Pediatric Echocardiographic Normal values

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Background

- An echocardiographic quantitative evaluation of the cardiac and vascular structures is often of critical importance for the diagnosis and management of congenital heart diseases.
- In the pediatric age echocardiographic measurements, as well as any other measurements, need to be normalized according to range of normality for a given age and body size.

How To Normalize

- In the pediatric age data are commonly normalized according to:
- Age
- Weight/height
- BSA

- BSA usually adopted for normalization in pediatric echocardiography

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The Why and How of Z Scores

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Editorial Comment

The Why and How of Z Scores

Steven D. Colan, MD, *Boston, Massachusetts*

The use of echocardiographic measurements to detect disease and predict outcomes can be confounded by a number of nondisease factors, including the effect of body size, that contribute to the variance of these measurements. The process of normal growth is associated with a nearly 200-fold increase in normal left ventricular end-diastolic volume (EDV) from premature infants up to large adolescents, making it imperative to account for changes in body size in pediatrics. Although this issue is often ignored in adult echocardiography, the sensitivity and specificity of parameters of left ventricular size are significantly improved when adjustment for body size in adults is performed.[1] The article by Mawad *et al*[2] in this issue of *JASE* addresses an important aspect of this process, although it is likely a topic that is unfamiliar to most echocardiographers, even those in pediatric cardiology who rely heavily on Z scores. The concept of Z scores itself is often unfamiliar to adult echocardiographers.

cardiomyopathy that includes EDV as an end point (see Table 1). The study design involves recruiting 10 age-matched, sex-matched, and BSA-matched pairs of various ages and conducting a placebo-controlled trial lasting 2 years. As shown in the table, we are assuming perfect matching (age and BSA are identical in both groups) and similar growth in both groups, which is unrealistic, but these are well-recognized sources of variance, and by eliminating them as potential confounders in this example, recognition of other sources of variance is enhanced. The EDVs and EDV Z scores in the two groups are insignificantly different at baseline. Paired comparison of change in EDV between the treatment and control groups detects no statistically significant clinical benefit ($P = .14$), whereas when adjustment for body size is performed by paired comparison of change in EDV Z score at the two time points, the effect is significant ($P = .04$).

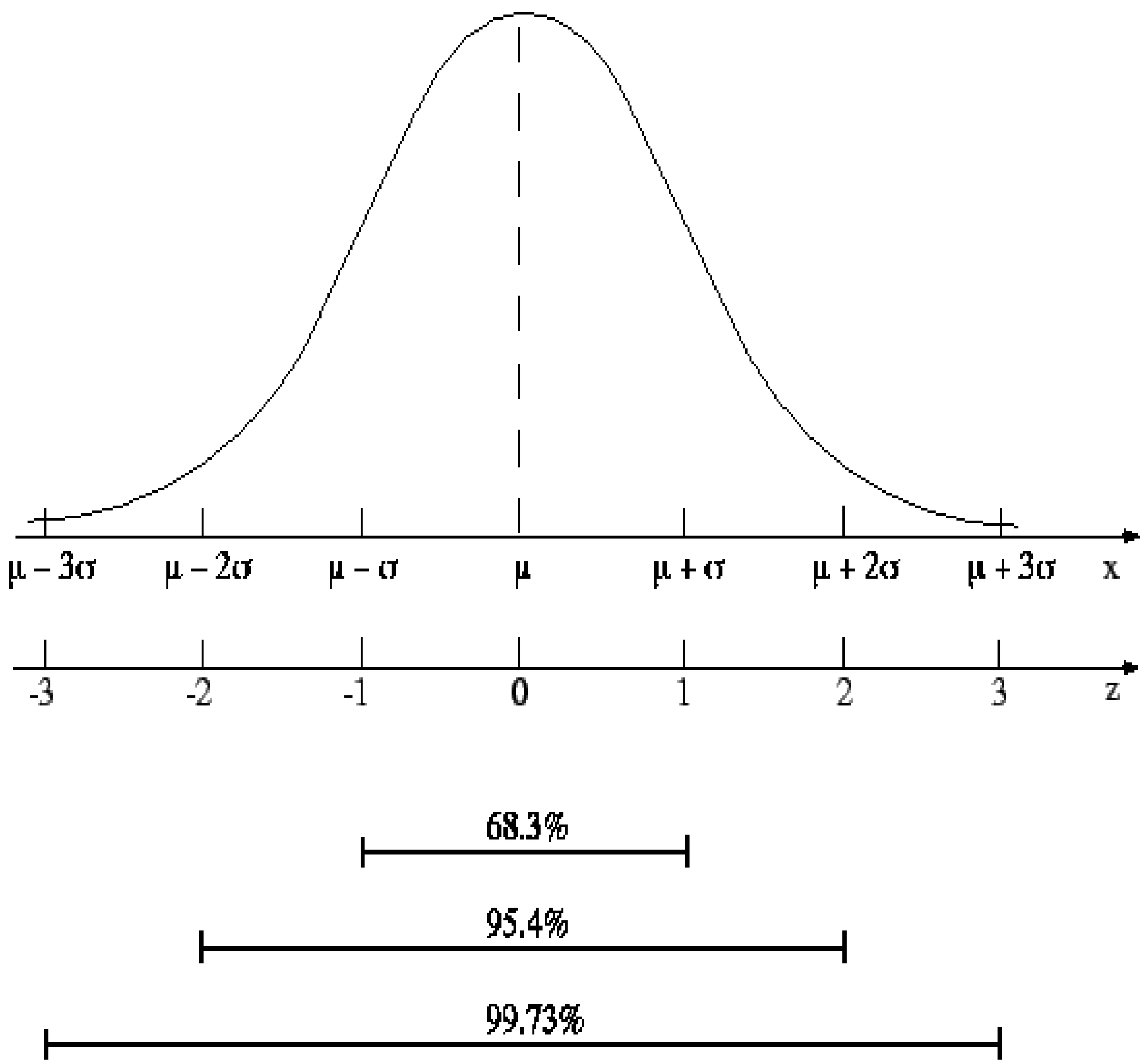
Why was the analysis based on Z scores more effective in detecting

How to express normalized data: Z scores

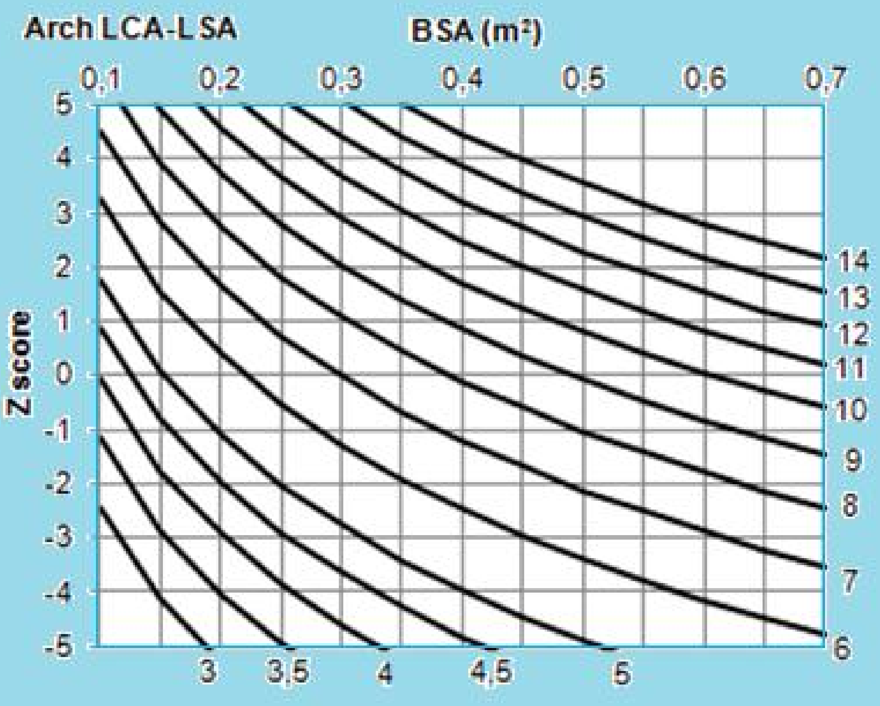
- Normalized data may be expressed in different ways, including the percentage of the mean normal value, percentile charts, and Z scores.
- The Z score of a measurement is the number of standard deviations of that value from the mean value. If a measurement is equal to the population mean, the
- ***Z score is 0; a Z score of +2 or 2 corresponds to the 95th percentile (i.e., 2 standard deviations above or below the mean)***

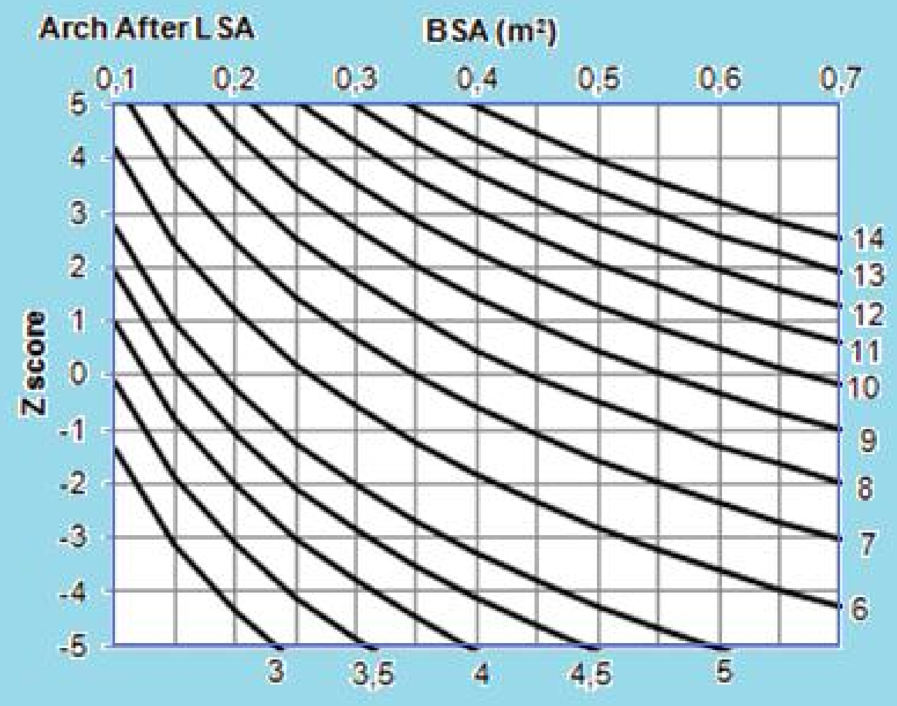
Nomograms and Z scores

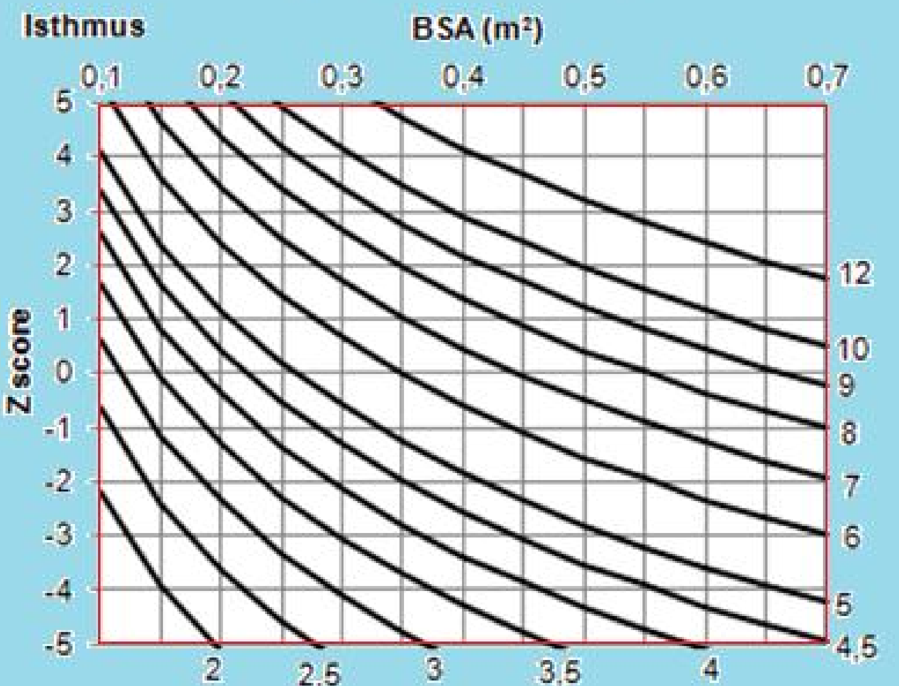
- Thus to normalize in pediatric echocardiography we use nomograms
- Normalized data are expressed as z score
- i.e. a z score > 2 indicate dilatation while a z score <2 indicate hypoplasia

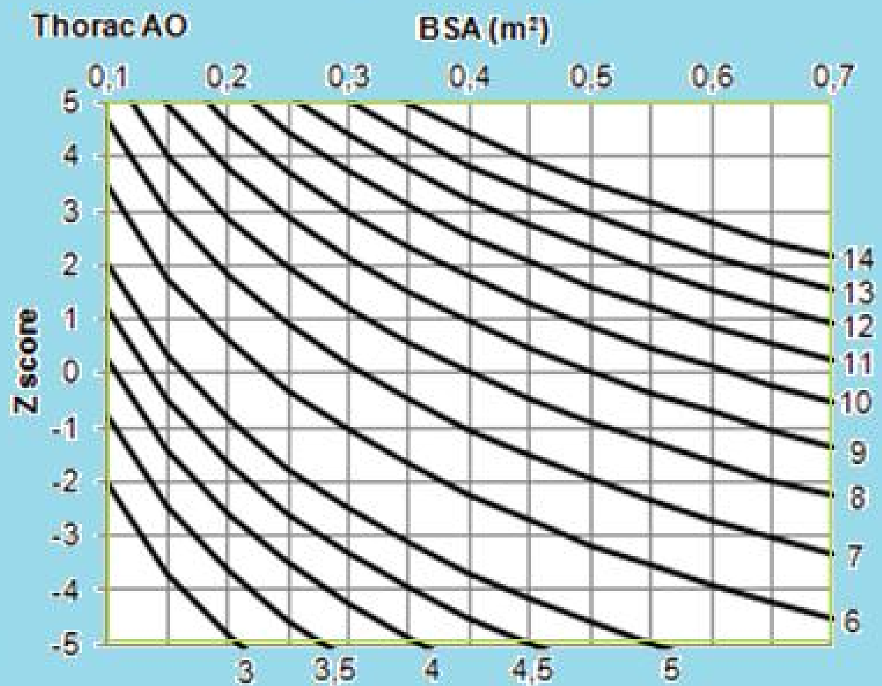


μ – 3σ
μ – 2σ
μ – σ
μ
μ + σ
μ + 2σ
μ + 3σ
x
-3
-2
-1
0
1
2
3
z
68.3%
95.4%
99.73%


Arch LCA-L SA
BSA (m²)
0,1 0,2 0,3 0,4 0,5 0,6 0,7
Z score
5 4 3 2 1 0 -1 -2 -3 -4 -5
14 13 12 11 10 9 8 7 6
3 3,5 4 4,5 5


Arch After LSA
BSA (m²)
0,1 0,2 0,3 0,4 0,5 0,6 0,7
Z score
5 4 3 2 1 0 -1 -2 -3 -4 -5
14 13 12 11 10 9 8 7 6
3 3,5 4 4,5 5


Isthmus
BSA (m²)
0,1 0,2 0,3 0,4 0,5 0,6 0,7
Z score
5 4 3 2 1 0 -1 -2 -3 -4 -5
12 10 9 8 7 6 5 4,5
2 2,5 3 3,5 4


Thorac AO
BSA (m²)
0,1 0,2 0,3 0,4 0,5 0,6 0,7
Z score
5 4 3 2 1 0 -1 -2 -3 -4 -5
14 13 12 11 10 9 8 7 6
3 3,5 4 4,5 5

To trust in z scores?

- Clinician often rely on z score to take very important clinical decision (i.e. biventricular versus single ventricle repair)
- Thus z scores should be accurate tools
- BUT……..

PART 1: dimensional Indexes

- Basically 2d values

Parameterz.com

Z-Scores of Cardiac Structures | Detroit Data

Calculate the z-scores of 21 common 2D and M-Mode echo measurements, related to body surface area. Measurement sites include the mitral valve, left ventricle, aortic valve, aortic arch, pulmonary valve, and pulmonary arteries. Data is from 782 patients evaluated at the Children's Hospital of Michigan.

