ACCURACY OF TWO-DIMENSIONAL ECHOCARDIOGRAPHY FOR MEASURING RIGHT VENTRICULAR OUTFLOW TRACT IN TETRALOGY OF FALLOT

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Although echocardiographic methods have been quite accurate for identifying patients with tetralogy of Fallot, little experience has been reported with regards to the capabilities of echo techniques for estimating the severity of subvalvar RV outflow obstruction or the size of the RV outflow obstruction or the size of the RV outflow tract. We have reviewed 2D echoes in 21 tetralogy, patients, aged 1 day to 15 years, and compared systolic and diastolic echo measurements of the subvalvar RV outflow tract to those obtained by biplane cineangiography. Imaging of the subvalvar RV outflow tract in the tetralogy patients was achieved with 5 MHz mechanical sector scanners or dynamically focused phased arrays in a short axis (SA) or a subcostal SA view. Measurements from echocardiograms and angiograms were performed in blinded fashion and were later compared. Two-dimensional echo measurements of RV outflow tract size consistently underestimated angiographic determination by approximately 10%.

Underestimation of angiographic dimension was slightly greater in subcostal SA views than in parasternal SA views, but a larger area of the outflow tract was visualized in the subcostal view. Despite the consistent underestimation by 2D echo, agood correlation was achieved between two-dimensional echocardiographic RV outflow tract measurement in the SA view (R = 0.88, SEE = ± 0,29cm.) and.in subcostal SA view (R = +0,92, SEE = : ± 0,20cm) compared to angiography. Prospectively applied, these imaging techniques should be useful for patient management and for planning cardiac catheterization.

Tetralogy of Fallot is the most frequent cyanotic congenital heart malformation seen in children surviving the perinatal period [1]. A ventricular septal defect, aortic overriding, pulmonary infundibular obstruction and right ventricular hypertrophy compose the classical tetrad of this entity. The clinical presentation is variable in both neonates and infants[2], since presence and of degree of cyanosis is dependent on the severity of right ventricular outflow tract obstruction[3] which can be progressive[4].

Two-dimensional echocardiography is of great value in establishing the anatomic diagnosis of tetralogy of Fallot[5-12]. Further, Caldwell et al[5] reported good correlation between the dimension of the subvalvar right ventricular outflow tract on a parasternal short axis plane and lateral right ventriculograms. However, in our experience, problems of near field definition occur because in a parasternal short axis plane, the subvalvar and valvar structures are directly under the transducer at the narrow apex of the sector.

In this study, we evaluated the capability of wide angle two-dimensional echocardiography to assess the size of the subvalvar right ventricular outflow tract by comparing parasternal short axis and subcostal planes with right ventriculography.

METHODS

The sample consisted of 21 children age 1 day to 15 years (mean 4,5 ± 4,4 years) with the diagnosis of tetralogy of Fallot confirmed by cardiac catheterization and angiography.

Thirteen were studied preoperatively and 8 after complete repair. Four patients required a patch to reconstruct the right ventricular outflow tract, and 4 had only right ventricular infundibulectomy.

Eighteen patients were studied 1 day prior to cardiac catheterization and 3 on the same day. Two -

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dimensional echocardiograms were performed utilizing a 3.5 or 5 MHz digitaly scan converted mechanical sector scanner (E for M/Honeywell), a 3.5 or 5 MHz mechanical sector (SmithKline 5000), a 2.5 MHz electronically focused phased array device (Toshiba SSA IOA) with a specially damped pediatric transducer (PS 24A-2) or a prototype 3.5 MHz dynamically focused phased array instrument designed and built at the General Electric Research and Development Center.

All studies were recorded on videotape and played back in slow motion for frame-by-frame analysis. Stop frames were obtained at both end systole and end diastole in the parasternal short axis and subcostal views of the right ventricular outflow tract[13-15]. Manipulation of gain and antero-posterior rotation of the transducer was used to optimize visualization right ventricular outflow tract and pulmonic valve visualization, particularly in the parasternal approach.

In the parasternal short axis plane, right ventricular outflow tract measurements were taken as the distance between the inner edge of the anterior wall of the aorta and the right ventricular anterior wal at both end systole (minimal distance) and end diastole (maximus distance). In the subcostal plane, these measurements were taken between the inner edge of the lateral wall of the aorta and the inner edge of the right ventricular anterior wall (fig. 1).

