MHA MEDIHEALTH ACADEMY

Surgery on Children

Review

doi:10.51271/SOC-0007

The importance and use of defibrillation in pediatric surgery

Nida Kıyıcı

Department of First and Emergency Aid, Vocational School of Health Services, Yozgat Bozok University, Yozgat, Turkiye

Received: 07/06/2024 ◆ **Accepted**: 21/06/2024 ◆ **Published**: 26/06/2024

Cite this article: Kıyıcı N. The importance and use of defibrillation in pediatric surgery. *Surg Child.* 2024;1(2):22-25.

Corresponding Author: Nida Kıyıcı, nidakyc@hotmail.com

ABSTRACT

Pediatric surgery is a complex and intricate medical procedure. Children have unique anatomical and physiological characteristics, which can increase the likelihood of complications during surgical interventions. Instances of sudden cardiac events and cardiac arrest are among the emergencies that necessitate immediate invention, with defibrillation being a crucial tool in such scenarios. Defibrillation is a procedure utilized to address life-threatening arrhythmia such as ventricular fibrillation and pulseless ventricular tachycardia, aiming to restore a normal heart rhythm through the application of an electric shock. In pediatric cases, defibrillation demands meticulous attention to timing and the use of appropriate energy levels to avoid potential harm and ensure effective management of surgical complications.

Keywords: Defibrillation, pediatric surgery, electroshock, pediatrics

INTRODUCTION

Pediatric surgery involves the diagnosis and treatment of congenital or acquired conditions requiring surgical intervention. The role of defibrillation in addressing cardiac arrest incidents in children during surgical procedures underscores the essentiality of defibrillator utilization in surgical setting. Cardiac complications pose significant risks during pediatric surgeries. Cardiac impacting both patients and the surgical team throughout and after procedures. Understanding and effectively managing cardiac issues in pediatric patients are paramount in ensuring successful surgical outcomes and overall patients well-being.[1,2]

COMMON CARDIAC COMPLICATIONS IN PEDIATRIC SURGERY

Pediatric surgical procedurs carry inherent risks due to the distinct anatomical and physiological characteristics of children, with cardiac complications being a primary concern. Anesthesia-related cardiac issues, surgical stress-induced complications, blood loss-related hemodynamic imbalances, and instances of cardiac arrest present critical challenges that can affect the general health and treatment outcomes of pediatric patients.[3,4]

1-Anesthesia-related cardiac complications

Anesthesia plays a vital role in ensuring safe and painless surgical procedures for children but may lead to certain cardiac issues. Bradycardia, hypotension, and arrhythmia are common concerns during pedaiatric surgeries, with precise monitoring and management being essential to prevent adverse effects on the heart and overall health.[3-5]

Bradycardia: It is the abnormal slowing of the heart rate. Children are more sensitive to anesthesia and have an increased risk of bradycardia. The limit values of bradycardia are determined according to age 6:

1. Newborns (0-1 month): <100 beats/minute
2. Infants (1 month - 1 year): < 90 beats/minute
3. Young children (1-3 years): < 80 beats/minute
4. Pre-school children (3-6 years): < 70 beats/minute
5. School children (6-12 years): < 60 beats/minute
6. Adolescents (12-18 years): < 50-60 beats/minute

Hypotension: Low blood pressure may cause cardiac complications during anesthesia. In children, hypotension may cause inadequate blood flow during surgery.[4,6]

Arrhythmia: Arrhythmia is defined as irregular heart rhythm and it is a common complication during pediatric surgery. It can occur as a result of anesthesia or surgical stress and can lead to serious health problems. Accurate and rapid diagnosis and management of arrhythmia is vital in children.[3-5]

2-Surgical Stress and Cardiac Complications

Surgical procedures cause significant stress on the body and this may lead to cardiac complications.[3-5]

Myocardial Ischemia: It is the inability to provide adequate blood flow to the heart muscle. Surgical stress may increase the risk of ischemia by increasing the oxygen demand to the heart.[3-5]