Height (cm): 50
Weight (kg): 3.5
BSA formula: DuBois 0.21 M²

Site	Measured (cm)	Mean	Range	Z-Score
RVD:		1.02	(0.68 - 1.51)	
IVSd:		0.36	(0.26 - 0.52)	
IVSs:		0.48	(0.36 - 0.65)	
LVIDd:		1.85	(1.57 - 2.18)	
LVIDs:		1.14	(0.93 - 1.41)	
LVPWd:		0.29	(0.21 - 0.39)	
LVPWs:		0.55	(0.43 - 0.70)	
Aortic Annulus:	0.5	0.68	(0.58 - 0.80)	-3.08
Sinuses:		0.96	(0.80 - 1.15)	
ST Junction:		0.75	(0.60 - 0.94)	
Transverse Arch:		0.77	(0.60 - 0.99)	
Isthmus:		0.54	(0.41 - 0.71)	

Height (cm): 5
Weight (kg): 3.5
BSA formula: Boyd 0.12 m²

Location	Measured	Mean	Range	Z-Score
Tricuspid Valve (cm):				
RV Inflow (cm):				
RV Outflow (cm):				
RV Area (cm²):				
Pulmonary Valve (cm):				
MPA (cm):				
RPA (cm):				
LPA (cm):				
Mitral Valve (A-P) (cm):				
Mitral Valve (Lat) (cm):				
LV Inflow (cm):				
LV Area (cm²):				
Aortic Valve (cm):	0.5	0.53	0.47 - 0.59	-0.83
Sinuses (cm):				
ST Junction (cm):				

Update

Journal of the
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On the Cover

New Issue Alert

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About the Journal

Journal of the American Society of Echocardiography – official publication of the American Society of Echocardiography – brings physicians and sonographers the very latest clinical, scientific, legal, and economic information regarding the use of

Current Issue | February 2012, Vol. 25, No. 2

Full Table of Contents

3.518 Impact Factor!

Issue Highlights

The Role of Echocardiography in the Management of Patients Supported by Extracorporeal Membrane Oxygenation
February 2012(Vol. 25 | No. 2 | Pages 131-141)
David Gerard Platts, John Francis Sedgwick, Darryl John Burstow, Daniel Vincent Mullany, John Francis Fraser

Limitations of Current Echocardiographic Nomograms for Left Ventricular, Valvular, and Arterial Dimensions in Children: A Critical Review
February 2012(Vol. 25 | No. 2 | Pages 142-152)
Massimiliano Cantinotti, Marco Scalese, Sabrina Molinaro, Bruno Murzi, Claudio Passino

Claudio Passino

Abstract | Full Text | PDF (372 KB)

Alteration in Subendocardial and Subepicardial Myocardial Strain in Patients with Aortic Valve Stenosis: An Early Marker of Left Ventricular Dysfunction?
February 2012(Vol. 25 | No. 2 | Pages 153-159)

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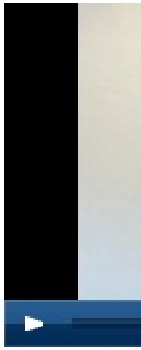

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About the
Echocard

Structures evaluated

We evaluated 31 published nomograms on 2 cardiac dimensions:

- ***LVED and LVES*** diameters in M-mode;
- ***MV annulus*** in apical 4CH-view and PLA view and the ***TV annulus*** in the apical 4CH-view;
- ***Pulmonary annulus, MPA, and pulmonary arteries*** in the parasternal SA view;
- ***Aorta***: AO annulus, the AO root at the sinuses of Valsalva, the sinotubular junction, and the ascending aorta in the PLA view;
- ***AO Arch*** at different levels: the proximal transverse arch (between the IA and LCA), the distal transverse arch (LCA and LSA) and the aortic isthmus (narrowest aortic segment distal to LSA).

RESULTS

- ➢The analysis highlights the accuracy of the latest studies but also underscores that some limitations remain.

2 major Limitations

- ➢Numerical
- ➢Methodological

Methodological Limitations

- the lack of standardization in echo measurements (ASE guidelines only recently available)
- the different types of body size measurements used for normalization (BSA, weight, height)
- the various ways to express normalized data.

Numerical limitations

- The number of healthy subjects was limited
- Poor differentiation among age subgroups
- ***Neonates*** poorly investigated
- Data for many cardiac structures were not numerous, especially for the aortic arch and pulmonary branches.

Echo measurements

- For a long period of time it was not clear which moment of the cardiac cycle to employ for measurements
- ASE guidelines only recently available
- 2D valvular and vessels diameters should be measured at the moment of maximum expansion (Ped Guidelines not Adult)

Confounders

- Potential confounders have scarcely evaluated
  - ➢Gender and race differences
  - ➢Interobserver and intra-observer variability
  - ➢Neonates: factor related to delivery

A huge heterogeneicity in estimation of the CHD

Case:

- **A male child with a BSA of 0.3 m2**
- **MV annulus of 11 mm**

significantly different results can be obtained according to the nomogram used,

from lower limits of normality **(-1.63)** up to a clear hypoplasia of **-4.84.**

Nomograms for LV diameters: Example BSA 0.3 m2

	Nr	BSA	R.E.	Age	LVED (mm)	LVES (mm)
Gutgesell HP et al. (11)	145 (80 M, 65 F)			1 day-19 yrs 30 neonates	y=37.75+12.88*ln(BSA) *22.24 (18.91-25.58)*	
Henry W.L. et al. (14)	105 (52 M, 53 F)			1 day-23 yrs 13 neonates	$y=-6.6+45.2*(BSA)^{1/3}$	$y=-3.8+28.3*(BSA)^{1/3}$
Akiba T. et al. (28)	110 (67 M, 43 F)			2-15 yrs	$y=41.4*BSA^{0.49}$	$y=28.1*BSA^{0.49}$
Ichida F. Et al. (31)	153 (97 M, 76 F)			1 day-15 yrs		y=3.861+1.365*ln(BSA) *22.2 (18.2-26.2)*
Huwez F.U. et al. (45)	127 (77 M, 50 F)			7 month-19.5 yrs	y=1.3988+1.0295*BSA	y=2.2326+1.59*BSA
Kampmann C. et al. (57)	2036			0-18 yrs 450 neonates	$y=38.537*BSA^{0.4509}$ *22.9 (18.0-25.8)*	$y=24.231*BSA^{0.4469}$ *14.8 (10.8-18.8)*
Sluysman T. et al. (61)	496			0-20 yrs	$y=3.935*BSA^{0.444}$	
Pettersen M. et al. (68)	782			1 day-18 yrs 82 neonates	$Ln(y)=0.105+2.859*BSA-2.119*BSA^2+0.552*BSA^3$ *22.0 (18.0-26.8)*	$ln(y)=-0.371+2.833*BSA-2.081*BSA^2+0.538*BSA^3$ *13.6 (10.5-17.5)*

Nomograms for AV valves: Example BSA 0.3 m2

	Nr	*Age*	*Mitral annulus 4-C (mm)*	*Mitral annulus PLA (mm)*	*Tricuspid annulus (mm)*
King D.H. et al. (25)	103	1 day-15 yrs	y=32.3+12.47*ln(BSA) 17.29 (13.71-20.86)	y=23.9+8.56*ln(BSA) *13.59 (10.91-16.28)*	y=32.4+12.29*ln(BSA) 17.60 (13.92-21.29)
Hanseus K. et al. (35)	120 (58 M, 62 F)	3 days-15.5 yrs	ln(y)=0.209+0.302*ln (BSA) 5.6 (3.2-9.9)		ln(y)=-0.209+0.302*ln(BSA) 5.6 (3.2-9.9)
Daubeney P.E. et al. (56)	125 (69 M, 56 F)	0-17 yrs	ln(y)=0.9651+0.4658*ln(BSA) 15.0 (12.5-18.0)	ln(y)=0.9445+0.5022*ln(BSA) 14.0 (11.6-17.0)	ln(y)=1.084+0.4945*ln(BSA) 16.3 (13.9-19.2)
Sluysman T. et al. (61)	496	0-20 yrs	y=0.125+2.002*(BSA)1/2	$y=0.117+1.844*(BSA)^{1/2}$	$y=0.155+2.075*(BSA)^{1/2}$
Zillberman MV et al. (63) Males	434	0-18 yrs	ln(y)=0.765+0.425*ln(BSA) 12.9 (9.2-18.1)		ln(y)=0.817+0.391*ln(BSA) 14.1 (10.0-19.9)
Zillberman MV et al. (63) Females	314	0-18 yrs	ln(y)=0.733+0.408*ln (BSA) 12.7 (8.9-18.3)		ln(y)=0.755+0.364*ln(BSA) 13.7 (9.5-19.9)
Pettersen M. et al. (68)	782	1 day-18 yrs 82 neonates	ln(y)=-0.271+2.446*BSA-1.70*BSA2+0.425*BSA3 13.8 (10.2-18.6)		$Ln(y)=-0.164+2.341*BSA-1.596*BSA^2+0.387*BSA^3$ 15.0 (10.3-21.9)

Parameterz.com

Z-Scores of Cardiac Structures | Detroit Data

Calculate the z-scores of 21 common 2D and M-Mode echo measurements, related to body surface area. Measurement sites include the mitral valve, left ventricle, aortic valve, aortic arch, pulmonary valve, and pulmonary arteries. Data is from 782 patients evaluated at the Children's Hospital of Michigan.

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Sinuses (cm):				
ST Junction (cm):				

Update

Conclusions

- The lack of valid nomograms based on a robust set of healthy children, using standardized approaches and formulas, substantially affects accuracy in estimating the severity of defects, especially in neonates.
- Despite advances, the process of normalization of pediatric echocardiographic measures is still incomplete.
- Indeed, differences between available nomograms may generate Z scores largely discordant for a given measurement.

Journal of the
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< Previous Article February 2014 Volume 27, Issue 2, Pages 179–191.e2 Next Article >

Echocardiographic Nomograms for Ventricular, Valvular and Arterial Dimensions in Caucasian Children with a Special Focus on Neonates, Infants and Toddlers

Massimiliano Cantinotti, MD, Marco Scalese, MS, Bruno Murzi, MD, Nadia Assanta, MD, Isabella Spadoni, MD, Pierluigi Festa, MD, Vittoria De Lucia, MD, Maura Crocetti, MD, Marco Marotta, MD, Sabrina Molinaro, PhD, Leo Lopez, MD, Giorgio Iervasi, MD

Structures evaluated

- ♥***22 cadiac structures***
- ♥***LVED and LVES*** diameters in M-mode;
- ♥***MV annulus*** in apical 4CH-view and PLA view and the ***TV annulus*** in the apical 4CH-view;
- ♥***Pulmonary annulus, MPA, and pulmonary arteries*** in the parasternal SA view;
- ♥***Aorta***: AO annulus, the AO root at the sinuses of Valsalva, the sinotubular junction, and the ascending aorta in the PLA view;
- ♥***AO Arch*** at different levels
- ♥**Ase Reccomendations (2010**)

Key points in the building of a z score..

- To measure in a reproducible, standardized method
- To use a rigorous statistical methods
- The choice of the parameter to be used for normalization
- Sample size
- Attention to confounders

How to measure?

GUIDELINES AND STANDARDS

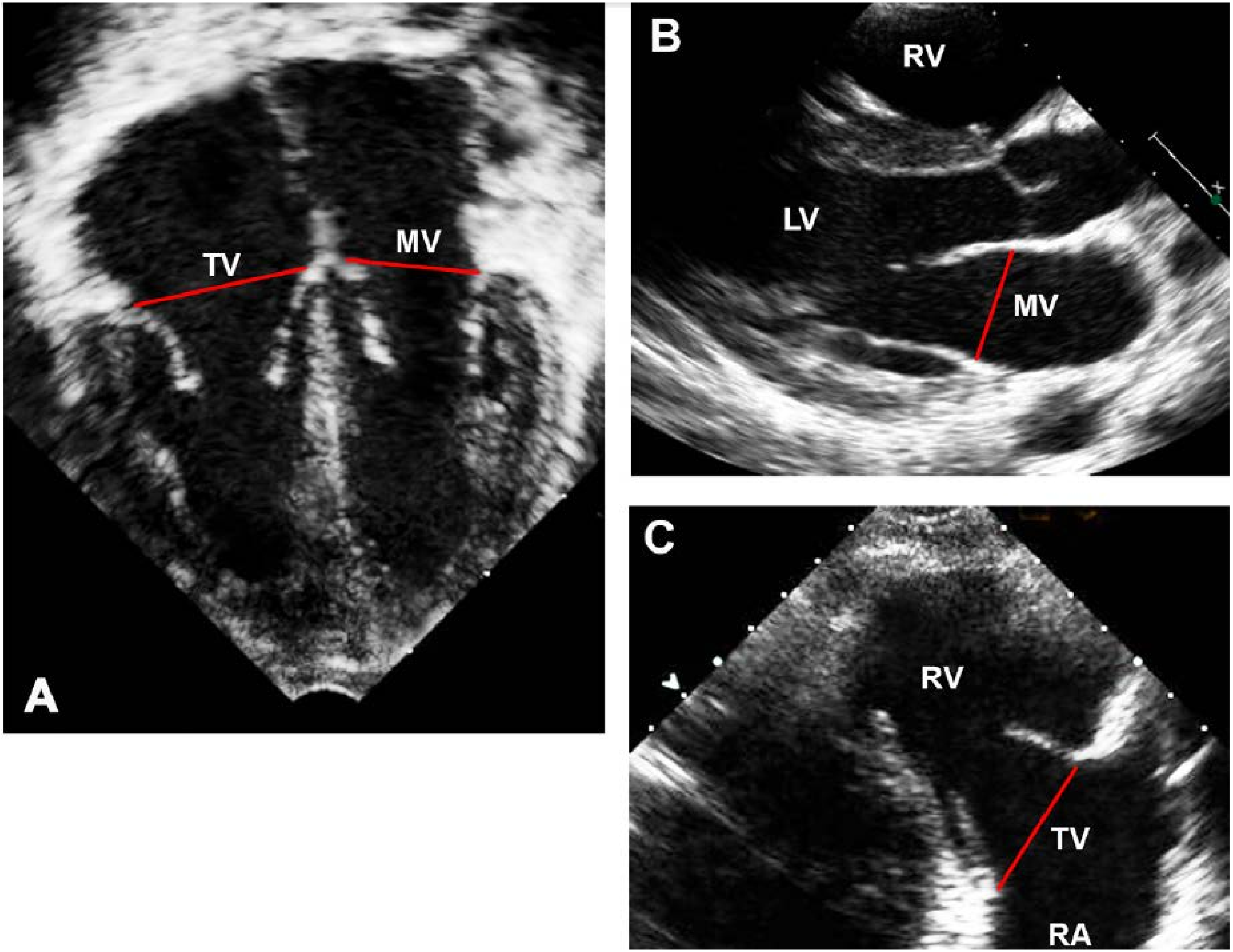
Recommendations for Quantification Methods During the Performance of a Pediatric Echocardiogram: A Report From the Pediatric Measurements Writing Group of the American Society of Echocardiography Pediatric and Congenital Heart Disease Council

Leo Lopez, MD, FASE, Chair, Steven D. Colan, MD, FASE, Peter C. Frommelt, MD, FASE, Gregory J. Ensing, MD, FASE, Kathleen Kendall, RDCS, FASE, Adel K. Younoszai, MD, FASE, Wyman W. Lai, MD, MPH, FASE, and Tal Geva, MD, FASE, *Bronx and New York, New York; Boston, Massachusetts; Milwaukee, Wisconsin; Ann Arbor, Michigan; Houston, Texas; Denver, Colorado*

