Cardiology in the Young

cambridge.org/cty

Parental holding of infants improves haemodynamics in the cardiac ICU

Justin J. Elhoff[1], Sebastian Acosta[2], Saul Flores[2], Julie LaSalle[3], Rohit Loomba[4], Molly McGetrick[2], Christy McKinney[3], Megan Ostrom[3], Chetna K. Pande[2], Robin Schlosser[3], Sarah Schwab[3] and Fabio Savorgnan[2]

[1]Department of Pediatrics, Pediatrix Medical Group, Sunrise Children's Hospital, Kirk Kerkorian School of Medicine at UNLV, Las Vegas, NV, USA; [2]Department of Pediatrics, Baylor College of Medicine, Houston, TX, USA; [3]Texas Children's Hospital, Houston, TX, USA and [4]Department of Pediatrics, Advocate Children's Hospital, Chicago Medical School, Rosalind Franklin University of Medicine and Science, Chicago, IL, USA

Original Article

Cite this article: Elhoff JJ, Acosta S, Flores S, LaSalle J, Loomba R, McGetrick M, McKinney C, Ostrom M, Pande CK, Schlosser R, Schwab S, and Savorgnan F (2023). Parental holding of infants improves haemodynamics in the cardiac ICU. *Cardiology in the Young*, page 1 of 6. doi: 10.1017/S1047951123003931

Received: 27 June 2023
Revised: 6 September 2023
Accepted: 27 October 2023

Keywords:
CHD; cardiac intensive care; holding; developmental care; skin-to-skin; physiologic response

Corresponding author:
J. J. Elhoff; Email: jelhoff@gmail.com

Abstract

We performed a single-centre, retrospective study to assess physiologic changes of infants in the cardiac ICU while being held by their parent. Continuous data streaming of vital signs were collected for infants included in the study from January 2021 to March 2022. Demographic and clinical characteristics were collected from the electronic medical record. The physiologic streaming data were analysed using mixed-effects models to account for repeated measures and quantify the effect of parental holding. Comparison analysis was also performed controlling for intubation, pre-operative versus post-operative status, and whether the holding was skin-to-skin or not. Ninety-five patients with complete physiologic data were included in the study. There were no immediate adverse events associated with holding. Heart rate decreased during the response time compared to its baseline value ($p = 0.01$), and this decrease was more pronounced for the non-intubated and pre-operative patients. The near-infrared spectroscopy-based venous saturation increased overall ($p = 0.02$) in patients while being held. We conclude that parental holding of infants in the cardiac ICU can be safely accomplished, and the haemodynamic and oximetric profile during the holding is favourable compared to the infants' baseline prior to holding.

Given the high prevalence of neurodevelopmental impairments in children born with complex CHD, there is an increasing focus to determine potentially modifiable practices within the cardiac ICU to improve neurodevelopmental trajectories in this population.[1–3] The inherently unnatural and stressful environment of the cardiac ICU for the newborn infant with CHD has significant potential negative impacts on brain development. Developmentally appropriate practices aiming to mitigate the infant stress experience are promising modifiable factors to improve neurodevelopmental outcomes.[4,5] However, there is wide variability in developmental care practices across cardiac ICUs.[6–8] Additionally, there is a growing recognition of the significant stress experienced by families of infants hospitalised with CHD, exacerbated by parental role alteration including the parents' inability to hold their infant in the cardiac ICU.[9–13] This additional stress and parental role alteration can impede parent–child bonding with the potential for significant negative impact on short- and long-term developmental outcomes.[14–16]

Being held is not only critical for an infant's motor development, but holding, especially skin-to-skin care, has been shown to reduce pain and stress as well as improve early clinical outcomes in preterm and term infants.[17–22] Holding is a vital mechanism to facilitate infant–parent bonding and may promote decreased stress in parents of hospitalised infants with CHD.[23–27] However, particularly within the cardiac ICU, there are potential barriers to holding. These include haemodynamic instability and concern for safety due to possible dislodgement of life-sustaining equipment such as endotracheal tubes, vascular access, and temporary pacing wires. While previous studies have demonstrated the safety of holding critically ill infants, including those with CHD, there is limited data regarding haemodynamic changes that occur when a potentially physiologically fragile infant with CHD is held.[28–33] This study seeks to leverage a high-fidelity physiologic data monitoring system to investigate the association of parental holding on important physiologic markers for critically ill infants with CHD.

