นิพนธ์ต้นฉบับ

Estimation of pulmonary artery pressure by Doppler echocardiography*

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Mean pulmonary artery pressures were estimated by continuous wave (CW) Doppler echocardiography and compared with those obtained from cardiac catheterization in 13 patients with congenital heart diseases. The acceleration time (AT)/ ejection time (ET) ration correlated with the mean pulmonary artery pressure; the regresssion equation is: mean PA pressure = 107.25 − 219.31 × AT/ET. The correlation coefficient (r) is − 0.75689 (p = 0.003). Estimation of pulmonary artery pressure by Doppler echocardiography is a non-invasive technique with acceptable accuracy. Use of this technique enable the avoidance of cardiac catheterization, which is an invasive procedure.

Key words: *Pulmonary artery pressure, Doppler Echocardiography*

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พีรวัฒน์ ลีประดิษฐวรรณ, วิโรจน์ สืบหลินวงศ์, จุล ทิสยากร, โชติมา ปัทมานันท์, ไพโรจน์ โชติวิทยาธารากร, พรเทพ เลิศทรัพย์เจริญ, ปรีชา เลาหคุณากร, สุนทร ม่วงมิ่งสุข. การใช้ ด๊อพเลอร์ เอคโอคาร์ดิโอกราฟฟี่ เพื่อประมาณค่าความดันของเส้นเลือดแดงสู่ปอด (pulmonary artery pressure) จุฬาลงกรณ์เวชสาร 2536 มกราคม; 37 (1): 7-12

Continuous Wave (CW) Doppler echocardiography เพื่อประมาณค่าเฉลี่ยของความดันของเส้นเลือดในปอดเปรียบเทียบกับการสวนหัวใจในผู้ป่วยเด็กที่เป็นโรคหัวใจพิการแต่กำเนิด 13 ราย ได้ความสัมพันธ์เชิงเส้นระหว่างค่า acceleration time (AT)/ ejection time (ET) ของ pulmonary blood flow กับค่าเฉลี่ยของความดันของเส้นเลือดในปอด โดยได้ความสัมพันธ์ : mean PA pressure = 107.25 − 219.31 × AT/ET โดยค่า correlation coefficient (r) = −0.75689 (p = 0.003) การใช้ Doppler echocardiography ในการประมาณค่าความดันของเส้นเลือดในปอดเป็น non-invasive technique ที่สามารถประมาณได้ถูกต้องพอสมควรโดยไม่ต้องสวนหัวใจ ซึ่งเป็นการตรวจที่ผู้ป่วยจะต้องเจ็บตัว

There have been several studies estimating pulmonary arterial (PA) pressures by Doppler echocardiography compared with PA pressures obtained from cardiac catheterization. M-mode echocardiography has been used for evaluating pulmonary hypertension by abnormal motion of the pulmonary valve, including a small or absent "a" dip,[1-3] decreased or negative diastolic slope, rapid opening velocity,[1,2] partial closure of the valve in mid-systole[1-3] and prolongation of the ratio of the right ventricular pre-ejection period (RPEP) to right ventricular ejection time (RVET).[2,4,5]

Later Doppler echocardiography was used to estimate PA pressures.[6-12] Kitabatake[8] and Kosturakis[9] found that the acceleration time of right ventricular (RV) ejection flow or acceleration time/RV ejection time correlated well with PA pressure. However, their results differ in several respects. Kosturakis[9] suggested that the best correlation was between acceleration time and systolic PA pressure, whereas Kitabatake[8] reported that acceleration time/RV ejection time correlated well with the logarithm of PA mean pressure. In addition, PA pressure could be estimated by the use of the maximum tricuspid regurgitant flow velocity.[12]

The purpose of this study is to compare the PA pressures obtained from continuous Doppler estimation with those from direct measurements during cardiac catheterization.

