**Supplementary Table 4. Characteristics of Included Studies Related to Oral Feeding in Neonates and Infants with Congenital Heart Disease (CHD)**

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| Study | Study Aim | Sample Size | Full-Term | Subject Age | Study Design | Data Collection Method | Statistical Analysis | Oral Feeding  IV/ DV | Oral Feeding Measurement | Timing of Oral Feeding Measurement | Predictors of Oral Feeding |
| Averin, K., Uzark, K., Beekman III, R. H., Willging, J. P., Pratt, J., & Manning, P. B. (2012). | 1) To evaluate the incidence of vocal cord (VC) and swallowing dysfunction in infants after the Norwood operation 2) To examine the relationship between laryngopharyngeal dysfunction and postoperative outcomes. | N=72 | NR | 3-5 days at time of surgery | Cohort | Retrospective | Univariate | IV | 1) % feeding by tube only with and without vocal cord dysfunction 2) % feeding by tube only with and without swallowing dysfunction | At discharge post Stage I neonatal surgery | 1) Swallowing dysfunction ~3x higher with VC dysfunction. 2) VC and swallowing dysfunction not significantly associated with ventilator time, ICU time, or hospital LOS; 3) Median hospital LOS 8 days longer with swallowing dysfunction 4) infants with VC or swallowing dysfunction ~ 2x as likely to be discharged home feeding by NG or G-tube only. |
| Chaves, A. H., Baker-Smith, C. M., & Rosenthal, G. L. (2020). | We hypothesized that undergoing arch reintervention following stage 1 palliation would be associated with post-operative feeding difficulties. | N=2201 | Included both pre-term and full-term | <56 days old | Cohort | Retrospective | Univariate and Multivariate | DV | Oral feeds only, Oral and NG/NJ feeds, Oral and Gtube, NG/NJ only, Gtube only | At discharge post Stage I neonatal surgery | 1) Association between type of repeat intervention and need for tube feeds at time of discharge: more likely to be discharged on only tube feeds with non-arch repeat intervention, and still more likely if they underwent an arch repeat intervention. 2) Patients discharged home on tube feeds only or some tube feeds had longer time to full feeds in post-operative period. |
| Coker-Bolt, P., Jarrard, C., Woodard, F., & Merrill, P. (2013). | To determine the effects of oral motor stimulation on infants born with complex univentricle anatomy who required surgery shortly after birth. | N=28 | Yes (all >37 weeks) | Neonate (<30 days) | Quasi-experimental with non-equivalent group design | NR for treatment group; retrospective for historical controls | Univariate | DV | Length of time to reach full bottle-feeding (defined as first time infant took eight oral feedings in one 24-hour period) | Six days/week data collected before, during, and after each oral treatment session | 1) Infants in treatment group achieved full bottle-feeds 2 days earlier than infants in comparison group, but not statistically significant. 2) 40% of infants from comparison group were discharged from the hospital with g-tube, whereas 22% of infants from treatment group required g-tube placement, but difference not statistically significant. |
| Davies, R. R., Carver, S. W., Schmidt, R., Keskeny, H., Hoch, J., & Pizarro, C. (2014). | Laryngopharyngeal dysfunction contributes significantly to morbidity, length of stay, and increased resource utilization after aortic arch interventions in infants. A prospective evaluation of laryngopharyngeal function was undertaken to assess and determine its importance in perioperative management. | N=101 | Included both pre-term and full-term | During infancy; exact age NR | Cohort | Retrospective review for postoperative feeding difficulties; prospective for laryngeal abnormalities | Univariate and Multivariate | DV | Inability to tolerate oral feedings at time of discharge | At discharge from neonatal hospitalization | 1) Factors predictive of abnormal postoperative feeding evaluation included genetic syndromes and preoperative mechanical ventilation. 2) A trend toward decreased long-term survival among patients who were intubated or had an abnormal preoperative feeding evaluation. |
| De Souza, P. C., Gigoski, V. S., Etges, C. L., & Barbosa, L. D. R. (2018). | To describe the findings of postoperative clinical evaluation of swallowing in infants with congenital heart disease (CHD). | N=31 | NR | 0-6 months old | Cross-sectional | Prospective | Univariate | DV | Clinical swallow evaluation (CSE) via application of the Assessment of Pediatric Dysphagia tool | Postoperative from neonatal surgery; mean age 21 days old (range 13-42 days old) | 1) Significantly higher number of swallowing changes with bottle feeding compared to breastfeeding. 2) Statistically significant correlation observed between duration of orotracheal intubation (OTI) >24 h and presence of dysphagia. |
