Evaluation of physical parameters in mitral valve stenosis by using Doppler Ultrasound

Numan Salman dawood MSc*
Mayadah Hassen Rhaf MSc**

Abstract:

Background: Mitral valve stenosis is a condition in which the hearts mitral valve is narrowed (stenosis), This narrowing blocks the valve from opening properly obstructing blood flow through the heart and the rest of the body and this causes changes in physical parameters (resistance and conductance).

Aim of the study: To assess the changes in the physical parameters in mitral valve stenosis disease in different gender and age by using Doppler ultrasound.

Methods : The examination of patients at the Division of Echo - at the Iraqi Center for Heart Disease in Medical City for surgery specialist - Baghdad - Iraq, during(February2009 till November2010). The current study included fifty eight cases containing (27 males and 31 females) ages ranging between (16- 82) and is divided between 29 people from healthy people (I) which contain (13 males and 16 females) ages ranging between (16- 82) and a standard deviation of 22.6. Twenty nine of patients with mitral valve stenosis were divided into group (II) contains (6 males and 8 females) ages ranging between (28-76) and the standard deviation of 17.8, group (III) contains (5 males and 4 females) ages ranging between (40-71) and the standard deviation of 16.1 and group (IV) contain (3 male and 3 female) ages ranging between (56-72) and the standard deviation of 17.9. Studying changes developments in physical factors resulting from mitral valve stenosis and depending on these factors were calculated to change the resistance and conductivity and studying the relationship of the change in area and the change of physical factors.

Results: The flow rate and area of mitral valve was significantly less in group IV than other groups, but pressure gradient, max velocity, pressure half time, max pressure were higher and more significantly in group IV. Resistance is significantly increases and it is higher in group IV compared with other groups. Conductance is higher in group I but more significant in group II.

Conclusion: There is a strong correlation between the pressure half time and area of mitral valve. Resistance was significantly increased and it is higher in sever mitral stenosis. Conductance is high in mild mitral stenosis. The increase in mitral pressure gradient is frequently compensated by a decreased conductance. Age was highly influential but sex exerts less influence to change the physical parameters.

Key word: Mitral valve stenosis, Area, Resistance, Conductance, Doppler US.

Introduction

Mitral stenosis (MS) refers to narrowing of the mitral valve orifice, resulting in impedance of filling of the left ventricle in diastole. It is usually caused by rheumatic heart disease. Less common causes include severe calcification of the mitral annulus, infective endocarditis, systemic lupus erythematosus, rheumatoid arthritis, and carcinoid heart disease [1]

In patients with mitral stenosis, an early, mid and late diastolic transvalvular gradient is present between the left atrium and ventricle and as the degree of mitral stenosis worsens a progressively higher gradient especially late in diastole occurs[2,3,4]. In case of mitral stenosis, the valve dose not open completely, and to transport the same amount of the blood the left atrium needs a higher pressure than normal to overcome the increased gradient[5].

Pressure half time is defined as the time interval in millisecond between the maximum mitral gradient in early diastole and the time point where the gradient is half the maximum initial value. [6]

By echocardiography, this is measured in apical-4- chambers view with continuous wave doppler aligned with the inflow jet of mitral valve. The spectral trace is recorded and the slope of the flow is measured from the beginning of E-wave ignoring the A-wave [7].

Mitral valve resistance is defined as the ratio of mean mitral gradient to transmitral diastolic flow rate, mitral valve resistance is an alternative measurement of the severity of mitral stenosis, which has been argued to be less dependent on flow condition. Mitral valve resistance correlates well with pulmonary artery pressure, however, it has not been shown to have an additional value for assessing the severity of mitral stenosis as compared with valve area.[8] In patients with mitral stenosis, heart failure results predominantly from resistance to left ventricular filling associated with a diastolic gradient across the mitral valve [9, 10].

Conductance is a measure of the blood flow through a vessel for a given pressure difference It is immediately evident that conductance is the reciprocal of resistance. The change of diameter cause tremendous changes in its ability to blood conductance. The conductance of the vessel increases in proportion to the fourth power of the diameter. [11].

Subjects and Methods

In this study patients with mitral valve stenosis were chosen. This study was conducted at the Iraqi Center for Heart Disease in the specialized Surgical Hospital-Medical city during (February2009 till November2010).

