Echo Reference Value

	Preterm +/- Term Neonates	Term Neonates – 18yo
(1) Left ventricle		
LV Systolic Function	**LVFS** >= 28% **LVEF** >= 56%	**LVFS** >= 28% **LVEF** >= 56%
LV Diastolic Function	**Hirose et al. (2015) JASE** Refer to Appendix 1	**Dallaire et al. (2015) Circ Cardiovasc Imaging** http://www.parameterz.com/refs/dallaire-circimaging-2015
LV Size & Dimension	**Choudhry et al. (2017) JASE** http://www.parameterz.com/refs/choudhry-jase-2017 https://www.rchsd.org/zscore/	**Lopez et al. (2017) Circ V Img (Pediatric Heart Network)** http://www.parameterz.com/refs/lopez-circimaging-2017 https://www.rchsd.org/zscore/
LV Aortic Arch +/- Root	**Dijkema et al. (2017) JASE** http://www.parameterz.com/refs/dijkema-jase-2017 https://www.rchsd.org/zscore/	**Cantinotti et al. (2017) J Cardiol** http://www.parameterz.com/refs/cantinotti-jcard-2017 https://www.rchsd.org/zscore/
(2) Right ventricle		
RV Systolic Function	**Koestenberger et al. (2011) Neonatology** **Koestenberger et al. (2013) Neonatology** **TAPSE:** Refer to Appendix 2 **RV s':** Refer to Appendix 2	**Koestenberger et al. (2009) JASE** **Koestenberger et al. (2012) Am J Cardiol** **TAPSE:** Refer to Appendix 3 **RV s':** http://www.parameterz.com/refs/koestenberger-ajc-2012 **RV FAC:** >= 35%
RV Size & Dimension	**Levy et al. (2015) JASE** Refer to Appendix 4	**Koestenberger et al (2014) Am J Cardiol** http://www.parameterz.com/refs/koestenberger-ajc-2014 https://www.rchsd.org/zscore/

	Preterm +/- Term Neonates	Term Neonates – 18yo
(3) Others structures		
Coronary arteries	Not available	**Kobayashi et al. (2016) JASE** http://www.parameterz.com/refs/kobayashi-jase-2016 https://www.rchsd.org/zscore/
Pulmonary arteries	**Abushaban et al. (2017) Pediatr Cardiol** Refer to Appendix 5	**Lopez et al. (2017) Circ V Img (Pediatric Heart Network)** http://www.parameterz.com/refs/lopez-circimaging-2017 https://www.rchsd.org/zscore/
PAAT (Pulmonary artery acceleration time)	Not available (Infer from Term – 18yo)	**Koestenberger et al. (2017) Circ Cardiovasc Imaging** **Levy et al. (2016) JASE** http://www.parameterz.com/refs/koestenberger-circimaging-2017 https://www.rchsd.org/zscore/ **PAAT/RVET:** >=0.31
LV Eccentricity Index (end systolic)	Not available (Infer from Term – 18yo)	**Skinner (2017) Frontiers in Pediatrics** **LV eccentricity index (systole):** < 1.15
(4) Haemodynamics		
LV Cardiac Output & Index	**LV Cardiac output:** 150 – 300 or 400ml/kg/min [(LVOT diameter(cm) / 2)^2 x 3.14(π) x VTI x HR] / BW (kg)	**LV Cardiac Index:** 3.5 – 5.0L/m^2/min (Decreased CO <2.5L/m2/min) [(LVOT diameter(cm) / 2)^2 x 3.14(π) x VTI x HR] / 1000 / BSA Refer to Appendix 7
	LVOT: Left ventricular outflow tract; HR: Heart rate; VTI: Velocity time integral; BW: Body weight; BSA: Body surface area	
Systemic Vascular Resistance Index (SVRI)	Not available (Infer from Term – 18yo)	**SVRI:** 800 – 1600 dynes/sec/cm^5/m^2 (MAP – CVP) / Cardiac Index x 80
	MAP: Mean arterial pressure; CVP: Central venous pressure	
Stroke volume variation (SVV) / Aortic blood flow peak velocity variation	Not available (Infer from Term – 18yo)	**Variation:** < 10 – 15% **SVV:** (VTI_{max} – VTI_{min}) / [(VTI_{max} + VTI_{min}) / 2] x 100(%) **Aortic blood flow peak velocity variation:** (V_{max} – V_{min}) / [(V_{max} + V_{min}) / 2] x 100 (%)
Inferior vena cava	Not available (Infer from Term – 18yo)	**Kathuria et al. (2015) J Ultrasound Med** Refer to Appendix 6 **Adult IVC size:** <= 2.1cm **Collapsibility index:** >= 50% (spontaneous breathing) **Transverse IVC / Aorta ratio:** >= 0.8

Table 2 LV systolic and Doppler-based diastolic function in preterm versus term infants at 4 weeks' postnatal age

	Preterm (n = 30)	Term (n = 30)	P
Heart rate (beats/min)	162 ± 15	141 ± 15	<.0001
Shortening fraction (%)	34.6 ± 4.4	32.2 ± 6.9	NS
Ejection fraction (%)	67.4 ± 5.6	63.9 ± 7.3	<.05
MV pulsed Doppler			
E wave (cm/sec)	56.3 ± 12.3	70.5 ± 15.2	<.01
A wave (cm/sec)	77.2 ± 14.0	70.1 ± 17.2	NS
E/A ratio	0.74 ± 0.11	1.02 ± 0.22	<.0001
MV DTI parameter			
e′ wave (cm/sec)	5.76 ± 1.51	8.35 ± 1.76	<.0001
a′ wave (cm/sec)	9.53 ± 2.53	8.23 ± 2.92	NS
s′ wave (cm/sec)	5.06 ± 1.01	5.83 ± 1.51	<.05
e′/a′ ratio	0.64 ± 0.18	1.09 ± 0.29	<.0001
E/e′ ratio	11.1 ± 3.29	8.45 ± 2.18	<.01
IVRT (msec)	42.8 ± 4.6	41.0 ± 5.1	NS
MPI	0.44 ± 0.06	0.43 ± 0.05	NS

Data are expressed as mean ± SD.
DTI, Doppler tissue imaging; *IVRT*, isovolumic relaxation time; *MPI*, myocardial performance index; *MV*, mitral valve.

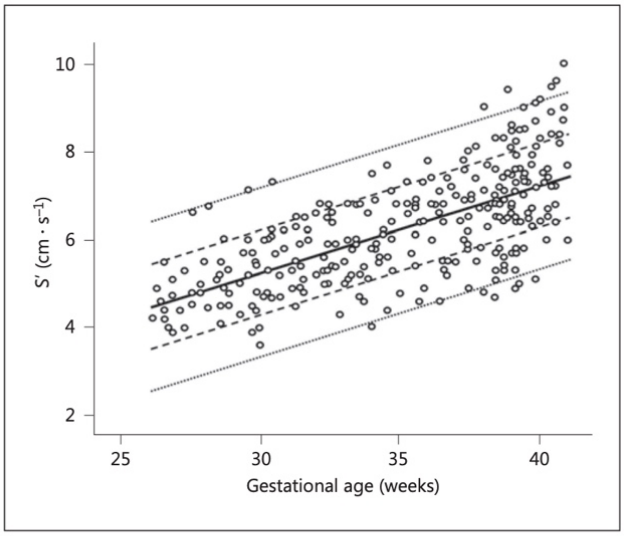


Fig. 2. Gestational week versus observed mean value of tricuspid annular peak systolic velocity (S′) ± 2 SD for gestational week versus S′. The mean is indicated by the black solid line, the Z-score ± 1 SD is indicated by the black broken lines, and the Z-score ± 2 SD is indicated by the black dotted lines.