| Dewan, K., Cephus, C., Owczarzak, V., & Ocampo, E. (2012). | To study the incidence and implications of vocal fold paresis (VFP) following congenital neonatal cardiac surgery. | N=94 | NR (but did comment on including less premature neonates compared to previous studies) | Average age 10 days old | Cohort | Prospective | Univariate | IV | Feeding by mouth at discharge | Discharge from neonatal hospitalization | 1) High incidence of VFP in infants who underwent manipulation of aortic arch; weighed less at time of discharge than those who did not undergo aortic arch surgery; 2) Type of surgery more of a significant factor than operative weight for postoperative VFP; 3) VFP associated with increased requirements for tube feeding, need for diet modification, and prolonged hospital stay |
| Gakenheimer-Smith, L., Glotzbach, K., Ou, Z., Presson, A. P., Puchalski, M., Jones, C., … Miller, T. (2019). | To evaluate the association between neonatal neurobehavioral state (NNNS) and oral feeding outcomes following congenital heart disease (CHD) surgery. | N=173 | Included both pre-term and full-term | <30 days old | Cohort | Retrospective | Univariate and Multivariate | DV | 1) Time to achieve full oral feedings postoperatively 2) Percent oral feeds at hospital discharge | 1) Time to achieve full oral feedings postoperatively (days) 2) Percent oral feedings at discharge | 1) Increased ventilator days, younger age at surgery, and aortic arch obstruction all negatively impact neonates’ ability to take oral feeds in the perioperative period. 2) Higher neonatal attention before cardiac surgery is associated with improved feeding outcomes. |
| Harrison, T M. (2011). | To describe the first steps in developing a longitudinal growth model for analyzing patterns of autonomic nervous system (ANS) response to the challenge of feeding infants with surgically corrected TGA at two points in time and to explore potential contributing factors. | N=15 | All full-term | 2 weeks old and 2 months old | Cohort | Secondary data analysis of a prospective cohort | Univariate | DV | Early Infant Feeding Skills Assessment to measure feeding skill. Higher scores indicated more feeding skill. | Measure was scored in real time by investigator during the 2-week and 2-month observations. At each age, ECG recordings were made for 30 minutes prior to the feeding, during the feeding, and for 60 minutes after the feeding. | 1) Marked between-infant variability in HF HRV across phases of feeding was apparent at both ages. 2) Four patterns of HF HRV trajectories across phases of feeding were identified and associated with feeding method, feeding skill, and maternal sensitivity. 3) Developmental increases in HF HRV were apparent in most breastfed, but not bottle-fed, infants. |
| Harrison, T. M. & Ferree, A. (2014). | To examine relationships among infant and maternal affect and behavior and quality of dyadic interaction, as measured by the Parent–Child Early Relational Assessment, and infant autonomic function, as measured by heart rate variability. | N=15 | All full-term (gestational age not specified) | 2 weeks old and 2 months old | Case-Control | Retrospective | Univariate | IV | Heart Rate Variability using EKG; parent, infant, dyadic subscales | During the first five minutes of feeding at 2 weeks and 2 months | 1) Older infants and infants with a greater HF HRV reduction with feeding had more positive affect and behavior. 2) Infants with higher HF HRV before feeding had lower scores in Infant Dysregulation, and infants with a greater HF HRV reduction with feeding had higher scores in Infant Dysregulation. 3) Health condition did not predict measures of infants’ affect and behavior. 4) TGA dyads had higher scores than healthy dyads. |
| Hsieh, A., Tabbutt, S., Xu, D., Barkovich, A. J., Miller, S., McQuillen, P., & Peyvandi, S. (2019). | To determine the association between neonatal perioperative brain injury and postnatal brain maturation with feeding-tube dependency in patients with single ventricle palliation at neonatal discharge and just before the stage-2 palliation. | N=48 | All full-term | <30 days old | Cohort | Prospective | Univariate and Multivariate | DV | 100% orally fed (yes/no) | At discharge from neonatal hospitalization and immediately prior to Stage II palliation | 1) Slower rate of postnatal brain maturation, but not perioperative brain injury, is associated with feeding modality in infancy. 2)Modified assessment of heart failure not associated with feeding modality. 3) Longer hospital length of stay significantly associated with tube feeding at each time point. 4) In subgroup of patients, vocal cord paresis did not affect our findings at the time of S2P. Early measures of brain development appear to be associated with feeding abilities among SVP patients. |