A total of 58 subjects were enrolled in the study including 27 males and 31 females, with ages ranging from (16-82) years, weight (60-72) Kg and height (168-175) cm, the subjects were divided into four groups: Group I (n=29) healthy subjects. Group II (n=14) mild mitral stenosis patients. Group III (n=9) moderate mitral stenosis patients and group IV (n=6) sever mitral stenosis patients.

All subjects underwent a complete echo cardiograph examination using VOLUSON 530 A with 2.5 or 3.5 MHZ transducer m-mode two dimensional and Doppler echocardiography examination were under taken.

The mitral annular area, pressure gradient (PG), flow rate, velocity max ($V_{MAX)}$, pressure half time ($P_{1/2}$) is obtained by tracing the deceleration slop of the E- wave on Doppler spectral display of transmitral flow and valve area is automatically calculated by the integrated software of currently used echo machines and pressure max were measured at end-diastolic . All these measurements were using to calculate resistance by (pressure (mmHg) / flow rate (ml sec^{-1})) and conductance (flow rate (ml sec^{-1}) / pressure (mmHg))[11]

Statistical analysis

All statistical test were achieved by using "Microsoft Excel 2003" statistical package which runs under Windows system erasing data were expressed as mean ± SD and the correlation was calculated used to look for correlations between variables. Differences in group means were analyzed using the 2- tailed unpaired – test, P- value < 0.05 was considered significant.

Results

The characteristics of the four groups are shown in table 1. The mean value ± SD of age (49.6 years ± 22.5) in healthy subjects was less than the other groups. The mean value ± SD of weight and height (65.5 Kg ± 20.5 and 155cm ± 5.05) of group IV was less than other groups. There was no significant difference between the four groups regarding age, weight and height.

The percentages of four study groups are (50%, 24%, 15%, 11% respectively). Figure 1 shows these Percentage according to the total numbers.

Table 1: Characteristics of subjects enrolled in this study

Characteristics	Group I (n=29)	Group II (n=14)	Group III (n=9)	Group IV (n=6)
Gender				
Male	13	6	5	3
Female	16	8	4	3
Age(years)				
Male	50.9 ± 22	55 ± 13.6	55. 2± 12.6	62 ± 6
Female	53.3 ± 20.9	51.9 ±17.9	60.5±10.4	66 ± 6
Total	49.6 ± 22.5	51 ±17.8	54 ±16	58 ± 17.9
weight (Kg)				
Male	73.8 ±13.9	71 ± 5.7	72 ±5.8	70.3 ±5.5
Female	71.9 ± 8.4	73.3 ±7.4	71 ±11.2	74.3 ± 6.8
Total	68.5 ± 19.4	69.2 ±16.4	67±18.9	65.5 ± 20.5
Height (cm)				
Male	170 ± 0.08	169 ± 0.06	170 ± 5.9	170 ± 3.6
Female	172 ± 0.06	171 ± 0.07	170 ± 4.4	107 ± 5
Total	163 ± 0.3	162 ± 0.4	160 ± 44.5	155 ± 5.05

The result are expressed as (mean ±SD)

The mean value ± SD of flow rate and area in group I (93.4ml sec^{-1} ± 27.9, 4.2cm2 ± 1.0 respectively) were higher but they were more significant in group IV (P=0.00012, 4.9 x10 $^{-14}$) compared with other three groups. The mean value ±SD of PG, Vmax, P1/2 time, Pmax, were highly significant in group IV compared with group I, II, III (table 2). There were a higher significant negative correlation value (P < 0.001) of Vmax, PG, and resistance with area in four study groups (Fig 2,3,4).

Table 3 illustrates the change of physical parameters which are calculated as shown in "Subjects method".

The mean value ±SD of resistance (0.12mmHg*sec/ml ±0.03) was significantly increased and it is higher in group IV compared with other groups .Conductance is behavior at the opposite contrast with the resistance and it is high in group I (19.1 mmHg *ml $^{sec-1}$ ± 5.2, 2.2 ml /mmHg ±0.9 respectively), but they were more significant in group II ($7x10^{-8}$, $1.14x10^{-7}$) than other groups.

Table 2: The measured parameters of the various groups recruited in the current study.