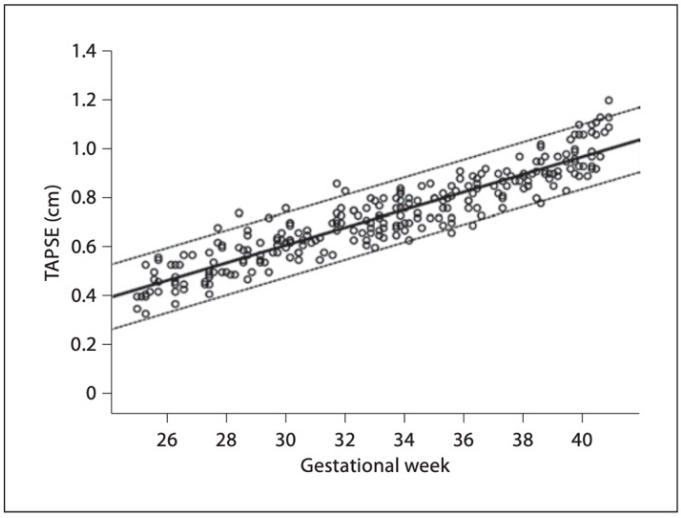


Fig. 2. Gestational week versus observed mean value of TAPSE ±2 SD for gestational week versus TAPSE. The mean is indicated by a solid black line, the Z-score ±2 is indicated by broken black lines.

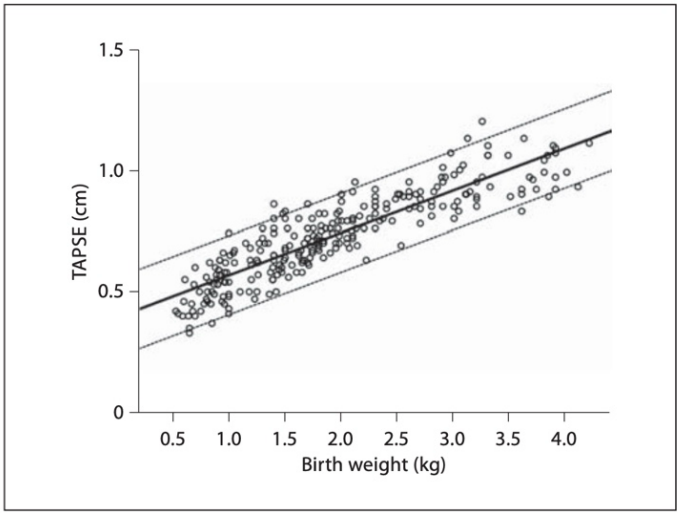


Fig. 3. Birth weight versus observed mean value of TAPSE ±2 SD for birth weight versus TAPSE. The mean is indicated by a solid black line, the Z-score ±2 is indicated by broken black lines.

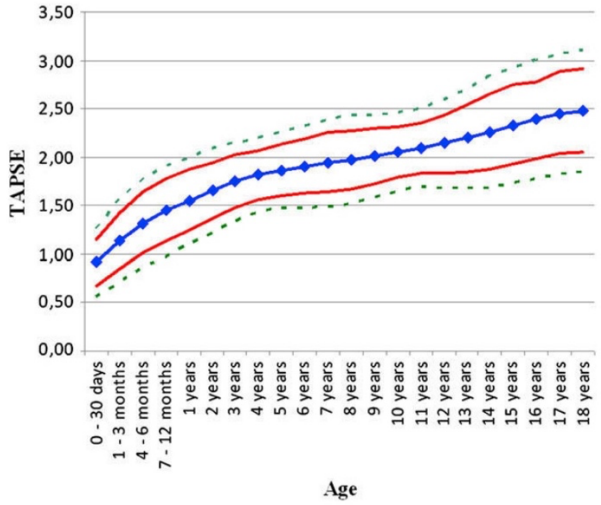
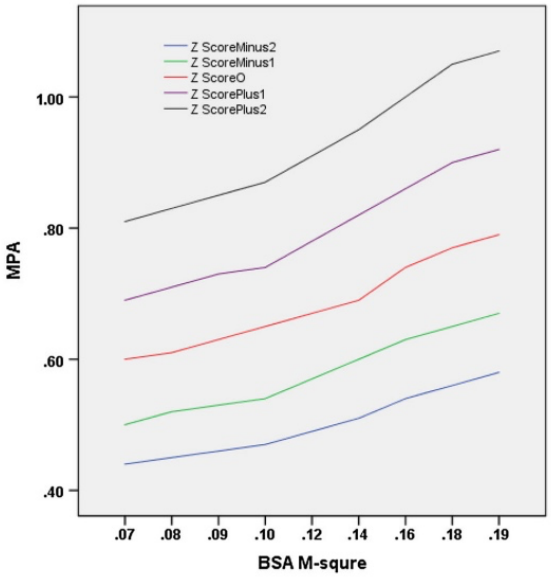


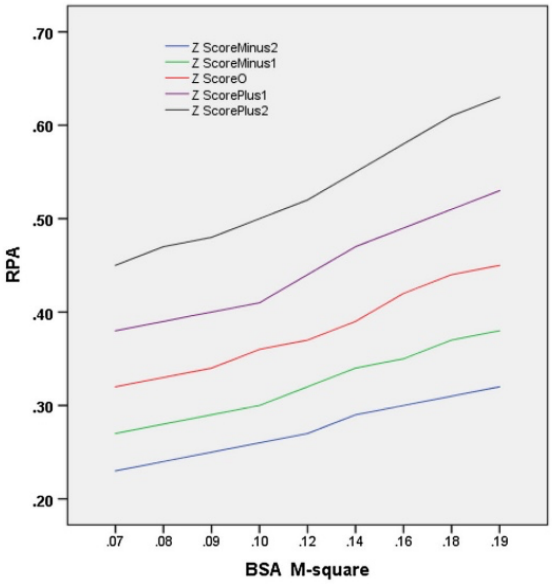
Figure 2 Age versus mean value of TAPSE ± 2 and 3 *z* scores for age versus TAPSE. The mean is indicated by the *blue solid line* with the *squares*. The *z* score ± 2 and *z* score ± 3 lines are indicated by the *red solid line* and *green broken line*, respectively.

Table 3 RV areas and FAC in preterm infants by weight

Weight (g)	Infants (*n*)	RVEDA (cm^2)	RVESA (cm^2)	RV FAC (%)
600	3	1.5 ± 0.2	1.2 ± 0.1	23 ± 2
700	3	1.9 ± 0.3	1.3 ± 0.2	29 ± 8
800	6	1.8 ± 0.2	1.3 ± 0.1	27 ± 5
900	6	1.9 ± 0.2	1.3 ± 0.2	28 ± 7
1,000	5	2.3 ± 0.4	1.4 ± 0.2	36 ± 6
1,100	11	2.3 ± 0.5	1.5 ± 0.3	34 ± 5
1,200	10	2.3 ± 0.4	1.6 ± 0.2	34 ± 6
1,300	13	2.4 ± 0.5	1.7 ± 0.4	34 ± 6
1,400	14	2.6 ± 0.4	1.8 ± 0.3	33 ± 4
1,500	13	2.7 ± 0.4	1.8 ± 0.4	36 ± 4
1,600	4	2.8 ± 0.3	2.0 ± 0.2	37 ± 5
1,700	10	2.9 ± 0.4	1.9 ± 0.3	36 ± 5
1,800	5	3.2 ± 0.7	2.3 ± 0.5	33 ± 4
1,900	6	3.2 ± 0.7	2.2 ± 0.6	34 ± 4
2,000	9	3.4 ± 0.5	2.4 ± 0.3	35 ± 6
2,100	5	3.5 ± 0.6	2.3 ± 0.4	37 ± 6
2,200	8	3.6 ± 0.4	2.3 ± 0.3	37 ± 7
2,300	8	3.8 ± 0.7	2.5 ± 0.5	35 ± 4
2,400	6	3.8 ± 0.6	2.7 ± 0.5	36 ± 5
2,500	7	3.9 ± 0.3	2.6 ± 0.4	34 ± 7
2,600	4	4.3 ± 0.7	3.1 ± 0.6	34 ± 5
2,700	4	4.4 ± 0.4	2.8 ± 0.2	36 ± 3

Data are expressed as mean ± SD.