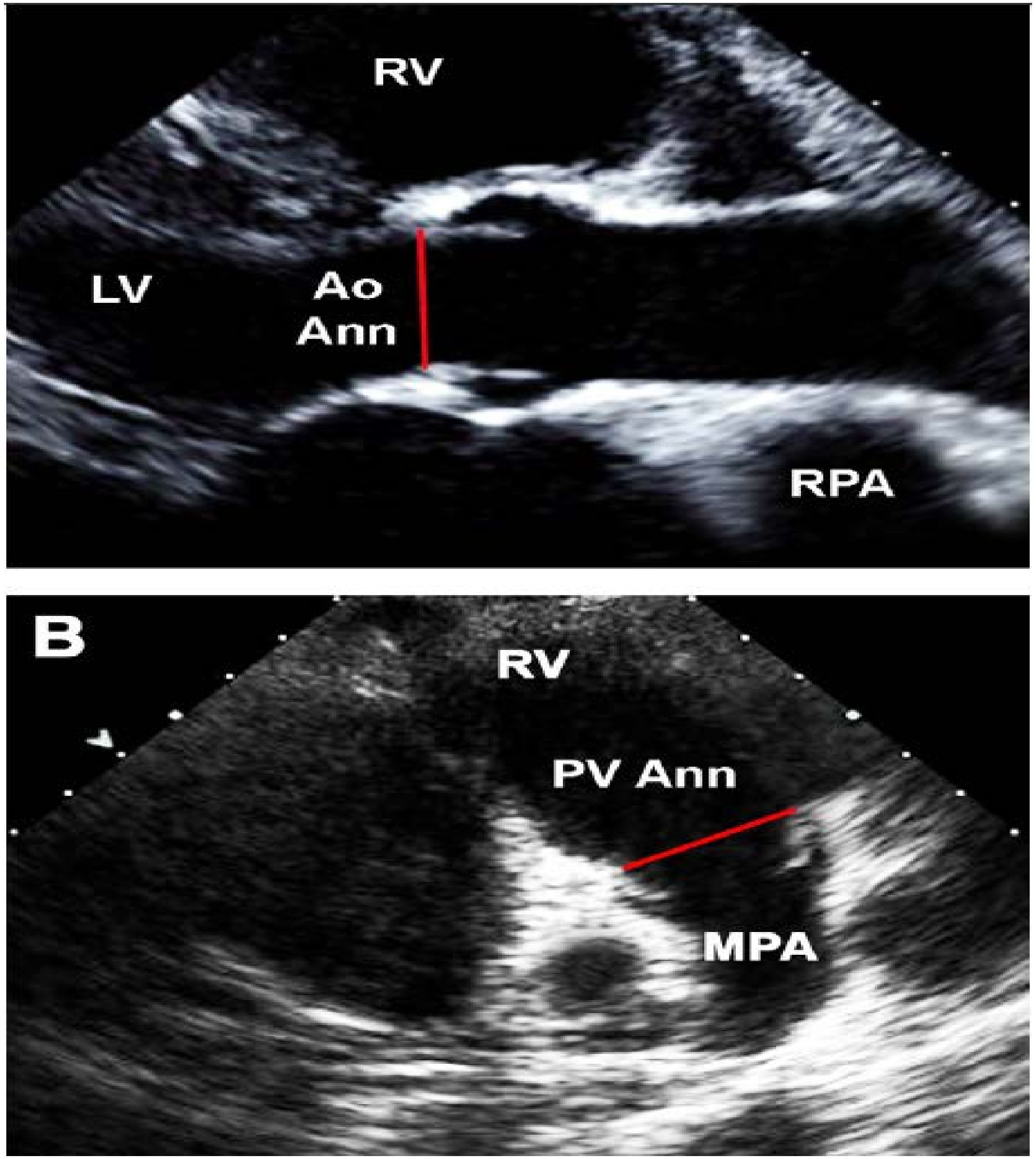
(J Am Soc Echocardiogr 2010;23:465-95.)

Keywords: Pediatric quantification, Measurements, *Z* scores, Normative database

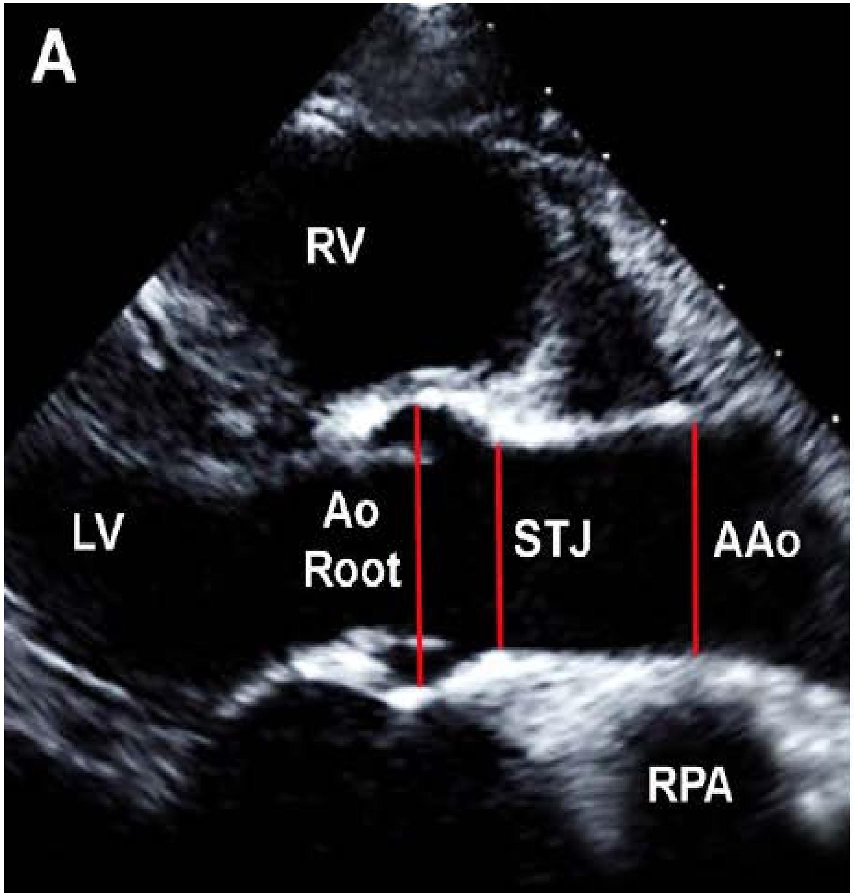
Atrio-ventricular valve measurement

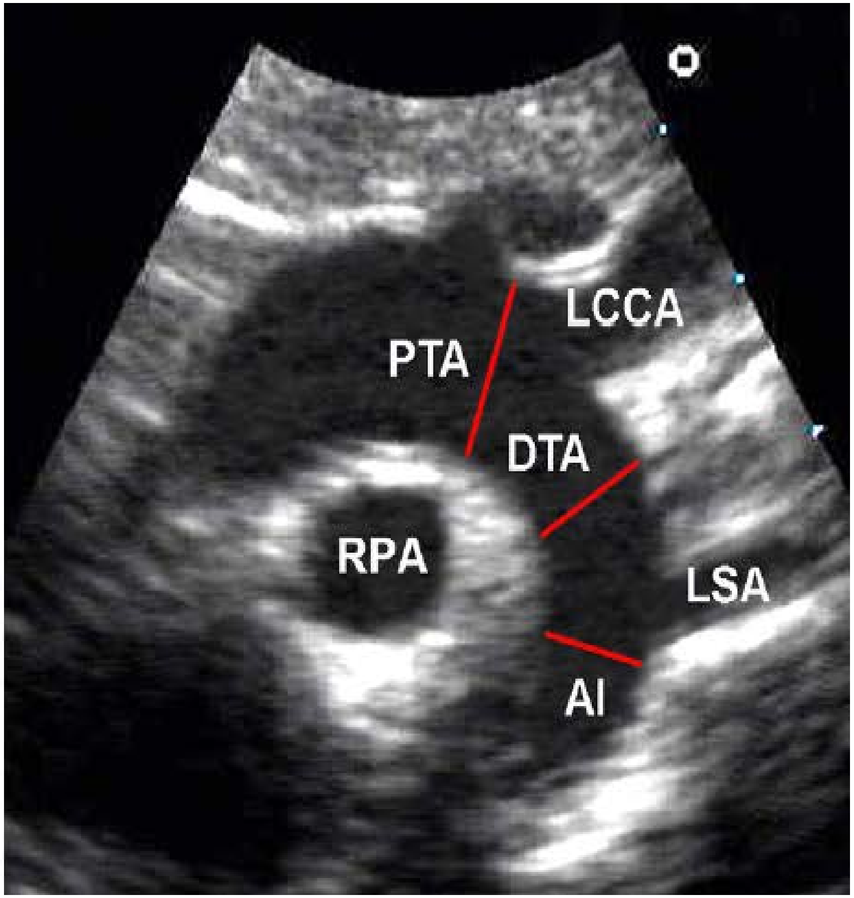


Semilunar valve measurement



Aorta and Aortic arch measurement





Statistical Methods

- ♥**Models** using logarithmic, exponential, and square root relationship tested
- ♥**Independent variables** used to normalize: age, weight, height and BSA
- ♥**Seven BSA formulas** employed (Haycock, DuBois, Mosteller, Dreyer, Meban, Boyd, Gehan)
- ♥**Heteroscedasticity** tested by White test and Breusch-Pagan Test

How to express normalized measurements: BSA issues

- BSA, weight, height, age
- ***BSA*** today accepted
- However, some mathematical limitations in the use of BSA still persist, including a dependence of BSA-adjusted measurements on BSA and ***high variability*** of results according to the formula used, ***particularly for lower height and weight.***

BSA formula

- 7 Formulas
- The ***DuBois formula*** most used, but it has been recently challenged by the Haycock formula.
- The DuBois formula in particular tends to increasingly underestimate for BSAs < 0.7 m2 compared with the Haycock formula.
- A similar problem of underestimation at low BSA values has also been observed for other formulas.

Population

- 448 Italian healthy subjects
- Age range 0 days -36 months
- 49% Female

BSA	N	%
[0.1-0.15)	5	1,1
[0.15-0.2)	77	17,2
[0.2-0.25)	111	24,8
[0.25-0.3)	63	14,0
[0.3-0.35)	34	7,6
[0.35-0.4)	46	10,3
[0.4-0.45)	38	8,5
[0.45-0.5)	28	6,2
[0.5-0.6)	33	7,4
[0.6-0.7)	13	2,9
Total	448	100,0

Measurements	N Valid
IVC	395
LVED M-mode	411
LVES M-mode	412
IVSd M-mode	405
LVPWd M-mode	406
Mass M-mode	382
Tricuspid annulus	436
Mitral annulus	434
Aortic annulus	431
Sinuses of Valsalva	432
Junction	424
Asc AO	414
Arch IA LCA	427
Arch LCA-LSA	431
Arch After LSA	401
Isthmus	363
Thorac AO	362
Abdominal Ao	396
Pulmonary annulus	347
MPA	428
LPA	432
RPA	434

Results

- *The **Haycock formula** provided the best results*
- DuBois, Mosteller, Deryer and Meban understimated
- Boyd and Gehan overstimated
- ***The Haicock formula used*** when presenting data as predicted values (mean ±SD)

Regression equations

BSA HAYCOCK. (ln[y] = a + b*ln[x]); Z value = (ln[Measurement] –(Intercept + B*ln[BSA]))/√MSE

Measurement	Intercept	B	SEE (√MSE)	R^2	SW	KS	BP	W
IVC	2.100	0.609	0.239	0.495	0.554	0.200	0.614	0.577
LVPWd M-mode	1.832	0.464	0.179	0.511	0.000	0.001	0.645	0.684
Tricuspid annulus	3.135	0.428	0.100	0.729	0.498	0.200	0.665	0.918
Aortic annulus	2.805	0.562	0.085	0.866	0.176	0.200	0.837	0.869
Sinuses of Valsalva	3.059	0.491	0.092	0.807	0.438	0.200	0.424	0.815
Junction	2.806	0.528	0.097	0.811	0.119	0.200	0.704	0.375
Asc AO	2.922	0.466	0.095	0.776	0.451	0.200	0.855	0.608
Arch IA LCA	2.719	0.495	0.121	0.703	0.660	0.200	0.776	0.242
Arch LCA-LSA	2.554	0.503	0.122	0.709	0.862	0.200	0.996	0.294
Arch After LSA	2.518	0.544	0.125	0.722	0.691	0.200	0.353	0.026
Isthmus	2.450	0.625	0.146	0.706	0.518	0.200	0.194	0.268
Thorac AO	2.552	0.520	0.127	0.695	0.106	0.200	0.923	0.458
Pulmonary annulus	2.916	0.543	0.108	0.779	0.897	0.200	0.934	0.995
RPA	2.516	0.656	0.150	0.738	0.651	0.200	0.109	0.318

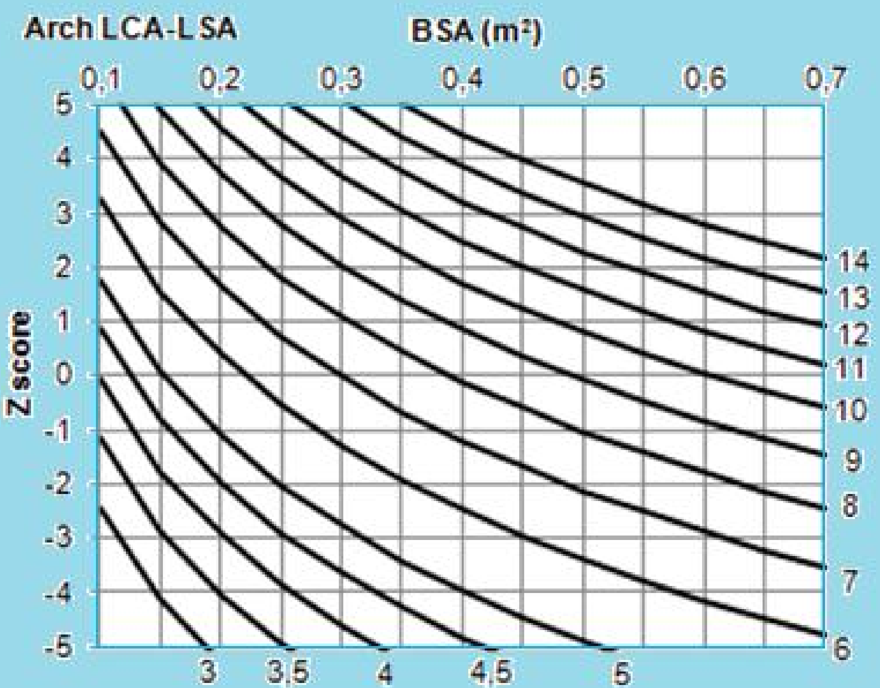
BSA HAYCOCK. (√y = a + b*√x); Z value = (√Measurement –(Intercept + B*√BSA))/√MSE

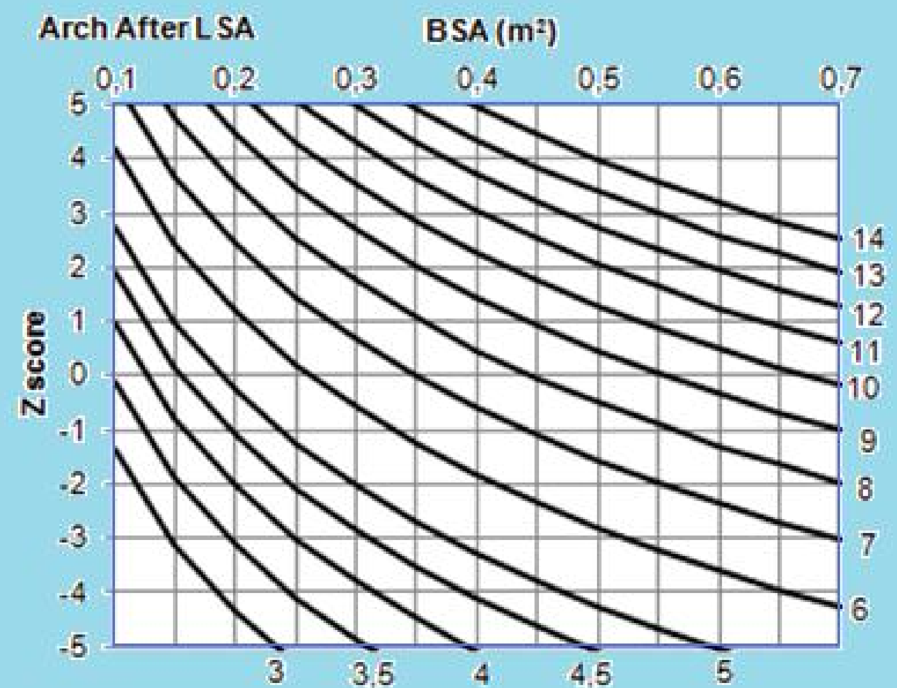
Measurement	Intercept	B	SEE (√MSE)	R^2	SW	KS	BP	W
LVED M-mode	2.414	4.040	0.209	0.820	0.270	0.200	0.571	0.704
IVSd M-mode	1.115	1.669	0.188	0.492	0.066	0.200	0.807	0.764
Mass M-mode	-1.316	0.918	0.412	0.863	0.106	0.007	0.186	0.782
Mitral annulus	1.948	3.088	0.164	0.800	0.798	0.200	0.774	0.075
MPA	1.632	2.947	0.186	0.734	0.024	0.200	0.997	0.428
LPA	0.844	2.716	0.190	0.702	0.754	0.200	0.364	0.324