Mean ± SD	**Group I (n=29)**	**GroupII (n=14)**	**Group III (n=9)**	**Group IV (n=6)**
PG(mmHg)				
Male	3..5±1.1	7.2±0.5	8.9±0.6	11.4±0.42
Female	3.9±1.09	7.3±0.6	8.3±2.3	11.5±0.64
Total	3.62±1.3	6.9±1.6	8.9±0.4	10.4±3.3
Flow rate (ml sec^{-1})				
Male	100±16.2	90.9±12.8	81.5±10.9	70.9±18.3
Female	102±10.2	91±12.4	81.2±10.1	67.4±17.7
Total	93.4±27.9	85.1±23.8	77.8±19.2	65.1±22.6
Vmax ($cmsec^{-1}$)				
Male	0.9±17.9	1.5±0.08	1.88±0.56	2.4±0.11
Femal	0.8±0.5	1.5±0.1	1.9±0.08	2.3±0.06
Total	0.8±0.2	1.4±0.3	1.75±0.5	2.2±0.7
$P_{1/2}$time msec				
Male	48.9±6.3	85.1±15.3	171.2±19.3	269±17.4
Femal	58.2±16.5	87.4±15.7	178.3±10	275±15.6
Total	52.1±17.4	82.9±22	162±43.9	247±77.6
Pmax (mmHg)				
Male	0.64±0.12	1.06±0.06	1.3±0.04	1.7±0.7
Femal	0.68±0.09	1.08±0.08	1.3±0.06	1.64±0.04
Total	0.65±0.14	1.02±0.2	1.2±0.3	1.5±0.4
Area (cm^2)				
Male	4.5±0.6	3.0±0.3	1.47±0.23	0.8±0.08
Femal	4.04±1.02	2.8±0.3	1.5±0.2	0.7±0.06
Total	4.2±1.0	2.7±0.6	1.4±0.4	0.7±0.2

The results are expressed as mean ±SD, probability values are compared with group I,
PG= (pressure gradient, P1/2=(pressure half time), Vmax=(maximum velocity), Pmax=(maximum pressure).

Table 3 : The calculated parameters of left atrium to the various groups recruited in the current study**.**

Mean ±SD	**Group I (n=29)**	**Group II (n=14)**	**Group III (n=9)**	**Group IV (n=6)**
Resistance (mmHg . $sec.ml^{-1}$				
Male	0.04±0.007	0.09±0.01	0.09±0.01	0.12±0.02
Female	0.06±0.02	0.09±0.01	0.09±0.01	0.11±0.01
Total	0.05±0.01	0.08±0.02	0.09±0.26	0.12±0.03
Conductance (mmHg . $ml.sec^{-1}$				
Male	20.9±3.4	11.3±2.1	10.2±1.26	8.8±1.5
Female	17.9±4.7	11.1±1.3	10.3±1.7	8.9±1.4
Total	19.1±5.2	10.7±2.8	9.6±2.7	8.2±2.5

The results are expressed as mean ± SD, probability value are compared with group I

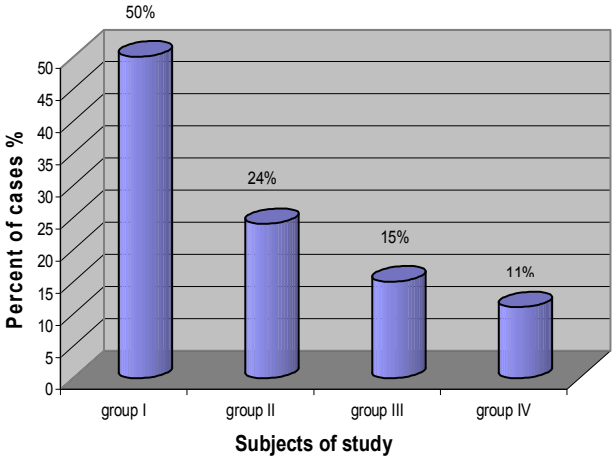

Figure 1: Frequency distribution in four study groups

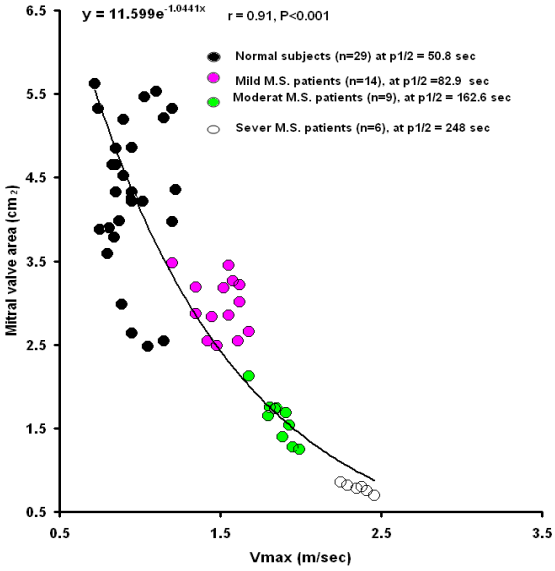

Figure 2 : Correlation between mitral valve area and Vmax in normal subjects (n = 29) and patients with mild (n = 14), moderate (n =9), and sever (n =6) MS.