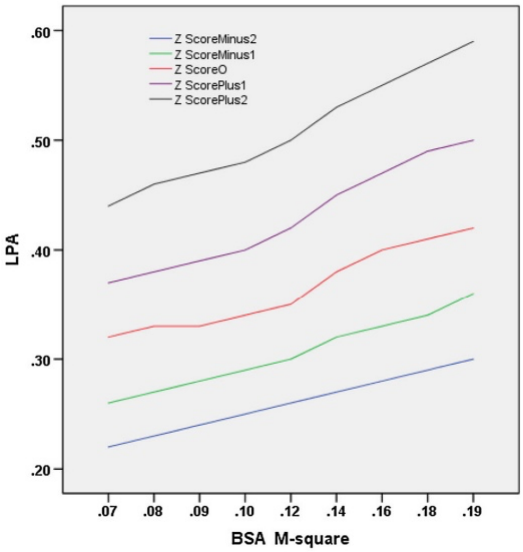


Figure 4. Maximum sagittal IVC diameter as a function of age.

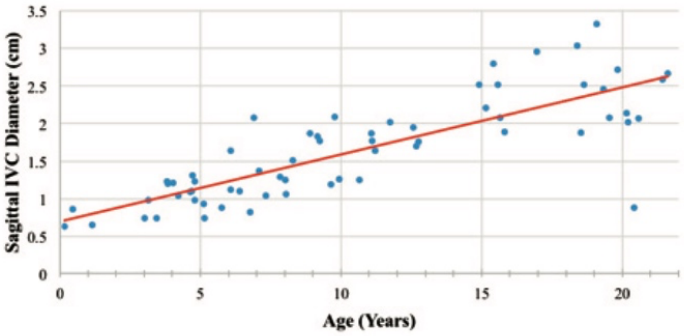
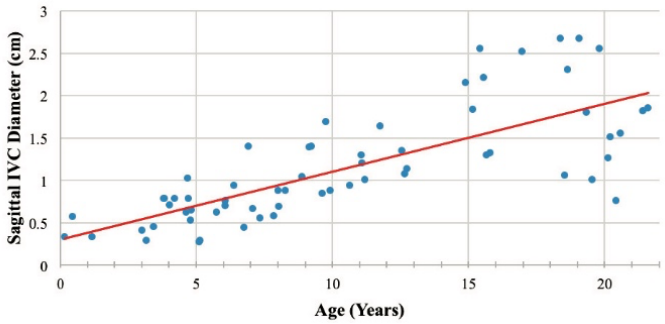


Figure 5. Minimum sagittal IVC diameter as a function of age.



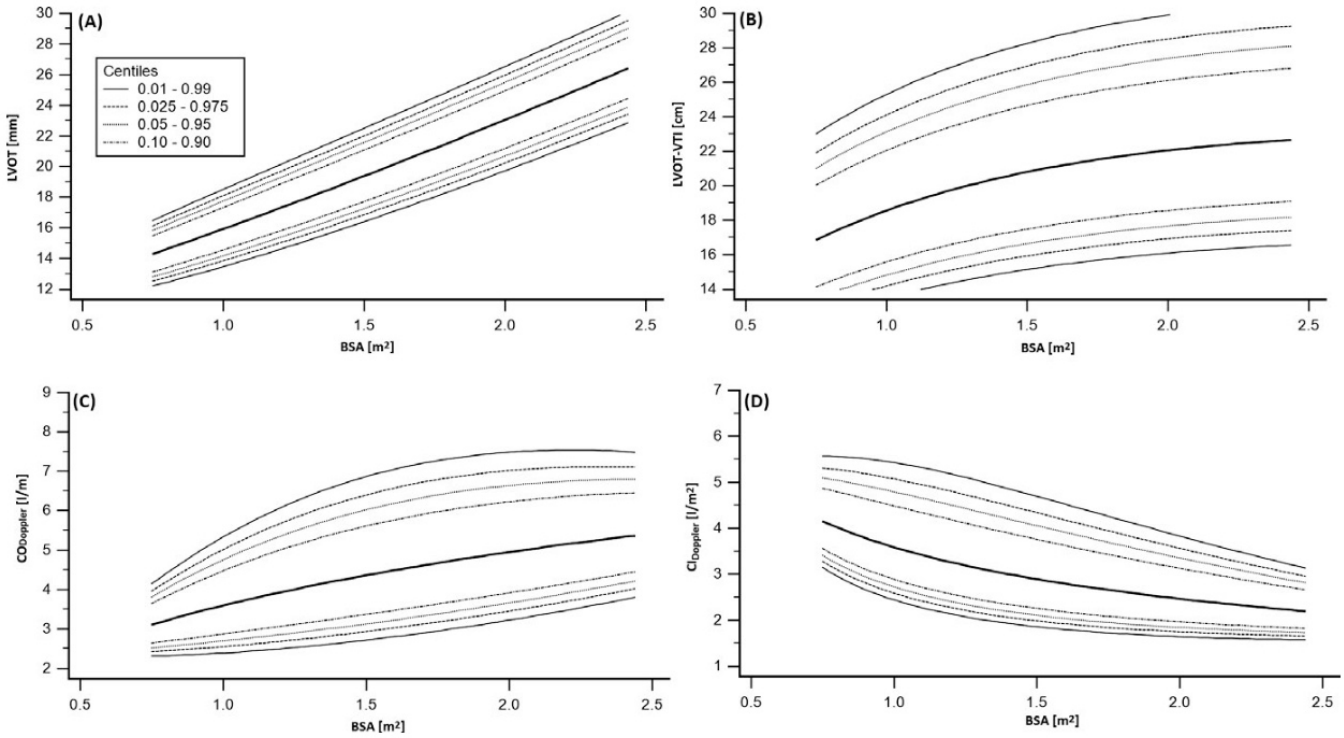
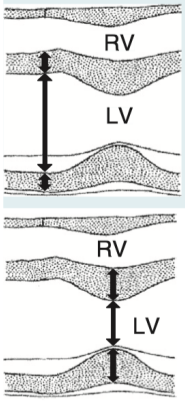


FIGURE 4 Body surface area-specific percentiles curves for left ventricular outflow tract (LVOT) diameter (A), left ventricular outflow tract velocity time integral (LVOT-VTI) (B), and cardiac output (CO) (C) and cardiac index (CI) (D) from Doppler- or LVOT-VTI-derived method, for the entire population of children and adolescents

TWO-DIMENSIONAL ECHOCARDIOGRAPHIC MEASUREMENTS OF ATRIOVENTRICULAR VALVES: MEAN (–2 SD TO +2 SD) (IN MM)*

ECHO VIEWS	BSA	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2
Mitral (Apical-4 chamber)		10.0 (8.0-12.0)	12.5 (9.5-15.0)	13.5 (10.5-17.5)	15.1 (12.0-19.0)	17.0 (12.5-21.0)	18.0 (13.5-22.5)	19.0 (14.5-24.0)	20.5 (15.0-25.5)	22.0 (15.5-27.5)	23.5 (16.5-30.5)	25.0 (17.5-33.0)	27.0 (18.0-35.5)	28.0 (18.5-37.5)	29.5 (19.0-40.0)	31.0 (19.0-42.0)
Tricuspid (Apical-4 chamber)		11.0 (7.5-14.0)	13.0 (8.5-17.0)	15.0 (10.5-18.5)	17.0 (12.0-20.5)	18.0 (13.0-22.5)	19.0 (14.0-23.5)	20.0 (15.0-25.0)	21.5 (16.0-27.5)	22.5 (17.0-28.0)	24.0 (18.0-30.5)	26.5 (19.0-33.0)	28.0 (20.5-35.0)	29.5 (21.5-37.5)	31.0 (22.5-39.5)	32.5 (23.5-42.0)

TWO-DIMENSIONAL ECHOCARDIOGRAPHY-DERIVED M-MODE MEASUREMENTS OF THE LV DIMENSION AND WALL THICKNESS: MEAN (–2 SD TO +2 SD) (IN MM)*



