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## Introduction:

The morphology of the preterm heart shows a thinner walled left ventricle (LV) and a functionally hypertrophied right ventricle (RV). After birth, during the transition period, the LV output exceeds the RV output. The mitral annular plane systolic excursion (MAPSE), as an M-mode derived measure of longitudinal LV function, has been shown to be an important parameter of the global LV function in premature infants too. The MAPSE has been described to correlate well with LV ejection fraction (EF). Normal MAPSE values in healthy children have been published recently. To be able to fully assess changes in systolic LV function in patients with congenital heart defects in the neonate, sufficient quantitative reference data are required. We undertook a prospective study to determine normal values for MAPSE in correlation with gestational age (GA), and birth weight (BW) and to calculate normal z-score values.

## Methods:

The study group consisted of 261 newborns (132 male; 129 female) with a GA range from 26/0-6 weeks to 40/0-6 weeks, and a BW range from 670 g to 4140 g. Perinatal data as Apgar scores at 1 and 5 minutes, pH of the umbilical artery and mode of delivery were documented. MAPSE was measured using the standard M-Mode technique with the cursor placed at the lateral site of the annulus from the apical 4-chamber view. Measurements of long-axis excursion of the lateral mitral ring were obtained by determining the distance between the nadirs of the annulus motion profile corresponding to the maximal backward excursion of the mitral ring from the apex.

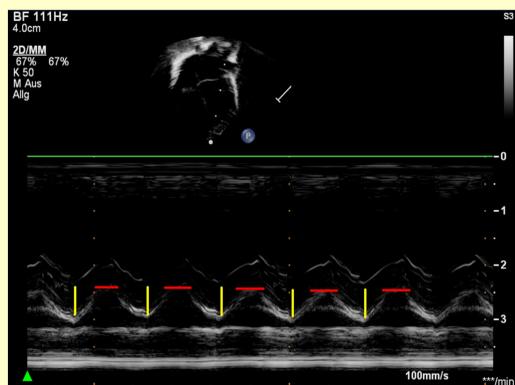


Figure 1: Apical 4-chamber view. Representative M-Mode image of the tricuspid annular plane systolic excursion (MAPSE) in a preterm infant (29/3 week of gestation) with normal RV and LV function. The absolute longitudinal displacement measure in centimeters (cm) is shown as the yellow line. The red line marks the upper measure point as the point of maximal upward excursion.

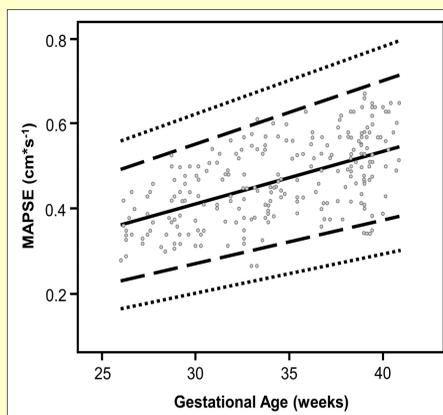


Figure 2: Gestational week versus observed mean value of tricuspid annular plane systolic excursion (MAPSE)  $\pm$  2 SD for GA versus MAPSE. The mean is indicated by the black solid line, the z-score  $\pm$  2 is indicated by the black broken lines.

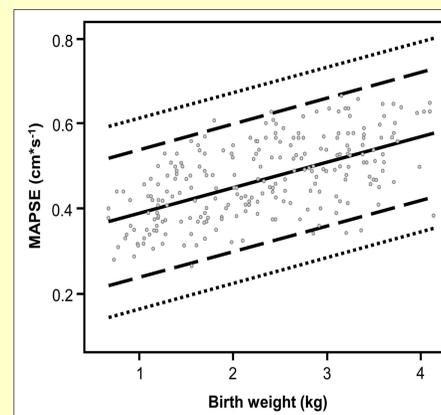


Figure 3: Birth weight versus observed mean value of MAPSE  $\pm$  2 standard deviation (SD) for birth weight versus MAPSE. The mean is indicated by the black solid line, the z-score  $\pm$  2 is indicated by the black broken lines.

GA (weeks)	n	Observed						Predicted					
		-3z	-2z	Mean	+2z	+3z	-3z	-2z	Mean	+2z	+3z		
26	11	0.21	0.26	0.36	0.46	0.51	0.17	0.23	0.36	0.49	0.56		
27	10	0.24	0.28	0.38	0.48	0.53	0.17	0.24	0.38	0.51	0.58		
28	12	0.17	0.25	0.4	0.55	0.62	0.18	0.25	0.39	0.52	0.59		
29	13	0.23	0.29	0.42	0.54	0.6	0.19	0.26	0.4	0.54	0.61		
30	14	0.18	0.26	0.42	0.58	0.66	0.2	0.27	0.41	0.55	0.62		
31	16	0.26	0.32	0.45	0.58	0.65	0.21	0.28	0.42	0.57	0.64		
32	15	0.19	0.27	0.43	0.59	0.67	0.22	0.29	0.44	0.58	0.66		
33	22	0.14	0.24	0.44	0.64	0.74	0.23	0.3	0.45	0.6	0.67		
34	23	0.3	0.36	0.48	0.6	0.66	0.24	0.31	0.46	0.61	0.69		
35	10	0.26	0.34	0.49	0.64	0.72	0.25	0.32	0.47	0.63	0.7		
36	17	0.25	0.33	0.48	0.63	0.71	0.26	0.33	0.49	0.64	0.72		
37	13	0.22	0.31	0.5	0.68	0.77	0.26	0.34	0.5	0.66	0.73		
38	32	0.35	0.41	0.53	0.65	0.71	0.27	0.35	0.51	0.67	0.75		
39	39	0.22	0.32	0.52	0.71	0.81	0.28	0.36	0.52	0.69	0.77		
40	15	0.31	0.4	0.56	0.73	0.81	0.29	0.37	0.54	0.7	0.78		

