SIGNIFICANCE OF LEFT VENTRICULAR INFLOW GRADIENTS IN PATIENTS WITH VENTRICULAR SEPTAL DEFECT

P. Jain
S. hrivastava
A. Saxena
R. Tandon

ABSTRACT

Hemodynamic data of 167 patients of isolated- ventricular septa] defect (VSD) was retrospectively analyzed for the presence of left ventricular inflow gradients. End diastolic gradients of>5mm Hg between the pulmonary artery wedge pressure and the left ventricular end diastolic pressure were recorded in 40 of these patients. In three of these cases, left atrium was also entered and identical pressure gradients were recorded between the left atrial pressure and the left ventricular end diastolic pressure. Two dimensional and Doppler echocardiographic or operative findings were available in 32 of the 40 patients. No statistical correlation was found between the presence and degree of left ventricular inflow gradients at end diastole and the degree of left to right shunt. Out of a total of 40 patients with left ventricular inflow gradients, gradients of 6-10 mm Hg were present in 24 patients. Echocardiographic or operative findings available in 19 of these did not show any left ventricular inflow obstruction. Enddiastolic gradients of 11-15 mm Hg were present in 14 patients. Echocardiographic or operative findings were available in 11 of these and one of these had congenital mitral stenosis at surgery. End diastolic gradients of more than 15 mm Hg were present in 2 patients and one of these had congenital mitral stenosis at surgery. Thus organic left ventricular inflow obstruction is rare with inflow mitral gradients of upto 15 mm Hg in patients of VSD.

Key words: *Ventricular septal defect, Left ventricular inflow gradients, Congenital mitral stenosis.*

A mitral diastolic rumble in post tricuspid left to right shunt has been accepted as being indicative of a large left to right shunt. Hemodynamically, in large post tricuspid shunts flow gradients of upto 5 mm Hg across the mitral valve may be present without any structural abnormality(l) and higher gradients are believed to suggest organic mitral stenosis. According to Rudolph(2), mitral diastolic flow gradient in patients with large left to right shunt is most prominent in the rapid inflow phase in early diastole whereas it is present both in the rapid inflow phase and at the time of atrial systole in patients with mitral stenosis. As such, end diastolic gradients across the mitral valve are not expected in post tricuspid left to right shunts. We analyzed the end diastolic gradients between the pulmonary artery wedge pressure (PAWP) and the left ventricular end diastolic pressure (LVEDP) in patients with ventricular septal defect with left to right shunt who had undergone cardiac catheterization as a part of preoperative work up. The main purpose of the study

From the Department of Cardiology, Cardiothoracic Centre, All India Institute of Medical Sciences, New Delhi 110 029.

Reprint requests: Dr. Anita Saxena, Associate Professor, Department of Cardiology, All India Institute of Medical Sciences, New Delhi 110 029.

Received for publication: March 18, 1994;
Accepted: November 3, 1994

was to define diastolic gradients which could be present in patients of ventricular septal defect (VSD) in the absence of organic left ventricular obstruction.

Material and Methods

The hemodynamic data of 294 patients of isolated VSD catheterized during a five year period (July 1985-June 1990) were retrospectively reviewed. PAWP recordings were not available in 127 patients who were excluded from the analysis. One hundred and sixty seven patients (105 males, 62 females; mean age 6.2 years, range 4 months-28 years) were considered for inclusion in this study. Out of these 167 patients, 69 patients had simultaneously recorded PAWP and LVEDP tracings whereas in 98 patients, consecutive PAWP and LVEDP tracings were available, the measurements being made at similar gain and paper speed. Out of these 167 patients, 40 patients (28 males, 12 females, mean age 5.35 years, range 4 months-27 years) had end diastolic gradient of more than 5 mm Hg between the PAWP and LVEDP. AJ1 patients were in sinus rhythm. PAWP was measured using an end hole catheter, *i.e.,* either a Swan Ganz or Cournard catheter connected to saline filled pressure transducer system and pressure trace obtained on Mingogaph 4 channel recorded at a paper speed of 100 mm/sec. This pressure trace was confirmed by the catheter tip position, oxygen saturation of the withdrawal sample and/or its wave form. LVEDP was recorded from a catheter placed in the left ventricular cavity. The gradient was measured at end diastole in patients with simultaneous pressure recordings and between a wave of PAWP and LVEDP in traces taken consecutively. The pulmonary and systemic blood flows were calculated by Pick Oxygen method using assumed oxygen consumption values predicted from the body surface area corrected for age and sex.

