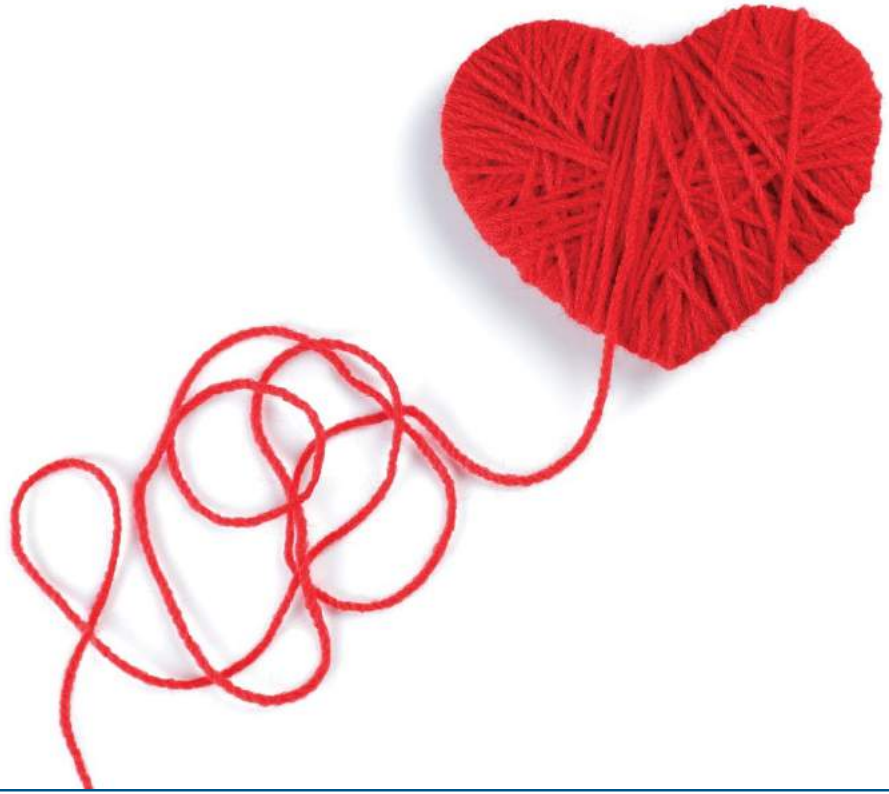
CARDIOLOGY 2023

Nutrition and Growth in Children with CHD



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22CME0420/PPT/01-23

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- Participated in conferences sponsored by Danone Medical.
- No conflict of interest.

Congenital Heart Defects

Nutrition and Growth

- Introduction
- Scope of the problem
- Etiology
- Impact of poor growth
- Interventions
- Conclusion

NUTRITION: INTRODUCTION

- Neonates with complex CHD are usually born full term and within normal weight ranges.
- All infants who experience neonatal cardiac surgery are at risk for experiencing growth faltering during the first year of life.
- Most at risk are infants with Single Ventricle heart defects.

ISV, SVR, NPCQIC

- **Infant Single Ventricle or ISV Trial** (2003-2007).
  Enalapril Vs. Placebo: Growth was primary outcome
- **Single Ventricle Reconstruction or SVR Trial** (2005-2008).
  Neonates with HLHS: BTT shunt or RV-PA shunt at the Norwood procedure.
- **National Pediatric Cardiology Quality Improvement Collaborative or NPCQIC** (established in 2008)
  Goal: Improve Outcomes in Infants with HLHS.

GROWTH ISSUES AT BIRTH

- 1245 neonates with Single Ventricle CHD were screened across 10 centers in North America for the Pediatric Heart Network's Infant Single Ventricle (ISV) Trial.

	CHD	Normal	P
LBW	18%	8%	<0.001
SGA	22%	10%	<0.001

- Thus growth failure may begin in utero due to alterations in fetal blood flow and other uncharacterized factors.

Williams RV et al. Congenit Heart Dis 2010:5:96-103.

BURDEN OF FEEDING AND GROWTH FAILURE

- **WAZ < -2 at discharge:**
- 36% in ISV Trial (2003-2007).
- 39% in SVR Trial (2005-2008).
- 35% NPCQIC (2016-2019).