BSA HAYCOCK. (y = a + b*x); Z value = (Measurement –(Intercept + B*BSA))/√MSE

Measurement	Intercept	B	SEE (√MSE)	R^2	SW	KS	BP	W
LVES M-mode	7.483	18.321	1.785	0.638	0.091	0.140	0.132	0.099
Abdominal Ao	3.471	7.857	0.755	0.624	0.178	0.200	0.512	0.540

	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50
	1.25	1.59	1.90	2.18	2.43	2.67	2.90	3.32
IVC	**2.01**	**2.57**	**3.06**	**3.51**	**3.92**	**4.31**	**4.67**	**5.35**
	3.24	4.15	4.94	5.66	6.33	6.95	7.54	8.64
	3.82	4.80	5.64	6.40	7.09	7.73	8.33	9.44
Aortic annulus	**4.53**	**5.69**	**6.69**	**7.58**	**8.40**	**9.16**	**9.88**	**11.19**
	5.37	6.75	7.93	8.99	9.96	10.86	11.71	13.27
	5.72	6.98	8.04	8.97	9.81	10.59	11.30	12.61
Sinuses of Valsalva	**6.88**	**8.39**	**9.67**	**10.79**	**11.80**	**12.72**	**13.59**	**15.16**
	8.27	10.09	11.62	12.97	14.18	15.30	16.33	18.22
	4.04	5.00	5.83	6.55	7.22	7.83	8.40	9.45
Junction	**4.90**	**6.08**	**7.07**	**7.96**	**8.76**	**9.50**	**10.20**	**11.47**
	5.96	7.38	8.59	9.66	10.64	11.54	12.38	13.93
	5.25	6.35	7.26	8.05	8.77	9.42	10.02	11.12
Asc AO	**6.35**	**7.67**	**8.78**	**9.74**	**10.60**	**11.39**	**12.12**	**13.45**
	7.68	9.28	10.61	11.78	12.82	13.77	14.66	16.26
	3.81	4.65	5.37	5.99	6.56	7.08	7.56	8.45
Arch IA LCA	**4.85**	**5.93**	**6.84**	**7.64**	**8.36**	**9.02**	**9.64**	**10.76**
	6.18	7.55	8.71	9.73	10.64	11.49	12.27	13.71
	3.16	3.88	4.48	5.02	5.50	5.94	6.35	7.11
Arch LCA-LSA	**4.04**	**4.95**	**5.72**	**6.40**	**7.02**	**7.58**	**8.11**	**9.07**
	5.15	6.32	7.30	8.17	8.96	9.68	10.35	11.58
	2,76	3,44	4,02	4,54	5,02	5,46	5,87	6,63
Arch After LSA	**3,54**	**4,42**	**5,17**	**5,83**	**6,44**	**7,01**	**7,53**	**8,51**
	4,55	5,67	6,64	7,49	8,27	9,00	9,67	10,92
	2.05	2.64	3.16	3.64	4.08	4.49	4.88	5.61
Isthmus	**2.75**	**3.54**	**4.24**	**4.87**	**5.46**	**6.01**	**6.54**	**7.51**
	3.68	4.74	5.68	6.52	7.31	8.05	8.75	10.06
	3,01	3,71	4,31	4,84	5,32	5,77	6,18	6,94
Thorac AO	**3,88**	**4,79**	**5,56**	**6,24**	**6,86**	**7,43**	**7,97**	**8,95**
	5,00	6,17	7,16	8,05	8,85	9,58	10,27	11,54
	2,75	3,14	3,53	3,93	4,32	4,71	5,10	5,89
Abdominal Ao	**4,26**	**4,65**	**5,04**	**5,44**	**5,83**	**6,22**	**6,61**	**7,40**
	5,77	6,16	6,55	6,95	7,34	7,73	8,12	8,91


Arch LCA-LSA
BSA (m²)
0,1 0,2 0,3 0,4 0,5 0,6 0,7
Z score
5 4 3 2 1 0 -1 -2 -3 -4 -5
14 13 12 11 10 9 8 7 6
3 3,5 4 4,5 5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BSA (m²)
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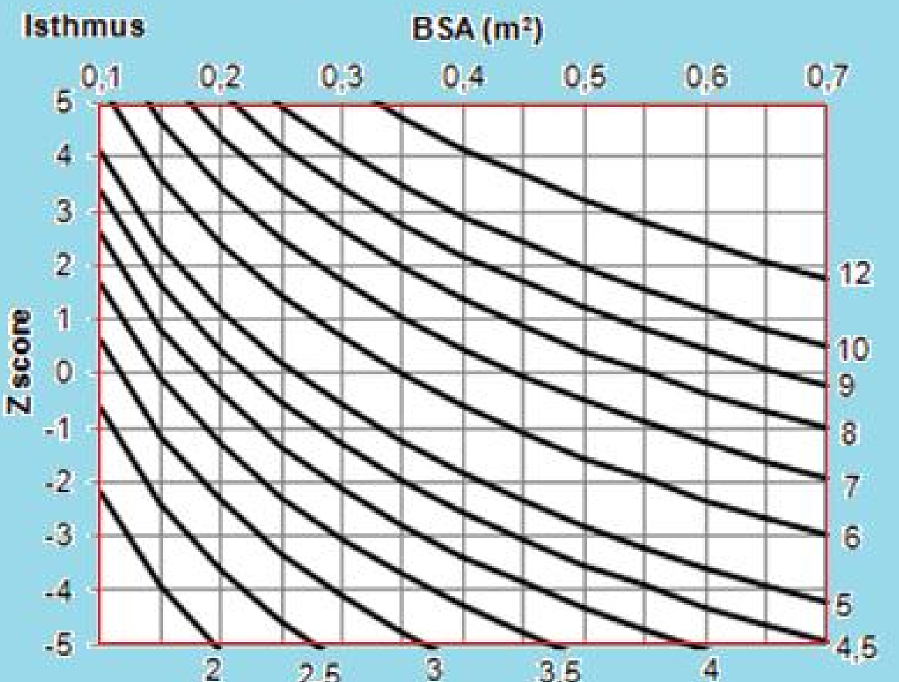
3 3,5 4 4,5 5


Isthmus
BSA (m²)
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Z score
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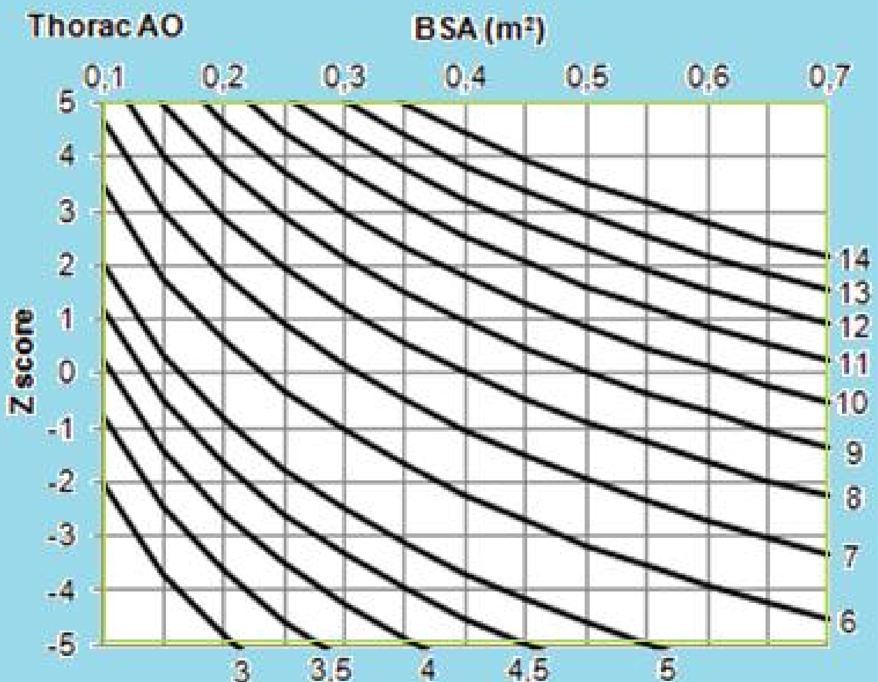
12 10 9 8 7 6 5 4,5
2 2,5 3 3,5 4


Thorac AO
BSA (m²)
0,1 0,2 0,3 0,4 0,5 0,6 0,7
Z score
5 4 3 2 1 0 -1 -2 -3 -4 -5
14 13 12 11 10 9 8 7 6
3 3,5 4 4,5 5

Comparison with other nomograms BSA 0.3 m2

	Cantinotti	Pettersen	Zilberman	Gautier
Mitral annulus 4 C	13.24 (10.97-15.74)	13.8 (10.2-18.6)	12.9 (9.2-18.1)	
Tricuspid annulus 4 C	13.73 (11.24-16.77)	13,8 (10.2-18.6)	12.7 (8.9-18.3)	
Aortic annulus	8.40 (7.09-9.96)	8.1 (6.6-9.9)		M 9.2 (7.5-11.2) F 9.2 (7.5-11.3)
Sinuses of Valsalva	11.80 (9.81-14.18)	11.3 (9.0-14.0)		M 12.3 (10.1-15.0) F 13.1 (10.9-15.7)
Junction	8.76 (7.22-10.64)	8.9 (6.8-11.6)		M 10.3 (8.4-12.6) F 10.9 (9.2-13.1)
Arch IA LCA	8.36 (6.56-10.64)	9.2 (6.8-12.4)		
Arch LCA-LSA	7.02 (5.5-8.96)	6.4 (4.6-8.9)		
Arch After LSA	6.44 (5.02-8.27)	6.8 (5.0-9.4)		
Pulmonary annulus	9.60 (7.74-11.92)	9.2 (6.8-12.5)		
MPA	10.54 (8.26-13.09)	9.7 (7.1-13.2)		
RPA	5.62 (4.16-7.59)	5.8 (4.2-8.0)		
LPA	5.44 (3.81-7.35)	5.2 (3.8-7.3)		
LVED M-mode	21,41 (17.71-25.45)	22.0 (18.0-28.6)		
LVES M-mode	12.98 (9.41-16.55)	13.6 (10.5-17.5)		

Conclusions

- ♥We report new, reliable echocardiography Z-scores derived from a large population of Caucasian neonates, infants and toddlers calculated using a rigorous statistical design
- ♥Our nomograms represent a valid diagnostic tool for echo quantification in this age group
- ♥Further studies are required to evaluate other parameters as well as the effects of race and ethnicity on reference values.

2D Nomograms

- Pettersen 0-18 yrs and Cantinotti 0-3 yrs acceptable
- Not all 2D measures covered, in partciular chamber area and diameters lacking (only M-mode)

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American Society of Echocardiography

< Previous Article | December 2014 Volume 27, Issue 12, Pages 1279–1292.e2 | Next Article >

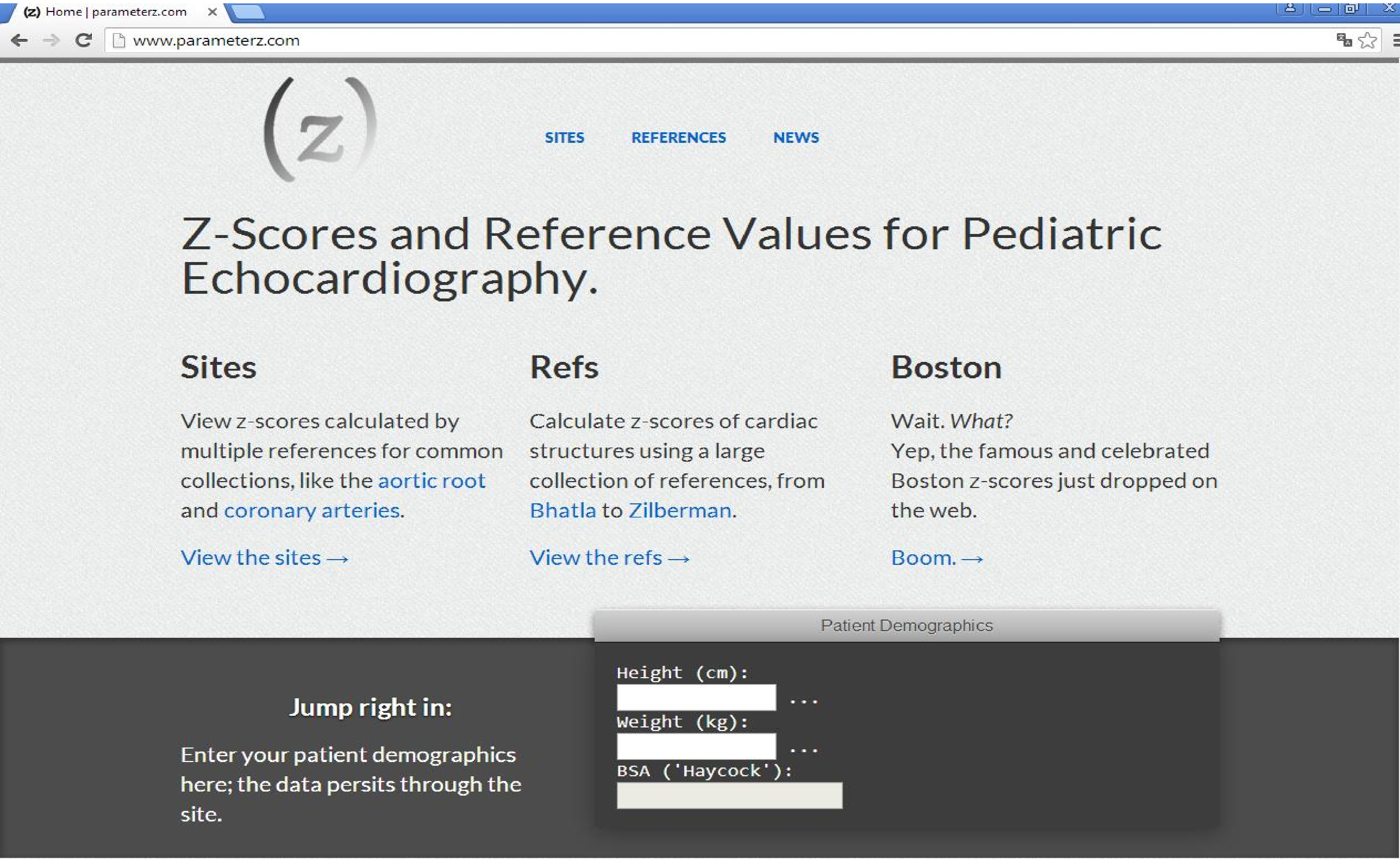
Echocardiographic Nomograms for Chamber Diameters and Areas in Caucasian Children

Massimiliano Cantinotti, MD, Marco Scalese, MS, Bruno Murzi, MD, Nadia Assanta, MD, Isabella Spadoni, MD, Vittoria De Lucia, MD, Maura Crocetti, MD, Alberto Cresti, MD, Milena Gallotta, MD, Marco Marotta, MD, Karin Tyack, PhD, Sabrina Molinaro, PhD, Giorgio Iervasi, MD

Echocardiographic nomograms for chamber diameters and areas in Caucasian children.

- A total of **1,091 Caucasian Italian healthy children** (age range, 0 days to 17 years; 44.8% female) with body surface areas (BSAs) ranging from 0.12 to 1.8 m(2) were prospectively enrolled.
- Echocardiographic reference values are presented for chamber area and diameters, derived from a large population of healthy children.
- These data partly cover a gap in actual pediatric echocardiographic nomograms.
- Further studies are required to reinforce these data, as well as to evaluate other parameters and ethnicities.

New parameterz.com



Aortic Arch

Calculate and compare z-scores of the aortic arch, including the aortic isthmus. Data from multiple references including recent data particularly suited for infants with arch hypoplasia or coarctation. References included conform to ASE Guideline methodology: measurements are made in systole, from inside edge to inside edge. (See the methods page for further details.)

Cantinotti et al., JASE 2014

Patient Demographics

Height (cm):
Weight (kg):
BSA (N/A): N/A
Gender: Female
Age: years

Measurements

Site	Z-Score	Range

Proximal Transverse Arch (mm):

Aortic Arch
Aortic Root
Coronary Arteries
M-Mode
Pulmonary Arteries
Valves

Cantinotti et al., JASE 2014

BSA-adjusted Z scores derived from a large population of Caucasian neonates, infants, and toddlers calculated using "*a rigorous statistical design*": particular attention was paid to matters of skew/distribution and heteroscedasticity.

