Children's Health Orange County (CHOC)
Best Evidence and Recommendations (BEaR)

Best Practice for Post-Operative Thermoregulation in Infants with Congenital Heart Defects

Cynthia Hernandez, BSN, RN, CCRN
Cynthia.Arellano@choc.org
Gina Thomson, MSN, RN, CCRN
GThomson2@choc.org

Abstract

Congenital heart defects (CHD) affect approximately 40,000 births annually, making it the most common birth defect **(**Centers for Disease Control and Prevention, 2024**)**. The care of infants with CHD, particularly after cardiac surgery, presents unique challenges for healthcare teams. Maintaining normothermia in this population is critical, as both hypothermia and hyperthermia, along with rapid rewarming, are associated with increased risks of morbidity and mortality (Xu et al., 2021). Despite the importance of post-operative temperature regulation, many pediatric institutions in the U.S. lack standardized protocols for managing body temperature after cardiopulmonary bypass. In the absence of such protocols, bedside staff are often left to manage thermoregulation on an individual basis, leading to variability in care.

This evidence-based practice project aimed to identify and recommend best practices for post-operative thermoregulation in infants with CHD following cardiopulmonary bypass. A review of the existing literature identified significant gaps in evidence regarding temperature management in this population. In addition to the literature review, consultation with clinical experts and a comparison of protocols across various institutions were conducted to inform best practices. Recommendations for improving post-operative temperature management include enhanced staff education, the use of appropriate transport equipment to maintain normothermia during transfers, and the development of standardized multidisciplinary protocols. These protocols are designed to promote consistent post-operative thermoregulation practices. Implementing standardized thermoregulation protocols for infants with CHD undergoing cardiopulmonary bypass can help maintain normothermia and reduce complications related to temperature fluctuations. These changes aim to improve post-operative outcomes and provide more consistent, evidence-based care for this vulnerable population.

Keywords

Infant, neonate, congenital heart defect, post-cardiopulmonary bypass, temperature, thermoregulation, rewarming, post-operative care, temperature management protocol.

PICOT

In infants with congenital heart disease (CHD) requiring intraoperative cardiopulmonary bypass for surgical repair, what are the best practices for thermoregulation to mitigate complications within the first twenty-four hours post operation?

Background and Significance

Temperature can have significant effects on heart rhythms, circulation, inflammation, infection, and neurological and renal functions (Xu et al., 2021). Deep hypothermia and inadequate rewarming of neonates during the perioperative and post-operative phases have been linked to higher rates of subclinical seizures, strokes, bleeds, and neurological abnormalities (Alkhatip et al., 2021). Additionally, cardiopulmonary bypass and hyperthermia have been shown to increase the incidence of post-operative arrhythmias and electrolyte imbalances (Entenmann et al., 2017). Ultimately, poor thermoregulation and rapid rewarming in neonates are associated with increased morbidity and mortality within the 24-hour post-operative period (Xu et al., 2021). Although there is no universal standard for intraoperative cooling, the literature supports the notion that rapid rewarming in the post-operative period can negate the neuroprotective benefits of intraoperative hypothermia (Starr et al., 2024). Despite the known risks of rapid rewarming, research remains limited, and post-operative temperature management in infants with congenital heart defects is understudied.

At our institution the CVICU is a growing unit with plans for future expansion to accommodate increased acuity and census. As surgical case volume and patient acuity rise, it becomes critical to implement strategies to improve patient outcomes. Currently there is no existing protocol for thermoregulation beyond maintaining normothermia in the first 24 hours post-operatively. Observation and review of selected clinical cases have highlighted the need for more standardized approaches to post-operative temperature management. Given the unit's growth in both census and bedside skill mix, it is essential to take proactive steps toward improving patient outcomes.

Framework

This EBP project utilized the "Translating Evidence into Practice: CHOC's Approach to EBP" model, adapted from the EBPI Model © 2007 Brown & Ecoff (Ecoff, Stichler & Davidson, 2020).

Search Strategies and Databases Reviewed

Databases searched for this review included CINAHL, PubMed and Google Scholar. Key search words: infants, neonatal, congenital heart defect, post-cardiopulmonary bypass, temperature, thermoregulation, rewarming, and complications. This search yielded over 50 articles; 10 of which were relevant to the scope of this project.

Personal communication regarding this topic was sent to top children's hospitals for cardiac surgery across the nation. Responses were received from Lurie's Children's Hospital Chicago, Children's Hospital of Philadelphia (CHOP), Texas Children's Hospital, and Rady's Children's Hospital.

Critical Appraisal and Synthesis of the Evidence

Key Literature:

- STEPP IN: Working together to keep infants warm in the perioperative period (Brozanski et al., 2020).
  - The focus of the study was to reduce post-operative hypothermia in infants.
  - Multiple centers implemented transport protocols and strategies to promote euthermia throughout the perioperative period.
  - Limitations included varied temperature measurement methods used by staff and challenges in collaboration between the multidisciplinary team.
  - A transport protocol was created to prevent heat loss during transport from the OR to the NICU, which included the use of proper transport equipment.
  - The interventions led to a 50% reduction in post-operative hypothermia in infants.