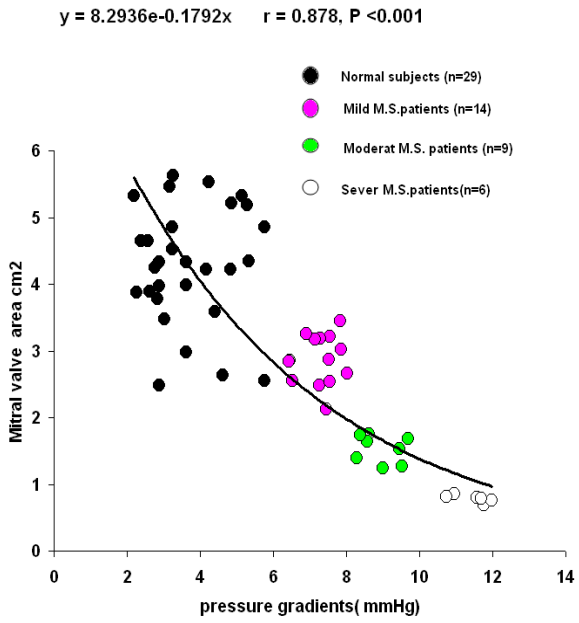

Figure 3 : Correlation between mitral valve area and pressure gradients in normal subjects (n = 29) and patients with mild (n = 14), moderate (n =9), and sever (n =6) MS

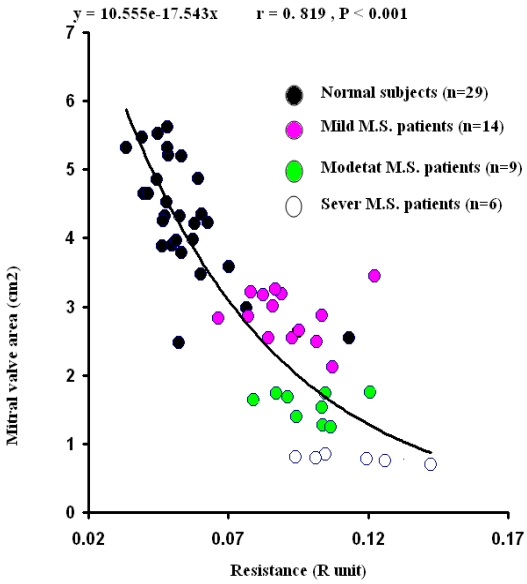

Figure 4. : Correlation between mitral valve area and resistance in normal subjects (n = 29) and patients with mild (n = 14), moderate (n =9), and sever (n =6) MS.

Discussion:

The current study shows that the mitral valve area is one of the best parameters for the evaluation of mitral stenosis is commonly calculated by echo-Doppler [12] .The normal area of the mitral valve orifice is about 3 to 6 cm^2 and under this condition a normal mitral valve will not impede the flow of blood from the left atrium to the left ventricle during (ventricular) diastole, and the pressure in the left atrium and the left ventricle during ventricular diastole will be equal. The result is that the left ventricle gets filled with blood during early ventricular diastole.

With only a small portion of extra blood contributed by contraction of the left atrium during late ventricular diastole. The pressure half time remains relatively constant for given valve area and over a large variation in flow [13]. When the mitral valve area goes below 2 cm^2, the valve causes an impediment to the flow of blood into the left

ventricle, creating a highly pressure gradient across the mitral valve (required to push blood through the stenotic valve) about (6-11mmHg) [14]. In group IV the pressure will increase when the mitral valve area goes less than 1 cm^2.

Since the normal left ventricular diastolic pressures is about 6mmHg, a pressure gradient across the mitral valve of 11 mmHg due to sever mitral stenosis will cause a left atrial pressure of about 20 mmHg due to sever mitral stenosis will cause a left atrial pressure of about 25 mmHg [7].