Materials and method

Infants in the cardiac ICU between January 2021 and March 2022 were included in the study. This study was performed in accordance with the standards of the Helsinki Declaration of 1975 and approved with waiver of consent by the Institutional Review Board of Baylor College of Medicine under protocol H-49933. As every episode of holding is not routinely documented in the CICU medical record and exact timing of holding is necessary to perform this analysis, infants were included when precise parental holding start and stop times were documented in the electronic medical record by a member of the study team. For purposes of this study, infants undergoing active vasoactive or sedative drip titration and those receiving bolus sedation or analgesia medication doses were excluded. As holding duration varied, we focused on the first 60 minutes of holding for data analysis.

Our cardiac ICU does not have formalised holding criteria, but general guidelines have been developed and are part of required annual nursing training. Contraindications to holding include open chest, central extracorporeal membrane oxygenation support, and patients being actively paced via temporary pacing wires who do not have an adequately perfusing underlying rhythm. For all other eligible patients, the safety and appropriateness for holding are discussed amongst the clinical team, which includes representatives from physicians, nurses, and occupational and physical therapists. Safety considerations for lines, drains, and airway securement prior to holding are shown in Supplemental Table 1. Patients greater than 1-week post-cardiac surgery can be considered for skin-to-skin holding once chest tubes have been removed.

Baseline data were collected over the 30-minute period prior to holding. Time zero indicates the start time of infant holding. The response interval was captured during the first 60 minutes of holding. This approach enabled the comparison of each patient's response to his/her own baseline.

The Sickbay clinical platform (Medical Informatics Corp; Houston, TX, USA) installed at Texas Children's Hospital was used to collect haemodynamic and oximetric data. Physiologic data included heart rate, pulse oxygen saturation, diastolic, systolic, and mean arterial blood pressures. These signals are sampled at 0.5 Hz, stored in the Sickbay system, and made available for retrospective studies. In the cardiac ICU, patients are routinely monitored using near-infrared spectroscopy oximeter to measure cerebral and renal venous oxygen saturation. Near-infrared spectroscopy signals were captured at a frequency of 0.2 Hz. The combined near-infrared spectroscopy-based venous oxygen saturation is calculated as: (cerebral oxygen saturation + renal oxygen saturation)/2.

Continuous variables are described as median and interquartile range. To establish a baseline value for each vital sign and patient, the vital sign was collected and averaged over the baseline interval (from -30 minutes to 0 minutes). The response variables provided a quantitative framework to analyse the physiologic changes during the infant holding time. These response variables were evaluated for each patient and subsequently aggregated for statistical tests. The response is the repeated evaluation of each vital sign as non-overlapping 10-minute moving average after the initiation of holding. Effects of infant holding on the physiologic variables were compared between the baseline and the response period using mixed-effects linear regression models to account for the repeated measurements every 10 minutes after the starting of infant holding time. This statistical design ensures that these patients use the data collected before the infant holding time as their controls.

The associations between physiological parameters of the response variables and factors including skin-to-skin holding, intubation status, and pre-operative or post-operative status were computed using mixed-effects models implemented in the "statsmodels v0.12.2" library available in the Python environment. For all tests, statistical significance was considered when the p-value was < 0.05.

Table 1. Demographic and clinical characteristics of the cohort and baseline vital signs (prior to infant holding).