- A Pilot Randomized Control Trial of Safety and Feasibility of a Delayed Rewarming Intervention for Infants Following Cardiopulmonary Bypass Surgery (Craig et al., 2021).
  - This study focused on delayed rewarming interventions, using a blanket warmer to gradually rewarm infants from 35°C to 36.5°C over a 12-hour period after surgery.
  - Key findings included decreased inotropic support, slower heart rates within the first five hours, and reduced chest tube output.
  - The pilot study had a small sample size and included infants with a diverse range of congenital heart defects.

- Targeted Temperature Management Protocol in a Pediatric Intensive Care Unit: A Quality Improvement Project (Prendergast et al., 2021).
  - The goal was to improve temperatures in patients with acute neurological injuries, including post-cardiac arrest.
  - Limitations included inconsistent temperature measurement devices and a lack of temperature interventions charted by nursing staff.
  - A significant takeaway was that implementing an order set increased adoption and documentation by the nursing staff.
  - Additionally, temperature management, anti-shivering, and sedation protocols were implemented and later adapted in their cardiac ICU.

Personal Communications:

The following children's hospitals were contacted and responded:

Lurie Children's Hospital in Chicago has an established temperature management protocol in their PICU, which was later adopted by their CVICU (see Prendergast, 2021).

Children's Hospital of Philadelphia (CHOP) does not have a formal temperature management protocol but expressed interest in this project's findings.

Texas Children's Hospital has a nonspecific temperature protocol but utilizes a transport shuttle to minimize heat loss during transport.

Rady Children's Hospital prioritizes staff education on the importance of infant temperature management but does not have a specific temperature protocol.

Practice Recommendations

- Implement Practice Changes
  - Adopt a rewarming protocol into the CVICU standard of care.
  - Utilize protocols that are currently in place within other departments, including:
    - NICU's rewarming protocol
    - NICU's transport protocol
  - Ensure nursing personnel prewarm and maintain the heat of transport beds.
  - Address and minimize documentation barriers related to thermoregulation interventions.

- Provide Education to Improve Thermoregulation Knowledge for Bedside Staff
  - Topics would include:
    - Early assessment of core temperatures.
    - Strategies to promote gradual rewarming and prevent large temperature swings.
    - Implementation of standardized care practices for temperature measurement and management.
    - Essential documentation for managing the infant's temperature.

- Utilize Equipment and Devices to Assess and Maintain Normothermia
  - Ensure consistent use of appropriate temperature measurement devices.
  - Adapt the use of:
    - Transport shuttles
    - Chemical mattress warmers

Outcomes

For CHD Patients:

- Maintain post-operative normothermia and prevent significant temperature fluctuations.
- Stabilize post-operative hemodynamics.
- Reduce the risk of post-operative neurological injury.
- Decrease the incidence of post-operative arrhythmias.

For Healthcare Providers:

- Increase awareness and adherence to standardized rewarming and temperature management protocols.
- Improve competency in assessing and managing thermoregulation in CHD patients.
- Enhance interdisciplinary collaboration in the peri-operative and post-operative care of CHD patients.
- Streamline documentation processes related to temperature management interventions.
- Reduce incidence of temperature-related complications, improving overall patient outcomes and safety.

Acknowledgements

- The Evidence-Based Scholars Program was supported by a grant from the Walden W. and Jean Young Shaw Foundation
- Jennifer Hayakawa, DNP, PCNS-BC, CNRN, CCRN, Nurse Scientist and Director of Nursing Research and Innovation, CHOC
- Vicky R. Bowden, DNSc, RN, Nurse Scientist, CHOC
- Paulina Schuler, BSN, RN, CCRN, Clinical Research Nurse Coordinator and EBP Scholar Program Mentor, CHOC
- Leigh Mohler, MSN, RN, PCNS-BC, CCRN, Clinical Nurse Specialist, CHOC
- Dr. Joanne Starr, ECLS Director, CHOC

References

Abjigitova, D., Notenboom, M. L., Veen, K. M., van Tussenbroek, G., Bekkers, J. A., Mokhles, M. M., & Bogers, A. J. J. C. (2.022). Optimal temperature management in aortic arch surgery: A systematic review and network meta-analysis. *Journal of Cardiac Surgery, 37*(12), 5379–5387. https://doi.org/10.1111/jocs.17206

Alkhatip, A. A. A. M. M., Kamel, M. G., Farag, E. M., Elayashy, M., Farag, A., Yassin, H. M., Bahr, M. H., Abdelhaq, M., Sallam, A., Kamal, A. M., Emady, M. F. E., Wagih, M., Naguib, A. A., Helmy, M., Algameel, H. Z., Abdelkader, M., Mohamed, H., Younis, M., Purcell, A., Elramely, M., ... Hamza, M. K. (2021). Deep hypothermic circulatory arrest in the pediatric population undergoing cardiac surgery with electroencephalography monitoring: A systematic review and meta-analysis. *Journal of Cardiothoracic and Vascular Anesthesia, 35*(10), 2875-2888. https://doi.org/10.1053/j.jvca.2021.01.039