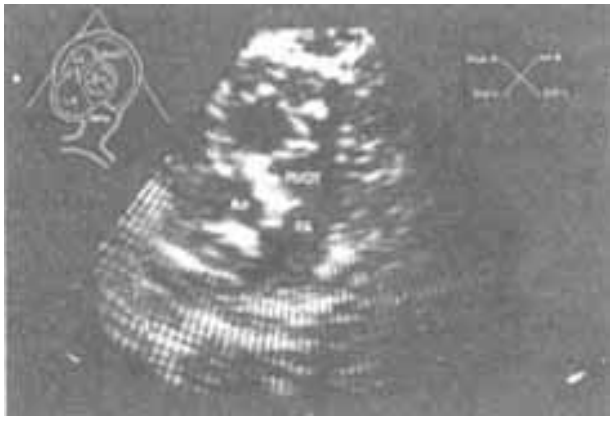

Fig. 1 - Subcostal short axis view in a patient with tetralogy of Fallot (preoperative group) showing the narrowed right ventricular outflow tract (RVCT). Ao = aorta, PA = pulmonary artery.

All patients underwent angiographic studied using standard techniques. Lateral projections were selected for right ventricular outflow tract measurements at end systole as the minimal dimension and end diastole as the maximal dimension. All measurements were done from inner edges of the contrast-filled outflow tract, just under the pulmonic valve. Catheter diameters were also measured to allow calculation of a correction factor for image magnification. Pressure pull backs were recorded with a fluid-filled catheter system on all patients at catheterization.

To determine repeatability, all measurements were performed in duplicate, at separate sittings, by one investigator. To test interobserver variability, all measurements were performed by two investigators who were unaware of each other's results.

Correlation coefficients were used to compare echochardiographic measurements to those obtained on angiography for all patients. Correlation coefficients were also calculated for preoperatory and postoperatory groups separately.

RESULTS

Adequate parasternal short axis two-dimensional echocardiograms were obtained in all 21 patients. Fourteen subcostal examinations were measurable. End systolic and end diastolic dimensions were obtained from all views recorded (table I).

End systolic dimensions ranged from 03 to 2.25 cm. (mean = 0.9 cm.; SD = ± 0.5 cm) in short axis, and from 03 to 2.0 cm (mean = 0.7 ± 0.6) in subcostal views. End diastolic dimensions ranged from 0.5 to 2.8 (mean = 13 ± 0.6) in short axis and from 0.5 to 2,8 (mean = 1.1 ± .6) in the subcostal views. Angiographic dimension correlated well with the parasternal short axis (R = .88, SEE = ± 29) as well as with the subcostal views (R = .92, SEE = ± .20) for both pre-and postoperative patients together. For the preoperative group alone, measurements derived from the subcostal view correlated better with angiographic measurements (R = 0.72, SEE = ± 0.23) than did those from the parasternal short axis plane (R = 0.46, SEE = ± 0.25). In the postoperative patients, correlation of the short axis measurements was good (R = 0.88), SEE = ± 027) but also improved significantly for the subcostal plane (R = 0.95, SEE= ± 0.19).

DISCUSSION

This study demonstrated that two-dimensional echocardiography provides a good method for visualization and quantification of the size of the subvalvar right ventricular outflow tract in patients with tetralogy of Fallot. Studies done by Caldwell demonstrated that with the parasternal short axis approach, good quantitative accuracy of right ventricular outflow tract dimension can be expected when compared with those derived from the lateral right ventriculograms. However, in our study, the subcostal approach proved to be superior to the parasternal in both pre-and postoperative patients, as well as in the combined group probably because, in the parasternal view, the right ventricular outflow tract structures are in close proximity to the chest wall and, consequently, to the narrow apex of the transducer within the area of most transducer artifacts. Cross-sectional echocardiography appears to be more effective when the transducer is placed in the subcostal plane, in a "down the barrel" view where the structures being imaged fall within the focal zone of most systems.

The better correlation in postoperative patients (fig. 2) is probably because the right ventricular

TABELA I - Tetralogy of Fallot patient data.