Patient variables (n = 95)	
Sex (male)	61 (64%)
Single ventricle	27 (28%)
Post-op	48 (51%)
Intubated	32 (34%)
Skin-to-skin	21 (22%)
Holder (mother)	78 (82%)
Age (days)	26 (8–90)
Weight (Kg)	3.5 (3.1–4.1)
Vital signs at baseline	
HR (bpm)	147 (131–160)
sBP (mmHg)	83 (72–93)
dBP (mmHg)	43 (38–51)
mBP (mmHg)	58 (51–64)
SpO2 (%)	91 (85–97)
SvO2 (%)	65 (55–72)

Categorical variables are listed as number (percentage) and continuous variables are listed as median (interquartile range).

Results

The initial cohort included 105 infants who were eligible for the study, 95 of whom had complete physiologic data available in the Sickbay database. Sixty-one (64%) were male, 27 (28%) had single-ventricle physiology, 48 (51%) were post-op cardiac surgery, 32 (34%) were intubated during holding, 21 (22%) were held skin-to-skin, and 78 (82%) were held by the mother and the rest by the father. The age, weight, and vital signs during the baseline window are listed in Table 1. There were no immediate adverse events, including medical equipment dislodgement, during any episodes of infant holding or while the patient was placed back into their crib.

Using the mixed-effects analysis, infants' heart rate significantly decreased while being held compared to each infants' own baseline ($p = 0.01$), and this decrease is more pronounced for the non-intubated and pre-operative patients (Table 2). Mean, systolic, and diastolic blood pressure decreased but did not reach statistical significance ($p = 0.37$, 0.12, and 0.82, respectively). Oxygen saturation increased but did not reach statistical significance ($p = 0.07$). We observed a significant increase in near-infrared spectroscopy-based venous saturation while being held ($p = 0.02$). Haemodynamic and oximetric changes with respect to baseline average values are displayed in graphical form in Figure 1.

The 21 infants who were held skin-to-skin did not exhibit significantly different physiologic responses compared with the 74 infants who were not held skin-to-skin (Table 2). While patients who were not intubated ($n = 63$) had a significant decrease in heart rate compared to intubated patients ($p = 0.01$), there were no significant physiologic differences noted in other parameters. Similarly, pre-operative patients ($n = 47$) displayed a significant decrease in heart rate compared to post-operative patients ($p = 0.02$), but significant differences in other parameters were not noted.

https://doi.org/10.1017/S1047951123003931 Published online by Cambridge University Press

Table 2. Mixed-effects analyses of vital signs during the response window.

	HR		mBP		sBP		dBP		SpO2		SvO2 (NIRS)	
	coeff	p-value	coeff	p-value	coeff	p-value	coeff	p-value	coeff	p-value	coeff	p-value
Intercept	**−3.46**	**0.01**	−1.22	0.37	−2.32	0.12	−0.29	0.82	0.83	0.07	**3.09**	**0.02**
Skin-to-skin	3.09	0.13	−1.48	0.48	0.64	0.79	−2.65	0.19	1.21	0.08	−0.57	0.79
Intubated	**5.32**	**0.01**	−2.52	0.16	−0.59	0.76	**−3.35**	**0.05**	−0.66	0.26	−0.38	0.84
Pre-Op	**−3.79**	**0.02**	1.24	0.46	0.30	0.87	1.34	0.40	−0.59	0.29	−2.26	0.19

dBP = diastolic blood pressure; HR = heart rate; mBP = mean blood pressure; sBP = systolic blood pressure; SpO2 = pulse oxygen saturation; SvO2 = NIRS-based venous saturation.
All patients were held for at least 1 hour (response window). "Skin-to-skin" is a binary variable referring to whether the patient was held skin-to-skin or not. "Intubated" is a binary variable referring to whether the patient was held while also being intubated.
"Pre-Op" is also a binary variable referring to whether the episode of holding was prior to index cardiac operation.