Patient Demographics

Height (cm):

Weight (kg):

BSA ("Haycock"):

Measurements

Site	Z-Score	Range
Interventricular Septum, Diastole (mm):		

PART 2: Functional Indexes

- Diastolic values
- Deformation indexes
- Others

Nomograms for Blood Flow and Tissue Doppler Velocities to Evaluate Diastolic Function in Children: A Critical Review

Massimiliano Cantinotti, MD, and Leo Lopez, MD, *Massa and Pisa, Italy; Bronx, New York*

Interest in diastolic function in children has increased recently. However, the strengths and limitations of published pediatric nomograms for echocardiographic diastolic parameters have not been critically evaluated, especially in the neonatal population. A literature search was performed within the National Library of Medicine using the keywords *normal/reference values*, *power Doppler/tissue Doppler velocities*, and *children/neonates*. The search was further refined by adding the keywords *diastolic function*, *myocardial*, *mitral/tricuspid inflow*, *pulmonary vein*, and *Tei index*. Thirty-three published studies evaluating diastolic function in normal children were included in this review. In many studies, sample sizes were limited, particularly in terms of neonates. There was heterogeneity in the methodologies to perform and normalize measurements and to express normalized data (*Z* scores, percentiles, and mean values). Although most studies adjusted measurements for age, classification by specific age subgroups varied, and few addressed the relationships of measurements to body size and heart rate (especially with higher neonatal heart rates). Although reference values were reproducible in older children, they varied significantly in neonates and infants. Pediatric diastolic nomograms are limited by small sample sizes and inconsistent methodologies for the performance and normalization of measurements, with few data on neonates. Some studies do reveal reproducible patterns in diastolic function in older children. A comprehensive pediatric nomogram of diastolic function involving a large population of normal infants and older children and using standardized methodology is warranted and would have tremendous impact in the care of children with acquired and congenital heart disease. (J Am Soc Echocardiogr 2013;26:126-41.)

Keywords: Echocardiography, Children, Neonates, Diastolic function

Materials and Methods

- Mitral and Tricuspid Inflow: E wave, the E/A ratio, DT, IVRT
- Mitral Velocities e' and a';
- Tei index for LV and RV
- 33 studies evaluating diastolic function in children were included in this review.

Methodological Limitations

- There was significant heterogeneity in the methodologies to perform and normalize measurements and to express normalized data ***(Z-scores, percentiles, and mean values).***
- Although ***most studies adjusted measurements for age,*** the classification systems dividing age into specific subgroups varied, and few addressed the relationships of measurements to body size and to **heart rate** (especially with the higher heart rates in neonates).

RESULTS

- As a results various nomograms showed quite different results
- For children >2-3 years references intervals were quite reproducible and not dissimilar from the ones published for young adults
- In neonates instead data were limited, often discordant and strongly influenced by various factors including age, prematurity and HR

Normal neonatal reference values for MV inflow velocities and other diastolic parameters

Study	Subjects*	N	M/F	Body Size	HR (bpm)*	E (cm/s)*	A (cm/s)*	DT (ms)*	E/A*	IVRT (ms)*
Schmitz, 2004	Total	164								
	Preterm (0.5 – 1 kg): 13 ± 10 da	34		0.93 ± 0.3 kg	151±15	32.7 ± 12.3	36.9 ± 10			53 ± 5
	Preterm (1 – 1.5 kg): 12 ± 9 da	29		1.34 ± 0.4 kg	156±13	38.5 ± 11.4	43.6 ± 11.9			54 ± 5
	Term: 15 ± 14 da	74		3.66 ± 0.6 kg	134±16	56.2 ± 16.4	50.8 ± 13.9			54 ± 8
	Preterm (0.5 – 1 kg): 132 ± 33 da	22		3.28 ± 0.8 kg	150±24	82 ± 14.5	66.5 ± 24.5			41 ± 4
	Preterm (1 – 1.5 kg): 138 ± 70 da	25		3.86 ± 1.4 kg	143±11	79 ± 10.9	75.1 ± 10.7			41 ± 5
	Term: 135 ± 36 da	28		6.46 ± 1.2 kg	140±13	86.2 ± 10.5	70.6 ± 13.1			41 ± 4
Schmitz, 2004	Total	127								
	Week 1 (3 ± 2 da)	53	33/20	3.4 ± 0.4 kg 51 ± 2 cm		46.1 (34.4, 63.8)	42.1 (27.4, 56.7)	88 ± 23		59 ± 7
	Week 2 (10 ± 2 da)	45	25/20	3.6 ± 0.5 kg 51 ± 2 cm		49.3 (34.6, 67.2)	45.9 (32.5, 73)	74 ± 24		55 ± 5
	Week 3 – 4 (21 ± 4 da)	29	19/10	3.7 ± 0.4 kg 52 ± 2 cm		63.1 (39, 85.4)	57.3 (37.8, 78.6)	66 ± 21		54 ± 7
Ekici, 2007	1 – 5 da	50				57.6 ± 10.2 (30 – 83)	52.4 ± 10.7 (33 – 85)			
Johnson, 1988	Preterm 32 wk: 28 – 35 da	18				55 ± 10	55 ± 13		1.01 ± 0.11	
	Term: 2 – 5 da	10				53 ± 19	47 ± 11		1.13 ± 0.30	
Kozak, 2001	Preterm: 1 – 4 da	15		2.52 ± 0.27 kg 46.2 ± 1.8 cm		40.1 ± 5.6	43.2 ± 6.0	83 ± 12	0.93 ± 0.03	
	Preterm: 1 mo					61.5 ± 5.2	56.9 ± 4.8	73 ± 10	1.08 ± 0.04	
	Term: 1 – 5 da	19		3.32 ± 0.44 kg 49.7 ± 2.3 cm		46.9 ± 5.2	44.3 ± 5.7	87 ± 10	1.06 ± 0.05	
	Term: 1 mo					62.8 ± 6.1	56.9 ± 5.4	80 ± 12	1.11 ± 0.05	
Ciccone, 2011	Preterm: 3.8 ± 2.1 da	20		2.15 ± 0.50 kg 44.5 ± 2.3 cm		45.3 ± 8.4	45.6 ± 7.8		1 ± 0.1	
	Term: 2.9 ± 0.01 da	53		3.19 ± 0.44 kg		53.4 ± 7.8	46.7 ± 7.9		1.16 ± 0.1	

Published normal paediatric reference values and regression equations for tissue Doppler diastolic parameters at the septal mitral annulus

Study	Subjects*	N	M/F	Body Size*	HR (bpm)*	e' (cm/s)*	a' (cm/s)*	E/e'*
Eidem, 2004 (18)	Total	325	177/148			y = 9.629 + 0.380*Age y = 20.190 + 0.083*HR	y = 5.049 + 0.020*Age y = 5.108 + 0.011*HR	
	<1 yr (0.40 ± 0.30 yr)	63	29/34	6.6 ± 2.7 kg 0.34 ± 0.08 m^2	124 ± 16	8.1 ± 2.5 (7.5 – 8.7)	6.1 ± 1.5 (5.7 – 6.4)	10.3 ± 2.7 (9.7 – 11.0)
	1 – 5 yr (3.05 ± 1.51 yr)	68	39/29	15.1 ± 5.4 kg 0.62 ± 0.14 m^2	105 ± 17	11.8 ± 2.0 (11.3 – 12.3)	6.0 ± 1.3 (5.7 – 6.4)	8.1 ± 1.8 (7.7 – 8.5)
	6 – 9 yr (7.91 ± 1.12 yr)	55	27/28	33.8 ± 14.9 kg 1.07 ± 0.27 m^2	80 ± 11	13.4 ± 1.9 (12.8 – 13.9)	5.9 ± 1.3 (5.5 – 6.3)	7.2 ± 1.6 (6.8 – 7.7)
	10 – 13 yr (11.9 ± 1.11 yr)	58	38/20	47.2 ± 16.3 kg 1.37 ± 0.29 m^2	75 ± 12	14.5 ± 2.6 (13.8 – 15.2)	6.1 ± 2.3 (5.6 – 6.7)	6.6 ± 1.4 (6.3 – 7.0)
	14 – 18 yr (16.0 ± 1.40 yr)	81	44/37	66.1 ± 15.5 kg 1.73 ± 0.25 m^2	69 ± 16	14.9 ± 2.4 (14.3 – 15.4)	6.2 ± 1.5 (5.9 – 6.6)	6.4 ± 1.5 (6.1 – 6.8)
Ekici, 2007 (23)	5 – 16 yr	54				17.9 ± 2.8	9.6 ± 2.5	4.2 ± 1.1
Kapusta, 2000 (25)	4 – 17.9 yr	160	77/83	17.5 – 83.5 kg		14.3 (11.2 – 18.5)	5.8 (4.4 – 7.9)	
Mori, 2000 (30)	2 mo – 19 yr (7.5 ± 5.5 yr)	131	69/62			13.5 ± 2.4 (5.9 – 18.0)	6.5 ± 1.4 (4.0 – 10.6)	

CONCLUSIONS

- Diastolic nomograms for children are limited by small sample sizes and inconsistent methodologies for performance and normalization of measurements, and there are few data on neonates.
- *<u>However, some studies do reveal some reproducible patterns in diastolic function in older children</u>*.

Abstract ▾ Send to: ▾

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Nomograms for mitral inflow Doppler and tissue Doppler velocities in Caucasian children.

Cantinotti M[1], Giordano R[2], Scalese M[3], Murzi B[1], Assanta N[1], Spadoni I[1], Crocetti M[1], Marotta M[1], Molinaro S[3], Kutty S[4], Iervasi G[5].

⊕ Author information

Abstract

BACKGROUND: Pediatric echocardiographic nomograms for systolic/diastolic functional indices are limited by small sample size and inconsistent methodologies. Our aim was to establish pediatric nomograms for mitral valve (MV) pulsed wave Doppler (PWD) and tissue Doppler imaging (TDI) velocities.

METHODS: We performed PWD/TDI measurements of MV velocities and generated models testing for linear/logarithmic/exponential/square root relationships. Heteroscedasticity was accounted for by White test or Breusch-Pagan test. Age, weight, height, heart rate (HR), and body surface area (BSA) were used as independent variables in different analyses to predict the mean values of each measurement.

RESULTS: In all, 904 Caucasian Italian healthy children (age 0 days-17 years; 45.5% females; BSA 0.12-2.12m^2) were prospectively studied. No individual variable provided equations with an acceptable coefficient of determination (R^2) and even the inclusion of multiple variables in the model resulted in only a partial amelioration of the R^2. Higher R^2 were obtained for PWD-E deceleration time (0.53), septal (Se') and lateral (Le') MV-TDI e' velocity (Se': 0.54; Le': 0.55). Variability was higher at lower age and BSA. In older children patterns were more reproducible; however, the exclusion of neonates did not substantially improve the final models. The low R^2 hampered building of z-scores and calculation of estimated percentiles. Thus normative data have been presented as observed percentile according to age for all measurements.

CONCLUSIONS: We report normal ranges for PWD and TDI mitral velocities derived from a large population of Caucasian children. Variability of diastolic patterns especially at lower ages needs to be taken into account.

Results

- In all, **904 Caucasian Italian healthy children** (age 0 days-17 years; 45.5% females; BSA 0.12-2.12 m2) were prospectively studied.
-
- *No individual variable provided equations with an acceptable coefficient of determination (R2) and even the inclusion of multiple variables in the model resulted in only a partial amelioration of the R2*.
- Higher R2 were obtained for PWD-E deceleration time (0.53), septal (Se') and lateral (Le') MV-TDI e' velocity (Se':0.54; Le':0.55).
- Variability was higher at lower age and BSA. In older children patterns were more reproducible, however the exclusion of neonates did not substantially improve the final models.
- *The low R2 hampered building of z-scores and calculation of estimated percentiles.*
- *Thus normative data have been presented as observed percentile according to age and BSA for all measurements.*
-

Table . Coefficients for regression equations relating echocardiographic measurements and body surface area, heart rate and age. The Standard Error of the Estimate, the determination coefficient. Normality test: Shapiro-Wilk. Heteroscedasticity test (White test and Breusch-Pagan test).

$\ln(y) = intercept + B_1 * \ln(BSA) + B_2 * \ln(HR) + B_3 * AGE$

Measurement	Intercept	$B_{(BSA)}$	$B_{(HR)}$	$B_{(AGE)}$	ADJ R^2	SEE	BP	W	SW
Mitral A	0.604	0.131	0.791	NS	0.376	0.193	0.273	<0.001	<0.001
Dec ms	6.264	0.226	-0.319	NS	0.510	0.223	<0.001	<0.001	<0.001
S'M	1.691	0.208	0.129	NS	0.337	0.145	0.952	<0.001	0.362
A'M	-0.718	0.093	0.609	NS	0.236	0.212	0.323	0.182	0.341
S'l	1.732	0.237	0.137	NS	0.334	0.165	0.063	<0.001	<0.001
A'l	-0.336	0.065	0.519	NS	0.184	0.220	0.551	0.291	0.039
E/e'	1.258	-0.140	0.157	NS	0.236	0.222	<0.001	0.099	<0.001

$rad(y) = intercept + B_1 * \ln(BSA) + B_2 * rad(HR) + B_3 * AGE$

Measurement	Intercept	$B_{(BSA)}$	$B_{(HR)}$	$B_{(AGE)}$	SEE	ADJ R^2	BP	W	SW
Mitral E	10.483	1.658	0.084	-0.010	0.314	0.819	<0.001	<0.001	<0.001
E'M	4.596	0.712	-0.048	-0.003	0.526	0.349	0.008	<0.001	0.063
E'l	4.726	0.717	-0.045	NS	0.552	0.355	0.104	<0.001	0.088

$\ln(y) = intercept + B_1 * \ln(BSA) + B_2 * \ln(HR) + B_3 * AGE$

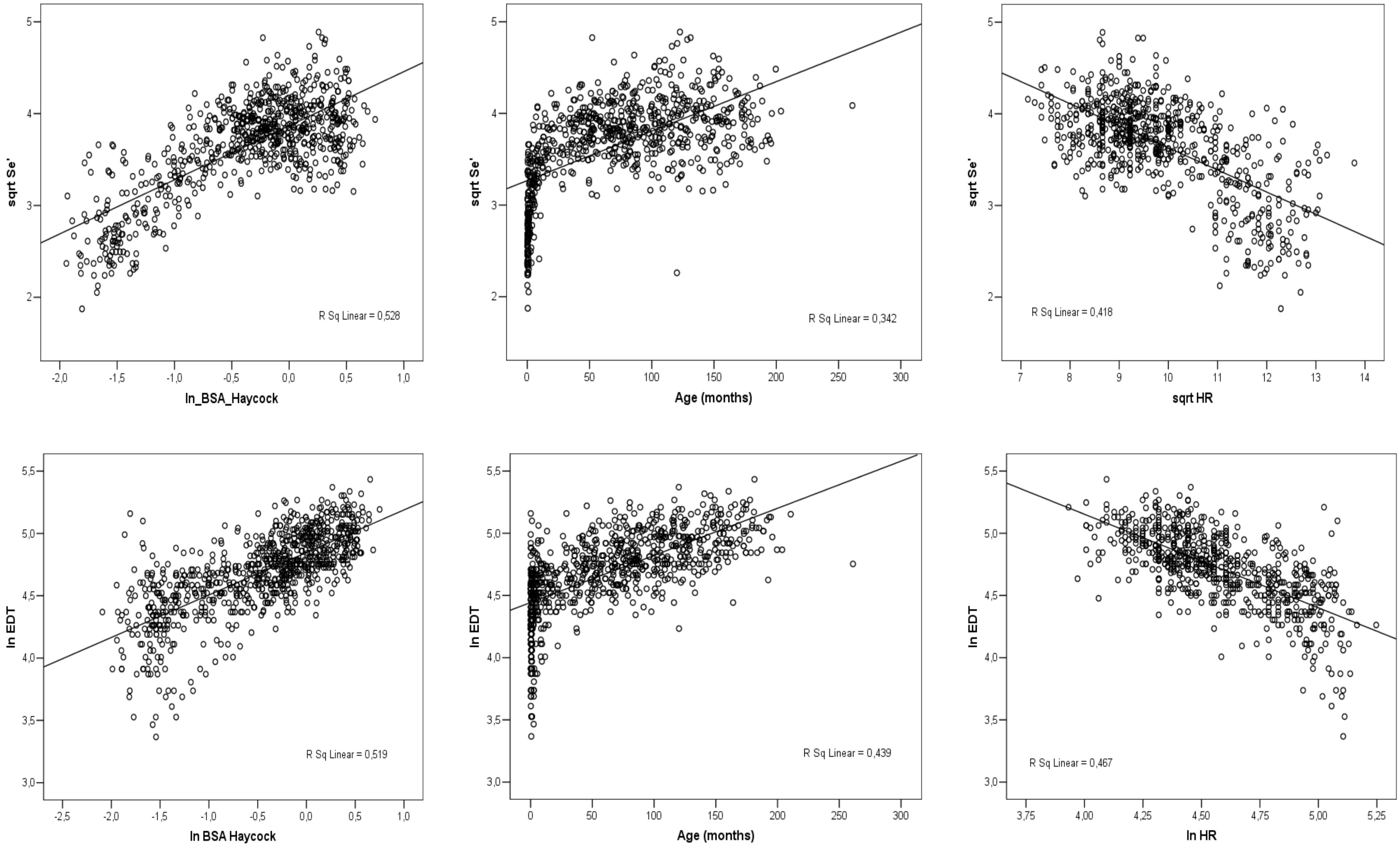
Measurement	Intercept	$B_{(BSA)}$	$B_{(HR)}$	$B_{(AGE)}$	ADJ R^2	SEE	BP	W	SW
A	0.604	0.131	0.791	NS	0.376	0.193	0.273	<0.001	<0.001
EDT	6.146	0.224	-0.292	NS	0.530	0.206	<0.001	<0.001	<0.001
Ss'	1.691	0.208	0.129	NS	0.337	0.145	0.952	<0.001	0.362
Sa'	-0.718	0.093	0.609	NS	0.236	0.212	0.323	0.182	0.341
Ls'	1.732	0.237	0.137	NS	0.334	0.165	0.063	<0.001	<0.001
La'	-0.336	0.065	0.519	NS	0.184	0.220	0.551	0.291	0.039
E/e'	1.258	-0.140	0.157	NS	0.236	0.222	<0.001	0.099	<0.001

$rad(y) = intercept + B_1 * \ln(BSA) + B_2 * rad(HR) + B_3 * AGE$

Measurement	Intercept	$B_{(BSA)}$	$B_{(HR)}$	$B_{(AGE)}$	ADJ R^2	SEE	BP	W	SW
E	10.483	1.658	0.084	-0.010	0.314	0.819	<0.001	<0.001	<0.001
Se'	4.641	0.714	-0.052	-0.003	0.537	0.344	0.049	<0.001	0.059
Le'	4.726	0.717	-0.045	NS	0.552	0.355	0.104	<0.001	0.088

Coefficients for regression equations relating echo measurements and BSA, the SSE, the determination coefficient and normality test: Shapiro-Wilk and Lilliefors

Heteroscedasticity test (White test and BreuschPagan test).