In 11 out of above 40 patients, two dimensional echocardiographic data on left ventricular inflow including pulmonary vein, left atrial cavity and mitral valve was available. This examination was done on Ultramark 8 or 9 ATL (Advanced Technology Laboratories) machine. In 3 patients with suspicion of left ventricular inflow obstruction on two dimensional echocardiography, Doppler derived gradients had been obtained to confirm left ventricular inflow obstruction. Two dimensional echocardiography, with Doppler is a reliable method to detect left ventricular inflow obstruction(3,4). Operative findings were available in 29 patients and either echocardiographic or surgical data was,*available for a total of 32 of these patients. Chi square test with correction factor was used for statistical analysis.

Results

Forty of the 167 (23%) patients with isolated ventricular septal defect had enddiastolic gradients of more than 5 mm Hg between the PAWP and LVEDP at cardiac catheterization (Tables I *& IT).* Left atrial pressure recordings were available in three of these 40 patients, identical gradients were present between the left atrial and left ventricular enddiastolic pressure. Thirty four patients had perimembranous VSD, 5 patients had muscular VSD and one patient had both a perimembranous and a muscular VSD.

Out of the 114 patients with a calculated left to right shunt of more than 2:1, in 29 (25.4%), the end diastolic gradient was more than 5 mm Hg. Out of 50 patients with a left to right shunt of less than 2:1, an end diastolic gradient of more than 5 mm Hg. Out of 40 patients with a gradient of more than 5 mm Hg, in 29 (72.5%) the left to right shunt was more than 2:1 and in 27.5% it was less than 2:1. However, no statistical correlation was found between the presence of significant end diastolic gradients between the PAWP and LVEDP and the degree of left to right shunt ($p>0.05$).

TABLE I- *Degree of Shunt Across VSD and End Diastolic Gradients Across Left Ventricular Inflow*

Left to right shunt	No.	No. with end-diastolic gradients of >5mm Hg
>2:1	114	29
<2:1	50	11
Right to left shunt	3	0
Total	167	40

$p > 0.05$.

On further analysis of these 40 patients, end diastolic gradients of 6-10 mm Hg were present in 24 patients and left ventricular inflow obstruction was detected in none of them. Enddiastolic gradients of 11-15 mm Hg were present in 14 patients *(Fig.* 7). Echocardiographic or operative findings were available in 11 of these, one of whom had congenital mitral stenosis due to a single papillary muscle (parachute mitral valve). The simultaneously obtained end diastolic gradient was 12 mm Hg in this patients. End diastolic gradients of more than 15 mm Hg were obtained in 2 patients, one of whom had congenital mitral stenosis due to a single papillary muscle with simultaneously obtained end diastolic gradient of 23 mm Hg.

Discussion

In the present study, whereas 40 (24.4%) of the 167 patients with a VSD had an end diastolic gradient of more than 5 mm Hg across the left ventricular inflow, only two patients (1.2%) had associated organic mitral stenosis. Seventy three per cent of the patients with a significant gradient across the left ventricular inflow had more than 2:1 left to right shunt but no correlation was found

TABLE II– *Severity of End Diastolic Gradients Across the Left Ventricular Inflow and the Presence of Left Ventricular Inflow Obstruction*

End diastolic gradients (mm Hg)	Total no. of patients	Patients in whom echocardiographic operative findings available	Patients with left ventricular inflow obstruction
6-10	24	19	Nil
11-15	14	11	1
>15	2	2	1