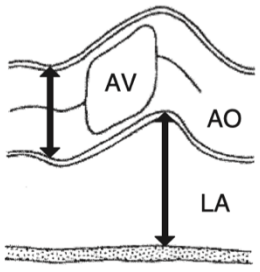
VIEWS	BSA	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2
LV EDD		19.5 (15.5-23.0)	23.0 (19.0-27.0)	26.0 (22.0-30.5)	29.5 (24.5-34.0)	31.5 (27.0-36.5)	33.5 (29.0-38.5)	35.5 (30.5-41.0)	37.5 (32.0-43.0)	39.5 (33.5-45.0)	42.0 (36.0-48.0)	45.0 (38.5-51.0)	47.0 (40.5-54.0)	49.5 (42.5-57.0)	51.5 (44.0-60.0)	53.5 (45.5-62.0)
IVS (D)		4.5 (3.0-5.5)	5.0 (3.5-6.0)	5.0 (4.0-6.5)	5.5 (4.0-7.0)	6.0 (4.5-7.5)	6.0 (4.5-8.0)	6.5 (4.5-8.5)	7.0 (5.0-9.0)	7.0 (5.0-9.5)	8.0 (5.5-10.0)	8.5 (6.0-11.0)	9.0 (6.0-12.0)	9.5 (6.5-12.5)	10.5 (7.0-13.5)	11.0 (7.5-14.5)
LVPW (D)		4.0 (3.0-5.0)	4.5 (3.0-5.5)	4.5 (3.5-6.0)	5.0 (3.5-6.5)	5.5 (4.0-7.0)	6.0 (4.0-7.5)	6.0 (4.5-8.0)	6.5 (4.5-8.0)	7.0 (5.0-8.5)	7.5 (5.5-9.5)	8.0 (5.5-10.0)	8.5 (6.0-11.0)	9.0 (6.5-11.5)	9.5 (7.0-12.0)	10.0 (7.5-13.0)
LV ESD		12.0 (8.0-15.0)	15.0 (11.5-18.0)	17.0 (13.5-20.0)	18.5 (15.0-22.5)	20.0 (16.5-24.5)	21.5 (17.5-26.0)	23.0 (18.5-28.0)	24.0 (19.5-29.0)	25.5 (20.5-31.0)	28.0 (22.0-33.5)	29.5 (23.5-35.5)	31.5 (24.5-37.5)	33.0 (25.5-39.5)	34.5 (26.5-41.5)	36.0 (27.5-43.0)
IVS (S)		6.5 (5.0-8.0)	7.0 (5.5-9.0)	7.5 (6.0-9.5)	8.0 (6.0-10.0)	8.5 (6.5-10.5)	9.0 (7.0-11.0)	9.5 (7.5-11.5)	9.5 (7.5-12.0)	10.0 (8.0-12.5)	10.5 (8.0-13.5)	11.5 (9.0-14.5)	12.0 (9.0-15.5)	12.5 (9.5-16.5)	13.5 (10.0-18.0)	14.0 (10.0-19.0)
LVPW (S)		6.5 (5.5-8.0)	7.0 (6.0-8.5)	8.0 (6.5-9.5)	9.0 (7.0-10.5)	9.5 (7.5-11.0)	10.0 (8.0-12.0)	10.5 (8.5-12.5)	11.5 (9.0-13.5)	11.5 (9.0-14.0)	12.5 (10.0-15.0)	13.0 (10.5-16.0)	14.0 (11.0-17.5)	14.5 (11.0-18.5)	15.0 (11.5-19.5)	16.0 (12.0-20.0)

TABLE 5-3. M-mode Measurements in Normal Preterm and Term Neonates in the First Week After Birth[4]

	750-1249g	1250-1749g	1750-2249g	2250-2749g	2750-3249g	3250-3749g	3750-4249g	>4250g
LA (cm)	0.72±0.7	0.85±0.10	0.96±0.08	1.03±0.09	1.08±0.10	1.16±0.10	1.2±0.10	1.25±0.07
Ao (cm)	0.63±0.06	0.73±0.06	0.84±0.05	0.89±0.08	0.93±0.06	0.99±0.06	1.03±0.06	1.06±0.08
LA/Ao ratio	1.14±0.11	1.16±0.11	1.14±0.11	1.17±0.10	1.16±0.11	1.17±0.10	1.16±0.09	1.18±0.09
LVIDd (cm)	1.26±0.15	1.33±0.12	1.52±0.15	1.73±0.22	1.79±0.21	1.83±0.20	1.93±0.24	2.12±0.23
LVIDs (cm)	0.85±0.12	0.91±0.10	0.98±0.15	1.15±0.14	1.17±0.15	1.21±0.17	1.25±0.17	1.44±0.16
FS %	33±5	31±4	36±6	34±4	35±4	34±4	35±5	35±5
IVSd (cm)	0.20±0.06	0.26±0.06	0.26±0.06	0.28±0.04	0.29±0.06	0.28±0.05	0.28±0.05	0.30±0.06
IVSs (cm)	0.30±0.10	0.44±0.08	0.44±0.08	0.48±0.07	0.45±0.09	0.46±0.08	0.47±0.07	0.48±0.09

LA = left atrium, Ao = aortic root, LVIDd = left ventricular diameter in diastole, LVIDs = left ventricular diameter in systole, FS = fractional shortening, IVSd = intraventricular septum thickness in diastole, IVSs = intraventricular septum thickness in systole

STAND-ALONE M-MODE ECHOCARDIOGRAPHIC MEASUREMENTS: RIGHT VENTRICLE, AORTA, LEFT ATRIUM BY BODY SURFACE AREA: MEAN (90% TOLERANCE LIMITS) (IN MM)*



ECHO VIEWS	BSA	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0
Aorta (diastolic)		10 (6-14)	12 (7.5-16)	13 (9-17.5)	14 (9.5-19)	15 (10.5-21)	16 (11.5-22)	17 (12.5-24)	18 (13-24.5)	19 (13.5-25)	21 (14.5-27)	22 (15.5-29)	23 (16-30.5)	24 (16-32)	24 (16-33)
LA (systolic)		13 (6-20)	16 (8-23)	18 (9-25)	19 (11-27)	20 (12-29)	22 (13-31)	23 (14-33)	24 (15-34)	26 (16-35)	27 (17-38)	28 (17-40)	29 (18-42)	29 (18-43)	30 (18-44)

TWO-DIMENSIONAL ECHOCARDIOGRAPHIC MEASUREMENTS OF AORTIC ROOT AND AORTA: MEAN (–2 SD TO +2 SD) (IN MM)*

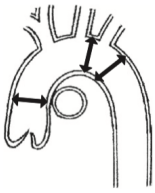
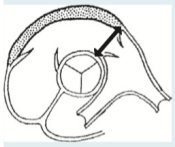
ECHO VIEWS	BSA	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2
	Aortic annulus	7.0 (5.5-9.0)	8.5 (7.0-10.0)	10.0 (8.0-12.0)	11.0 (9.0-13.5)	12.0 (10.0-14.5)	13.5 (11.0-15.5)	14.0 (11.5-16.5)	15.0 (12.5-17.5)	15.5 (13.9-18.5)	17.5 (14.5-20.5)	18.5 (15.0-22.0)	20.0 (16.0-23.5)	21.0 (17.0-25.0)	22.0 (18.0-26.0)	23.0 (18.5-27.5)
	Sinus of Valsalva	9.5 (7.0-12.0)	11.5 (9.0-14.0)	13.0 (10.0-16.0)	14.5 (11.5-17.5)	16.0 (13.0-19.5)	17.5 (14.0-21.0)	18.5 (15.5-22.05)	19.5 (15.5-23.5)	20.5 (16-25.0)	22.0 (18.0-27.0)	24.0 (19.0-30.0)	25.5 (20.0-31.5)	27.0 (21.0-33.5)	28.5 (22.0-35.5)	30.5 (23.0-38.5)
	Sinotubular junction	8.0 (6.0-10.0)	10.0 (7.5-12.0)	11.0 (9.0-13.5)	12.5 (10.0-15.0)	14.0 (11.0-16.5)	15.0 (12.0-18.0)	16.0 (12.5-19.0)	16.5 (13.0-20.5)	17.5 (14.0-21.5)	19.5 (15.5-24.0)	21.0 (16.5-26.0)	22.0 (17.0-27.5)	24.0 (18.0-29.0)	25.0 (19.0-31.0)	26.0 (20.0-32.0)
	Ascending-aorta	8.0 (5.5-11.0)	10.0 (7.0-13.0)	11.5 (8.5-15.0)	13.0 (10.0-16.0)	14.5 (11.0-17.5)	15.5 (12.0-19.0)	16.5 (13.0-20.5)	17.5 (14.0-21.5)	18.5 (14.5-23.0)	20.5 (15.5-25.5)	22.0 (16.5-27.5)	24.0 (18.0-29.5)	25.5 (19.0-31.0)	26.5 (20.0-33.0)	28.0 (21.0-35.0)
	Transverse aorta	6.5 (4.0-8.5)	8.0 (5.5-10.0)	9.5 (8.0-13.0)	10.5 (8.0-13.0)	11.5 (9.0-14.5)	12.5 (9.5-15.5)	13.0 (10.0-17.0)	14.0 (11.0-18.0)	15.0 (11.5-19.0)	17.0 (12.5-20.5)	18.0 (14.0-22.0)	19.5 (15.0-24.0)	20.5 (15.5-25.5)	21.5 (16.0-27.0)	22.5 (17.0-28.5)
	Aortic isthmus	5.5 (3.0-7.5)	6.5 (4.0-9.0)	7.5 (5.0-10.0)	8.5 (6.0-11.0)	9.5 (6.5-12.5)	10.5 (7.0-13.5)	11.0 (7.5-14.5)	12.0 (8.0-15.5)	12.5 (8.5-16.0)	13.5 (9.5-17.5)	15.0 (10.0-19.5)	16.0 (10.5-21.0)	17.0 (11.0-22.0)	17.5 (11.5-23.5)	18.0 (12.0-25.0)