*Examples of p*redicted values (Mean ±2SD) of measured echocardiography variables expressed by BSA (Haycock).

percentiles	0.15-0.20	0.20-0.25	0.25-0.30	0.30-0.35	0.35-0.40	0.40-0.45	0.45-0.50	0.50-0.55	0.55-0.60
E									
10	42.8	52.6	68.3	76.1	70.9	92.1	80.3	83.6	86.9
25	51.1	60.9	82.3	87.7	83.4	100.0	88.3	92.1	94.1
50	64.9	75.7	98.7	99.1	95.8	109.0	106.5	105.0	104.0
75	72.4	88.0	107.0	109.0	109.0	118.0	122.0	113.0	121.0
90	83.9	103.0	118.0	118.5	115.0	132.0	135.0	129.0	128.0
A									
10	45.0	50.7	63.3	67.1	57.0	69.0	45.0	53.7	48.7
25	51.3	57.6	74.0	76.0	64.3	73.1	55.6	62.7	56.9
50	64.2	72.4	88.2	90.3	77.3	78.2	71.4	70.0	67.1
75	80.6	84.7	97.9	97.9	88.5	84.8	88.2	81.6	79.6
90	97.9	96.7	105.0	104.5	104.0	91.6	100.0	91.5	80.9
EDT									
10	48.0	48.0	42.0	50.0	74.0	61.0	69.0	79.0	82.0
25	53.0	66.0	77.0	79.0	82.0	92.0	79.0	87.0	98.0
50	72.0	74.0	90.0	92.0	98.0	106.0	93.5	95.0	108.0
75	95.0	87.0	98.0	106.0	106.0	116.0	100.0	108.0	116.0
90	132.0	103.0	106.0	111.0	114.0	137.0	114.0	116.0	127.0
Ss'									
10	5.5	5.8	6.9	7.7	7.6	7.7	7.1	7.3	6.8
25	6.1	6.6	7.4	8.2	8.2	8.0	8.3	7.7	8.3
50	6.6	7.1	7.8	8.6	8.9	8.9	8.7	8.8	9.3
75	8.0	7.7	8.5	9.2	9.7	10.2	9.7	9.6	9.7
90	8.9	8.8	9.1	10.4	10.4	12.4	10.1	9.8	10.0
Se'									
10	4.5	5.6	5.6	7.2	8.8	9.6	10.2	11.7	11.1
25	5.6	6.2	7.6	8.1	10.5	10.7	11.2	12.3	12.7
50	6.8	7.1	8.5	10.1	11.2	12.3	13.0	13.2	15.7
75	8.4	8.4	9.9	10.9	12.3	14.4	14.7	15.1	16.6
90	12.0	11.4	11.3	12.7	14.0	16.1	16.0	15.8	17.2
Sa'									
10	6.4	6.3	8.2	6.7	6.4	6.3	6.3	5.2	5.3
25	6.8	8.3	8.4	7.6	7.5	7.3	7.1	6.2	6.9
50	7.9	8.9	9.9	9.4	8.8	9.2	7.8	7.7	8.2
75	9.7	10.9	11.7	11.6	10.9	11.5	9.1	8.6	8.8
90	12.0	11.4	12.2	12.8	14.2	14.3	12.0	9.6	10.1
Ls'									
10	5.6	6.4	7.2	7.5	7.6	7.7	7.5	7.8	8.3
25	5.8	7.1	7.9	8.1	7.9	8.6	8.3	8.2	9.1
50	6.5	7.6	8.3	8.5	9.1	9.6	9.2	8.8	10.0
75	7.5	8.3	9.2	8.8	9.7	11.0	10.4	9.5	10.3
90	8.0	9.3	11.4	10.0	11.3	13.5	11.4	10.3	12.1

percentiles	0.60-0.65	0.65-0.70	0.70-0.75	0.75-0.80	0.80-0.85	0.85-0.90	0.90-0.95	0.95-1.00	1.00-1.05
E									
10	86.2	85.8	83.4	86.4	84.2	84.6	92.8	84.2	84.0
25	94.5	94.6	92.8	94.0	93.4	87.9	95.8	94.8	95.6
50	107.5	105.0	101.0	105.0	98.0	103.5	103.0	103.0	105.0
75	113.5	116.0	116.0	118.0	107.0	110.0	114.0	107.0	114.0
90	120.0	120.0	126.0	123.0	118.0	118.0	121.0	119.0	125.5
A									
10	49.4	53.3	47.0	48.4	47.0	49.5	49.9	45.9	45.9
25	54.3	59.4	54.6	54.4	52.1	52.1	53.2	49.5	52.1
50	63.2	67.1	62.3	61.1	61.1	57.8	57.3	60.3	57.0
75	72.3	73.5	73.5	66.1	69.3	61.1	65.8	66.5	66.5
90	80.9	77.9	82.9	77.0	74.2	68.4	78.5	73.4	79.0
EDT									
10	90.0	85.0	92.0	95.0	87.0	90.0	109.0	111.0	100.5
25	99.0	98.0	98.0	103.0	103.0	106.0	116.0	116.0	111.0
50	108.0	116.0	116.0	114.0	116.0	119.0	120.0	137.0	127.0
75	125.5	129.0	128.0	129.0	140.0	137.0	145.0	151.0	151.0
90	135.0	137.0	158.0	148.0	156.0	169.0	158.0	165.0	156.5
Ss'									
10	7.9	7.6	8.3	7.5	8.1	8.0	7.9	7.7	7.9
25	8.4	8.4	8.7	8.5	9.0	8.8	8.7	8.5	8.4
50	9.3	9.1	9.6	9.2	10.3	9.4	9.2	9.4	9.1
75	10.2	9.9	10.1	10.5	11.4	10.1	10.0	10.4	10.1
90	10.9	11.0	10.8	12.0	11.8	10.4	10.7	10.9	10.5
Se'									
10	12.6	12.2	12.9	12.7	12.7	12.7	12.6	12.3	12.3
25	13.1	13.5	13.7	13.8	14.6	13.5	13.7	13.9	13.4
50	14.6	14.9	14.5	14.7	15.1	14.8	15.8	15.0	14.9
75	15.7	15.6	15.8	16.9	17.0	16.3	17.1	17.1	16.6
90	18.1	16.1	16.8	17.8	18.8	17.5	18.4	18.1	17.5
Sa'									
10	5.9	5.6	5.5	5.3	6.0	6.2	4.9	5.2	5.0
25	6.6	6.5	6.4	6.3	7.0	6.5	5.7	5.8	6.0
50	7.2	7.0	7.0	7.0	8.0	7.2	6.7	6.8	6.8
75	7.9	8.1	8.4	8.0	8.6	8.3	7.8	7.9	8.1
90	9.1	9.0	9.5	9.5	9.5	9.2	9.4	10.0	9.2
Ls'									
10	8.5	8.5	7.8	7.7	8.4	8.7	8.6	7.5	8.4
25	9.1	9.0	8.5	8.4	9.1	9.2	9.1	8.7	9.2
50	9.5	9.8	9.5	9.8	10.1	10.1	10.2	10.1	9.9
75	10.5	11.0	10.2	11.6	11.0	11.1	11.1	10.8	10.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Conclusions

♥We report normal ranges for PWD and TDI mitral velocities derived from a large population of Caucasian children.
♥There was no ideal body size variable for normalization and the inclusion of multiple variables (BSA, HR and age) resulted only in a partial amelioration of the final models.
♥The high variability in the regression analyses hampered the possibility of z score calculations, so data are presented as percentiles mean values (plus/minus standard deviation).
♥The highest variability was seen in the lowest age groups, while satisfactory reproducibility was observed in older children, so we recommend caution in the use of diastolic functional indices in the lower age groups.
♥Further studies are required to reinforce these data, as well to evaluate other parameters of pediatric systolic and diastolic function.

Other functional index

- **RVOT escursion** Koestenberger M et al. **Reference values of the right ventricular outflow tract systolic excursion in 711 healthy childrenand calculation of z-score values.** Eur Heart J Cardiovasc Imaging. 2014 Sep;15(9):980-6
- **TAPSE** Koestenberger M, Systolic right ventricular function in **children and young adults with pulmonary artery hypertension secondary to congenital heart disease and tetralogy of Fallot: tricuspid annular plane systolic excursion (TAPSE) and magnetic resonance imaging data.** Congenit Heart Dis. 2012 May-Jun;7(3):250-8.
- **TV s' TDI** Weismann CG, **Normal pediatric data for isovolumic acceleration at the lateral tricuspid valve annulus-a heart rate -dependent measure of right ventricular contractility.** Echocardiography. 2015 Mar;32(3):541-7.
- ETC…….

Deformation indexes

Heart Fail Rev. 2015 Sep;20(5):601-12. doi: 10.1007/s10741-015-9492-9.

Review and status report of pediatric left ventricular systolic strain and strain rate nomograms.

Cantinotti M[1], Kutty S, Giordano R, Assanta N, Murzi B, Crocetti M, Marotta M, Iervasi G.

⊕ **Author information**

Abstract

Interest in strain (ε) and strain rate (SR) for the assessment of pediatric left ventricular (LV) myocardial function has increased. However, the strengths and limitations of published pediatric nomograms have not been critically evaluated. A literature search was conducted accessing the National Library of Medicine using the keywords myocardial velocity, strain, strain rate, pediatric, reference values, and nomograms. Adding the following keywords, the results were further refined: neonates, infants, adolescents, range/intervals, and speckle tracking. Ten published studies evaluating myocardial velocities, ε, or SR nomograms were analyzed. Sample sizes were limited in most of these studies, particularly in terms of neonates. Heterogeneous methods-tissue Doppler imaging, two- and three-dimensional speckle tracking-were used to perform and normalize measurements. Although most studies adjusted measurements for age, classification by specific age subgroups varied. Few studies addressed the relationships of ε and SR measurements to body size and heart rate. Data have been generally expressed by mean values and standard deviations; Z scores and percentiles that are commonly employed for pediatric echocardiographic quantification have been never used. Reference values for ε and SR were found to be reproducible in older children; however, they varied significantly in neonates and infants. Pediatric nomograms for LV ε and SR are limited by (a) small sample sizes, (b) inconsistent methodology used for derivation and normalization, and (c) scarcity of neonatal data. Some of the studies demonstrate reproducible patterns for systolic deformation in older children. There is need for comprehensive nomograms of myocardial ε and SR involving a large population of normal children obtained using standardized methodology.

LV strain normal values children

Author	Population	Global longitudinal strain	Global circumferential strain	Global radial strain	Global S
3d					
Zhang_L 2013_China (4)	< 1 n 23 (M 13) 0.56 ±0.23 yrs	-17.31 ±2.27	-16.87 ±2.73	61.58 ±18.82	-29.77 ±4.45
	1-5 n 83 (M 45) 2.7 ±1.19 yrs	-17.34 ±2.56	-17.06 ±3.25	60.28 ±13.37	30.13 ±3.47
	5-9 n 61 (M 33) 6.88 ±1.16 yrs	-17.56 ±2.221	-17 ±3.43	59.49 ±13.29	-30.24 ±3.61
	9-13 n 36(M 17) 10.86 ±1.23 yrs	-18.75 ±1.72	-18.83 ±3.32	64.65 ±8.42	-31.52 ±2.65
	13-18 n 25 (M 11) 14.83± 1.88 yrs	-16.64 ±2.8	-16.26 ±4.11	56.62 ±14.89	-28.96 ±4.53
Speckle tracking		Septal			
Macus K 2011 USA (7)	0 yrs n 24 (13 M) 0.3 ±0.3 yrs	-18.3 ± 1.9 P5 -14.5 P 95 -22.1	*PM* *MV* -18.6 ± 3.3 -17.5 ± 2.5 P5 -12 P5 -12.5 P95 -25.2 P95 -22.5	*PM* *MV* 52.0 ± 9.9 49.9 ± 4.3 P5 32.2 P5_41.3 P95 71.8 P95 58.5	
	1-4 yrs n 34 (19 M) 2.9 ± 1.0 yrs	-20.7 ±1.3 P5 -18.1 P95 -23.3	*PM* *MV* -21.3 ± 2.0 -19.7 ± 2.0 P5 -17.3 P5 -15.7 P95 -25.3 P95 -23.7	*PM* *MV* 53.5 ± 6.7 50.0 ±5.7 P5_40.1 P5 38.6 P95 66.9 P95 61.4	
	5-9 Yrs n 36 (25 M) 7.2 ± 1.2 yrs	-21 ± 1.3 P5 -18.4 P95 -23.6	*PM* *MV* -23.4 ± 1.7 -20.9 ± 2.0 P5 -20 P5 -16.9 P95 -26.8 P95 -24.9	*PM* *MV* 54.9 ± 5.5 52.3 ± 4.5 P5 43.9 P5_43.3 P95_65.9 P95_61.3	
	10-14 y n 29 (16 M)	-21.8 ± 1.3 P5 -19.2	*PM* *MV*	*PM* *MV*	

Part 3:Other field of application and future prospective

- Other imaging techniques: MRI, CT, angio
- Easy approach to z scores: app, web site implementation

MRI z scores

J Cardiovasc Magn Reson. 2015 Apr 18;17:29. doi: 10.1186/s12968-015-0111-7.

Normal values for cardiovascular magnetic resonance in adults and children.

Kawel-Boehm N[1], Maceira A[2], Valsangiacomo-Buechel ER[3], Vogel-Claussen J[4], Turkbey EB[5], Williams R[6], Plein S[7], Tee M[8], Eng J[9], Bluem

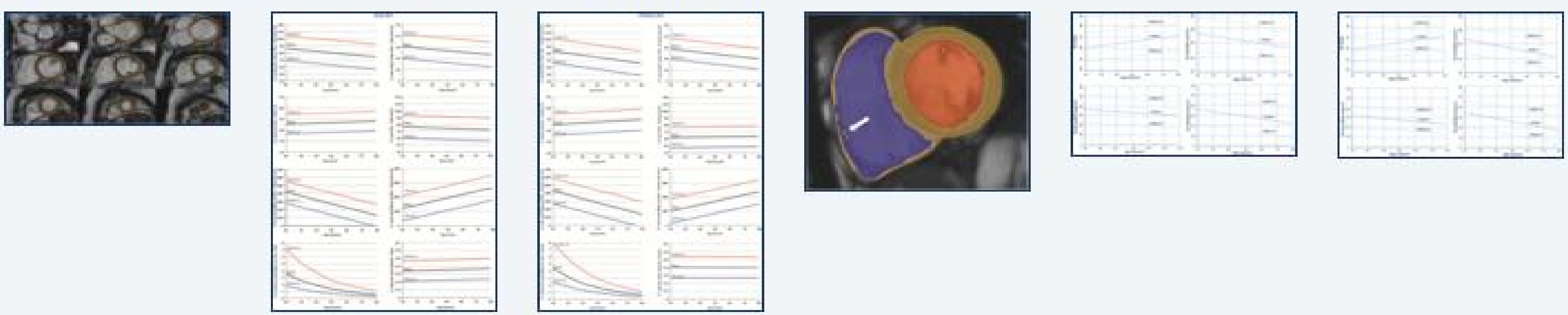
Author information

Abstract

Morphological and functional parameters such as chamber size and function, aortic diameters and distensibility, flow and T1 and T2* can be assessed and quantified by cardiovascular magnetic resonance (CMR). Knowledge of normal values for quantitative CMR is c interpretation of results and to distinguish normal from disease. In this review, we present normal reference values for morphological a CMR parameters of the cardiovascular system based on the peer-reviewed literature and current CMR techniques and sequences.