Brozanski, B.S., Piazza, A.J., Chuo, J., Natarajan, G., Grover, T. R., Smith, J. R., Mingrone, T., McClead, R.E., Rao, R., Rintoul, N., Guidash, J., Bellflower, B., Holston, M., Richardson, T., & Pallotto, E.K. (2020). STEPP IN: Working together to keep infants warm in the perioperative period. *Pediatrics, 145* (4). https://doi.org/10.1542/peds.2019-1121

Centers for Disease Control and Prevention, (2024, May 15th). *Congenital heart defect (CHD): Data and statistics*. https://www.cdc.gov/heart-defects/data/index.html

Chalak, L. F., Pappas, A., Tan, S., Das, A., Sánchez, P. J., Laptook, A. R., Van Meurs, K. P., Shankaran, S., Bell, E. F., Davis, A. S., Heyne, R. J., Pedroza, C., Poindexter, B. B., Schibler, K., Tyson, J. E., Ball, M. B., Bara, R., Grisby, C., Sokol, G. M., … Higgins, R. D. (2021). Association between increased seizures during rewarming after hypothermia for neonatal hypoxic ischemic encephalopathy and abnormal neurodevelopmental outcomes at 2-year follow-up: A nested multisite cohort study. *JAMA Neurology, 78*(12), 1484–1493. https://doi.org/10.1001/jamaneurol.2021.3723

Craig, A. K., Deerwester, K. S., McAllister, L. M., Noubary, F., & Hourihan, M. E. (2021). A pilot randomized control trial of safety and feasibility of a delayed rewarming intervention for infants following cardiopulmonary bypass surgery. *Pediatrics and Neonatal Medicine, 1*(2), 1-6. https:// 10.33425/2768-0363.1009

de Lange, F., Jones, W.L., Mackensen, G.B., & Grocott, HP. (2008). The effect of limited rewarming and postoperative hypothermia on cognitive function in a rat cardiopulmonary bypass model. *Anesthesia & Analgesia, 106*(3), 739-745. doi: 10.1213/ane.0b013e318162d026

Ecoff, L., Stichler, J.F., & Davidson, J.E. (2020). Design, implementation and evaluation of a regional evidence-based practice institute. *Applied Nursing Research, 55*(2), 151300. http://10.1016/j.apnr.2020.151300

Entenmann, A., Michel, M., Herberg, U., Haas, N., Kumpf, M., Gass, M., Egender, F., & Gebauer, R. (2017). Management of postoperative junctional ectopic tachycardia in pediatric

patients: a survey of 30 centers in Germany, Austria, and Switzerland. *European Journal of Pediatrics, 176*(9), 1217-1226. https://doi.org/10.1007/s00431-017-2969-x

Grigore, A. M., Murray, C. F., Ramakrishna, H., & Djaiani, G. (2009). A core review of temperature regimens and neuroprotection during cardiopulmonary bypass: does rewarming rate matter? *Anesthesia and Analgesia, 109*(6), 1741–1751. https://doi.org/10.1213/ANE.0b013e3181c04fea

Iwata, Y., Newburger, J. W., Zurakowski, D., & Jonas, R. A. (2007). Postoperative hypothermia and blood loss after the neonatal arterial switch procedure. *Annals of Thoracic Surgery, 84*(5), 1627–1632. https://doi.org/10.1016/j.athoracsur.2007.06.02

Prendergast, E., Allen, K. Y., Mills, M. G., Moran, T., Harris, Z. L., Malakooti, M., Smith, C. M., Wainwright, M. S., & McCarthy-Kowols, M. (2021). Targeted temperature management protocol in a pediatric intensive care unit: A quality improvement project. *Critical Care Nurse, 41*(5), 41–50. https://doi.org/10.4037/ccn2021554

Sakakeeny, K. H., Connor, J. A., del Nido, P. J., Odegard, K., & Degrazia, M. (2015). Heat retention head wrap for rewarming infants undergoing cardiopulmonary bypass surgery. *American Journal of Critical Care, 24*(2), 141–147. https://doi.org/10.4037/ajcc2015939

Starr, J.P., Karamlou, T., Steele, A., Artis, A.S., Rajeswaran, J., Hammoud, M.S., & Gates, R.N. (2024). Temperature and neurologic outcomes in neonates undergoing cardiac surgery: A society of thoracic surgeons study. *Journal of the American College of Cardiology, 84*(5), 450–463. https://doi.org/10.1016/j.jacc.2024.04.059

Trevisanuto, D., Testoni, D., & de Almeida, M.F.B. (2018). Maintaining normothermia: Why and how? *Seminars in Fetal & Neonatal Medicine, 23*(5), 333-339. https://doi.org/10.1016/j.siny.2018.03.009

Xu, F., Zhang, C., Liu, C., Bi, S., & Gu, J. (2021). Relationship between first 24-h mean body temperature and clinical outcomes of post-cardiac surgery patients. *Frontiers in Cardiovascular Medicine, 8*, 746228. https://doi.org/10.3389/fcvm.2021.746228