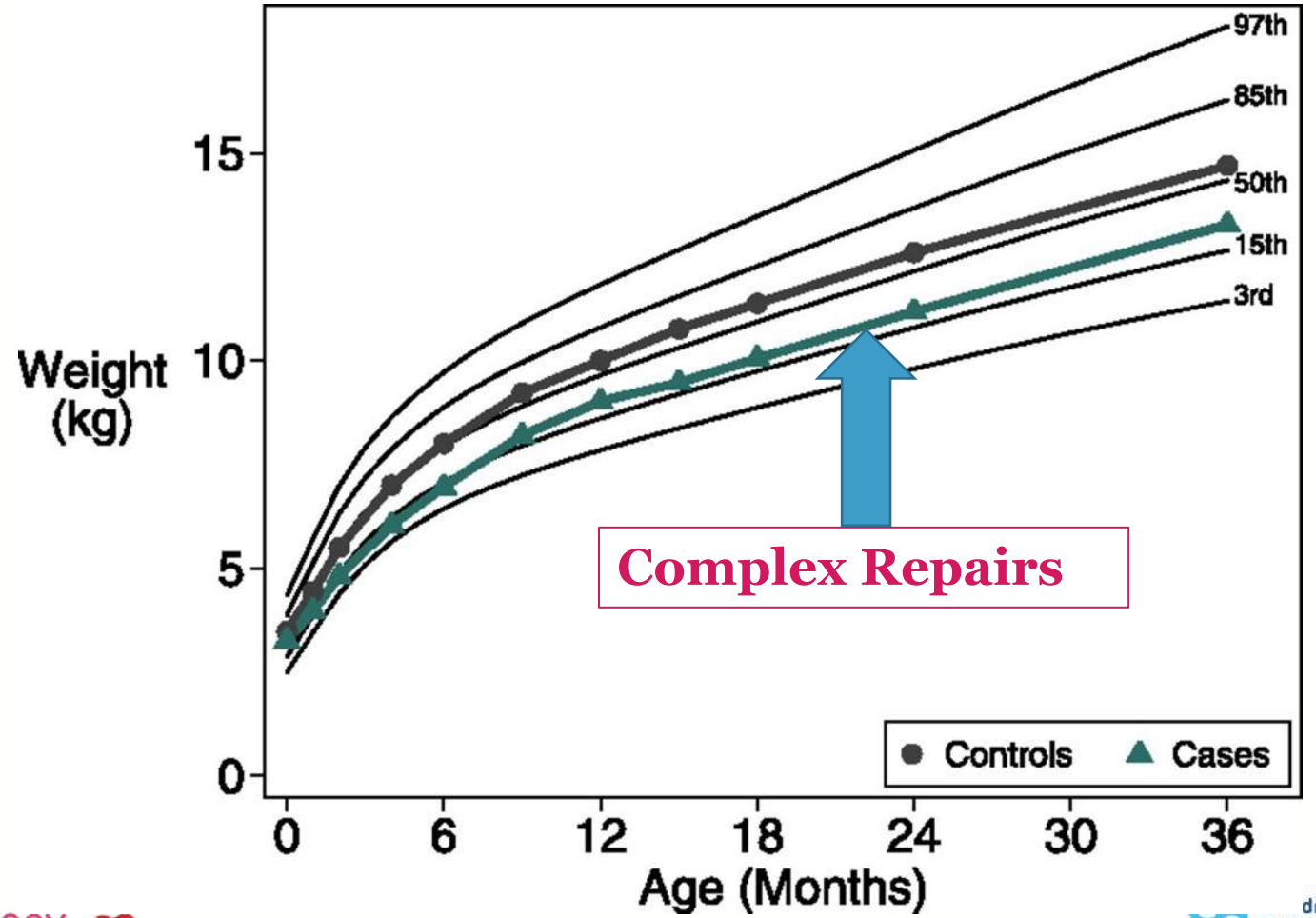
- More than half these infants are discharged home on tube feedings, either exclusive or combined with oral feedings.