PMID: 25928314 [PubMed - in process] PMCID: PMC4403942 Free PMC Article

Images from this publication. See all images (20) Free text



Baby Norm Calculator
Pediatric Normal Values and Drug Doses

COMING SOON!!!!!

Applications

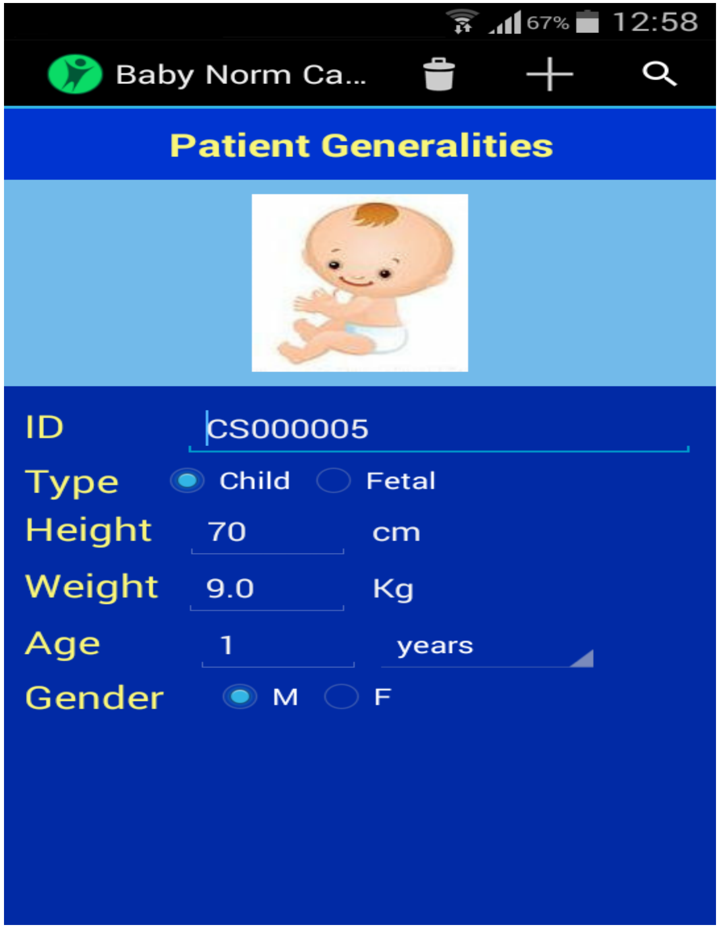
Cardiac

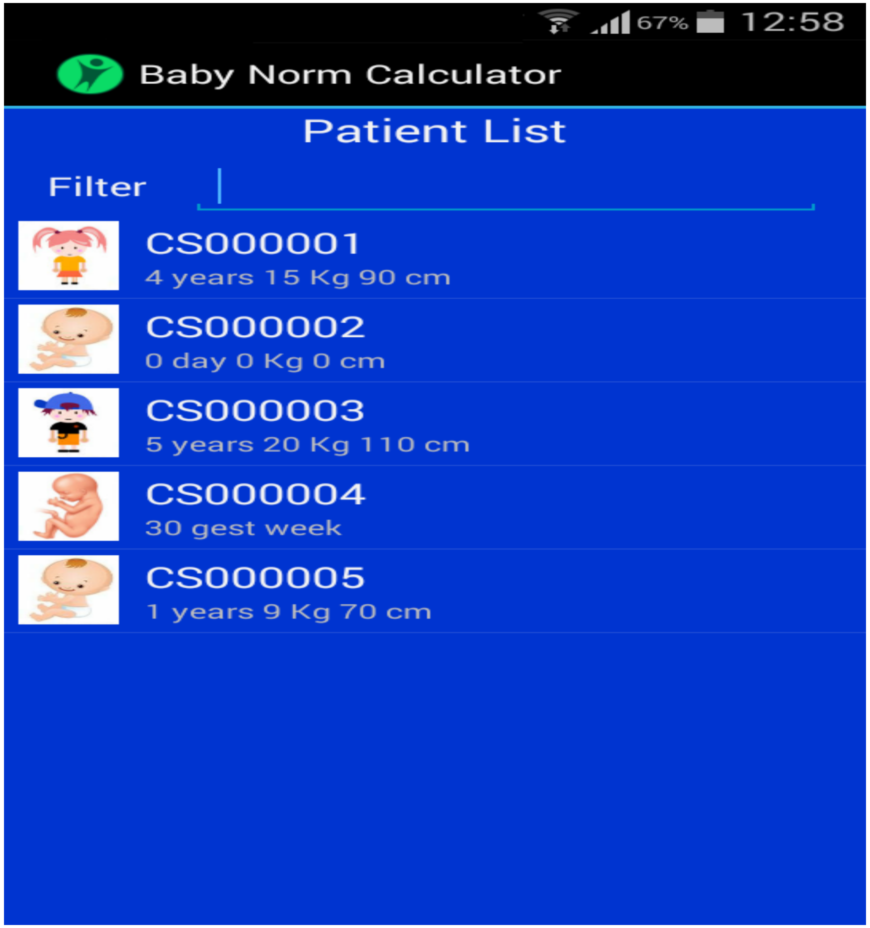
- Echocardiography
- Fetal Echocardiography
- MRI
- ECG
- Stress Test

Basic

- Vital Parameters, Anthropomorphic Data, Blood pressure, Drug Doses, laboratory tests

Home page: Patient detail

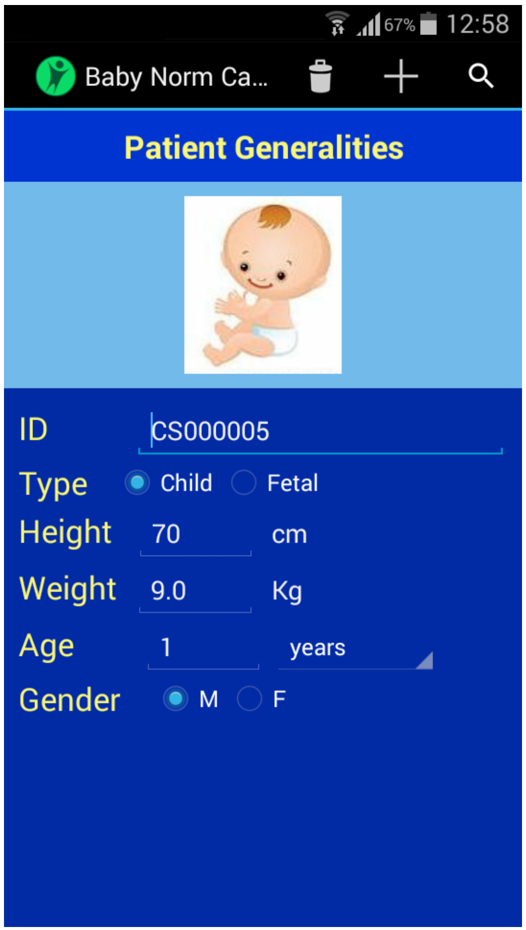


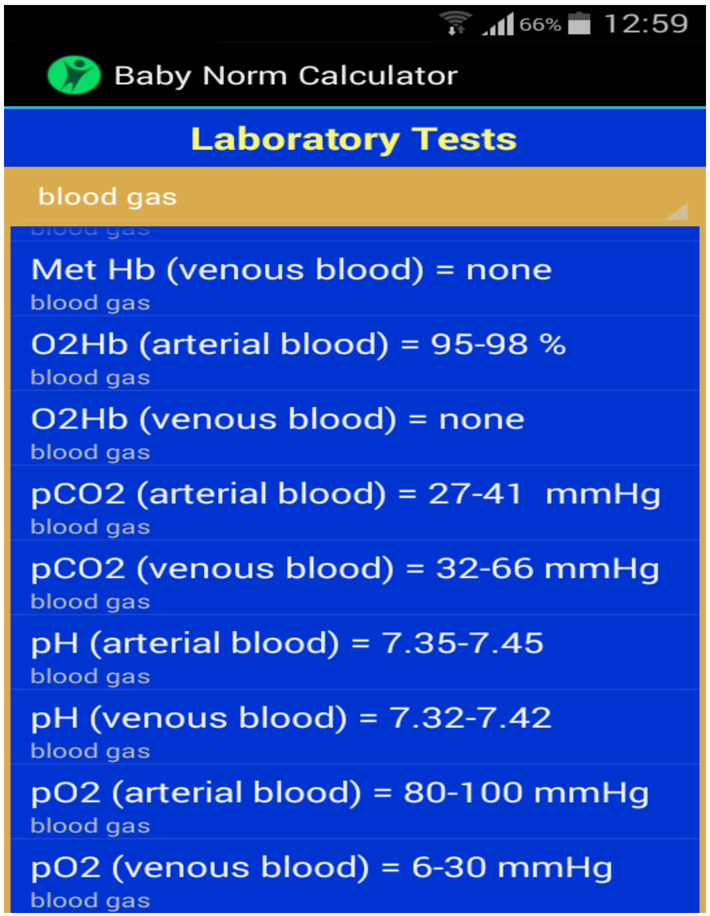


Home page

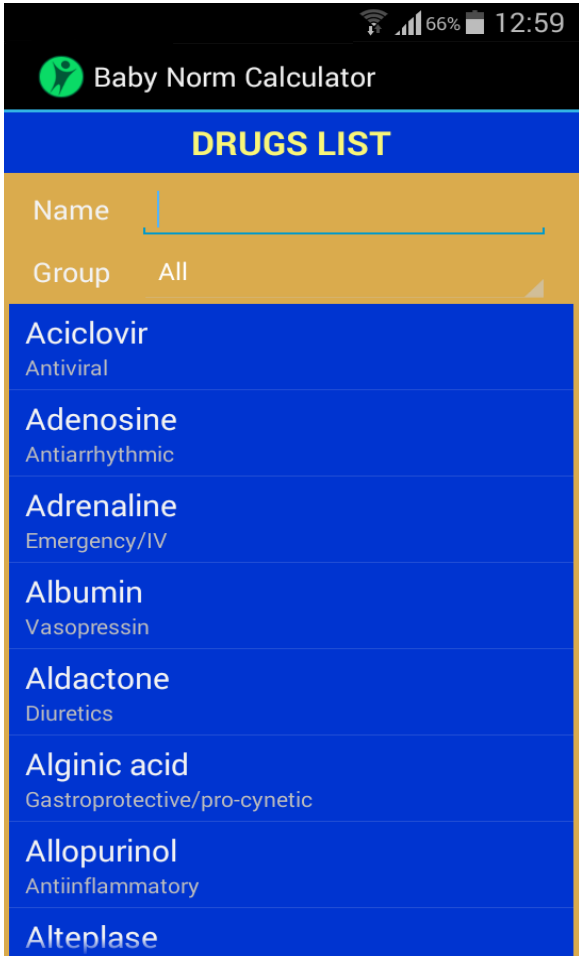

66% 13:00
Baby Norm Calculator
Child Growth Standards
Vital parameters/Anesthesia
Blood Pressure
Laboratory Tests
Drug doses
Echocardiography
Fetal Echocardiography
Cardiac MRI
ECG
Stress Tests
Nutrition