Materials and methods

Patients : Thirteen patients with congenital heart diseases (3 males and 10 females) admitted to the Department of Pediatrics, Chulalongkorn Hospital from July 1991 to June 1992, for echocardiography and cardiac catheterization were included in the study. Their ages ranged from 3 to 15 years (mean 8.4 + 3.7 years (standard deviation)). The categories of cases were as follows: secundum atrial septal defect (ASD) six cases, ventricular septal defect (VSD) four cases, secundum ASD and VSD one case, both primum and secundum ASD one case, and single ventricle with normal related great arteries one case.

Continuous Doppler technique : Continuous wave Doppler examinations were performed with Aloka SSD 860. A 3.5 MHz sector scanner was used to identify the main PA in the parasternal long axis view (right ventricular out flow tract). Acceleration time of pulmonary blood flow (AT) – the time to peak flow velocity from Doppler tracings and ejection time (ET) – and the time between the origin and the end of pulmonary blood flow were obtained five times (Figure 1). The data were then averaged. In all cases, the Doppler angle between the ultrasound beam and the long axis of blood flow was within 20 degrees. When the Doppler angle was less than 20 degrees, the error introduced into the peak blood flow velocity measurement was less than 6 per cent of the peak blood flow velocity.[13-14] Echocardiography was performed on all patients within three days of cardiac catheterization. During this period, there was no change of drug therapy that could alter the hemodynamics of the patients.

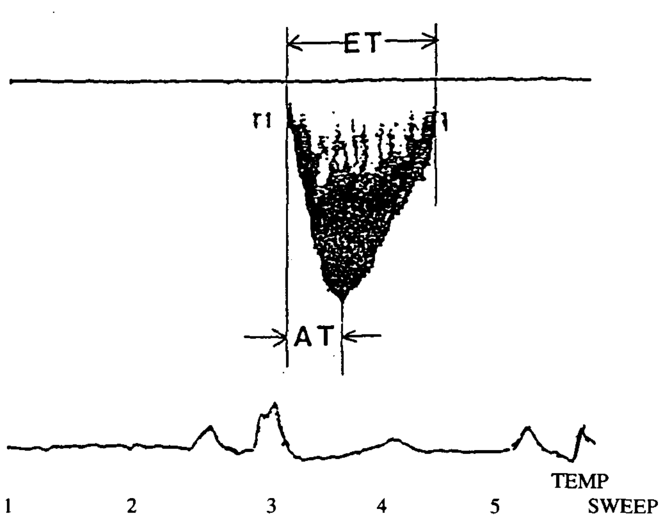

Figure 1. Continuous wave (CW) Doppler signal Showed pulmonary blood flow. Acceleration time (AT) and ejection time (ET) of pulmonary blood flow were measured in the manner shown in this figure.

Cardiac catheterizations : Diagnostic right-sided cardiac catheterization was performed in the catheterization laboratory using a Shimadzu C-arm stand (MH 10). All intracardiac and pulmonary arterial pressures were measured with fluid-filled catheters (NIH catheter No.6 or 7, 80 or 100 centimeters) and pressure transducers. Mean pulmonary artery pressures were recorded in mm Hg. All of the patients were in sinus rhythm.

Statistical analysis : Simple linear regression analysis was used to assess the correlation between AT/ET and mean PA pressure.

Results

Table 1. Detailed data of each patient.

Diagnosis	Sex	Age (years)	MPAP (mmHg)	AT (sec)	ET (sec)	AT/ET
ASD 1, ASD 2	F	7	19	0.107	0.310	0.345
ASD 2	F	9	25	0.120	0.310	0.387
ASD 2	F	11	18	0.120	0.330	0.364
ASD 2	F	11	68	0.060	0.250	0.240
ASD 2	F	9	57	0.060	0.280	0.214
SV	F	4	54	0.080	0.240	0.333
VSD	M	3	40	0.110	0.340	0.324
VSD	F	7	54	0.080	0.300	0.267
VSD	M	5	52	0.060	0.236	0.254
ASD 2, VSD	F	4	60	0.063	0.257	0.245
ASD 2	F	11	26	0.127	0.323	0.393
VSD	M	14	20	0.130	0.340	0.382
ASD 2	F	15	22	0.093	0.261	0.261
Mean		**8.4**	**39.62**	**0.093**	**0.297**	**0.308**
S.D.		**3.7**	**17.71**	**0.026**	**0.039**	**0.061**

