Longitudinal myocardial deformation in children after the Fontan operation: feasibility and impact of ventricular morphology in a multicenter setting

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funded by the dutch heart foundation

Background:

Assessment of single ventricle (SV) function in patients after the Fontan operation is clinically important. Controversy exists whether SV anatomy (right ventricular [RV] versus left ventricular [LV] morphology) influences SV function. Two-dimensional echocardiography is commonly used to assess SV function, but quantification is difficult due to differences in SV geometry compared to normal hearts. Myocardial deformation by speckle tracking echocardiography (STE) is less geometry dependent.

Study aims:

To assess feasibility of STE in patients after the Fontan operation and to investigate whether STE parameters differ between children with dominant RV and LV morphology.

Methods:

Cross-sectional, prospective, multicenter study. Apical SV echocardiographic views were acquired using General Electric (GE, Vivid 7) or Philips (iE33) platforms. STE peak longitudinal strain and systolic strain rate (SR) of the lateral wall of the dominant ventricle were measured using vendor dependent software (EchoPac and QLAB). Independent T test was used to compare groups. Reproducibility was expressed as bias (limits of agreement) and the coefficient of variation, COV (the standard deviation of the difference of paired samples divided by the average of the paired samples times 100).

Results:

- **Feasibility of global lateral longitudinal strain and systolic SR measurement for GE and Philips was 75% and 75% for the apical lateral segment, 84% and 78% for the mid lateral segment, 64% and 75% for the basal lateral segment and 77% and 78% for global lateral longitudinal strain respectively (P > 0,05 for all comparisons).**
- **Global lateral longitudinal strain was -19,1 ± 3,7% for GE and -18,2 ± 4,4% for Philips (p = 0,33) and global lateral longitudinal systolic SR was -1,13 ± 0,34 1/s. for GE and -1,15 ± 0,38 1/s. for Philips (p = 0,79).**

Table 1: general characteristics

	AI participants (n = 109)	Echo by GE (n = 77)	Echo by Philips (n = 32)	P-value GE v Philips
Gender male	66 (60,6%)	43 (55,8%)	23 (71,9%)	0,14
Age at study (years)	12,0 (9,7-14,6)	11,8 (9,7-14,3)	12,4 (9,6-15,5)	0,89
Age at TCPC (years)	3,1 (2,5-3,9)	3,3 (2,5-3,9)	2,9 (2,1-3,9)	0,22
BSA (m^2)	1,25 (1,10-1,53)	1,27 (1,09-1,53)	1,24 (1,11-1,51)	0,70
Resting HR (beats/min)	76 (65-89)	76 (68-88)	73 (63-91)	0,61
Resting SaO_2 (%)	95 (94-97)	96 (94-97)	95 (93-97)	0,22
SBP (mm Hg)	112 (105-118)	112 (104-118)	112 (106-118)	0,73
DBP (mm Hg)	66 ± 9	67 ± 9	65 ± 8	0,37
Dominant LV morphology	70 (64,2%)	55 (71,4%)	15 (46,9%)	0,03
Dominant RV morphology	39 (35,8%)	22 (28,6%)	17 (53,1%)	
Type of TCPC (ECC/ILT)	42/67	11/66	31/1	< 0,001

BSA = body surface area; DBP = diastolic blood pressure; HR = heart rate; ILT = intra-atrial lateral tunnel; LV = left ventricle; RV = right ventricle; SaO2 = oxygen saturation; SBP = systolic blood pressure.

Table 2: reproducibility myocardial deformation

	Global lateral longitudinal strain			Global lateral longitudinal SR		
	Bias (%)	Limits of agreement (%)	COV (%)	Bias (1/s.)	Limits of agreement (1/s.)	COV (%)
Intra observer GE	-0,65	-4,4 to 3,3	10,9	0,02	-0,11 to 0,16	6,0
Inter observer GE	0,63	-3.5 to 4.8	12,0	-0,03	-0,32 to 0,27	13,2
Intra observer PH	-0,53	-4,2 to 3,2	9,8	0,02	-0,33 to 0,36	14,6
Inter observer PH	-1,03	-5,5 to 3,4	12,3	-0,03	-0,39 to 0,33	14,7

COV = coefficient of variation; GE = general electric; PH = Philips; SR = strain rate

Table 3:Lateral longitudinal strain and systolic SR, depending on type of dominant ventricle (mean + SD)

	Longitudinal peak strain (%)			Longitudinal systolic SR (1/s.)		
	LV	RV	p-value	LV	RV	p-value
Apical-lateral	-19,3 ± 5,8	-17,2 ± 6,1	0,13	-1,15 ± 0,34	-1,00 ± 0,44	0,10
Mid-lateral	-20,9 ± 5,8	-17,6 ± 6,4	0,02	-1,18 ± 0,46	-1,07 ± 0,45	0,28
Basal-lateral	-19,6 ± 6,0	-18,6 ± 5,0	0,44	-1,26 ± 0,51	-1,10 ± 0,45	0,16
Global lateral	-19,5 ± 3,5	-17,7 ± 4,2	0,04	-1,20 ± 0,35	-1,04 ± 0,33	0,04

LV = left ventricle; RV = right ventricle; SR = strain rate

Conclusion:

- STE is challenging in patients after the Fontan operation, but feasibility and reproducibility are acceptable
- Results for longitudinal deformation are comparable between 2 vendors.
- Longitudinal deformation is slightly lower in children with dominant RV's compared to dominant LV's.

Funded by the Dutch Heart Foundation; grant 2008T037

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