A Case of Right Atrial Myxoma

— Effect of Large Myxoma in the Right Atrium Studied by M-mode and Doppler Echocardiography —

Masayoshi Shimizu, M.D., Haruhiko Okuri, M.D., Kaoru Yokoyama, M.D.
Hiroshi Kawada, M.D., Toshiki Takizawa, M.D.
and Ryuichi Kikawada, M.D.

Doppler profiles are rarely used to assess cardiac function that has been partially impaired by a sizeable myxoma in the right atrium or to evaluate the improvement caused by extirpation of the tumor. In a 54-year-old man with a large right atrial myxoma (6.5×5.5×4.0 cm) along with first-degree atrioventricular (AV) block, M-mode and pulsed Doppler echocardiography were used to evaluate the left ventricular systolic and diastolic function before and 1 month after surgical removal of the myxoma. End-diastolic left ventricular (LV) and left atrial diameters increased postsurgically from 47 to 51 mm and from 38 to 41 mm, respectively, while end-systolic LV remained unchanged. In the LV inflow pattern, peak early filling velocity (E) increased substantially (preoperative 31, postoperative 58 cm/sec), with no change in peak late filling velocity (A) (53 cm/sec), which gave a favorable E/A ratio (from 0.58 to 1.09). First-degree AV block resolved after tumor resection (PR interval: 0.23 vs 0.20 sec). Improved LV diastolic function associated with natural recovery from the myxoma was ascribed to the restoration of preload and recovery of systolic function. The results of this study show that removal of a large myxoma in the right atrium is important not only for preventing possible obstruction of the tricuspid orifice, eliminating pulmonary emboli, and maintaining systolic function, but also for restoring LV diastolic function.

(*Jpn Circ J* 1995; **59**: 579–586)

MYXOMA, the most common benign primary tumor of the heart, occurs in the right atrium about 3 to 5 times less frequently than in the left atrium^{1,2}. With the advent of echocardiography and the refinement of user techniques, symptomatic as well as asymptomatic myxomas are sometimes found incidentally^{3,4}. However, even though transesophageal echocardiography

has proven to be useful for the diagnosis and surgical management of atrial tumors, little is known regarding the hemodynamic responses to extirpation of myxoma from the right atrium⁵. A relationship between preload and left ventricular (LV) diastolic filling has been reported with fairly consistent results based on pulsed Doppler examinations following pharmacological intervention or physiologic maneuver, eg, nitroglycerin^{6,7}, sodium nitroprusside⁸, or lower body negative and positive pressure^{9,10}, inflation of blood pressure cuffs placed at the root of the four limbs¹¹, change in position¹², and ventric-

Key words:

Right atrial myxoma
Preload
Diastolic function
Pulsed-Doppler echocardiography
First-degree atrioventricular block

(Received November 22, 1993; accepted November 2, 1994)

Department of Internal Medicine, Kitasato University School of Medicine, Sagami-hara, Japan

Mailing address: Masayoshi Shimizu, M.D., Department of Internal Medicine, Kitasato University School of Medicine, 1-15-1 Kitasato, Sagami-hara, Kanagawa 228, Japan

Fig.1. Two-dimensional end-diastolic (left panel) and end-systolic (right panel) 4-chamber apical views showing a sizeable myxoma in the right atrium of a 54-year-old male patient.

TABLE I PREOPERATIVE AND POSTOPERATIVE CARDIODYNAMICS REVEALED BY M-MODE AND DOPPLER ECHOCARDIOGRAPHY IN A PATIENT WITH RESECTION OF A RIGHT ATRIAL MYXOMA

	Preoperative	Postoperative
Systolic blood pressure (mmHg)	102	104
Diastolic blood pressure (mmHg)	72	66
Heart rate (beats/min)	64	66
Aortic diameter (mm)	33	35
Left atrial diameter (mm)	38	41
LV end-diastolic diameter (mm)	47	51
LV end-systolic diameter (mm)	32	32
Peak early filling velocity (E) (cm/sec)	31	58
Peak late filling velocity (A) (cm/sec)	53	53
E/A ratio	0.58	1.09
Time velocity integral of E wave (cm)	4.1	5.1
Time velocity integral of A wave (cm)	4.1	3.7
E/A time velocity integral ratio	1.00	1.38
Peak velocity in LV outflow (cm/sec)	61	103
Peak velocity in RV outflow (cm/sec)	49	62

LV=left ventricular, RV=right ventricular

ulography employing the contrast agents Renograffin 76 or Hexabrix⁷. However, conflicting results were reported under left atrial loading conditions produced by vena caval occlusion in canine models¹³. Although experimental studies are useful for partially clarifying certain cardiac functions, chemical or mechanical intervention imposes limitations on the understanding of preload variations encountered in routine clinical settings. In the present investigation, we used M-mode and Doppler echocardiography to

assess the preload pattern before and after removal of a large myxoma from the right atrium of a patient who was not under drug therapy.