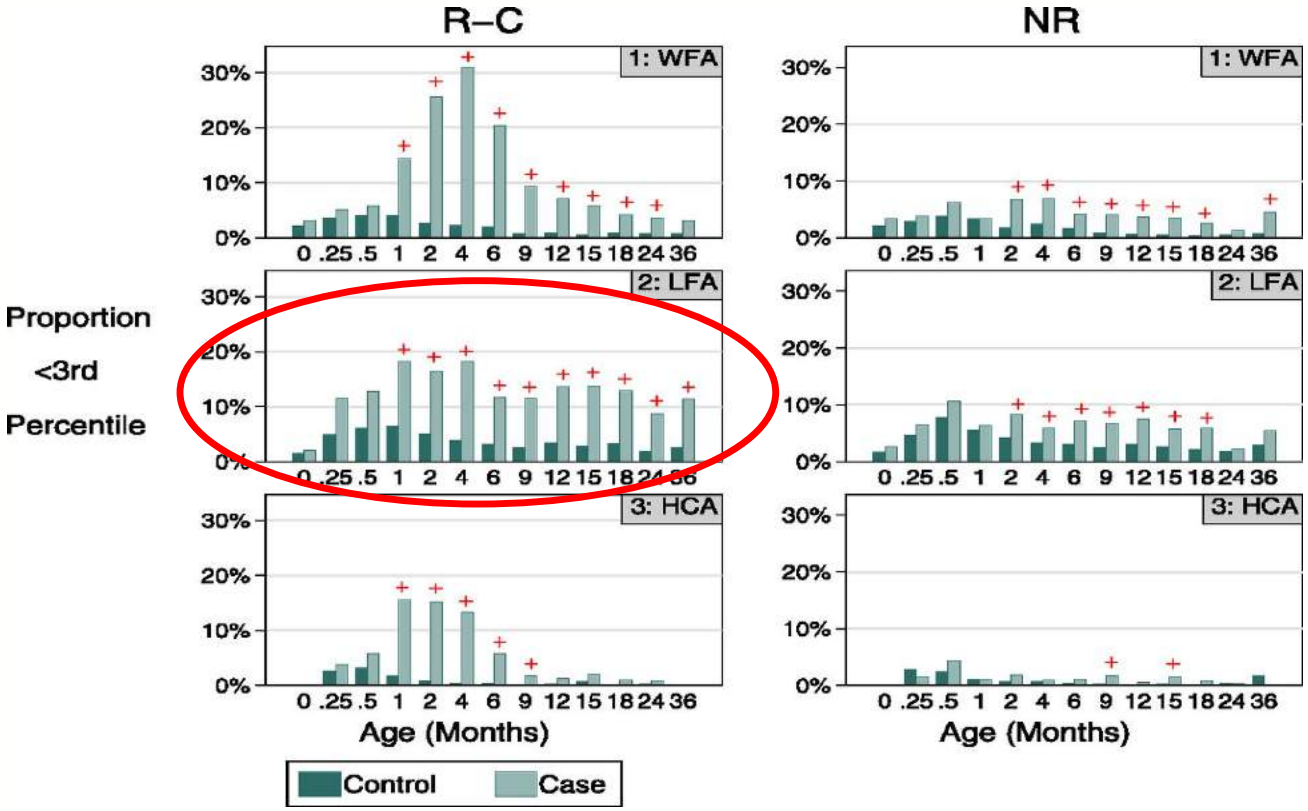
Hsu DH et al. Circulation 2010;122:333-340.
Burch PT, Gerstenberger E, Ravishankar C, et al.
J Am Heart Assoc. 2014; 3: e 000079.
Moza R, Dongngan TT, Lambert LM, et al. J Pediatr. 2021 ; 23: 20-26.

GROWTH IN CHILDREN WITH CHD

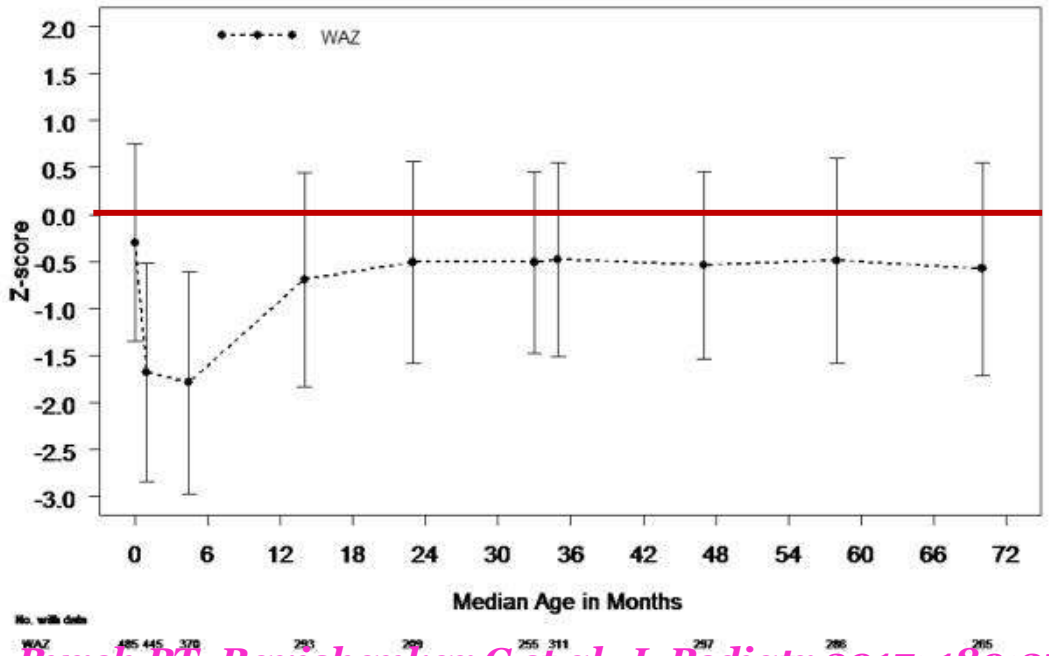
- A retrospective cohort matched study identified children with CHD in a large primary care network in Pennsylvania, New Jersey and Delaware and matched them 10:1 with control subjects.
- Primary outcome
- Difference in weight for age, length for age and HC for age z-scores at traditional ages for preventive visits.