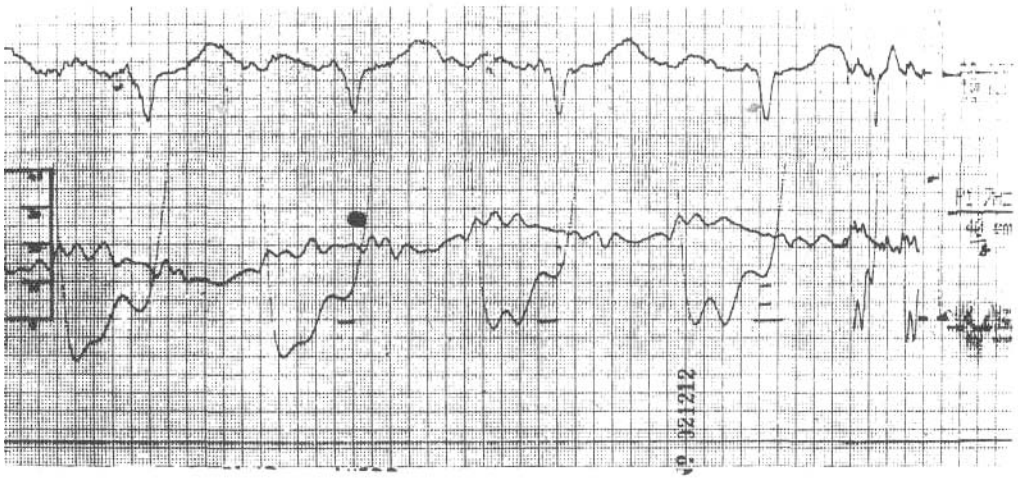

Fig. 1. Simultaneously recorded PAWP and LVEDP in a patient with isolated VSD showing an enddiastolic gradient of 10-12 mm Hg.

between the size of the left to right shunt and the presence of an end diastolic gradient across the left ventricular inflow. None of the patients with an end diastolic gradient of upto 10 mm Hg had organic left ventricular inflow obstruction.

Gradients between PAWP and LVEDP can result from obstruction at the pulmonary vein level, within the left atrial cavity or at the mitral valve level. The exact site of gradients in these patients has not been well studied. Rudolph(5) observed a pressure difference between the pulmonary vein and the left atrium in infants and small children with large left to right shunts frequently and attributed it to high flow and possibly associated with the presence of the catheter in a vein of small diameter. The fact that we had recorded high left atrial pressure identical to PAWP in three of these patients suggests that the site of the gradient is at the mitral valve level.

The mechanisms related to functional pulmonary stenosis in patients with large atrial septal defects have been postulated as increased flow, lack of dilatation of the pulmonary valve in relation to the right ventricular outflow tract and the pulmonary artery(6) and changes in the elasticity of the wall of the pulmonary artery along with post valvular dilatation(7). A similar pathogenesis does not apply to the functional gradients across the mitral valve in patients with post tricuspid shunts because of its larger surface area; only large flows have been related to as the causative factor by most authors(l,2). Though we did not find any direct relationship to the size of flow and the presence of end diastolic gradients between the PAWP and LVEDP the fact that we assumed oxygen consumption values to calculate pulmonary and systemic blood flows, is also likely to have introduced considerable error in the accurate calculation of the degree of shunts(8). However, the

precise reason why some patients have gradients and some do not have is not absolutely clear. It is possible that some additional factors are responsible and this requires further study.

The methodological fallacies in this retrospective study were: *(i)* simultaneous gradients between the PAWP and LVEDP were not recorded in all patients, and *(ii)* it did not give us information regarding the 'safe' diastolic mitral gradients which could be present in patients with VSD in the absence of organic left ventricular inflow obstruction. The chances of coexistent organic left ventricular inflow obstruction are negligible in the presence of diastolic mitral gradients of upto 10 mm Hg. Organic left ventricular inflow obstruction appears infrequent even in the presence of diastolic mitral gradients of upto 15 mm Hg. A preoperative meticulous echocardiographic examination should be done in all these patients. End diastolic gradients of more than 15 mm Hg suggest associated organic left ventricular inflow obstruction.

REFERENCES

1. Grossman W. Cardiac Catheterization and Angiography, Philadelphia, Lea and Febiger, 1986, p 452.
2. Rudolph AM. Congenital Disease of the Heart, 3rd edn. Chicago, Year Book Publishers, 1974, p 137.
3. Snider AR, Roge tL, Schiller NB, Silverman NH. Congenital left ventricular inflow obstruction evaluated by two dimensional echocardiography. Circulation 1980, 61: 848-855.
4. Grenadier E, Sahn DJ, Valdes-Gauz LM, Allen HD, Lina CD, Goldberg SJ. Two dimensional echo doppler study of congenital disorders of the mitral valve. Am Heart J 1984, 107: 319-325.
5. Rudolph AM. Congenital Diseases of the Heart. Chicago, Year Book Publisher, 1974, p 136.
6. Rudolph AM, Nadas AS, Goodale MD. Intracardiac left to right shunt with pulmonic stenosis. Am Heart J 1954,48:808-816.
7. Shephard RJ. Pulmonary arterial pressure in acyanotic congenital heart disease. Br Heart J 1954, 16: 361-374.
8. Kenorick AH, West J, Papouchado.M, Rozkoree A. Direct Fick cardiac output. Are assumed values of oxygen consumption acceptable? Eur Heart J 1988, 9: 337-342.