Discussion

This study demonstrates that infants in the cardiac ICU exhibit improved haemodynamic changes while being held by a parent in comparison to a baseline period prior to being held, including evidence of improved systemic oxygen delivery as derived from regional near-infrared spectroscopy data. These findings are consistent with our team's anecdotal experience that many infants often become more "calm" when being held characterised by reduced heart rate and increased near-infrared spectroscopy. By utilising data from a high-fidelity physiologic data monitoring system, we were able to quantify these changes in a relatively stable cohort of infants within the cardiac ICU. Additionally, it is important to note that over 100 instances of holding of critically ill infants with CHD were accomplished without any immediate complications or adverse events.

It has been consistently shown that longer ICU and hospital length of stay are associated with worse neurodevelopmental outcomes for infants with critical CHD.[34–36] Although specific in-hospital factors have not been delineated, disruptions to natural neonatal developmental progression may provide some answers. Infants born with critical CHD are exposed early to an inherently unnatural and stressful environment. They are routinely separated from their parents and encounter frequent noxious stimuli from medical procedures as well as poorly controlled light, sound, and temperature stimulation. Necessary perioperative care in the cardiac ICU frequently disrupts the infant's natural cues and sleep patterns, further exacerbating stress, pain, physiologic instability, and disorganised behaviour.[37–39] Historically, this care has been practiced primarily in concordance with the daily rhythm and convenience of cardiac ICU providers. However, as we strive to improve cardiac ICU care to optimise long-term outcomes, it is important to consider that providing developmentally appropriate care and facilitating parental bonding may not only have important longitudinal benefits but also promote positive physiologic states in this fragile population.

At birth, the most developed portion of the sensory system is tactile sensation, and providing a positive sensory experience is influential in overall brain development.[40] Holding is not only a vital aspect of promoting parent–infant bonding but a fundamental process providing positive sensory input for normal newborn development. The preponderance of previous literature related to the benefits of infant holding has focused on skin-to-skin care and the premature infant population, and the findings of this study corroborate relative patient stability during kangaroo care noted in recent meta-analyses on the topic.[38,41] A recent pilot study examined physiologic stability, pain scores, and salivary cortisol levels during skin-to-skin care specifically in infants hospitalised with CHD.[23] Similar to our current study, they found a relative improvement in vital signs during holding (compared to baseline) as well as lower pain scores despite no change in salivary cortisol levels. While pharmacologic intervention with sedative medications may produce similar physiologic effects, they come with well-described negative sequelae.[42] As such, it is promising to consider that a simple, low-resource, and physiologically natural activity such as holding may be increasingly incorporated not only to improve long-term patient outcomes but could be considered as a key therapeutic intervention in helping infants with CHD during their period of critical illness.

Although this study focused on measuring infant physiologic changes, it is worth noting that caregivers experience high levels of stress during times when a child is admitted to the cardiac