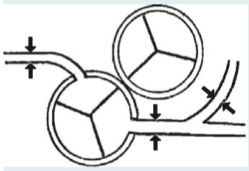
Table 2 Means and SDs for aortic arch dimensions across the range of BW at t_1

BW (g)	*n*	Valid *n*	Ascending aorta	Valid *n*	Transverse aorta	Valid *n*	Isthmus	Valid *n*	Descending aorta
<1,000	91	63	4.7 ± 0.6	59	3.7 ± 0.6	52	2.8 ± 0.7	44	3.8 ± 0.6
1,000–1,250	94	70	5.2 ± 0.8	66	3.9 ± 0.5	53	2.9 ± 0.7	37	3.8 ± 0.6
1,250–1,500	93	71	5.5 ± 0.6	64	4.1 ± 0.5	54	3.1 ± 0.9	40	4.1 ± 0.8
1,500–1,750	60	47	5.7 ± 0.7	44	4.3 ± 0.6	35	3.1 ± 0.8	31	4.3 ± 1.0
>1,750	47	30	6.3 ± 0.7	31	4.6 ± 0.8	23	3.6 ± 1.0	17	4.9 ± 1.2

TWO-DIMENSIONAL ECHOCARDIOGRAPHIC MEASUREMENTS OF THE PULMONARY VALVE AND PULMONARY ARTERIES: MEAN (–2 SD TO +2 SD) (IN MM)*

ECHO VIEWS	BSA	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2
	Pulmonary annulus	8.5 (6.0-10.5)	10.0 (8.0-12.5)	11.5 (9.0-14.0)	13.0 (10.0-16.0)	14.0 (11.0-17.5)	**15.5** (11.5-19.0)	16.5 (12.0-20.5)	17.5 (13.0-21.5)	18.5 (13.5-23.0)	20.0 (15.0-25.0)	22.0 (16.0-27.5)	23.5 (17.0-29.0)	25.0 (18.0-30.5)	26.0 (19.0-33.0)	27.0 (19.5-34.0)
	Main PA	7.5 (5.0-10.0)	9.0 (6.5-12.0)	10.5 (7.5-14.0)	12.0 (9.0-15.0)	13.0 (9.5-16.5)	14.0 (10.0-17.5)	15.0 (11.0-18.5)	16.0 (11.5-20.0)	17.0 (12.0-21.0)	18.5 (13.5-23.0)	20.0 (14.5-25.5)	21.0 (15.0-**28.0**)	22.5 (16.0-30.0)	24.0 (16.5-32.0)	25.0 (17.0-33.0)
	Right PA	5.0 (3.5-7.0)	6.0 (4.5-8.0)	7.0 (5.0-9.0)	8.0 (5.5-10.0)	9.0 (6.0-11.0)	9.5 (6.5-12.0)	10.0 (7.0-13.0)	10.5 (7.5-13.5)	11.0 (8.0-14.0)	12.5 (9.0-16.0)	13.0 (9.5-17.5)	14.0 (10.0-18.5)	15.0 (10.5-20.0)	15.5 (10.5-21.0)	16.5 (11.0-22.0)
	Left PA	4.5 (3.0-6.5)	5.5 (4.0-7.5)	6.5 (4.5-8.5)	7.5 (5.0-9.5)	8.0 (5.5-10.5)	9.0 (6.0-11.0)	9.5 (6.5-12.0)	10.0 (7.0-13.0)	10.5 (7.5-14.0)	11.5 (8.0-15.5)	12.5 (8.5-16.5)	13.5 (9.0-18.0)	14.0 (9.0-19.0)	15.0 (9.5-20.0)	15.5 (10.0-21.0)

TWO-DIMENSIONAL ECHOCARDIOGRAPHIC MEASUREMENTS OF MEAN AND PREDICTION LIMITS FOR 2 AND 3 STANDARD DEVIATIONS FOR MAJOR CORONARY ARTERY SEGMENTS*

ECHO VIEWS	BSA		0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0
	Left anterior descending (LAD)	Mean	1.2	1.4	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.7	2.8	2.9	3.0
		Mean +2 SD	1.5	1.8	2.1	2.3	2.5	2.7	2.8	3.0	3.3	3.5	3.7	4.0	4.2
		Mean +3 SD	1.7	2.0	2.3	2.5	2.8	3.0	3.2	3.4	3.8	4.0	4.3	4.5	4.7
	Right coronary artery (RCA)	Mean	1.3	1.4	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.7	2.8	3.0	3.2
		Mean +2 SD	1.9	2.1	2.3	2.4	2.6	2.7	2.8	3.1	3.4	3.6	3.8	4.0	4.3
		Mean +3 SD	2.2	2.4	2.6	2.8	3.0	3.1	3.3	3.5	3.8	4.1	4.3	4.5	4.8
	Left main coronary artery (LMCA)	Mean	1.7	1.9	2.1	2.3	2.4	2.5	2.7	2.9	3.1	3.3	3.4	3.6	3.7
		Mean +2 SD	2.3	2.6	2.8	3.0	3.3	3.4	3.6	3.9	4.2	4.4	4.6	4.8	5.1
		Mean +3 SD	2.7	3.0	3.2	3.4	3.7	3.9	4.0	4.3	4.7	4.9	5.2	5.5	5.8

Measurements of Mitral Annular Plane Systolic Excursion (cm) From the Lateral Hinge of the Atrioventricular Plane

GA	Mean – 2SD	Mean	Mean + 2SD
26	0.26	0.36	0.46
27	0.28	0.38	0.48
23	0.25	0.4	0.55
29	0.29	0.42	0.54
30	0.26	0.42	0.58
31	0.32	0.45	0.58
32	0.27	0.43	0.59
33	0.24	0.44	0.64
34	0.36	0.48	0.6
35	0.34	0.49	0.64
36	0.33	0.48	0.63
37	0.31	0.5	0.68
38	0.41	0.53	0.65
39	0.32	0.52	0.71
40	0.40	0.56	0.73

Measurements of Tricuspid Annular Plane Systolic Excursion (cm) by Gestational Age

GA	Mean – 2SD	Mean	Mean + 2SD
26	0.30	0.44	0.59
27	0.36	0.48	0.61
28	0.37	0.52	0.68
29	0.41	0.57	0.73
30	0.48	0.60	0.71
31	0.53	0.63	0.74
32	0.51	0.68	0.85
33	0.58	0.70	0.83
34	0.60	0.73	0.87
35	0.61	0.74	0.88
36	0.65	0.78	0.92
37	0.68	0.82	0.96
38	0.75	0.86	0.97
39	0.77	0.90	1.02
40	0.81	0.95	1.10