Modified from: Carrie Daymont et al. Pediatrics 2013;131:e236-e242.


97th
85th
50th
15th
3rd
Weight (kg)
15
10
5
0
0
6
12
18
24
30
36
Age (Months)
Controls
Cases
Complex Repairs

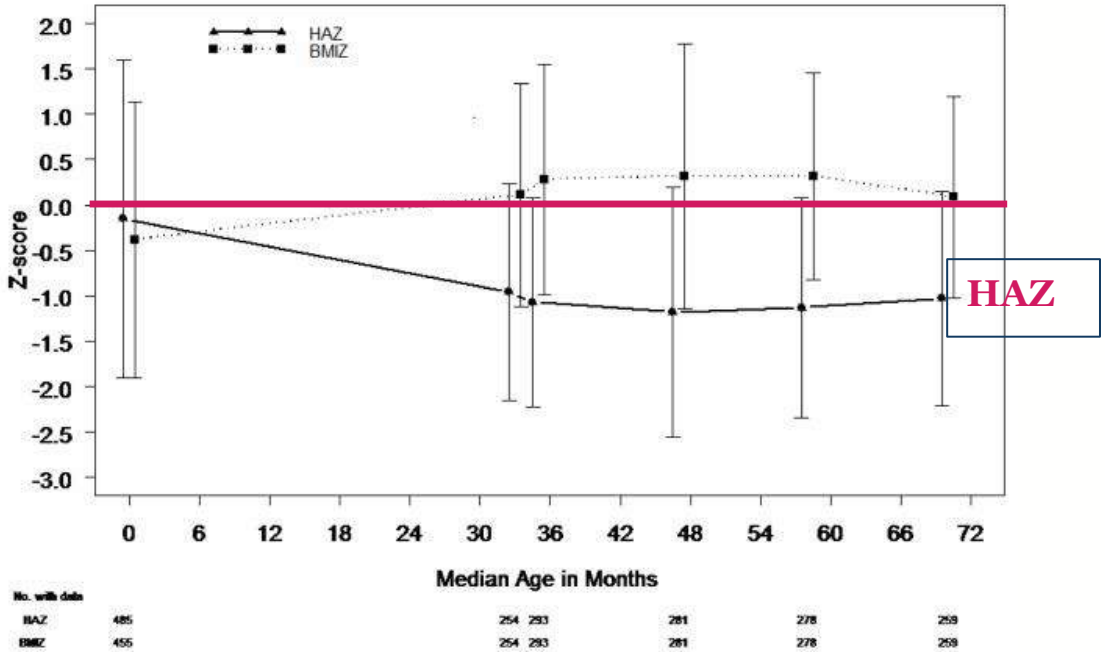

R–C
NR
1: WFA
2: LFA
3: HCA
Proportion
<3rd
Percentile
30%
20%
10%
0%
0 .25 .5 1 2 4 6 9 12 15 18 24 36
Age (Months)
Control
Case

WAZ at 6 years in HLHS: Single Ventricle Reconstruction Trial (n=265)



Burch PT, Ravishankar C et al. J. Pediatr 2017: 180;270-274.

Height at 6 years in HLHS



Burch PT, Ravishankar C et al. J. Pediatr 2017: 180;270-274.

ETIOLOGY OF FEEDING CHALLENGES AND GROWTH FAILURE

Demand/ Expenditure

Supply/ Intake

ETIOLOGY OF FEEDING CHALLENGES AND GROWTH FAILURE

Feeding difficulty
Vocal cord injury
Gastroesophageal Reflux
Malabsorption
Fluid restriction
Concern for NEC

ETIOLOGY OF FEEDING CHALLENGES AND GROWTH FAILURE

Hemodynamic burden
Effects of CPB
Exacerbated by TR, ventricular dysfunction

Tachypnea
Poor coordination
Vocal cord injury
Gastroesophageal Reflux
Malabsorption
Fluid restriction
Concern for NEC

GENETIC FACTORS

- Known syndromes such as Down's.
- Swallowing issues (DiGeorge syndrome).
- Other genetic syndromes.

OTHER FACTORS

- A prospective observational pilot study in neonates with SV (n=38) explored the relationship between heart failure as assessed by BNP and growth factors such as insulin like growth factor I (IGF-1) and insulin like growth factor binding protein 3 (IGFBP-3).
- Measurements before discharge from the neonatal hospitalization, immediately before and after discharge from the SCPC.
- **Serum BNP levels decreased over time and IGF-I Z score increased over time but remained less than 0.**

Gardner MG, Faerber J, Glatz A, et al. Am J Cardiol 2022; 171: 146-150.

HEART FAILURE AND GROWTH

	Estimate	P Value
Change in BNP Vs. Change in IGF-1 Visit 1 to Visit 2	-2.38, 95% CI (-4.71, -0.045)	0.046
Change in BNP Vs. Change in IGF-1 Visit 2 to Visit 3	-4.33, 95% CI (-8.62, -0.034)	0.048

A greater decrease in BNP was associated with a greater increase in IGF-1 between study visits.