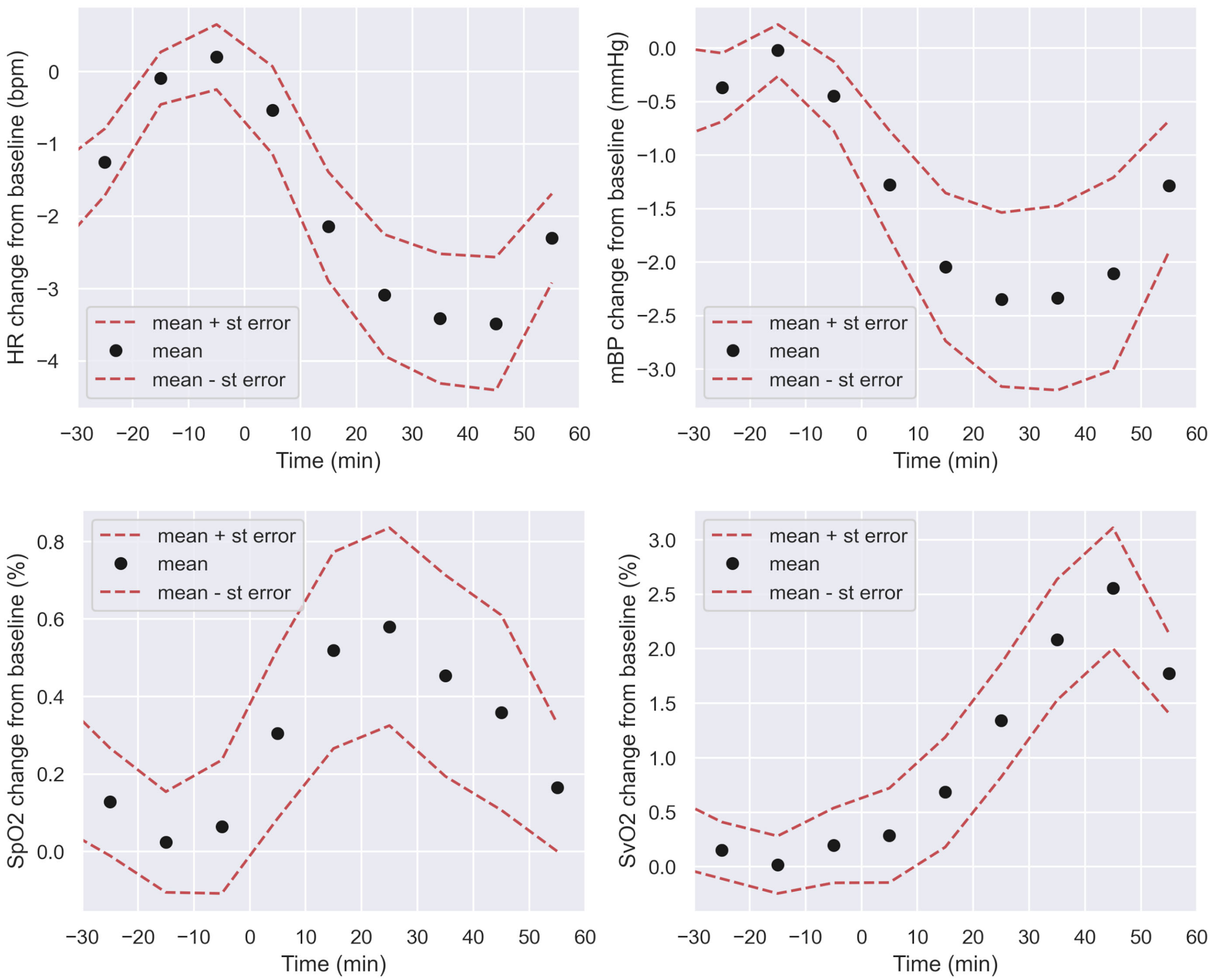

Figure 1. Changes in haemodynamic and oximetric parameters during baseline and response windows with respect to their baseline average values. Time zero indicates the time at which the holding started. The baseline interval ranges from -30 to 0 minutes. The response interval ranges from 0 to 60 minutes. HR = heart rate (top-left). mBP: mean blood pressure (top-right). SpO2 = pulse oxygen saturation (bottom-left). SvO2 = venous oxygen saturation (bottom-right).

ICU.[9,11,43] Care in the ICU may disrupt bonding between caregivers and infants and contribute to a sense of lost parental role. Studies have demonstrated that kangaroo care yields protective effects on parental stress and promotes parent–infant attachment.[44,45] Given that long-term neurodevelopment is largely influenced by familial factors, facilitation of holding on a more routine basis may have compounded benefit on infants with CHD.[10]

While assessing differences in physiologic changes between different groups of patients was not the primary aim of the study, we detected that pre-operative and non-intubated patients experienced a more pronounced decrease in heart rate in comparison to post-operative and intubated patients. This highlights the need for future investigations to determine the association between varying anatomical and physiological states, as well as different points in hospital course, with responses to being held. Additionally, a more detailed study of differences in skin-to-skin versus non-skin-to-skin holding is needed as we suspect that the former may produce a more favourable physiologic response based on previous literature. To facilitate further investigation into these questions, we advocate for routine accurate documentation of holding in the electronic medical record to the same standards as other vital aspects of care documented during cardiac ICU admission. Routine and accurate documentation of this intervention could provide valuable information about physiologic trends during times of holding, while also providing an avenue for answering additional questions such as the relationships between time held and sedation utilisation, feeding tolerance, cardiac ICU and hospital length of stay, and long-term neurodevelopmental and quality-of-life outcomes.

