singapore.¹³

Pediatric heart programs are often attached to well-established adult cardiology and cardiac surgery programs, and PCICU care is sometimes delivered in a common setting with shared space, infrastructure, and personnel. Sometimes it is run by anesthesiologist. In small private establishments, it is delivered by a small group of professionals attached to the surgical unit.¹⁴⁻¹⁶

Necessity of Paediatric Cardiac Intensive Care Unit

Pediatric cardiac intensive care has emerged as a distinct clinical entity. With the advances in technology and training, more and more children are undergoing cardiac interventions and surgical treatment for CHD, so there is increasing demand for dedicated specialized intensive care of these critically ill children.¹³

Cardiac intervention and primary surgical repair during early infancy or newborn period of many congenital heart lesions is now well established.¹⁷ In several centers, where pediatric cardiac care is linked to busy adult surgical programs, health-care professionals trained in adult cardiac care may not be able to provide optimal care for neonates and small infants.

Several studies evaluated the benefits of a dedicated PCICU in the early postoperative outcomes of patients undergoing surgery for CHD and found that establishment of a dedicated PCICU has shown better outcomes in terms of lower blood stream infections, earlier extubation, de-intensification, and discharge from the ICU.^{18,19}

Studies showed that multidisciplinary team approach is vital to a successful pediatric cardiac intensive care program.¹² A dedicated team dictating specialized

intensive care in a defined unit has translated into better outcome.^{16,20-23} The team-oriented focus allows all members of the unit to have intellectual ownership in the heart program and contribute to the care of the child, thus exploiting the full advantage of each discipline.

Basic infrastructure of PCICU in resource limited country

PICU design and equipments: PCICU should be designed to receive children with congenital and acquired heart disease. A 6-10 bed ICU with scope for future expansion is a reasonable start. Proximity to the operating rooms and cardiac catheterization laboratory are desirable for obvious reasons. Easy accessibility to the elevators is mandatory to facilitate transport to and from other areas of the hospital.²⁴ Doctor's room, staff rest rooms, and family waiting areas should also be close to the ICU. The design should also allow provision for at least two isolation rooms, clean and dirty utility rooms, nourishment preparation areas, medication station, narcotic locker, and a refrigerator. A conference room for staff education, conferences, and case discussions is desirable.

The central station should offer good visibility to all patient beds and overhead monitors. Adequate space should be allowed for the doctors and nurses to write case details and order sheets. It should have a central hemodynamic display monitor. Telephone lines and intercom facilities should be available. Beds should be arranged in a manner which allows visibility from a central care station. Patient area in the open PCICU should be 150-200 sq ft.²⁵ There should be adequate space around the bed for accommodating ventilators, syringe pumps, and IV poles. There should be enough space for performing routine ICU procedures. Monitoring equipment can be wall mounted to save physical space, to avoid overcrowding, and to allow easy visibility from a distant care station. Sufficient washbasins should be available to allow frequent hand washing. Oxygen, medical compressed air and vacuum outlets sufficient in number to supply all necessary equipment should meet regulatory standards.²⁴ Backup power supply should be immediately available. The unit should be centrally air-conditioned. In addition, cardiac intensive care units also need specialized equipments like echocardiography machines and portable X-ray machine.²⁶

Medical personnel: A survey of both North American and worldwide paediatric cardiac surgical programmes showed that 73% of North American units and 59% of worldwide units involved care by paediatric intensivists.²⁷ Paediatric cardiac intensivists usually train in either paediatric medicine or anaesthesia as a 'base specialty', with further specialist training in paediatric intensive care and paediatric cardiac intensive care or cardiology. While they clearly must have expertise in the management of congenital and acquired heart disease in children, these intensivists also require expertise in the management of non-cardiac organ failure and the interaction of whole body systems. Their role is to provide supportive care during cardiorespiratory and or multi-organ failure or recovery from surgical interventions.²⁶

In a developing nation, a specially trained pediatric cardiac intensivist is a rarity. Under this circumstance, the leadership for the PCICU should preferably come from a physician trained in one of the pediatric cardiac subspecialties. The intensivist in-charge can be expected to act as a multidisciplinary team leader, coordinating care provided by the members of the team, establishing policies and protocols in collaboration with members of other subspecialties in the team, implementation of the policies and protocols including admission and discharge criteria, provide primary or consultative care for all the PCICU patients along with the physician on call in the ICU, co-ordinate and participate in staff education and research, maintain a database that describes unit experience and performance.^{24,25}

A systematic review analyzing the staffing patterns of ICU has found that the greater use of intensivists in the ICU led to a significant reduction in ICU and hospital mortality and length of stay.²⁸ The Leapfrog group, a United States business consortium of healthcare sector purchasers, had recommended that board-certified, critical care specialists be available during the daytime hours and be able to return to the ICU or arrange for an onsite physician to do so within five minutes of being paged.²⁹ A subsequent literature review by Young et al³⁰ concluded that by recruiting intensivists according to the Leapfrog standards would save approximately 54,000 lives per year in the United States.