HEART FAILURE AND GROWTH

- An inverse correlation between BNP and IGF-1 Z-scores.
- This is suggestive that the "heart failure" state present in shunt dependent infants may play a mechanistic role in impaired growth.
- This deserves further exploration in a larger cohort.

IMPACT OF POOR GROWTH

GROWTH AND POSTOPERATIVE OUTCOMES

- Lower WAZ has been associated with longer ventilation time and LOS irrespective of type of surgery.
- WAZ<-2 has been associated with a higher risk of infection in the postoperative period.
- Lack of growth after discharge has been associated with late mortality.

Anderson JB et al. J Thorac Cardiovasc Surg 2009;138:397-404. Wallace MC, et al, Ann Thorac Surg 2011; 91:1445-52. Eskedal LT et al. Arch Dis Child 2008;93:495-501.. Anderson JB et al. Ann Thorac Surg 2011;91:1460-6.

GROWTH AND ND OUTCOME

- In the ISV Trial, poor linear growth was associated with worse MDI and PDI scores.
- Similarly, lower WAZ, HAZ and HCAZ has been associated with worse ND outcome at 6 and 12 months.
- In addition, tube assisted feeding has been associated with worse ND outcome in infancy.

Ravishankar C et al. J Pediatr. 2013; 162: 250-256.
Medoff-Cooper B. et al. J. Pediatr. 2016;169: 154-159.

PARENTAL STRESS

- To test the effect of a 4-month telehealth home monitoring program (*REACH*), layered on usual care on parental stress.
- Inclusion: Neonates requiring cardiac surgery.
- From 2012-2016, 219 parent-infant dyads were enrolled.
- 109 in the intervention group and 110 in the control group.
- When added to usual care, the *Telehealth* intervention was not associated with an improvement in parent outcomes.
- Total PSI score: 347 (>99th %le).
- **Nearly 20% met PTSD criteria.**

Fleck DA et al. Cardiol Young 2018; 28:961-967.
Medoff-Cooper B, Marino BS, Fleck DA, et al. Pediatrics 2020; 146 (3): e 20200531.

INTERVENTIONS

GENERAL RECOMMENDATIONS

- The role of a dedicated registered dietitian cannot be emphasized enough both during the neonatal hospitalization and subsequently on outpatient follow up after discharge.
- **Type of feeds:**
- Human milk is preferred but may need to be fortified.
- Higher concentration of standard formulas are frequently required.
- In infants with a history of NEC or significant feeding intolerance, semi elemental and elemental formulas are reasonable.
- **Mode of feeding:**
- Post pyloric rather than gastric tube feedings are frequently used in infants with marginal respiratory status and in those with severe gastroesophageal reflux.

PREOPERATIVE PERIOD: IS IT SAFE TO FEED?

- The NPCQIC feeding algorithm published in 2013 recommends feeding ductal dependent neonates, who are hemodynamically stable.
- Recent analysis of 944 infants with HLHS and variants in the NPCQIC registry:
- 58% were fed in the preoperative period (majority po).
- 30% were not fed for clinical reasons.
- 12% due to institutional practice.
- Preoperative oral feeding was not associated with an increased risk of NEC.
- Institutional practice of not feeding in the preoperative period did not reduce the risk of NEC.

Sagiv E, Tjoeng YL, Davis M, et al. Pediatr Cardiol 2022 ; 43: 1141-1155.
Slicker J, Hehir DA, Horsley M, et al. Congenit Heart Dis 2013; 8 (2): 89-102.

SAFE TO FEED IN THE PREOPERATIVE PERIOD

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- **Preoperative oral feeding was not associated with an increased risk of NEC.**
- **Institutional practice of not feeding in the preoperative period did not reduce the risk of NEC.**

POSTOPERATIVE PERIOD

- Use of parenteral nutrition in the early postoperative period while advancing enteral feeds.
- Initiation of enteral feeds as soon as hemodynamic stability is established.
- Use of a standardized protocol/ algorithm for nutrition that includes guidance on type of feeds, mode of feeding, feed advance, red flags etc.
- Standardization of airway evaluation and swallowing ability/safety in infants with suspected vocal cord injury and feeding difficulties.
- Optimization of therapy for gastroesophageal reflux.