This study has several limitations. To avoid confounding, we included only infants whose clinical status was not rapidly evolving and excluded those undergoing interventions which might influence their haemodynamic profile. This may limit our ability to extrapolate these findings to infants in a more dynamic physiologic state. A larger study sample inclusive of infants with various physiological states and at different stages of their clinical course would be necessary to better describe which infants might benefit most from holding. Despite our intention to analyse a

https://doi.org/10.1017/S1047951123003931 Published online by Cambridge University Press

haemodynamically stable patient population, it is possible that routine care occurring during either the baseline or holding period (such as feeding or scheduled medication administration) could influence haemodynamic parameters, leading to unmeasured confounding. As mentioned, only infants whose precise holding times were documented by a member of the study team were included – this could lead to selection bias and other infants may not experience the same physiologic responses. Since infants were repositioned during the study, the limitation of our monitoring tools must also be considered.

By using high-fidelity physiologic monitoring, this study demonstrates that infants being held by their parents in the cardiac ICU exhibit evidence of an improved haemodynamic profile. As we continue to investigate opportunities to intervene in the cardiac ICU to improve long-term neurodevelopmental outcomes for patients with CHD, we can utilise these monitoring systems to provide more robust evidence that our interventions may also positively impact physiologic status in the short term.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1047951123003931.

Acknowledgements. None.

Financial support. This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

Competing interests. None.

Ethical standard. The authors assert that all procedures contributing to this work comply with the ethical standards of Helsinki Declaration of 1975, as revised in 2008, and have been approved with waiver of consent by the Institutional Review Board of Baylor College of Medicine under protocol H-49933.