Heart failure: It is a condition in which the heart cannot pump effectively enough during or after surgery. It is especially likely to occur after long and complex surgical procedures.[3-5]

3-Blood Loss and Hemodynamic Imbalances

Blood loss during surgery may cause hemodynamic imbalances and cardiac complications in children.[3-5]

Hypovolaemic Shock: It is a condition that occurs as a result of excessive blood loss. This condition causes the heart not to pump enough blood and the organs not to receive enough oxygen.[3-5]

Transfusion Reactions: Reactions that may occur during blood transfusions may lead to cardiac complications. Children may be more sensitive to transfusion reactions.[3-5]

4-Cardiac Arrest

Cardiac arrest is a condition in which the heart suddenly stops pumping blood. This condition causes the flow of oxygenated blood to vital organs to stop and requires urgent medical attention. Cardiac arrest can occur suddenly and can often be fatal within a few minutes. Symptoms of cardiac arrest include sudden loss of consciousness, respiratory arrest and acrotism. Studies conducted have shown that cardiac arrest during pediatric surgery is more common in children under than 1 year of age, in children who undergo emergency surgery and in children who have American Society of Anesthesiologists (ASA) classification of III and above.[7,8] Rapid and effective intervention is required in this situation; otherwise, life-threatening consequences may occur.

In pediatric surgery, cardiac complications are an important risk factor both after surgery and during postoperative period. Complications may affect the success of surgical interventions and the general health of patients. Identification and management of these complications require the surgical team to be prepared and appropriate intervention strategies to be implemented. Resuscitation is required for the management of cardiac arrest which occurs during cardiac complications.9,10

DEFIBRILLATOR USE DURING SURGERY

Sudden cardiac events that may occur under anesthesia during pediatric surgery necessitate the availability of defibrillators. Research shows that when performed early and correctly, defibrillation increases survival rates in pediatric cardiac arrest cases significantly. In one study, it was found that defibrillation performed at appropriate energy levels produced successful results and decreased complication risks in pediatric patients.[11] For this reason, timely administration of defibrillation requires the surgical team to be trained and prepared. Defibrillation involves the administration of electric shock to normalize the heart rhythm. It should be performed in case of cardiac arrest. Cardiac arrest occurs when the child is unconscious, has no pulse and stops breathing. The four fatal rhythms that may occur during cardiac arrest are ventricular fibrillation (VF), pulseless ventricular tachycardia (nVT), pulseless electrical activity and asystole. In cases of VF and nVT, shock with defibrillator is required.[9,10]

Ventricular Fibrillation (VF)

VF is a condition in which the ventricles of the heart make irregular and rapid contractions. In this arrhythmia, the heart cannot pump blood effectively and rapid defibrillation is required. VF is one of the most common causes of cardiac arrest and may be fatal if not treated urgently.[9-10]

Pulseless Ventricular Tachycardia (nVT)

nVT is a condition in which chambers of the heart contract rapidly but cannot pump blood effectively. Defibrillation is required in this condition when no pulse can be taken.[9-10]

Asystole

It is a condition in which the electrical activity of the heart stops completely and ECG (electrocardiogram) appearance known as “flat line” appears. Asystole is one of the most fatal forms of cardiac arrest and defibrillation is not effective. Treatment occurs through cardiopulmonary resuscitation (CPR) and adrenaline.[9-10]

Pulseless Electrical Activity (PEA/NEA)

NEA is the absence of an effective contraction and therefore pulse, despite the persistence of electrical activity of the heart. NEA can occur due to a variety of underlying causes and treatment involves identification and correction of the underlying causes. CPR and epinephrine administration are required.[9-10]

DEFIBRILLATOR USE AND ADMINISTRATION PROTOCOLS

Defibrillation is performed in accordance with the protocols specified in the guidelines of authorities such as American Heart Association (AHA) and European Resuscitation Council (ERC). In pediatric patients, defibrillation can be performed with an automatic external defibrillator (OED) or manual defibrillator. Defibrillator is used by healthcare professionals. Healthcare professionals should determine the energy level in shockable rhythms depending on the age and weight of the child.