This study shows that there is increasing of resistance in IV group according to the increase in pressure gradient and decreasing of flow rate to the left ventricle but this caused decrease in conductance depending to the change of pressure gradient and flow rate.

The relationship between the area and other physical parameters was linear in all normal study groups but there is an exponential relationship in other groups Fig (2,3,4). This study explain the rather good correlation between $T_{1/2}$ and other measurement of mitral valve area which is higher in sever group and also showed that the age was higher parameters but sex act as a weak parameters to change the physical parameters. There was no significant difference found between the four study groups regarding age, weight and height. There were a higher significant negative correlation value of resistance with area in four study groups because the change of resistance inversely proportional to the fourth power of the radius. The relation between the decrease of mean gradient and mitral valve area has been described by using Doppler date.

There is a strong correlation between the pressure half time and area of mitral valve. Resistance was significantly increased and it is higher in sever mitral stenosis. Conductance is high in mild mitral stenosis. The increase in mitral pressure gradient is frequently compensated by a decreased conductance. Age was highly influential but sex exerts less influence to change the physical parameters. Further study is recommended to evaluate the change compliance a corroding to the mitral valve stenosis.

References

1- Carapetis JR, Steer AC, Mulholland EK, et al (2005): The global burden of group A streptococcal diseases. Lancet Infect Dis., 5:685-694.

2- Harrison MR, Macphail B, Gurley JC, et al (1989): Usefulness of color Doppler flow imaging to distinguish ventricular septal defect from acute metal regurgitation complicating acute myocardial infaction. Am J Cardio; 64:697.

3- Smith MD, Cassidy JM, Gurley JC, et al (1995): Echo Doppler evaluation of patients with acute mitral regurgitation: superiority of transesophageal echocardiography with color flow imaging. Am Heart J; 129:967.

4- Stewart WJ, Currie PJ, Salcedo EE, et al (1992): Evaluation of mitral leaflet motion by ecohocardiography and jet direction by Doppler color flow mapping to determine the mechanism of mitral regurgitation. J Am Coll Cardiol; 20:1353.

5- Mitral Stenosis: (2009): Heart Valve Disorders: Merck Manual Home Edition. http://www.merck.com/mmhe/sec03/ch028/ch028d.html. Retrieved 03-14

6- Thomas J.D. Weyman A.E. (1987): Doppler mitral pressure half- time: a clinical tool in search of theoretical justification. J.A.m Coll Cardiol ; 10:923-9.

7- http://www.wikidoc.org/index.php/Mitral_stenosis

8- Izgi C, Ozdemir N, Cevik C, Ozveren O, Bakal RB, Kaymaz C, et al.(2007): Mitral valve resistance as a determinant of resting and stress pulmonary artery pressure in patients with mitral stenosis: a dobutamine stress study. J Am Soc Echocardiogr; 20:1160-6.

9- Choi B.W., Bacharach S.L., Barbour D.J., Leon M.B., McCarthy K.E., Bonow R.O.(1995): Left ventricular systolic dysfunction, diastolic filling characteristics, and exercise cardiac reserve in mitral stenosis. Am J Cardiol; 75:526-529.

10- Heller S.J., Carleton R.A. (1970): Abnormal left ventricular contraction in patients with mitral stenosis. Circulation; 42: 1099-1110

11- Arthur C. Guyton, M.D. (1986): Medical physiology (seventh edition).Physics of blood, blood flow and pressure: Hemodynamics. Pag: 212.

12- Evandro Cesar Vidal Osterne, Jorge Haddad, Vicente Paulo da Motta et al (2006): Determination of mitral valve area through pressure half time measurements in left atrium and pulmonary capillary wedge.Arq Cardiol;87(6):645-650.

13- Brogan WC, Lange RA, Hillis L.D (1991). Simplifiied formula for the calculation of mitral valve area: potential inaccuracies in patients with tachycardia cathet cardiovasc Diagn ; 23:81-3

14- Taranta A., Kleinberg E., Feinstein, AR, (1964): Along term epidemiologic study of subsequent prophylais streptoccal infections and clinical sequalae Ann.Intern. Med. (suppl5):47-57

**Department of Physiology Collage of Medicine, the University of Baghdad*

***Department of Physiology, Collage of Medicine, the University of Mustansiriya*