Abbreviations: ASD 1 = primum atrial septal defect; ASD 2 = secundum atrial septal defect; SV = single ventricle; VSD = ventricular septal defect; F = female; M = male; MPAP = mean pulmonary artery pressure; AT = acceleration time; ET = ejection time; S.D. = standard deviation.

Correlation was made between AT/ET and mean PA pressure using linear regression (Figure 2). The correlation coefficient (r) is -0.75689 ($p = 0.003$). The standard error of the estimate (S.E.E.) is 12.582 mmHg. The regression equation is: mean PA pressure = 107.25-219.31xAT/ET.

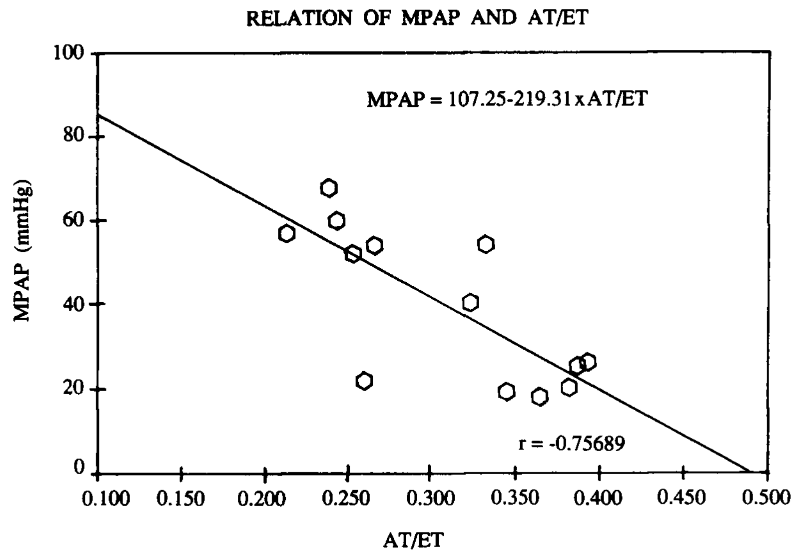

Figure 2. Correlation and linear regression analysis of mean pulmonary artery pressure (MPAP) and acceleration time (AT)/ ejection time (ET) ratio. The regression equation is: MPAP = $107.25 - 219.31 \times AT/ET$. The correlation coefficient (r) is -0.75689 (0 = 0.003). The standard error of the estimate (S.E.E.) is 12.582 mmHg.

The correlation between AT/ET and the logarithm of mean PA pressure was decreased ($r = -0.73232$).

Discussion

The purpose of this study was to estimate PA pressures by continuous wave Doppler echocardiography and try to compare the values obtained to those from direct measurement by cardiac catheterization. In all of the patients studied, no one demonstrated flow velocity pattern with mid-systolic notching which indicated pulmonary hypertension.[15]

In this study, patients with pulmonic stenosis were excluded because of prolongation of ejection time leading to the change of AT/ET ratio. Those with d-transposition of the great arteries (d-TGA) were excluded because right and left ventricular activation time were not the same.

There was a negative linear regression correlation between AT/ET and mean PA pressure. Therefore when the value of AT/ET decreased, the value of mean PA pressure increased.

Quantitative evaluation of the severity of pulmonary hypertension by CW Doppler technique has potential advantages. It can be used to perform repeated examinations without any side effects; it can also be used to follow stages in the development of pulmonary hypertension complicating certain disease processes and to evaluate the effects of therapeutic agents in addition to determine the correct timing for corrective surgery. Post-operative PA pressures can also be followed conveniently.

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