| Indramohan, G., Pedigo, T. P., Rostoker, N., Cambare, M., Grogan, T., Federman, M. D., & Pedigo, T. (2017). | Application of oral motor intervention would help improve infants born at gestational age 37 0/7 weeks and beyond who underwent complex cardiac surgery oral feeding skills and thereby reduce the need for nasogastric or gastrostomy feedings at discharge. | N=23 | All full-term | <1 month of age | Non-Randomized Control Trial | Prospective | Univariate and  Multivariate | DV | Time (days) to full oral feeding | Feeding program stopped once taking full oral feeds for 24 hours | This study identified diagnosis of hypoplastic left heart syndrome, duration of intubation and withholding of oral feeds, and presence of gastroesophageal reflux disease as predictors of failure to achieve full feeding at discharge for infants who underwent surgery for complex CHD. |
| Jeffries, H. E., Wells, W. J., Starnes, V. A., Wetzel, R. C., & Moromisato, D. Y. (2006). | To document the incidence, impact, and risk factors associated with GI morbidity (including NEC, supplemental enteral nutrition, and feeding difficulties) in neonates with HLHS after the modified Norwood procedure. | N=117 | NR | Less than or equal to 30 days old | Cohort | Retrospective | Univariate and Multivariate | IV | Time to attain full oral feeding | Days to attain full oral feeding (continuous variable) | Patients were more likely to have GI complications if they had one or two infection or higher postoperative inotrope score. 2) Prolonged hospital stay exclusively related to feeding problems found more likely to have a higher PRISM score, multiple infections, and female sex. 3) Development of NEC had univariate association with lower weight, later attainment of full feedings, positive blood culture, and higher PRISM score. 4) NEC cohort had larger modified Blalock-Taussig shunt indexed to body weight. |
| Karsch, E., Irving, S. Y., Aylward, B. S., & Mahle, W. T. (2017). | To examine the prevalence and effects of aspiration among neonates who had undergone cardiac surgery at the time of their discharge. | N=62 | 85.5% were > 37 weeks and 14.5% were < 37 weeks (N=9 premature) | Less than or equal to 30 days old | Cohort | Retrospective | Univariate | IV | NR | After neonatal cardiac surgery | Aspiration events and laryngeal penetration are common after neonatal heart surgery. As a result, many infants are discharged home with feeding tubes because of concern for aspiration. Our results suggest that increased use of the modified barium swallow study may be an initial step to identify infants with increased risk for aspiration events and laryngeal penetration. |
| Kataria-Hale, J., Cognata, A., Hagan, J., Zender, J., Sheaks, P., Osborne, S., Roddy, J., & Hair, A. (2021). | To evaluate the association of preoperative risk factors and postoperative outcomes in infants with complex congenital heart disease. | N=399 | Pre-term and full-term | Neonates | Cohort | Retrospective | Univariate and Multivariate | IV | Days to achieve full feeding defined as number of days from surgery to reach at least 120 mL/ kg/d enteral feeds (nasogastric or oral) without the need for parenteral nutrition | At neonatal hospital discharge | Cardiac lesions with ductal-dependent systemic blood flow were associated with a hospital length of stay of 19.6 days longer than those with ductal-dependent pulmonary blood flow (*p* < 0.001) and 2.9 days longer to reach full feeds than those with ductal- dependent pulmonary blood flow (*p* < 0.001), after controlling for prematurity. Nasogastric feeding route preoperatively was associated with a length of stay of 29.8 days longer than those fed by mouth (*p* < 0.001) and 2.4 days longer to achieve full feeds (*p* < 0.001), after controlling for prematurity and cardiac lesion. Preoperative diet itself was not associated with significant change in length of stay or days to reach full feeds. |
| Kogon, B. E., Ramaswamy, V., Todd, K., Plattner, C., Kirshbom, P. M., Kanter, K. R., & Simsic, J. (2007). | Following neonatal congenital heart surgery, one of the factors impacting patient recovery is feeding difficulty. The aim of this study is to identify the risk factors. | N=93 | All full-term | 15 days old or younger | Cohort | Retrospective | Univariate and Multivariate | DV | A prolonged transition to oral feeds requiring tube feeds at discharge | 1) Prolonged time to reach goal feeds. 2) Prolonged transition to oral feeds requiring tube feeds at discharge. 3) Need for procedures to facilitate feeding (Gtube placement) | Significant risk factors for all endpoints: increased RACHS score and prolonged intubation. Significant risk factors for endpoint 1: Delayed sternal closure; endpoint 3: A single functional ventricle and the presence of a shunt. Only prolonged intubation remained significant for outcome 1 and higher RACH score for outcomes 2 and 3. The most important risk factors were increased RACHS score and prolonged postoperative intubation. |