The effectiveness and safety of defibrillation varies depending on the age and weight of the child. Defibrillation can be

administered to all age groups except newborns (0-28 days). However, defibrillation methods and device selection vary depending on age and weight[9,10,12,13]

Infants and young children (1 month-8 years): OED or manual defibrillators may be used in this age group. The use of spoons/pads and settings is recommended while using defibrillators. Manual defibrillators have pediatric spoons placed inside adult spoons. Pediatric spoons/pads provide safe defibrillation by reducing the shock energy.[9]

Older children and adolescents (8 years and older): Adult OEDs and manual defibrillators can be used in children aged 8 years and older. Adult spoons/pads and settings are suitable for defibrillation in this age group.[9]

During the administration of defibrillator, the placement of spoons/pads should be adjusted as sternum-apex. There should be a distance of at least 3 cm between the spoons or pads. If the spoons/pads are not of the appropriate pediatric size for children under 8 years of age, they should still be used, but the placement should be anteroposterior because when placed as sternum-apex, the 3 cm distance between them may not be provided and the spoons/pads may overlap. Spoons should contact the body fully. A weight of approximately 3 kg should be applied to the spoons in children under 10 kg and approximately 5 kg should be applied to the spoons in children over 10 kg. Energy level selections should be administered at the recommended doses according to AHA and ERC guidelines during defibrillation. According to AHA 2020 guidelines, while the first shock is administered as 2 J/kg, it is recommended to administer the second shock as 4 J/kg and the consequent shocks as >4 J/kg. It has been stated that a maximum dose of 10 J/kg or adult dose should not be exceeded. According to ERC 2021 guideline, it is recommended for the first shock to be administered as 4 J/kg, the consequent ones to be administered as 4J/kg and in case of persistent VF/Nvt (>5 shock), the shock dose should be increased gradually. It has been stated that maximum dose of 8 J/kg or 360J value should not be exceeded.[9,10,12-14]

Defibrillator Use Skills[15,16]

1- Preparation of materials

2- If there is wetness or moisture on the child's chest, it should be dried

3- Pediatric size spoons should be removed

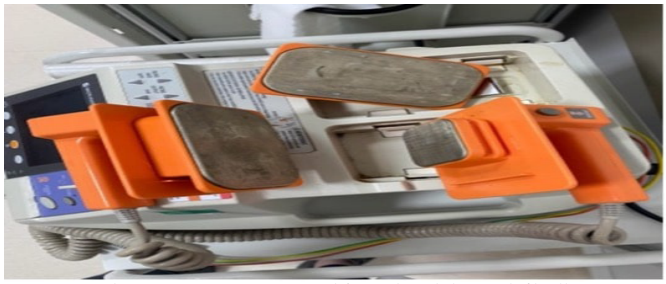

Figure 1. Pediatric size spoons removed from the adult size defibrillator spoons

4- Defibrillator should be switched on from the On/Off button

5- Depending on the characteristics of the monitor, there may be some differences in switching to child mode. The defibrillator is switched from off to on while pressing and holding the button labelled child mode.

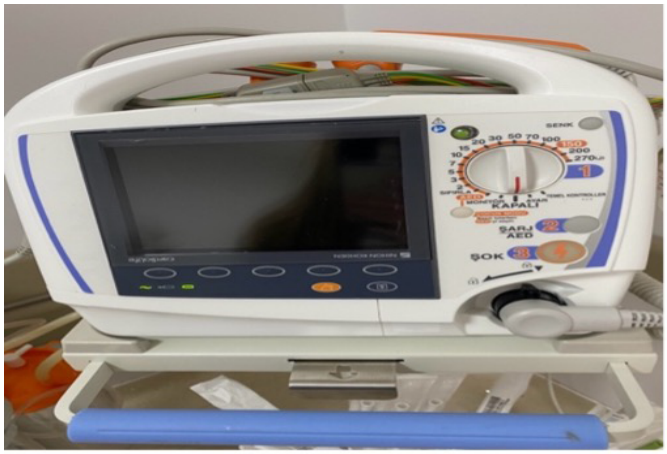

Figure 2. Defibrillator

6- Energy level should be chosen as Joule (J) (in accordance with the recommendations of AHA/ERC guidelines)