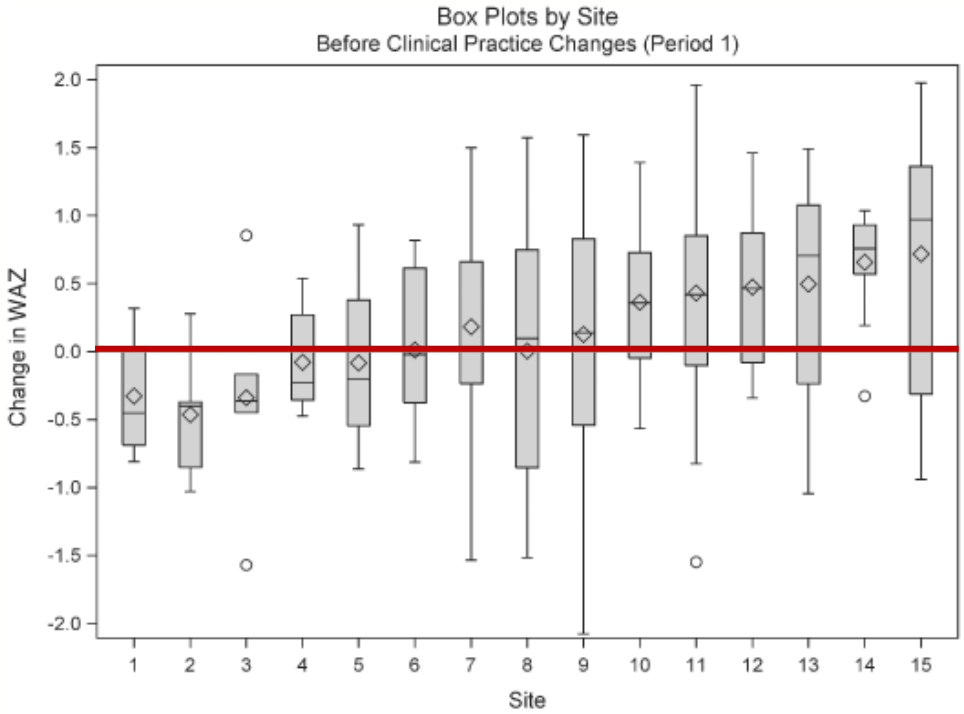
Slicker J, Hehir DA, Horsley M, et al. Congenit Heart Dis 2013; 8 (2): 89-102.
Lisante AJ, Savoca M, Gaynor JW, et al. J Pediatr. 2021; 231 : 124-130 e1.

AFTER DISCHARGE

- Ongoing nutritional surveillance and interventions after discharge for all infants requiring interventions in the neonatal period.
- Includes neonates with biventricular repair.

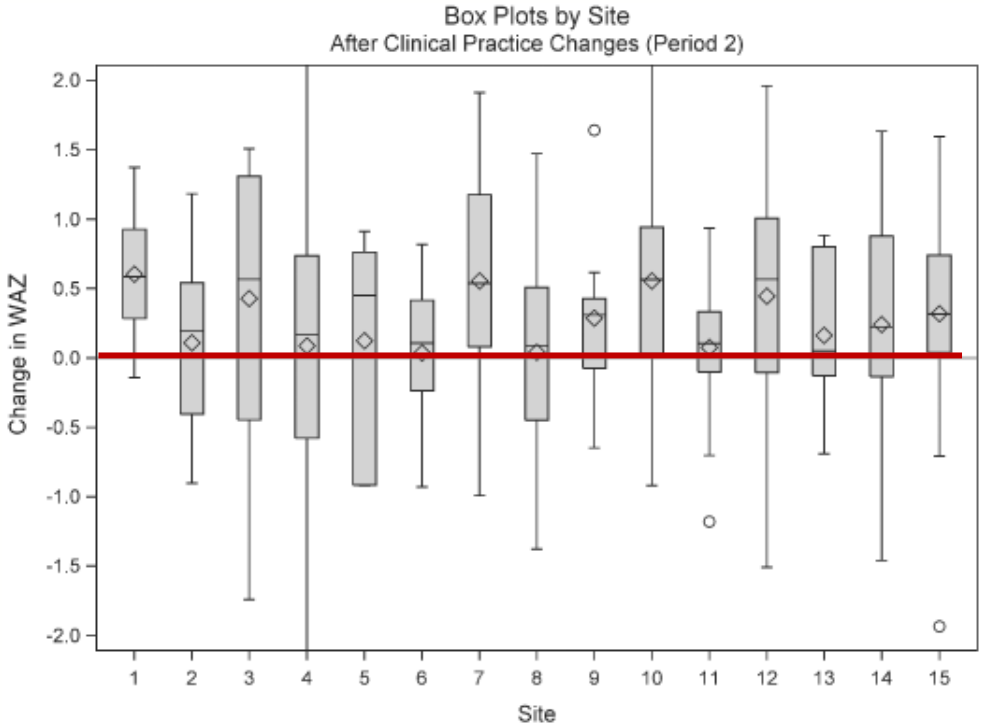
USE OF A LEARNING NETWORK TO IMPROVE VARIATION IN INTERSTAGE WEIGHT GAIN AFTER THE NORWOOD OPERATION

Implementation of a growth bundle



Modified from Anderson JB et al. Congenit Heart Dis. 2014;9:512-520.