PT=	AGE	Parasternal systolic	RVOT (CM) systolic	Subc RVOT (CM) systolic	Diastolic	Angio (CM) systolic	Diastolic	Operative status	RVOT gradient (MM HG)
1	9 mos	.65	1.0			.4	.8	Pre	90
2	3 yrs	2.25	2.5	2.0	2.2	2.4	2.8	Post	50
3	4 yrs	.60	1.2	.3	1 0	.4	.8	Pre	88
4	2 yrs	.90	1.2			.5	0 8	Pre	80
5	2 yrs	.80	1.25			.4	1.0	Pre	40
6	7 mos	.65	1.0	.9	1.4	1.0	1.6	Pre	20
7	8 yrs	1.05	1.5			.92	1 3	Post	20
8	7 yrs	.45	.85	.3		.4	.8	Pre	90
9	15 yrs	1.0	1.5			1.4	1.8	Post	24
10	4 yrs	1.0	1.5		1.1	.8	1.2	Post	0
11	6 mos	.4	.6	3	5	.3	.6	Pre	120
12	6 yrs	2.0	2 5			2.3	2.8	Post	35
13	8 yrs	.5	.8	.4	.7	.7	1.1	Pre	100
14	1 day	.3	.5	.3	.5	.4	.6	Pre	70
15	1.3 yrs	.4	.8	.4	.8	.8	1.2	Pre	100
16	3 yrs	.8	1.0	.5	1.0	.3	.5	Pre	99
17	5 yrs	.11	1.5			1.0	1.6	Post	15
18	6 mos	.8	1.5	.8	1.3	.6	.9	Pre	70
19	6 yrs	1.5	2.2	1.0	1.5	1.1	1.5	Post	13
20	15 yrs	1.6	2.8	2.0 0	2.8	2.1	2.7	Post	0
21	2 mos	.5	.8	.4	.7	.3	.6	Pre	84

Pt - patietns; RVOT - right ventricular outflow tract; Pre - preoperative; Post - postoperative; Subc - subcostal; Angio - angiography.

outflow tract dimension was larger and easier to measure than in the preoperative group, where technician difficulties occasionally precluded accurate measurement of very small structures in both echocardiograms and angiograms. Technical difficulties were also found in some patients while attempting to image from the subcostal plane. These were mostly abdominal discomfort and consequent failure of patient cooperation.

Despite the limitations, our study confirms that two-dimensional echocardiography provides two alternative sites to accurately measure the degree of subvalvar right ventricular outflow tract obstruction in patients with tetralogy of Fallot.

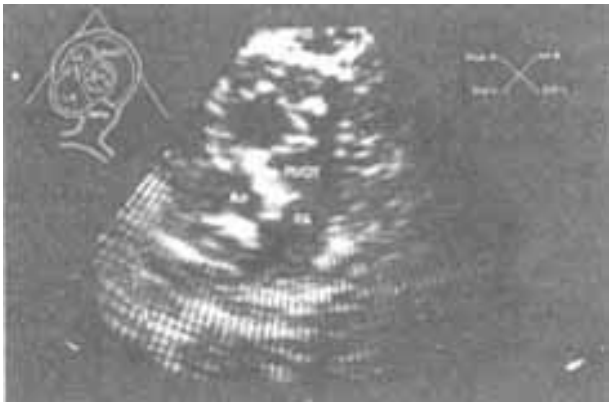

Fig. 2 - Parasternal short axis view in a patient with tetralogy of Fallot (postoperative group) showing the surgically enlarged right ventricular outflow tract (RV A = aorta, RV = right ventricle).

RESUMO

As medidas ecocardiográficas do trato de saída do ventrículo direito de 21 pacientes com tetralogia de Fallot, com idades entre 1 dia e 15 anos, realizadas em fim de sístole e diástole foram comparadas com as medidas correspondentes obtidas pela angiografia biplana,

As medidas ecocardiográficas subestimaram as angiográficas em aproximadamente 10%. Houve melhor correlação entre as dimensões ecocardiográficas e angiográficas nos pacientes submetidos à correção cirúrgica, provavelmente em virtude das maiores dimensões da via de saída do ventrículo direito e, conseqüentemente, melhor resolução e maior facilidade na realização das medidas nesse grupo de pacientes.

Aplicada de maneira prospectiva a ecocardiografia bidimensional pode ser de utilidade no manuseio clínico desses pacientes, bem como no planejamento do momento oportuno para realização do cateterismo cardíaco.

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