References

1. Butler SC, Huyler K, Kaza A, Rachwal C. Filling a significant gap in the cardiac ICU: implementation of individualised developmental care. Cardiol Young 2017; 27: 1797–1806.
2. Verrall CE, Blue GM, Loughran-Fowlds A, et al. 'Big issues' in neurodevelopment for children and adults with congenital heart disease. Open Heart 2019; 6: e000998.
3. Cassidy AR, Butler SC, Briend J, et al. Neurodevelopmental and psychosocial interventions for individuals with CHD: a research agenda and recommendations from the cardiac neurodevelopmental outcome collaborative. Cardiol Young 2021; 31: 1–12.
4. Butler SC, Sadhwani A, Stopp C, et al. Neurodevelopmental assessment of infants with congenital heart disease in the early postoperative period. Congenit Heart Dis 2019; 14: 236–245.
5. Lisanti AJ, Vittner D, Medoff-Cooper B, Fogel J, Wernovsky G, Butler S. Individualized family-centered developmental care: an essential model to address the unique needs of infants with congenital heart disease. J Cardiovasc Nurs 2019; 34: 85–93.
6. Sood E, Berends WM, Butcher JL, et al. Developmental care in north American pediatric cardiac intensive care units: survey of current practices. Adv Neonatal Care 2016; 16: 211–219.
7. Miller TA, Lisanti AJ, Witte MK, et al. A collaborative learning assessment of developmental care practices for infants in the cardiac intensive care unit. J Pediatr 2020; 220: 93–100.
8. Miller TA, Elhoff JJ, Alexander NM, et al. Developmental care practice and documentation variability in the cardiac ICU. Pediatr Crit Care Med 2022; 23: e180–e185.
9. Sood E, Karpyn A, Demianczyk AC, et al. Mothers and fathers experience stress of congenital heart disease differently: recommendations for pediatric critical care. Pediatr Crit Care Med 2018; 19: 626–634.
10. Kasparian NA, Kan JM, Sood E, Wray J, Pincus HA, Newburger JW. Mental health care for parents of babies with congenital heart disease during intensive care unit admission: systematic review and statement of best practice. Early Hum Dev 2019; 139: 104837.
11. Woolf-King SE, Anger A, Arnold EA, Weiss SJ, Teitel D. Mental health among parents of children with critical congenital heart defects: a systematic review. J Am Heart Assoc 2017; 6: 6.
12. Lisanti AJ, Golfenshtein N, Medoff-Cooper B. The pediatric cardiac intensive care unit parental stress model: refinement using directed content analysis. ANS Adv Nurs Sci 2017; 40: 319–336.
13. Lisanti AJ, Kumar A, Quinn R, Chittams JL, Medoff-Cooper B, Demianczyk AC. Role alteration predicts anxiety and depressive symptoms in parents of infants with congenital heart disease: a pilot study. Cardiol Young 2021; 31: 1842–1849.
14. Treyvaud K, Anderson VA, Howard K, et al. Parenting behavior is associated with the early neurobehavioral development of very preterm children. Pediatrics 2009; 123: 555–561.
15. Pineda R, Bender J, Hall B, Shabosky L, Annecca A, Smith J. Parent participation in the neonatal intensive care unit: predictors and relationships to neurobehavior and developmental outcomes. Early Hum Dev 2018; 117: 32–38.
16. McCusker CG, Doherty NN, Molloy B, et al. A randomized controlled trial of interventions to promote adjustment in children with congenital heart disease entering school and their families. J Pediatr Psychol 2012; 37: 1089–1103.
17. Ferber SG, Makhoul IR. The effect of skin-to-skin contact (kangaroo care) shortly after birth on the neurobehavioral responses of the term newborn: a randomized, controlled trial. Pediatrics 2004; 113: 858–865.
18. Scher MS, Ludington-Hoe S, Kaffashi F, Johnson MW, Holditch-Davis D, Loparo KA. Neurophysiologic assessment of brain maturation after an 8-week trial of skin-to-skin contact on preterm infants. Clin Neurophysiol 2009; 120: 1812–1818.
19. Conde-Agudelo A, Diaz-Rossello JL. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants. Cochrane Database Syst Rev 2016; 2016: CD002771. DOI: 10.1002/14651858.CD002771.pub4.
20. Neu M, Hazel NA, Robinson J, Schmiege SJ, Laudenslager M. Effect of holding on co-regulation in preterm infants: a randomized controlled trial. Early Hum Dev 2014; 90: 141–147.
21. Moore ER, Bergman N, Anderson GC, Medley N. Early skin-to-skin contact for mothers and their healthy newborn infants. Cochrane Database Syst Rev 2016; 11: CD003519.
22. Boundy EO, Dastjerdi R, Spiegelman D, et al. Kangaroo mother care and neonatal outcomes: a meta-analysis. Pediatrics 2016; 137: 137.
23. Lisanti AJ, Demianczyk AC, Costarino A, et al. Skin-to-skin care is a safe and effective comfort measure for infants before and after neonatal cardiac surgery. Pediatr Crit Care Med 2020; 21: e834–e841.
24. Lisanti AJ, Demianczyk AC, Costarino A, et al. Skin-to-skin care is associated with reduced stress, anxiety, and salivary cortisol and improved attachment for mothers of infants with critical congenital heart disease. J Obstet Gynecol Neonatal Nurs 2021; 50: 40–54.
25. Torowicz D, Lisanti AJ, Rim JS, Medoff-Cooper B. A developmental care framework for a cardiac intensive care unit: a paradigm shift. Adv Neonatal Care 2012; 12: S28–32.
26. Lisanti AJ, Allen LR, Kelly L, Medoff-Cooper B. Maternal stress and anxiety in the pediatric cardiac intensive care unit. Am J Crit Care 2017; 26: 118–125.
27. Reynolds LC, Duncan MM, Smith GC, et al. Parental presence and holding in the neonatal intensive care unit and associations with early neurobehavior. J Perinatol 2013; 33: 636–641.
28. Levesque V, Johnson K, McKenzie A, Nykipilo A, Taylor B, Joynt C. Implementing a skin-to-skin care and parent touch initiative in a tertiary cardiac and surgical neonatal intensive care unit. Adv Neonatal Care 2021; 21: E24–E34.
29. Lisanti AJ, Helman S, Sorbello A, et al. Holding and mobility of pediatric patients with transthoracic intracardiac catheters. Crit Care Nurse 2020; 40: 16–24.
30. Gazzolo D, Masetti P, Meli M. Kangaroo care improves post-extubation cardiorespiratory parameters in infants after open heart surgery. Acta Paediatr 2000; 89: 728–729.