USE OF A LEARNING NETWORK TO IMPROVE VARIATION IN INTERSTAGE WEIGHT GAIN AFTER THE NORWOOD OPERATION



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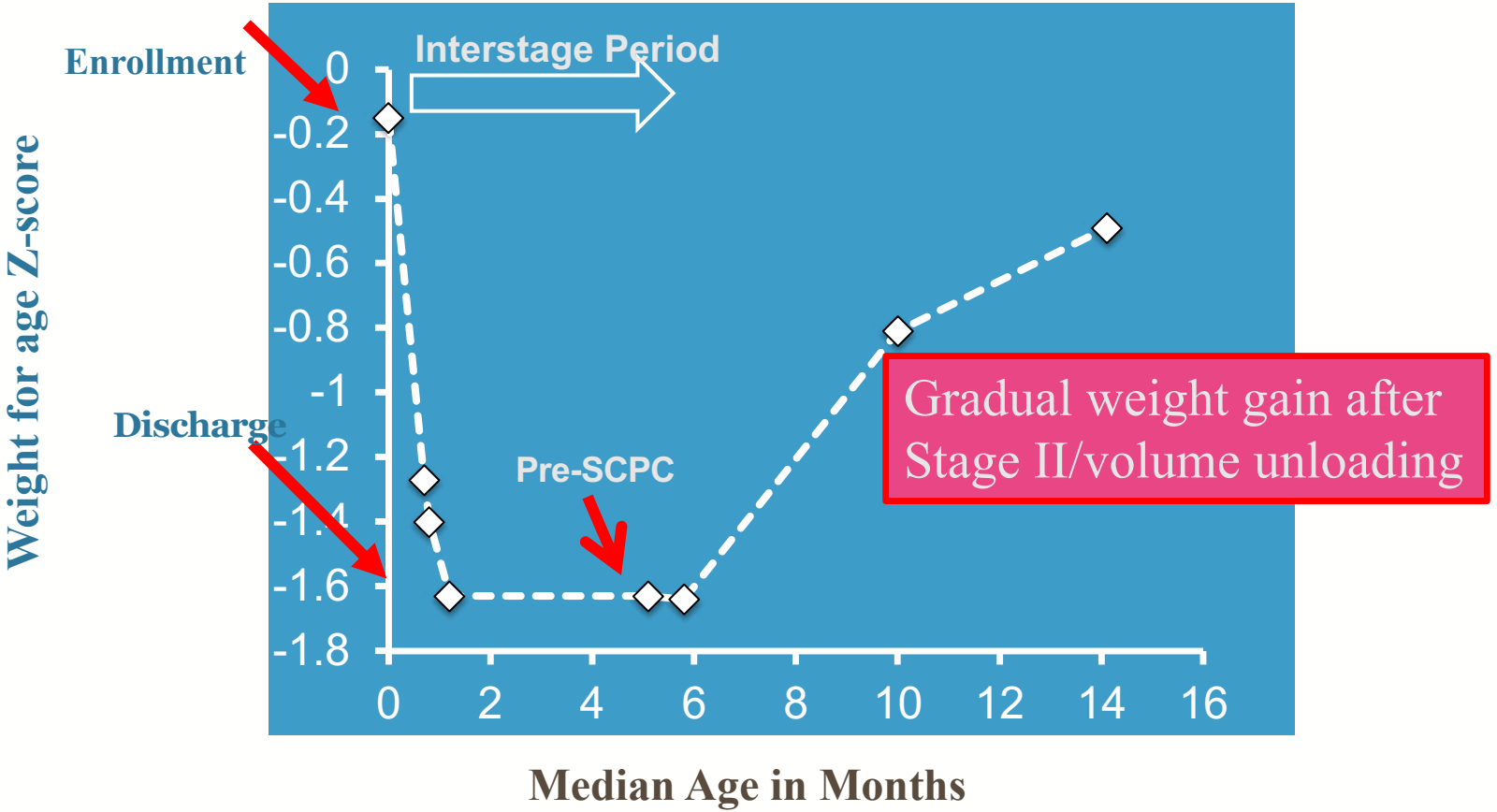
MEAN WEIGHT FOR AGE Z-SCORE VS. AGE



WHAT'S NEW?

- In a single center pilot study of 15 neonates undergoing cardiac surgery including 13 Norwood procedures, oxandrolone appears safe and may have a potential benefit in improving weight in the immediate postoperative period.
- A safety and efficacy trial entitled "Use of oxandrolone to promote growth in infants with hypoplastic left heart syndrome: a phase I/II pilot study" sponsored by the PHN is currently underway.