| Lambert, L. M., Pike, N. A., Medoff-Cooper, B., Zak, V., Pemberton, V. L., Young-Borkowski, L., & Williams, R. V. (2014). | To assess variation in feeding practice at Norwood discharge, factors associated with tube feeding, and associations between site, feeding mode, and growth prior to stage II. | N=555 | All full-term | <30 days old | Cohort | Secondary data analysis of a prospective cohort | Univariate and Multivariate | DV | (1) oral only: all nutrition provided via oral route (breast or bottle feeding); (2) oral/tube: nutrition provided via oral feeding and supplemented by enteral tube feeding; (3) nasogastric/jejunal tube feeding only (N-tube): all nutrition received via a nasogastric or nasojejunal tube; and (4) gastrostomy tube only (G-tube): all nutrition received via a gastrostomy or gastrojejunostomy tube | Discharge from Norwood hospitalization | When clinical site not included in the model, number of post-Norwood medications and log-transformed length of hospitalization explained 30% of the variation in feeding mode. When anti-reflux medications were excluded from the analysis, total number of medications remained independent predictor of feeding mode. Feeding mode at discharge varied among sites. Prolonged hospitalization and greater number of medications at time of discharge were associated with tube feeding. Infants exclusively fed orally had a higher WAZ pre-stage II than those fed exclusively by tube. |
| McKean, E. B., Kasparian, N. A., Batra, S., Sholler, G. F., Winlaw, D. S., & Dalby-Payne, J. (2017). | To examine the prevalence and potential correlates of feeding difficulties in infants who underwent cardiac surgery in the neonatal period and to investigate resource utilization by infants with feeding difficulties. | N=79 | 9% of sample premature (<37 weeks) | <28 days old | Cohort | Retrospective | Univariate and Multivariate | DV | Difficulty feeding | Discharge home with feeding tube from neonatal hospitalization | Presence of a genetic syndrome and preoperative feeding assistance were identified as key determinants of feeding difficulty. |
| Pereira, K. D. R., Firpo, C., Gasparin, M., Teixeira, A. R., Dornelles, S., Bacaltchuk, T., & Levy, D. S. (2013). | To describe the alterations in swallowing found in infants with congenital heart defect during their hospitalization. | N=19 | NR | <7 months old | Cross-sectional | Prospective | Univariate | DV | Preterm Oral Feeding Readiness Assessment scale | NR: patients were at various ages, unclear timing | Dysphagia often occurs in infants after corrective surgery for congenital heart condition. The use of the preterm readiness for an oral feeding protocol enabled us to verify that infants with congenital heart defect may present with very similar behavior to those of preterm newborns. |
| Pham, V., Connelly, D., Wei, J. L., Sykes, K. J., & O’Brien, J. (2014). | To determine the incidence of vocal cord (VC) paralysis and dysphagia after aortic arch reconstruction, including the Norwood procedure. | N=151 | 4.6% of sample premature | <2 months old (range 7-49 days old) | Cohort | Retrospective | Univariate | DV | Dysphagia (defined as inability to tolerate full oral feedings without tube supplementation) | Form of feeding upon discharge | 79.5% of patients required modified feeding regimen. Significantly higher proportion of Norwood patients required altered form of feeding compared with arch repair patients. Our study is first to show that the rate of dysphagia is significant after Norwood and arch reconstruction even if there is no VC dysfunction identified postoperatively. |
| Pierick, A. R., Pierick, T. A., & Reinking, B. E. (2020). | To compare the growth and method of feeding following neonatal cardiac surgery in infants with normal versus abnormal genetic testing | N=53 | Included both pre-term and full-term | At birth | Cohort | Retrospective | Univariate and Multivariate | DV | Enteral tube, oral, or combination of oral and enteral tube | At birth, hospital discharge, and monthly until 6 months of age | Most infants received feeds via an enteral tube in the immediate post-operative period. At each follow up visit, percentage of infants exclusively orally fed increased. Those with normal genetic testing transitioned to all oral feeds more quickly than those with genetic defects, with significantly more infants taking all oral feeds at 3 months and 4 months of age. By 5 months of age, those with abnormal genetic testing taking feeds orally increased; no significant difference between the two groups. Multinomial logistic regression models found no variable significantly impacted method of feeding between immediate post-operative period and 5 months post operation. |