31. Harrison TM, Ludington-Hoe S. A case study of infant physiologic response to skin-to-skin contact after surgery for complex congenital heart disease. J Cardiovasc Nurs 2015; 30: 506–516.
32. Harrison TM, Brown R. Autonomic nervous system function after a skin-to-skin contact intervention in infants with congenital heart disease. J Cardiovasc Nurs 2017; 32: E1–E13.
33. Harrison TM, Chen CY, Stein P, Brown R, Heathcock JC. Neonatal skin-to-skin contact: implications for learning and autonomic nervous system function in infants with congenital heart disease. Biol Res Nurs 2019; 21: 296–306.
34. Mussatto KA, Hoffmann R, Hoffman G, et al. Risk factors for abnormal developmental trajectories in young children with congenital heart disease. Circulation 2015; 132: 755–761.
35. Wernovsky G, Licht DJ. Neurodevelopmental outcomes in children with congenital heart disease-what can we impact? Pediatr Crit Care Med 2016; 17: S232–242.
36. Pande CK, Noll L, Afonso N, et al. Neurodevelopmental outcomes in infants with cardiac surgery associated acute kidney injury. Ann Thorac Surg 2022; 114: 2347–2354.
37. Franck LS, Ridout D, Howard R, Peters J, Honour JW. A comparison of pain measures in newborn infants after cardiac surgery. Pain 2011; 152: 1758–1765.
38. Hehir DA, Easley RB, Byrnes J. Noncardiac challenges in the cardiac ICU: feeding, growth and gastrointestinal complications, anticoagulation, and analgesia. World J Pediatr Congenit Heart Surg 2016; 7: 199–209.
39. Lisanti AJ, Uzark KC, Harrison TM, et al. Developmental care for hospitalized infants with complex congenital heart disease: a science advisory from the American heart association. J Am Heart Assoc 2023; 12: e7967.
40. Cabral TI, da Silva LG, Martinez CM, Tudella E. Analysis of sensory processing in preterm infants. Early Hum Dev 2016; 103: 77–81.
41. Cleveland L, Hill CM, Pulse WS, DiCioccio HC, Field T, White-Traut R. Systematic review of skin-to-skin care for full-term, healthy newborns. J Obstet Gynecol Neonatal Nurs 2017; 46: 857–869.
42. Naguib AN, Tobias JD, Hall MW, et al. The role of different anesthetic techniques in altering the stress response during cardiac surgery in children: a prospective, double-blinded, and randomized study. Pediatr Crit Care Med 2013; 14: 481–490.
43. McMahon E, Chang YS. From surviving to thriving - parental experiences of hospitalised infants with congenital heart disease undergoing cardiac surgery: a qualitative synthesis. J Pediatr Nurs 2020; 51: 32–41.
44. Cho ES, Kim SJ, Kwon MS, et al. The effects of kangaroo care in the neonatal intensive care unit on the physiological functions of preterm infants, maternal-infant attachment, and maternal stress. J Pediatr Nurs 2016; 31: 430–438.
45. Morris AR, Turner A, Gilbertson CH, Corner G, Mendez AJ, Saxbe DE. Physical touch during father-infant interactions is associated with paternal oxytocin levels. Infant Behav Dev 2021; 64: 101613.