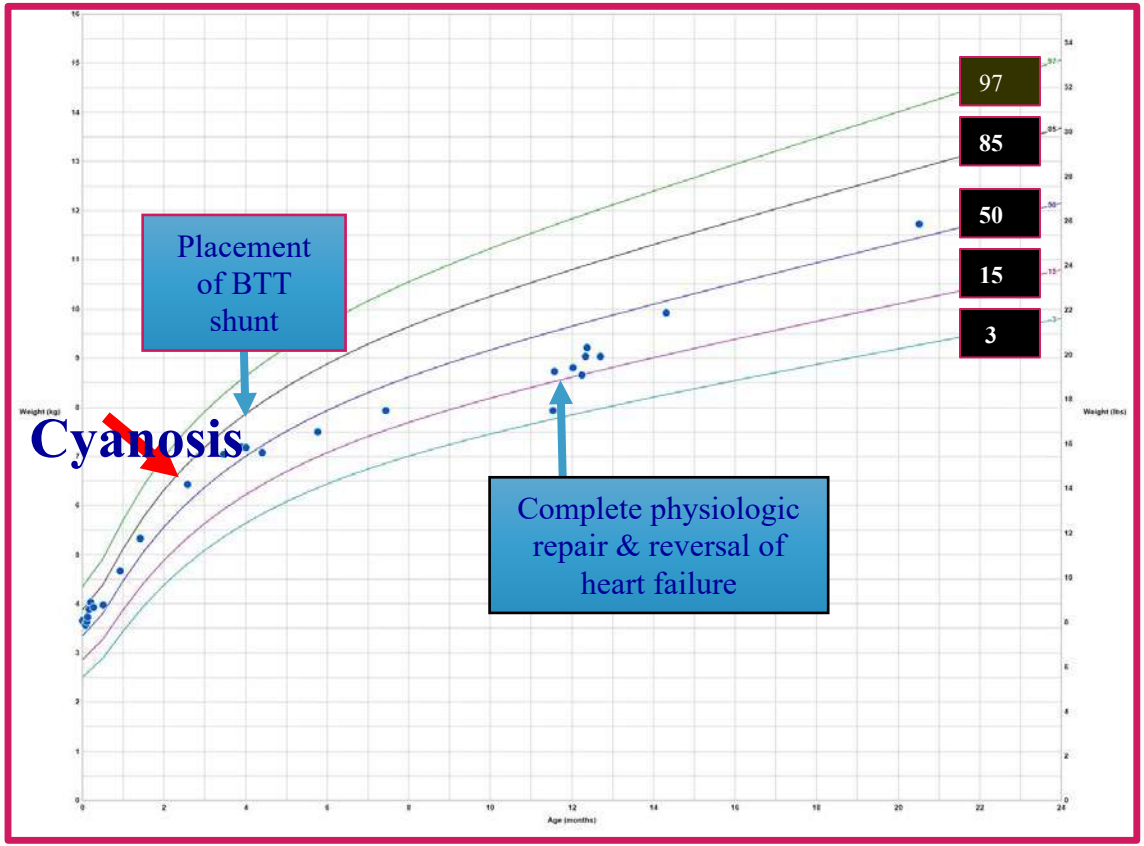
Marino LV, Eveleens RD, Morton K, et al. J. Human Nutr Diet 2019; 32 (3): 400-408.
Burch PT, Spigarelli MG, Lambert LM, et al. Congenit Heart Dis. 2016; 11: 693-699.

WHAT'S NEW?

- There are some recently published reports regarding the safety of peptide nutrient-energy dense formulas in neonates and infants with CHD.
- Another important initiative supported by the NPCQIC is the utilization of intense feeding programs to transition infants with univentricular physiology from tube feedings to oral feeds by the first year of life.

Marino LV, Eveleens RD, Morton K, et al. J. Human Nutr Diet 2019; 32 (3): 400-408.

D-TGA / VSD / PS


97
85
50
15
3
Placement of BTT shunt
Cyanosis
Complete physiologic repair & reversal of heart failure
Weight (kg)
Weight (lbs)
Age (months)

CONCLUSIONS

- Challenges related to feeding and growth emerge shortly after birth in neonates with CHD and are often lifelong issues.
- Collaboration among centers (NCQIC,PC4,PAC3) has resulted in identifying best feeding practices and standardization of care.
- Treatment of heart failure and balancing the circulation may have a greater impact on growth than nutritional interventions.
- Neonates undergoing biventricular repair should receive as much attention as those with univentricular physiology.

CONCLUSIONS

- “Stunting” or short stature is a significant problem in children with complex CHD.
- “Stunting” in infancy has been associated with worse early neurodevelopmental outcome.
- Clinicians should be attentive to poor linear growth in infancy as a marker for potential neurodevelopmental issues.

CONCLUSIONS

- Nurses not only play a critical role in feeding these fragile neonates at the bedside, but they should also be encouraged to take the lead in research efforts on this topic.
- Future efforts should focus on improving our understanding of the etiology of growth failure and exploring novel therapeutic options.

ACKNOWLEDGEMENT

- Dr. Barbara Medoff-Cooper.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