RV performance in newborns by s' using TDI of the RV free wall

Gestational age, weeks	TDI S′ velocities, cm/s							Birth weight, kg		
	observed				predicted			observed		
	n	mean	−2 SD	+2 SD		−2 SD	+2 SD	mean	min	max
26^{0-6}	11	4.5	3.6	5.5	4.5	2.6	6.4	0.76	0.66	0.95
27^{0-6}	9	5.0	3.5	6.5	4.7	2.8	6.6	0.96	0.78	1.10
28^{0-6}	12	5.1	3.6	6.6	4.9	3.0	6.8	1.25	1.11	1.44
29^{0-6}	16	5.0	3.2	6.8	5.1	3.2	7.0	1.34	1.09	1.57
30^{0-6}	14	5.6	4.1	7.1	5.3	3.4	7.2	1.53	1.23	1.83
31^{0-6}	17	5.7	4.3	7.1	5.5	3.6	7.4	1.52	1.26	1.76
32^{0-6}	19	5.7	4.3	7.1	5.7	3.8	7.6	1.76	1.11	2.65
33^{0-6}	18	5.7	3.9	7.6	5.9	4.0	7.8	1.95	1.51	2.25
34^{0-6}	18	6.1	4.4	7.8	6.1	4.2	8.0	2.08	1.63	2.35
35^{0-6}	14	6.4	4.5	8.2	6.3	4.4	8.2	2.39	1.87	3.00
36^{0-6}	17	6.3	4.5	8.1	6.5	4.7	8.4	2.62	1.90	3.36
37^{0-6}	21	6.7	4.5	8.8	6.7	4.9	8.6	2.94	2.23	4.14
38^{0-6}	39	6.8	4.7	8.9	6.9	5.1	8.8	3.34	2.69	4.25
39^{0-6}	40	7.0	4.6	9.4	7.1	5.3	9.0	3.34	2.71	4.45
40^{0-6}	25	7.8	5.5	10.1	7.3	5.5	9.2	3.74	2.87	4.30

	TAPSE, mm			RV lateral wall s’		
	mean	-2SD	+2SD	mean	-2SD	+2SD
Gestation wk (n)						
22 (7)	3.5	2.2	5.1	3.8	2.2	5.4
23 (16)	3.9	2.9	4.9	4.0	3.0	5.0
24 (16)	4.4	3.2	5.6	4.2	3.4	5.0
25 (19)	4.4	3.2	5.6	4.1	2.8	5.5
26 (30)	4.4	2.8	6.0	4.2	2.8	5.6
Weight g (n)						
400-500 (8)	3.6	1.8	5.4	3.9	1.7	6.1
500-600 (16)	4.1	2.9	5.3	3.9	2.9	4.9
600-700 (20)	4.1	2.9	5.3	4.2	3.2	5.2
700-800 (13)	4.3	3.3	5.3	4.1	3.3	4.9
800-900 (14)	4.2	3.0	5.4	4.1	2.7	5.5
900-1000 (10)	4.6	3.0	6.2	4.2	3.0	5.4

	LV septum s’			LV lateral wall s’		
	mean	-2SD	+2SD	mean	-2SD	+2SD
Gestation wk (n)						
22 (7)	2.7	2.1	3.3	3.2	2.4	4.0
23 (16)	2.8	2.4	3.2	3.3	2.5	4.1
24 (16)	2.8	2.0	3.6	3.3	2.7	3.9
25 (19)	2.9	2.1	3.7	3.5	2.3	4.7
26 (30)	2.8	2.0	3.6	3.3	2.3	4.3
Weight g (n)						
400-500 (8)	2.8	2.0	3.6	3.2	2.8	4.0
500-600 (16)	2.8	2.2	3.4	3.2	2.8	4.0
600-700 (20)	2.7	1.9	3.5	3.4	2.2	4.4
700-800 (13)	2.8	2.2	3.4	3.3	2.5	4.1
800-900 (14)	2.8	2.0	3.6	3.3	2.1	4.5
900-1000 (10)	2.9	2.1	3.7	3.7	2.5	4.9

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Table 8.6 Normal annular tissue Doppler imaging values in infants and children

Age group	*N*	e′-wave velocity	a′-wave velocity	s′-wave velocity	ICT	IRT	E/E′ ratio
Mitral annular							
<1 y	63	9.7 ± 3.3 (8.8–10.5)	5.7 ± 1.8 (5.3–6.2)	5.7 ± 1.6 (5.3–6.1)	77.4 ± 18.4 (72.7–82.0)	57.0 ± 14.8 (53.1–60.8)	8.8 ± 2.7 (8.1–9.5)
1–5 y	68	15.1 ± 3.4† (14.3–15.4)	6.5 ± 1.9 (6.1–7.0)	7.7 ± 2.1† (7.2–8.2)	76.9 ± 15.9 (72.8–80.9)	62.1 ± 13.2 (58.9–65.4)	6.5 ± 2.0† (6.0–7.0)
6–9 y	55	17.2 ± 3.7† (16.2–18.3)	6.7 ± 1.9 (6.2–7.3)	9.5 ± 2.1† (8.9–10.1)	77.9 ± 18.9 (72.4–83.4)	62.9 ± 11.9 (59.5–66.3)	5.8 ± 1.9 (5.3–6.4)
10–13 y	58	19.6 ± 3.4† (18.7–20.5)	6.4 ± 1.8 (5.9–6.9)	10.8 ± 2.9* (10.0–11.5)	76.6 ± 16.2 (72.4–80.9)	62.6 ± 12.4 (59.4–65.9)	4.9 ± 1.3 (4.6–5.2)
14–18 y	81	20.6 ± 3.8 (19.7–21.4)	6.7 ± 1.6 (6.3–7.1)	12.3 ± 2.9† (11.6–12.9)	78.9 ± 15.4 (75.4–82.3)	69.5 ± 15.5* (66.1–73.0)	4.7 ± 1.3 (4.4–5.0)
Total	325	16.5 ± 5.3 (16.0–17.1)	6.4 ± 1.9 (6.2–6.6)	9.3 ± 3.4 (8.9–9.7)	77.5 ± 16.7 (75.7–79.5)	63.2 ± 14.4 (61.7–64.9)	6.1 ± 2.4 (5.9–6.4)
Septal							
<1 y	63	8.1 ± 2.5 (7.5–8.7)	6.1 ± 1.5 (5.7–6.4)	5.4 ± 1.2 (5.1–5.7)	77.5 ± 17.5 (73.0–82.0)	53.0 ± 11.7 (50.0–56.0)	10.3 ± 2.7 (9.7–11.0)
1–5 y	68	11.8 ± 2.0† (11.3–12.3)	6.0 ± 1.3 (5.7–6.4)	7.1 ± 1.5† (6.8–7.5)	80.1 ± 15.5 (76.3–83.9)	59.8 ± 12.0 (56.9–62.7)	8.1 ± 1.8† (7.7–8.5)
6–9 y	55	13.4 ± 1.9† (12.8–13.9)	5.9 ± 1.3 (5.5–6.3)	8.0 ± 1.3 (7.6–8.4)	82.8 ± 15.3 (78.4–87.2)	65.6 ± 10.7 (62.5–68.7)	7.2 ± 1.6 (6.8–7.7)
10–13 y	58	14.5 ± 2.6 (13.8–15.2)	6.1 ± 2.3 (5.6–6.7)	8.2 ± 1.3 (7.9–8.5)	87.9 ± 16.4* (83.6–92.2)	72.5 ± 12.3 (69.3–75.8)	6.6 ± 1.4 (6.3–7.0)
14–18 y	81	14.9 ± 2.4 (14.3–15.4)	6.2 ± 1.5 (5.9–6.6)	9.0 ± 1.5 (8.7–9.3)	88.4 ± 15.6 (84.9–91.9)	77.5 ± 14.5 (74.3–80.8)	6.4 ± 1.5 (6.1–6.8)
Total	325	12.6 ± 3.4 (12.2–13.0)	6.1 ± 1.6 (5.9–6.3)	7.6 ± 1.9 (7.4–7.8)	83.5 ± 16.5 (81.7–85.4)	66.1 ± 15.3 (64.4–67.9)	7.7 ± 2.3 (7.5–8.0)
Tricuspid annular							
<1 y	63	13.8 ± 8.2 (11.7–15.9)	9.8 ± 2.4 (9.1–10.5)	10.2 ± 5.5 (8.8–11.7)	68.7 ± 18.2 (63.9–73.5)	52.0 ± 12.9 (48.5–55.4)	4.4 ± 2.3 (3.8–5.0)
1–5 y	68	17.1 ± 4.0† (16.1–18.1)	10.9 ± 2.7 (10.2–11.6)	13.2 ± 2.0† (12.7–13.7)	77.7 ± 15.0 (73.9–81.5)	59.0 ± 13.9 (55.4–62.5)	3.8 ± 1.1 (3.5–4.1)
6–9 y	55	16.5 ± 3.0 (15.7–17.4)	9.8 ± 2.7 (9.0–10.6)	13.4 ± 2.0 (12.8–14.0)	91.8 ± 21.5† (85.5–98.0)	58.5 ± 17.5 (53.4–63.6)	3.6 ± 0.8 (3.4–3.9)
10–13 y	58	16.5 ± 3.1 (15.7–17.4)	10.3 ± 3.4 (9.3–11.2)	13.9 ± 2.4 (13.2–14.5)	98.1 ± 21.7 (92.2–103.9)	61.7 ± 19.9 (56.4–67.1)	3.5 ± 1.4 (3.2–3.9)
14–18 y	81	16.7 ± 2.8 (16.0–17.3)	10.1 ± 2.6 (9.5–10.7)	14.2 ± 2.3 (13.7–14.7)	101.9 ± 20.4 (97.2–106.6)	62.9 ± 18.9 (58.5–67.3)	3.7 ± 1.0 (3.5–3.9)
Total	325	16.1 ± 4.7 (15.6–16.7)	10.2 ± 2.8 (9.9–10.5)	13.0 ± 3.4 (12.6–13.4)	88.2 ± 23.1 (85.6–90.8)	59.0 ± 17.2 (57.0–60.9)	3.8 ± 1.4 (3.6–4.0)