A resident medical officer skilled in emergency care to critically ill children with CHD should be present round the clock. Resident medical officer should not

be involved in any other simultaneous responsibilities while on duty in PCICU.²⁵

Nursing staff: Nurses provide a unique contribution to the delivery of care for PCICU patients. Specialized nursing staff are a crucial presence at the patient's bedside for quality of care, and have a strong influence on the rate of preventable adverse events. A study conducted recently demonstrated that 51% of incidents in ICUs are detected by direct observation by nurses versus 27% by monitors.³¹

There should be a senior nurse (Nurse in Charge) for managing critically ill children with CHD. The work pattern should be organized as an 8 or 12 h shift based on the availability of staff nurses in the critical care team. There should preferably be a nurse in-charge for every shift. The ratio of nurses to patients is typically 1:1 or 1:2.³² The nurse-in-charge should be responsible for the nursing program, delegation of roles, and responsibilities to members of the nursing team, implementation of policies and procedures, quality assurance, the provision of supplies and equipment, and staff education and training. The bedside nurse should be entrusted with the care-giving function. He or she should perform repeated clinical assessment of the patient, collect vital information, communicate relevant information to the physician staff and other members of the team, and provide compassionate care to the critically ill child. PCICU nurses should also interact with the family members and participate in patient and family education.²⁶ They should possess basic knowledge about the anatomy and pathophysiology of the common CHD, hemodynamic monitoring of cardiac patients, essentials of pace makers and cardiac pacing, pharmacology of cardiovascular drugs, recognition and management of the common postoperative complications, mechanical support of the heart, diagnosis and management of cardiac arrhythmias, and cardiopulmonary resuscitation techniques.²⁶

Concept of step down beds: Paediatric cardiac patients requiring monitoring and care after recovery from life threatening conditions and after cardiac surgery and cardiac intervention, yet require more monitoring and care than can safely be performed on a general pediatric cardiac ward may be treated in intensive step down beds. The PCICU stepdown beds may exist within the current PCICU location and will therefore be indistinguishable from the current ICU beds.^{33,34}

Staff education: The initiation of staff development and training should begin much before the actual implementation of the program. It would be ideal for a senior member of each of the subspecialties to visit a well-established centre and observe the day-to-day functioning of the unit. Arranging a short period of observation or overseas training can help substantially when a new program is being established with limited resources. Continuing an in-house education programs is vital for all the medical and paramedical personnel in the unit.

Bangladesh perspective

There is wide gap between the developed and developing countries regarding pediatric cardiac care. Absence of pediatric cardiac centers, presence of cardiac centers only in large cities, unstable political systems affecting social stability, and absence of specific health care policies in various countries are the reasons for this variation.³⁵ Due to a lack of resources cardiac care inadequacy cannot be solved within a short span of time. Giving urgent attention to two important reasons for inadequate pediatric cardiac treatment in Bangladesh can change the scenario drastically. These are lack of awareness about CHD and high rate of unsupervised home deliveries because of which CHD are not detected at birth.³⁶

With facilities for accurate diagnosis more and more children are undergoing intervention and surgery. Congenital heart surgery, together with trans-catheter interventions, has resulted in a marked improvement in cardiac care in Bangladesh. Already there are few dedicated PCICUs established in tertiary care hospitals run under supervision of paediatric cardiologist and paediatric cardiac surgeons but very few of them have paediatric cardiac intensivist. But this new subspecialty demands expertise and experience in the pediatric subspecialties of cardiology, cardiac intervention, intensive care, cardiac surgery, cardiac anesthesia, neonatology, and others.

Dhaka Shishu (Children) Hospital Paediatric Cardiac Intensive Care Unit model

The paediatric cardiology unit of Dhaka Shishu Hospital was started in 1988 to provide treatment, control and prevention of childhood cardiac problems. The unit was upgraded as Pediatric Cardiac Centre from January 2012 and Cardiac ICU, as a part of Pediatric Cardiac Centre was started from March 2012. Here the physicians and staff provide comprehensive care

for complex medical and surgical patients. The PCICU is one of only a few intensive care units in the country dedicated exclusively to pediatric cardiac care. The PCICU is equipped to provide the highest complexity therapies and dealing with all aspect of acute paediatric cardiology problems, which include patient care, teaching and research. The multidisciplinary team has a specific cardiac focus and includes cardiologist, cardiac surgeon, intensivist, specialized nurse, as well as specifically trained physicians in pediatric cardiology and critical care medicine. PCICU deals with

- Medical management of patients in all Complex Congenital Heart Disease
- Diagnosis and treatment of arrhythmias
- Treatment of acquired heart disease including cardiomyopathy, heart failure and hypertensive emergency
- Monitoring after cardiac catheterization with interventional procedure
- Comprehensive preoperative and postoperative care

The Cardiology Inpatient Service has 44 active beds available for emergency admission, of which 16 are designated cardiac intensive beds. There are two medical teams to care for the patients in the a) PCICU and b) Ward Service. Patients are admitted to the PCICU from inpatient from Emergency and referred patients from other hospitals. The PCICU is structured as

- **Cardiac Intensive Care Unit (CICU) Service:** PCICU is a 7 bed unit offering comprehensive intensive care management of critically ill paediatric cardiac patients. The level of patient care includes the use of life support systems as well as hemodynamic monitoring. The PCICU is equipped to care for critically ill cardiac patients who have an immediate risk of life threatening conditions. All 7 beds have full electrocardiographic monitoring.
- **Recovery unit:** Recovery unit has 5 beds which deals with post cardiac surgery patients. All 5 beds have full electrocardiographic monitoring. It has option of step down beds which permit continuity of care of patients after surgery. These beds also have full electrocardiographic monitoring.

- **Post cardiac cathlab service:** Post cardiac cath lab has 4 beds and deals with monitoring after cardiac catheterization with interventional procedure.

PCICU model of Dhaka Shishu (Children) is working well with some limitations. It needs more and more dedicated manpower and logistics to care paediatric cardiac patients. Although there has been establishment of pediatric cardiac intensive care services in some other tertiary level hospitals, the time has arrived to promote further enhancement in the country.

Conclusion

Pediatric cardiac intensive care in Bangladesh is still in infancy. The establishment of a pediatric cardiac intensive care unit in a limited resource environment is a major challenge. Delivery of optimal care in the backdrop of limited resources and lack of trained personnel require good teamwork, perseverance, and dedication.

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