BW (kg)	n	Observed						Predicted					
		-3z	-2z	Mean	+2z	+3z	-3z	-2z	Mean	+2z	+3z		
0.8	10	0.2	0.26	0.37	0.48	0.54	0.15	0.23	0.38	0.53	0.6		
1	13	0.21	0.26	0.35	0.45	0.5	0.17	0.24	0.39	0.54	0.62		
1.2	25	0.23	0.29	0.4	0.51	0.57	0.18	0.25	0.4	0.55	0.63		
1.4	15	0.29	0.35	0.47	0.58	0.64	0.19	0.26	0.42	0.57	0.64		
1.6	20	0.13	0.23	0.42	0.62	0.72	0.2	0.28	0.43	0.58	0.65		
1.8	13	0.21	0.29	0.44	0.59	0.67	0.21	0.29	0.44	0.59	0.67		
2	15	0.23	0.3	0.44	0.59	0.66	0.22	0.3	0.45	0.6	0.68		
2.2	17	0.27	0.33	0.47	0.6	0.67	0.24	0.31	0.46	0.61	0.69		
2.4	22	0.25	0.33	0.5	0.66	0.74	0.25	0.32	0.48	0.63	0.7		
2.6	14	0.31	0.38	0.51	0.63	0.7	0.26	0.34	0.49	0.64	0.71		
2.8	15	0.25	0.33	0.49	0.62	0.72	0.27	0.35	0.51	0.66	0.73		
3	17	0.21	0.3	0.48	0.65	0.74	0.28	0.36	0.51	0.66	0.74		
3.2	24	0.26	0.35	0.53	0.71	0.8	0.3	0.37	0.52	0.67	0.75		
3.4	15	0.31	0.38	0.52	0.66	0.74	0.31	0.38	0.53	0.69	0.76		
3.6	13	0.33	0.4	0.53	0.67	0.74	0.32	0.4	0.55	0.7	0.77		
3.8	7	0.4	0.46	0.58	0.7	0.77	0.33	0.41	0.56	0.71	0.78		
4	6	0.25	0.36	0.57	0.78	0.89	0.35	0.42	0.57	0.72	0.8		

Table 1: Classification table for the MAPSE values. A.) For each GA the observed and predicted mean and  $\pm 2z$  and  $\pm 3z$  is presented. B.) For the BW the observed and predicted mean and  $\pm 2z$  and  $\pm 3z$  is presented.

## Results:

The MAPSE ranged from a mean of 0.36 cm (Range: 0.26 – 0.46 cm) in preterm neonates with a GA of 26/0-6 to 0.56 cm (Range: 0.40 – 0.73 cm) in neonates with a GA of 40/0-6 weeks. GA and BW related z-scores for the MAPSE are shown in Table 1.

A representative M-Mode image of the MAPSE (neonate with a GA 29/3 weeks) with normal RV and LV function is shown in Figure 1. The MAPSE values increased in a linear way from GA of 26/0-6 to GA of 40/0-6, as would be expected because of the larger cardiac size. To investigate a possible effect of nasal CPAP therapy on MAPSE values we determined the MAPSE in 10 preterm neonates (GA: 26/0-6 – 28/0-6) without the need for nasal CPAP support and in 12 GA-matched preterm neonates with nasal CPAP therapy. There was no significant difference in the MAPSE values between both groups. Graphs demonstrating the mean value plus or minus two and three z-scores for MAPSE versus GA and MAPSE versus BW are presented in Figure 2 and Figure 3, respectively.

## Discussion:

MAPSE values increase with GA and BW. Due to developmental changes it is accurate not to use a single value throughout the population but rather reference the MAPSE to both GA and to BW to best interpret the results. MAPSE values were lower in preterm neonates compared to term neonates in this study. If the markedly lower MAPSE in lower weeks of gestation is solely a marker of growth-related changes within the study population or if it is a sign of altered systolic function in lower GA neonates due to the immaturity of the LV musculature remains unclear. As expected our normal values for MAPSE in the 40/0-6 term neonates are similar to MAPSE normal reference values of infants available in the literature. In our current study no significant differences of MAPSE values were found between male and female neonates. We did not find significant differences in the MAPSE values between 10 preterm neonates (GA: 26/0-6 – 28/0-6) without the need for nasal CPAP support and in 12 GA-matched preterm neonates with CPAP therapy.

## Conclusion:

We have established normal reference values of MAPSE in preterm and term neonates with respect to GA and BW that could serve as a reference data base for preterm and term neonates with CHD and suspected LV dysfunction. The M-mode derived MAPSE is a non-invasive method for evaluation of LV function that is specially a useful parameter in non-cooperative and vulnerable infants where a prolonged examination may be inappropriate or when the endocardium is suboptimal for tracing. In our opinion the MAPSE should be included in neonatal echocardiography guidelines to allow neonatologists to assess the ventricular function in newborns in the future.