A, Late diastolic velocity; a′, late diastolic annular velocity; ICT, isovolumic contraction time; E, early diastolic inflow Doppler velocity; e′, early diastolic annular velocity; IRT, isovolumic relaxation time; S, systolic velocity; s′, systolic annular velocity.

*$p < 0.05$; †$p < 0.01$ compared with preceding age group.

Data expressed as mean ± SD (95% confidence interval). Doppler tissue imaging velocities are expressed in cm/s. Time intervals are expressed in milliseconds.

Source: Eidem et al. 2004 [36]. Reproduced with permission of Elsevier.

Table 8.5 Normal inflow Doppler values in infants and children

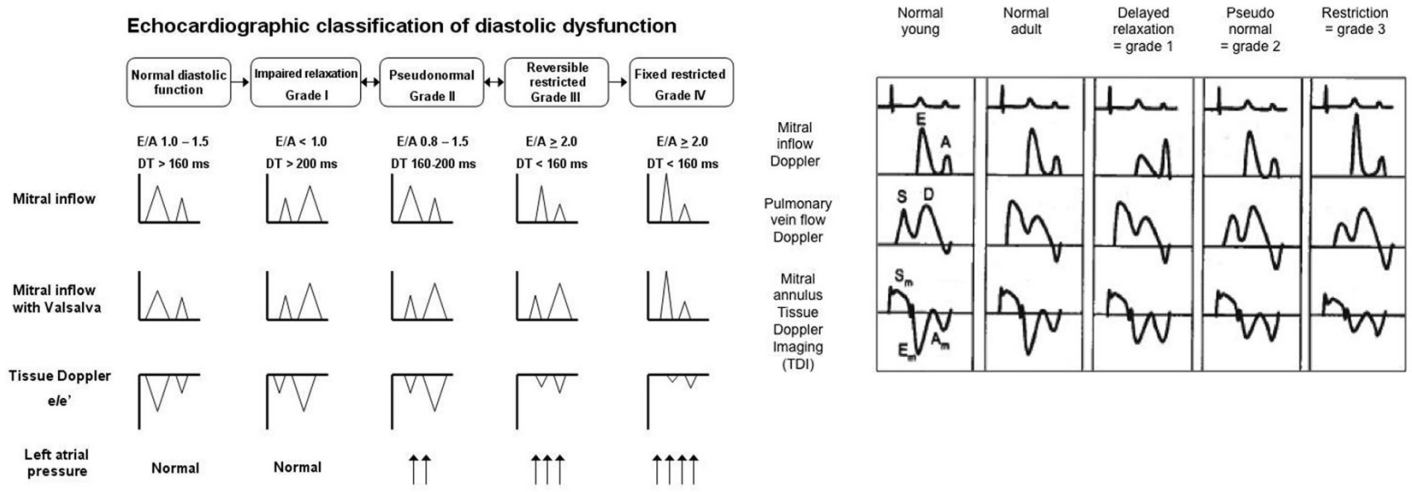
Demographics	<1 year	1–5 y	6–9 y	10–13 y	14–18 y	Total
N	63	68	55	58	81	325
Male	29	39	27	38	44	177
Age (y)	0.40 ± 0.30	3.05 ± 1.51†	7.91 ± 1.12†	11.99 ± 1.11†	16.0 ± 1.40†	78 ± 6.0
Weight (kg)	6.6 ± 2.7	15.1 ± 5.4†	33.8 ± 14.9†	47.2 ± 16.3†	66.1 ± 15.5†	33.3 ± 25.2
BSA (m^2)	0.34 ± 0.08	0.62 ± 0.14†	1.07 ± 0.27†	1.37 ± 0.29†	1.73 ± 0.25†	1.0 ± 0.6
HR (bpm)	124 ± 16	105 ± 17†	80 ± 11†	75 ± 12	69 ± 16	90 ± 26
Echocardiographic						
LV EDD (cm)	2.3 ± 0.3	3.1 ± 0.4†	3.9 ± 0.4†	4.3 ± 0.4†	4.7 ± 0.4†	3.6 ± 1.0
LV ESD (cm)	1.4 ± 0.2	1.9 ± 0.3†	2.4 ± 0.3†	2.7 ± 0.3†	3.0 ± 0.4†	2.3 ± 0.6
LV PWT (cm)	0.4 ± 0.1	0.6 ± 0.1†	0.7 ± 0.1*	0.8 ± 0.1*	0.9 ± 0.2	0.7 ± 0.2
LV SWT (cm)	0.5 ± 0.1	0.6 ± 0.1†	0.8 ± 0.1†	0.8 ± 0.2	1.0 ± 0.2†	0.7 ± 0.2
LV mass (g/m^2)	18.9 ± 6.5	43.6 ± 16.4†	82.3 ± 28.3†	110.1 ± 32.9†	158.4 ± 48.5†	81.8 ± 58.9
Mitral E velocity	79.7 ± 18.8	95.2 ± 19.5†	94.4 ± 14.8	94.5 ± 16.0	90.3 ± 17.8	90.8 ± 18.5
Mitral A velocity	65.3 ± 13.3	61.3 ± 12.1	49.4 ± 12.5†	49.5 ± 13.8	45.5 ± 13.2	54.4 ± 15.0
Mitral E/A ratio	1.24 ± 0.30	1.60 ± 0.46†	1.99 ± 0.51†	2.02 ± 0.58	2.13 ± 0.65	1.79 ± 0.61
PV S-wave velocity	44.6 ± 10.3	48.0 ± 8.9	50.7 ± 11.3	49.0 ± 11.1	47.7 ± 7.3	48.7 ± 9.2
PV D-wave velocity	46.0 ± 9.5	54.5 ± 11.0†	53.3 ± 11.4	58.4 ± 12.1	57.9 ± 15.0	54.6 ± 12.9
PV A-reversal velocity	16.4 ± 6.3	20.6 ± 4.3†	20.2 ± 3.8	21.2 ± 4.9	20.0 ± 5.2	20.5 ± 5.1
Tricuspid E velocity	53.3 ± 12.3	61.6 ± 12.5*	60.5 ± 13.9	59.6 ± 11.4	60.4 ± 10.9	59.2 ± 12.4
Tricuspid A velocity	53.2 ± 13.0	48.3 ± 12.3*	42.4 ± 10.8*	39.2 ± 11.3	34.5 ± 11.2*	43.3 ± 13.5
Tricuspid E/A ratio	1.01 ± 0.38	1.27 ± 0.31†	1.49 ± 0.40†	1.61 ± 0.47*	1.88 ± 0.56†	1.47 ± 0.53
SF (%)	38.9 ± 4.1	38.0 ± 3.6	37.4 ± 3.8	37.4 ± 4.2	36.4 ± 4.3	37.6 ± 4.1
LV MPI	0.33 ± 0.08	0.34 ± 0.07	0.32 ± 0.06	0.34 ± 0.06	0.34 ± 0.08	0.33 ± 0.08
RV MPI	0.29 ± 0.09	0.28 ± 0.07	0.29 ± 0.08	0.28 ± 0.08	0.29 ± 0.08	0.28 ± 0.08