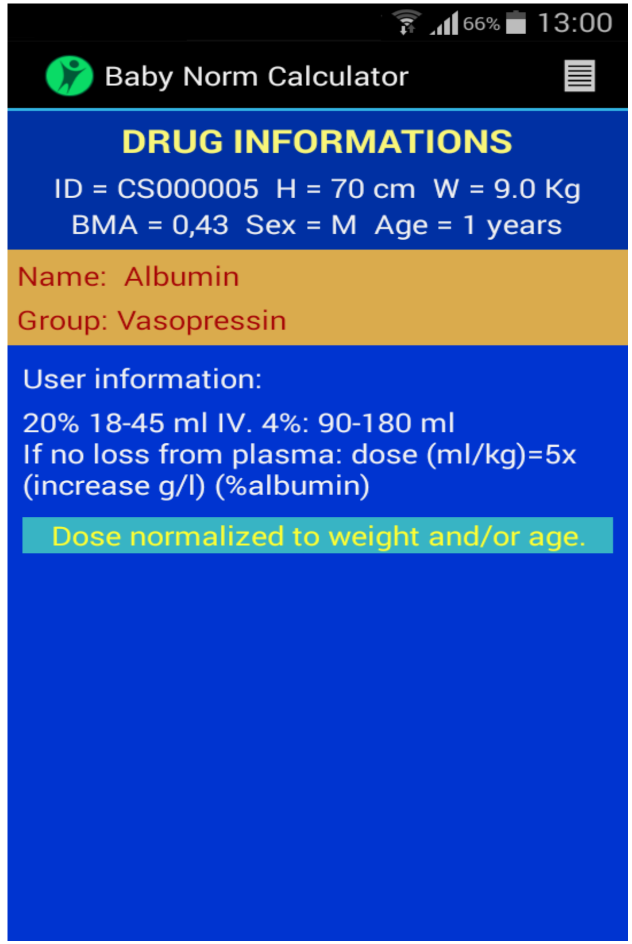
Blood pressure/Laboratory tests



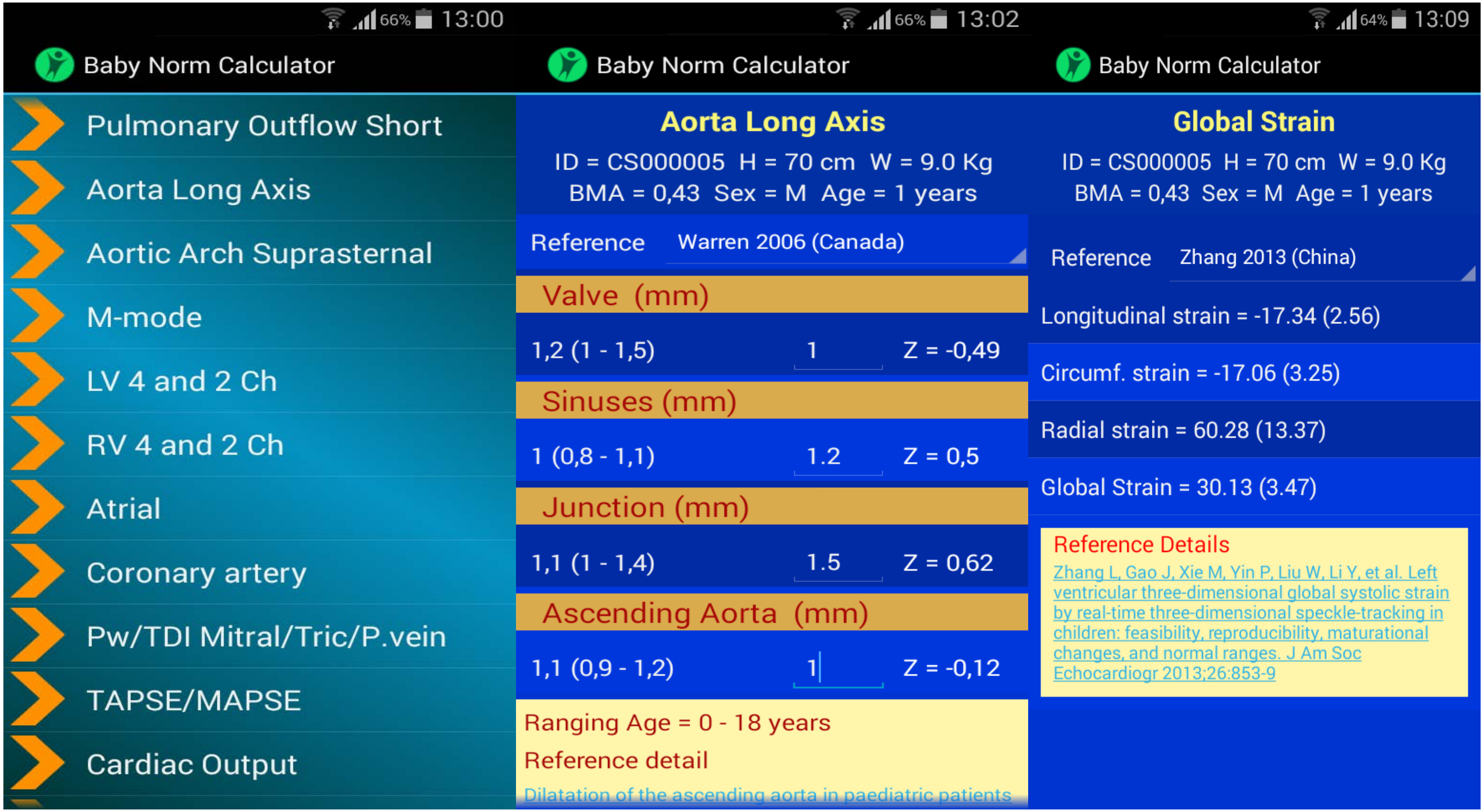


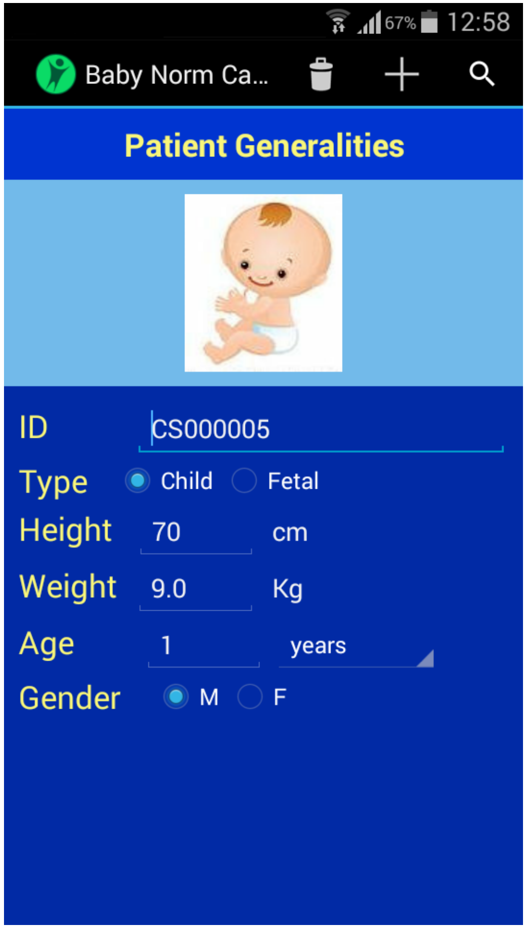
Drug doses

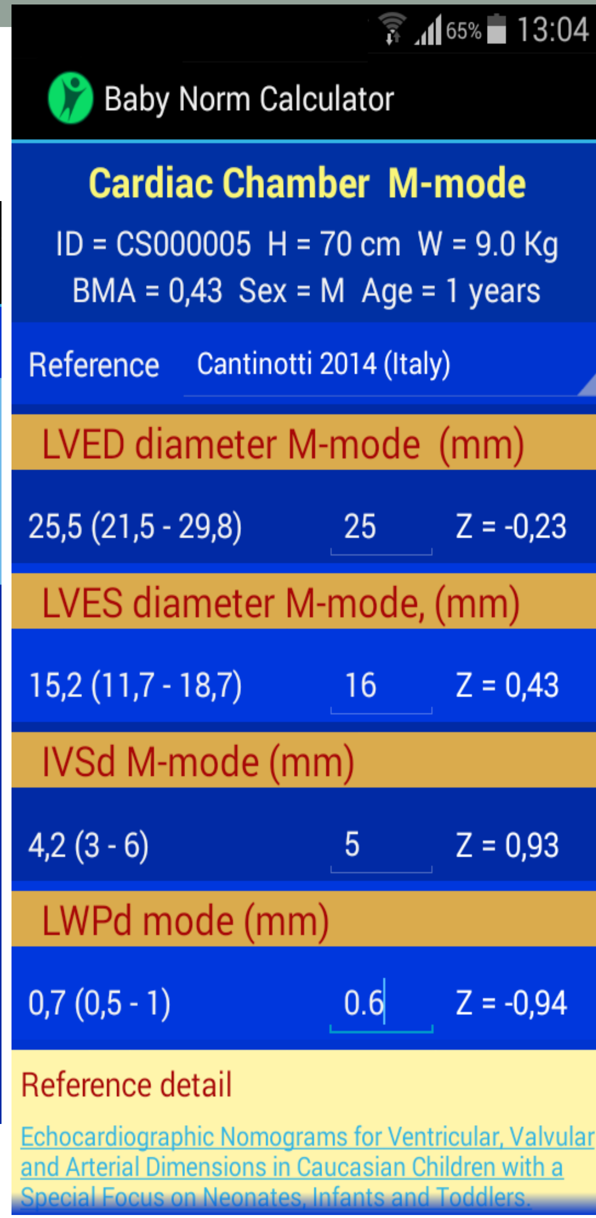

66% 12:59
Baby Norm Calculator
DRUGS LIST
Name
Group All
Aciclovir
Antiviral
Adenosine
Antiarrhythmic
Adrenaline
Emergency/IV
Albumin
Vasopressin
Aldactone
Diuretics
Alginic acid
Gastroprotective/pro-cynetic
Allopurinol
Antiinflammatory
Alteplase

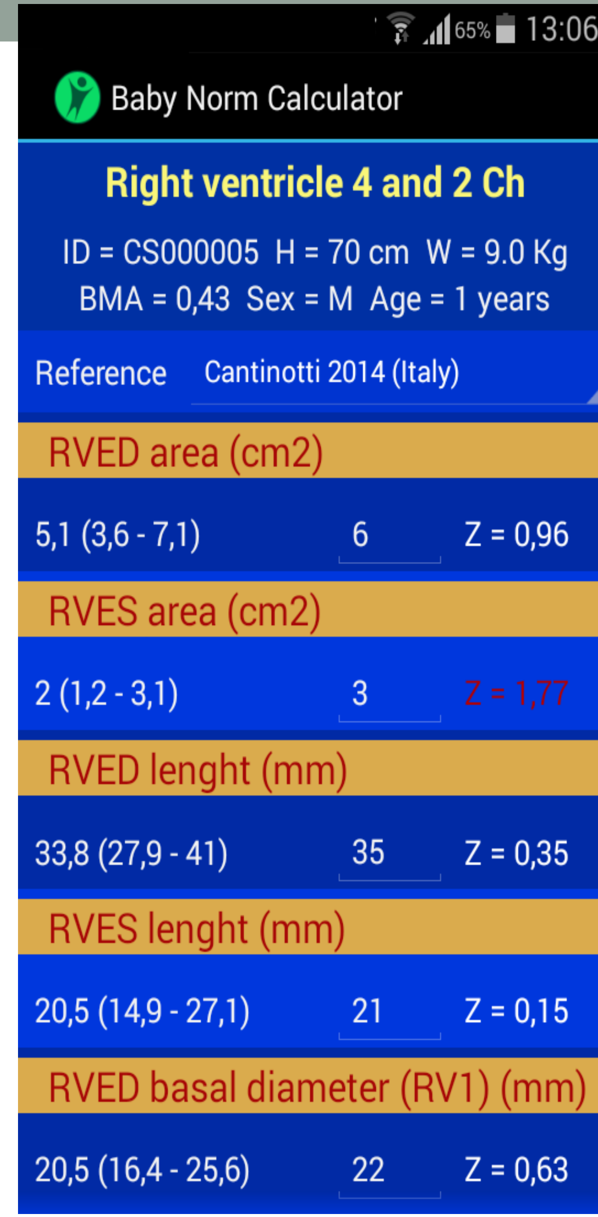

66% 13:00
Baby Norm Calculator
DRUG INFORMATIONS
ID = CS000005 H = 70 cm W = 9.0 Kg
BMA = 0,43 Sex = M Age = 1 years
Name: Albumin
Group: Vasopressin
User information:
20% 18-45 ml IV. 4%: 90-180 ml
If no loss from plasma: dose (ml/kg)=5x
(increase g/l) (%albumin)
Dose normalized to weight and/or age.

Echocardiography: a high level application

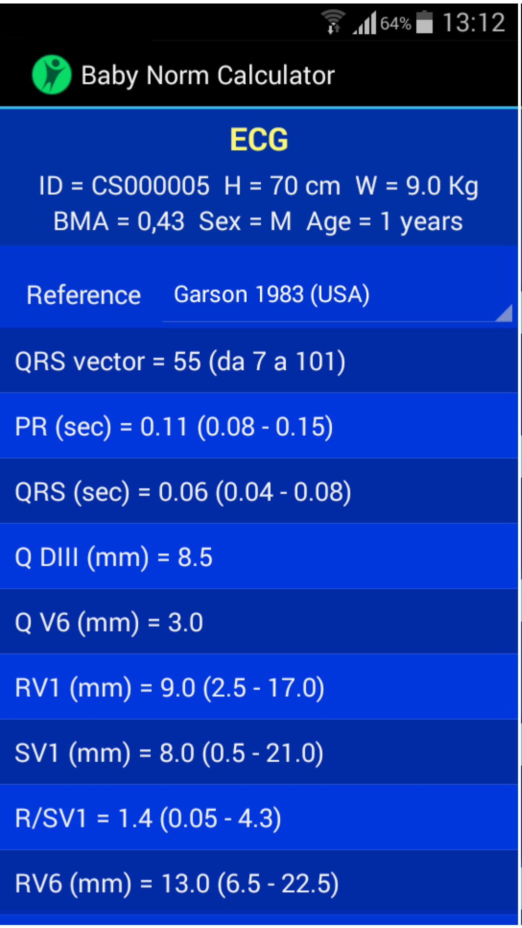


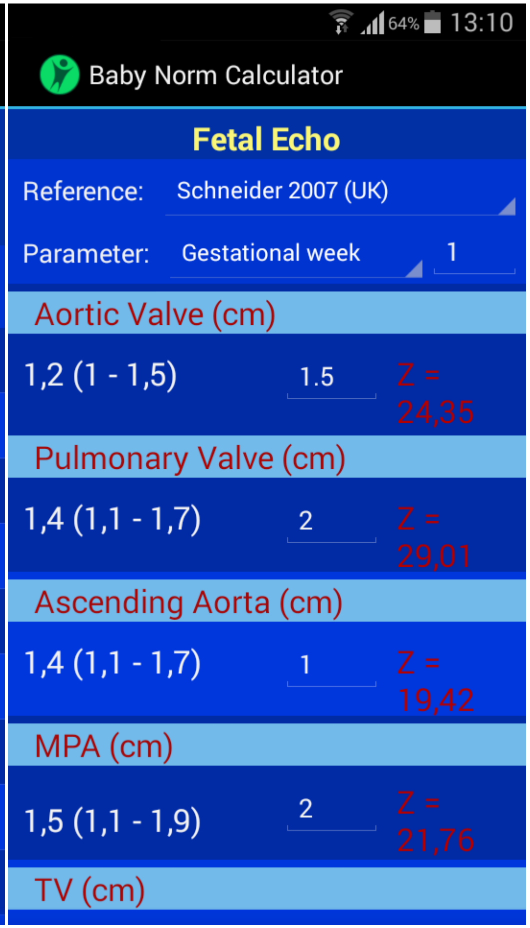

67% 12:58
Baby Norm Ca...
Patient Generalities
ID CS000005
Type Child Fetal
Height 70 cm
Weight 9.0 Kg
Age 1 years
Gender M F

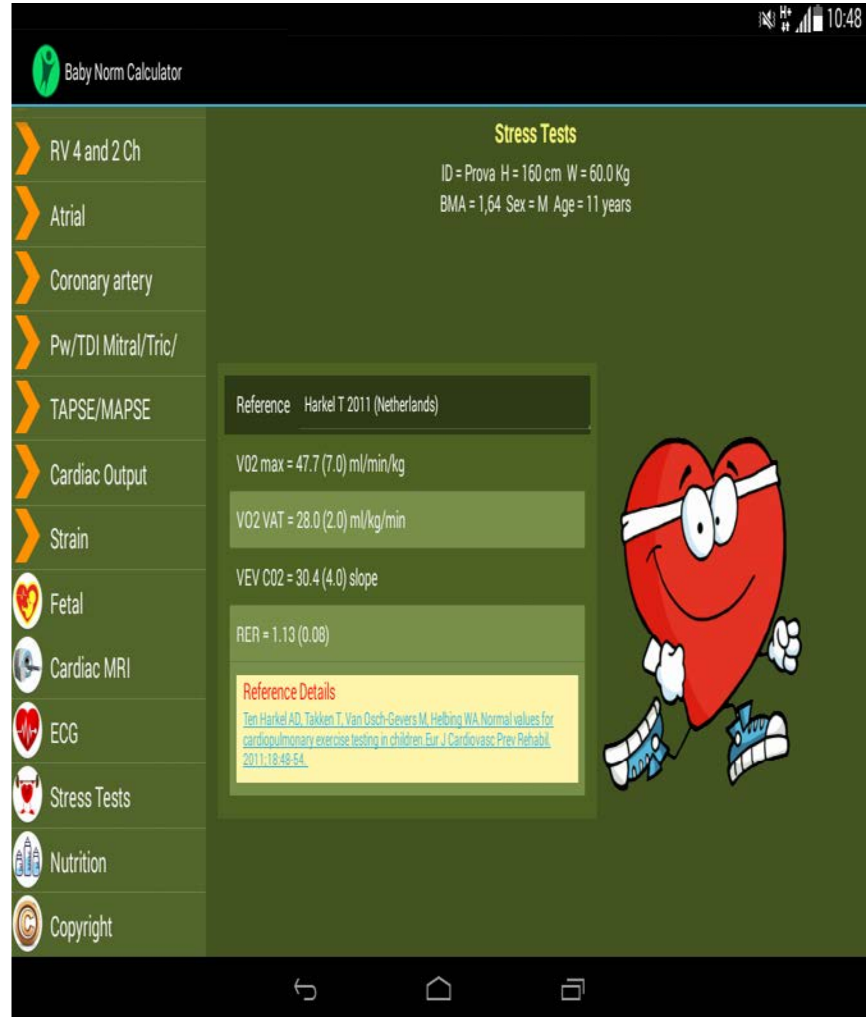

65% 13:04
Baby Norm Calculator
Cardiac Chamber M-mode
ID = CS000005 H = 70 cm W = 9.0 Kg
BMA = 0,43 Sex = M Age = 1 years
Reference Cantinotti 2014 (Italy)
LVED diameter M-mode (mm)
25,5 (21,5 - 29,8) 25 Z = -0,23
LVES diameter M-mode, (mm)
15,2 (11,7 - 18,7) 16 Z = 0,43
IVSd M-mode (mm)
4,2 (3 - 6) 5 Z = 0,93
LWPd mode (mm)
0,7 (0,5 - 1) 0.6 Z = -0,94
Reference detail
Echocardiographic Nomograms for Ventricular, Valvular and Arterial Dimensions in Caucasian Children with a Special Focus on Neonates, Infants and Toddlers.


65% 13:06
Baby Norm Calculator
Right ventricle 4 and 2 Ch
ID = CS000005 H = 70 cm W = 9.0 Kg
BMA = 0,43 Sex = M Age = 1 years
Reference Cantinotti 2014 (Italy)
RVED area (cm2)
5,1 (3,6 - 7,1) 6 Z = 0,96
RVES area (cm2)
2 (1,2 - 3,1) 3 Z = 1,77
RVED lenght (mm)
33,8 (27,9 - 41) 35 Z = 0,35
RVES lenght (mm)
20,5 (14,9 - 27,1) 21 Z = 0,15
RVED basal diameter (RV1) (mm)
20,5 (16,4 - 25,6) 22 Z = 0,63

ECG/Fetal echo/Stress Test







Future prospective

- 3D z scores
- Deformation index z scores
- Z scores also for other imaging modalities
- Not only actual pediatric nomograms need to be reinforced and completed
- Pediatric normal values need to be implemented and/or created according to the development new diagnostic tools

Conclusions

- Nomograms are useful but not perfect tools
- Knowledge of the problem: how to interpret nomograms
- Substantial improvement have been made
- Effort ongoing both in Europe and North America
- A never ending research

Thank you for your attention!