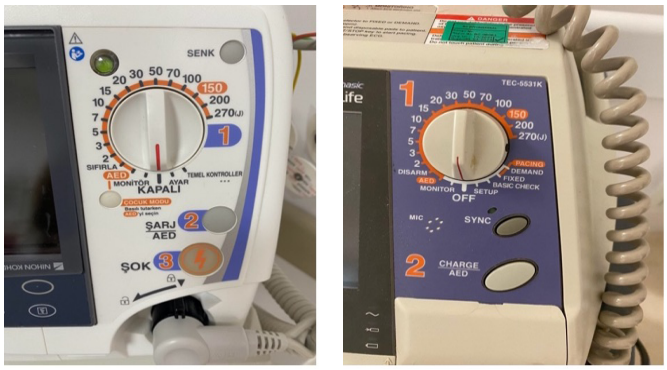

Figure 3. Buttons on the defibrillator

7-The charge button on the defibrillator or also on the spoons is pressed on the defibrillator or on the spoonsto charge it.

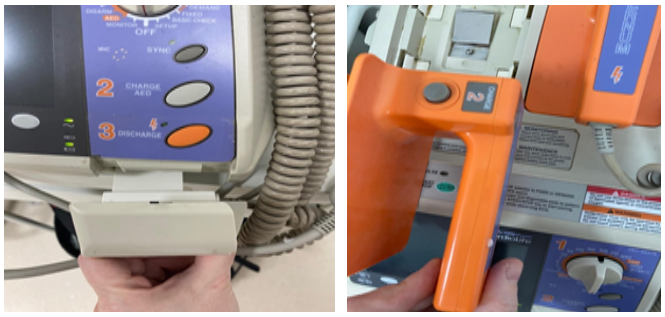

Figure 4. "charge" buttons on the defibrillator and spoons

8- If there are individuals contacting the child, they are sent away.

9- Warnings are made such as defibrillator is being charged, do not contact the child, do not approach.

10- The spoons/pads should be placed as sternum-apex or anteroposterior

11- If pads are to be used, spoons should be removed and pads should be connected to the defibrillator

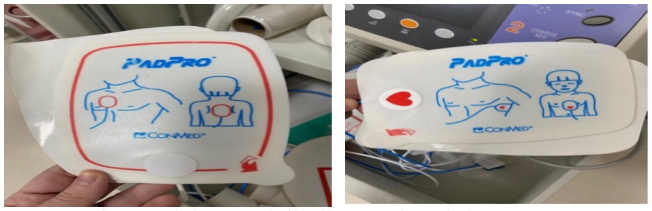

Figure 5. The visual showing defibrillator pads and placement

12- After the defibrillator is charged, make sure that everyone, including you, is not touching the pediatric patient.

13- Energy should be discharged by pressing the discharge button on the defibrillator or the spoons.

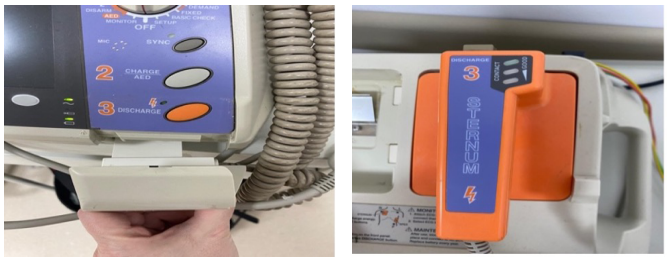

Figure 6. "discharge" buttons on the defibrillator and spoons

14- After giving shock, the spoons should be placed on the defibrillator. If a pad has been used, it should remain adhered to the child's breast.