A, atrial; BSA, body surface area; D, diastolic; E, early diastolic velocity; EDD, end-diastolic dimension; ESD, end-systolic dimension; HR, heart rate; LV, left ventricular; MPI, myocardial performance index; PV, pulmonary venous; PWT, posterior wall thickness; S, systolic; SF, shortening fraction; SWT, systolic wall thickness.
*$p < 0.05$, †$p < 0.01$ compared with preceding column.
Data expressed as mean ± SD.
Doppler velocities expressed as cm/s.
Source: Eidem et al. 2004 [36]. Reproduced with permission of Elsevier.

Table 8.4 Classification of left ventricular diastolic function

	Mitral inflow	Pulmonary venous flow	TDI septal
Normal	E/A 2.3 ± 0.6 109 ms ≤ DT ≤ 216 ms	S < D MVA_{dur} > PVA_{dur}	E/e′ < 10
Abnormal relaxation	E/A ≤ 1.0 DT age/HR dependent	S > D MVA_{dur} > PVA_{dur}	E/e′ < 10
Pseudo-normal	E/A similar to normal DT similar to normal	S < D MVA_{dur} < PVA_{dur}	E/e′ > 10
Restrictive physiology	E/A > 1.5 DT < 150 ms	S < D MVA_{dur} < PVA_{dur}	E/e′ > 10

A, mitral velocity at atrial contraction; D, pulmonary venous diastolic velocity; DT, mitral deceleration time; TDI, tissue Doppler imaging; E, mitral inflow E-wave velocity; e′, mitral early diastolic septal annular velocity; MVA_{dur}, duration of mitral A-wave velocity; PVA_{dur}, duration of pulmonary venous atrial reversal velocity; S, pulmonary venous systolic velocity.



	Normal	Grade I	Grade II	Grade III
LV relaxation	Normal	Impaired	Impaired	Impaired
LAP	Normal	Low or normal	Elevated	Elevated
Mitral E/A ratio	≥0.8	≤0.8	>0.8 to <2	>2
Average E/e′ ratio	<10	<10	10–14	>14

Determination of Diastolic Function Grade

	Normal	Mild (Grade 1)	Moderate (Grade 2)	Severe (Grade 3)	Severe (Grade 4)
PW-mitral inflow					
DT (ms)	160–240	>240	160–240	<160	<130
E/A	0.9–1.5	<0.9	0.9–1.5	>2.0	>2.5
Modifiers DTI					
e' (cm/s)	≥10	<10	<8	<5	<5
E/e' (septal)	1–14	≥15	≥15	≥20	≥25
LAVI (ml/m²)	22 ± 6	>28	>28	>35	>40
Valsalva	Negative	Positive	Positive	Positive	Negative
PVAR and mitral A duration	<30 ms	≥ or <30 ms (depending on LVEDP)	>30 ms	>30 ms	>30 ms
PV flow	PVs2 ≥ PVd (PVs2 can be < PVd in young persons)	PVs2 ≫ PVd	PVs2 < PVd	PVs2 ≪ PVd	PVs2 ≪ PVd
IRVT (ms)	70–90	>90	<90	<70	<70
Mitral inflow propagation					
Vp (cm/s)	≥50	<50	<50	<50	<50
E/Vp	≤1.5	>1.5	>1.5	>1.5	>1.5

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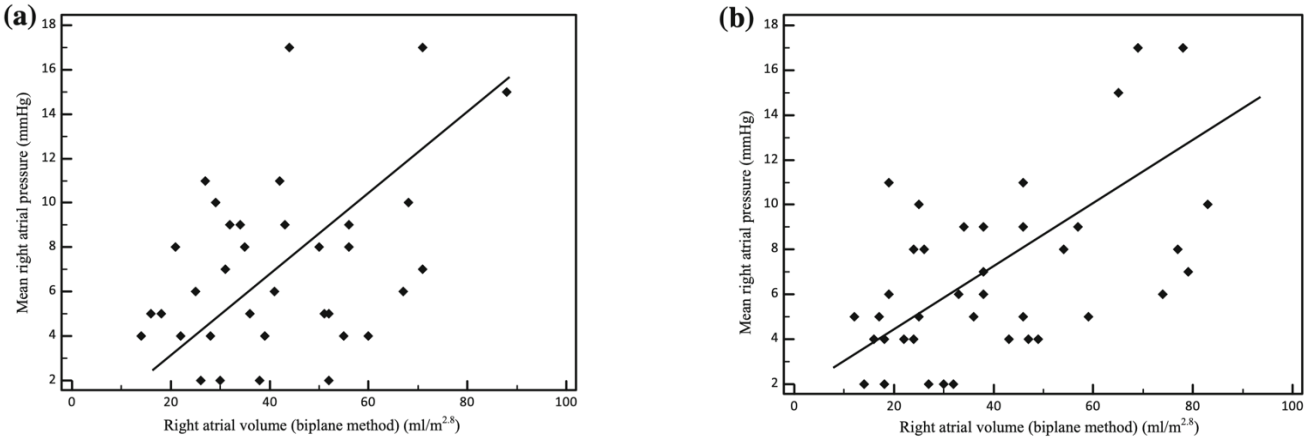
Right atrial pressure

- RAV was indexed to BSA$^{1.4}$
- RA area and length were measured at ventricular end-systole in 4-chamber and 2-chamber apical images.
- RAV was calculated by
  - 4-chamber area–length method: (0.85 x atrial area^2)/atrial length
  - Biplane method: (0.85 x 2-chamber atrial area x 4-chamber atrial area)/atrial length



Systolic Pulmonary artery pressure [sPAP]

Assuming no obstruction of RVOT: i.e. RVSP ~ sPAP

- With TR: sPAP ~ TR jet gradient [CW Doppler] + RAP
- With VSD: sPAP ~ LVSP (SBP) - VSD jet gradient [CW Doppler]
- With PDA:
  - SPAP=SBP – PDA jet gradient (for left to right shunts)
  - SPAP=SBP + PDA jet gradient (for right to left shunts)

Diastolic pulmonary artery pressure [dPAP]

- Obtaining from pulmonary regurgitation
- Pressure gradient from PA to RV: peak, end-diastole, CW
- End-diastolic PR gradient = dPAP – RVEDP
- Assuming RVEDP ~ RAP
- **dPAP = end-diastolic PR gradient + RAP**
- Using regression equation [Masuyama et al 1986]: **dPAP = [end-diastolic PR gradient + 2]/0.61**

Mean Pulmonary artery pressure [mPAP]

- Obtaining from pulmonary regurgitation
- Peak pressure gradient from PA to RV: **mPAP ~ peak PR gradient + RAP**
- Using regression equation [Masuyama et al 1986]: **mPAP = [peak PR gradient + 2]/0.70**

Pulmonary acceleration time-RV ejection time index

- PAAT/RVET (normal >0.3, neonate >0.25)