| Piggott, K. D., Babb, J., Yong, S., Fakioglu, H., Blanco, C., DeCampli, W., & Pourmoghadam, K. (2018). | To identify risk factors for G-tube placement in neonates following the Norwood procedure at our institution. | N=84 | Included both pre-term and full-term | <30 days old | Cohort | Retrospective | Univariate and Multivariate | DV | G-tube placement at discharge | Postoperative from Norwood surgery, prior to neonatal hospitalization discharge | Significant difference between G-tube and no G-tube group for rate of reintubation, duration of sedative/narcotic infusion, need for Ativan taper, and incidence of vocal cord dysfunction postoperatively. Vocal cord dysfunction and longer duration of sedative/narcotic infusion independently associated with G-tube placement. Mean HLOS was significantly longer in the G-tube group. More G-tubes placed during the 2011-2015 era. Duration of sedative/narcotic infusion statistically significant, greater during 2011-2015 era. Vocal cord dysfunction and longer duration of sedative/narcotic infusions may be at risk of requiring G-tube. |
| Pourmoghadam, K. K., DeCampli, W. M., Ruzmetov, M., Kosko, J., Kishawi, S., O’Brien, M.,…Fakioglu, H. (2017). | The aims of this investigation were to evaluate the incidence and clinical effect of suspected recurrent laryngeal nerve (RLN) injury in neonates undergoing aortic arch repair by reviewing postoperative evaluations of vocal cord and swallowing function. | N=101 | NR | <30 days old | Cohort | Retrospective | Univariate and Multivariate | DV | Feeding ability at discharge (full oral feeding, oral + G-tube, G-tube only) | At discharge from neonatal hospitalization | Patients with VCD have a significantly higher incidence of gastrostomy placement and aspiration. In Norwood population, length of stay is not associated with presence or absence of VCD. >70% of patients in each group who had direct flexible laryngoscopy follow-up recovered vocal cord function. |
| Sables-Baus, S., Kaufman, J., Cook, P., & Da Cruz, E. M. (2012). | This study aims to describe predictors of oral feeding outcomes for neonates after early surgical interventions. | N=56 | 86% were >37 weeks | <1 month of age | Cohort | Retrospective | Univariate | DV | 1) Amount taken by mouth with bottle for each feeding both as an episode and as an amount; 2) breastfeeding as a time interval only (yes/no); 3) requirement of a feeding tube at time of discharge (yes/no). | Preoperative/  postoperative | Time from surgery to initiation of oral feeding, the amount of first feeding after intervention, cross-clamp and circulatory arrest times, and the presence of a genetic syndrome significant markers of oral feeding outcomes. Almost half of the neonates in this study required invasive means to supplement oral feeds upon discharge, and none of the infants discharged were successfully solely breastfeeding. |
| Skinner, M. L., Halstead, L. A., Rubinstein, C. S., Atz, A. M., Andrews, D., & Bradley, S. M. (2005). | To evaluate the incidence and significance of recurrent laryngeal nerve (RLN) and swallowing dysfunction after a Norwood procedure compared with that after biventricular aortic arch reconstruction. | N=54 | NR | <30 days old | Cohort | Prospective | Univariate | IV | G-tube placement at discharge | Prior to discharge after neonatal surgery | Postoperative laryngoscopy documented vocal fold paralysis in 9% of patients compared with 25% of patients after aortic arch reconstruction as part of a biventricular repair. 3 patients with glottic gap all had aspiration on initial MBS. Two had gastrostomy tubes placed before hospital discharge. A glottic gap is high-risk marker and a strong indication for gastrostomy tube placement. Patients with an abnormal MBS result had a longer mean intensive care unit stay and hospital stay. Feeding gastrostomy tubes were placed in 18% of patients before hospital discharge. |
| Yi, S.H., Kim, S.J., Huh, J., Jun, T.G., Cheon, H.J., & Kwon, J.Y. (2014). | The aims of this study were to evaluate the prevalence and the clinical predictors of dysphagia and to determine the characteristics of video fluoroscopic swallowing study findings in infants after open heart procedures. | N=149 | All full-term | <12 months old | Cohort | Retrospective | Univariate | DV | Dysphagia defined as (1) feeding desaturation, increased work required for breathing during feeding, coughing/ choking during feeding, altered crying, or other signs; (2) failure of any clinical modification in improving oral feeding; and (3) tube feeding until discharge | Postoperative and feeding mode at discharge | 1) 24% had dysphagia symptoms. 2) Infants with dysphagia had lower body weight at surgery, more syndromes, longer operation time, and more complex operations. 3) The infants with dysphagia required more time to achieve full oral feeding and had longer hospital stays. 4) 97% exhibited at least one abnormal finding on videofluoroscopic study and 63.6% had tracheal aspiration. |