CONCLUSION

The relationship between paediatric surgery and defibrillation is critical especially in terms of cardiac complications that may occur during and after surgery. Defibrillation is an important tool for the surgical team to intervene immediately and correct administration is vital in terms of improving surgical results.[17] As stated in the literature, the effectiveness of defibrillation practices is directly associated with the preparation of equipment and training of the team. Therefore, pediatric surgery teams should be well-trained and prepared in this regard.[9,10]

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Holcomb GW, Murphy JP, St. Peter SD. Holcomb and Ashcraft's Pediatric Surgery. Elsevier Health Sciences. 2020.
2. Costello, JM. "Predictors of Cardiac Arrest in Pediatric Patients Undergoing Anesthesia." *Anesthesia & Analgesia*, (2011).13(6), 1325-1331.
3. Smith SE, Cote CJ. Cardiovascular complications in pediatric anesthesia.Lerman, J. (Eds.). *Prac Anesth Inf Child*, *Elsevier*. 2015;5:123-145.
4. Grosfeld J, LO'Neill JA, Coran AG. (Eds.). *Pediatric Surgery* (7th ed.). Mosby. St. Louis, MO. 2012.
5. Das BB,heart failure in children and young adults from molecular mechanisms to medical and surgical strategies: Anthony C. Chang, Jeffrey A. Towbin (eds). Saunders Elsevier: Philadelphia, PA, 2006, 800 pp, ISBN: 0-7216-0692-X, *Cardiology in the Young*, 16(2), 200.
6. Cantinotti M, Crocetti M, Murzi B,Marotta M. Pediatric electrocardiogram interpretation: Part I: Age-related interpretation of the normal pediatric electrocardiogram. *J Am Coll Cardiol*, (2016) 17 (6), 399-404.
7. Bharti N, Batra YK, Kaur H. Paediatric perioperative cardiac arrest and its mortality: database of a 60-month period from a tertiary care paediatric centre. *Eur J Anaesthesiol*. 2009 Jun;26(6):490-5. doi: 10.1097/EJA.0b013e328323dac0. PMID: 19300269.
8. Gobbo Braz L, Braz JR, Modolo NS, do Nascimento P, Brushi BA, Raquel de Carvalho L. Perioperative cardiac arrest and its mortality in children. A 9-year survey in a Brazilian tertiary teaching hospital. *Paediatr Anaesth*. 2006 Aug;16(8):860-6. doi: 10.1111/j.1460-9592.2006.01876.x. PMID: 16884469.
9. American Heart Association (AHA) 2020 Guidelines for CPR and ECC. (https://www.heart.org/en/cpr).
10. European Resuscitation Council (ERC) Guidelines 2021. (https://www.erc.edu).
11. Berg MD, Nadkarni VM, Zuercher M, Berg RA. In-Hospital Pediatric Cardiac Arrest. Pediatric Clinics, (2010).57(6), 1267-1278.
12. Atkins, D. L., Berger, S., Duff, J. P., et al. (2020). Part 11: Pediatric Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*, 142(2), 469-523.
13. Maconochie IK, Bingham R, Eich C, et al. european resuscitation council guidelines 2021: *Pediatric Life Support*. Resuscitation, 161, 327-387.
14. Van de Voorde, P., Turner N.M., Djakow J, Lucas, N., Martinez-Mejias, A. et al. European Resuscitation Council Guidelines 2021: *Paediatric Life Support*. Resuscitation.2021;161:327-387. doi:10.1016/j.resuscitation.2021.02.015
15. Cander B. Hastane Öncesi Acil Tıp ve Paramedik. *İstanbul Tıp Kitapevleri*. 2019; 301-312.
16. Usta G. ve Sarı A. Tüm Yönleriyle Kardiyopulmoner Resüsitasyon (KPR) Uygulamaları. *Kongre Kitabevi*. 2020; 151-164.
17. Donnelly LF, Frush DP. "Pediatric Imaging: The Fundamentals". Elsevier Health Sciences. (2010).