CASE REPORT

A 54-year-old man presented with frequent spells of dizziness brought on by standing, in addition to effort dyspnea incurred during exertion, such as walking or climbing up stairs. The symptoms had been

Fig.2. M-mode echocardiograms recorded before (above) and 1 month after (below) extirpation of right atrial myxoma. End-diastolic diameter of the left ventricle and left atrial diameter were greater after the operation, with no change in the end-systolic diameter of the left ventricle.

apparent for 8 months, and had gradually worsened a month before admission. The patient had no history of syncopal attack. On admission (December 11, 1991), blood pressure in the supine position was 102/72 mmHg, and heart rate was regular at 72 beats/min. His height was 170 cm, and body weight was 68 kg. Physical examination disclosed a moderate holosystolic regurgitant murmur (Levine 2/6) at the third right sternal border, suggesting tricuspid regurgitation. However, no signs of right heart failure were manifested, and on auscultation no evidence was found of protodiastolic plop sound or pulmonary rales.

By 2-dimensional echocardiography, a sizeable mass with mobility and cystic abnormality (6.9×4.4 cm) was found in the right atrium near the orifice of the tricuspid valve (Fig. 1). The right atrium and ventricle were slightly enlarged compared to the left atrium and ventricle. Chest X-ray showed no indication of pulmonary congestion, and the cardiothoracic ratio was 57%. Except for first-degree atrioventricular (AV) block (PR interval: 0.23 sec), the electrocardiogram

appeared normal. A previous electrocardiogram from a medical check-up (May 8, 1985) showed a PR interval of 0.18 sec. Laboratory tests indicated slightly elevated levels of hepatic enzymes: glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), gamma-glutamyl transpeptidase (γ -GTP), and C-reactive protein (CRP). Based on the tentative but strongly suspected diagnosis of right atrial myxoma, surgery was performed on the second day of admission.

In the right atrium, a large pedunculated myxoma was found arising from the fossa ovalis cordis. The mass was resected and an ASD patch was performed. The tumor was benign, despite measuring $6.5 \times 5.5 \times 4$ cm and weighing 90 g. Just before the operation, central venous pressure was 13–14 mmHg. Six hours after extirpation, central venous pressure fell to 8 mmHg. The patient made a rapid and uneventful recovery, and dizziness and dyspnea were obliterated without medication. First-degree AV block gradually resolved, the PR interval became normal (0.20 sec) and the cardiothoracic

Fig.3. Doppler echocardiograms of the left ventricular inflow tract before (above) and 1 month after (below) the operation. Peak rapid filling velocity (E) increased after tumor resection, with peak late filling velocity (A) remaining unchanged.

Fig.4. Doppler echocardiograms of the left ventricular outflow tract before (above) and 1 month after (below) the operation. The maximum velocity was greater after myxoma extirpation.

ratio on chest X-ray was 53% 13 days after surgery.

M-mode and Doppler echocardiographic examinations were performed with a Hewlett-Packard 77020 AC phased-array scanner (Hewlett-Packard Co, Andover, MA, USA) equipped with a 2.5-MHz transducer, and the echocardiograms recorded 1 month after myxoma resection were compared with those obtained on admission. Doppler measurements were determined by averaging 5 consecutive beats during normal respiration in the supine position, and the M-mode echocardiograms were evaluated according to standards set by the American Society of Echocardiography¹⁴. The time velocity integral of the left ventricular inflow wave was

also measured by a computer system with a digitizer for graphic analysis (PC-9801, Graphtec-510 mk2, NEC Co, Tokyo, Japan).

In both blood pressure and heart rate, the postoperative (33 days after surgery) and preoperative differences were negligible (Table I). However, left atrial diameter (preoperative 38, postoperative 41 mm) and end-diastolic diameter of the left ventricle (preoperative 47, postoperative 51 mm) were dramatically larger after tumor resection, while end-systolic LV diameter remained unchanged (Fig. 2). Accordingly, the percent fractional shortening of the LV minor axis [$100 \times (\text{LV end-diastolic diameter} - \text{LV end-systolic diameter}) / \text{LV end-diastolic diameter}$]

Fig. 5. Doppler echocardiograms in the right ventricular outflow tract before (above) and 1 month after (below) the operation. Peak velocity increased after myxoma extirpation.

was 5% higher after tumor extirpation (preoperative 32%, postoperative 37%). Before the operation, the right ventricular inflow wave was not observed due to the large myxoma. Therefore, manifest tricuspid regurgitant flow was not confirmed. Post-surgically, the right atrium and ventricle became slightly smaller, but were still somewhat enlarged with mild tricuspid regurgitation (peak velocity was approximately 2 m/sec by continuous wave Doppler). Curiously, the LV inflow wave changed markedly after resection: Peak early filling velocity (E) increased from 31 to 58 cm/sec, with peak late filling velocity (A) remaining constant (53 cm/sec), thus resulting in a normal E-to-A postoperative ratio of 1.09, in

stark contrast to the preoperative ratio of 0.58 (Fig. 3). Like the behavior of E and A, the time velocity integral of the E wave increased markedly from 4.1 to 5.1 cm, while that of the A wave slightly decreased from 4.1 to 3.7 cm. At the same time, the deceleration half-time of the E wave shortened from 113 to 71 msec. Peak velocity in the LV outflow tract (Fig. 4) increased substantially (from 61 to 103 cm/sec), as did that of the RV outflow tract (from 49 to 62 cm/sec), as shown in Fig. 5.

DISCUSSION

M-mode and Doppler echocardiographic examinations revealed a positive correlation between cardiac function and the increase in preload caused by extirpation of right atrial myxoma from the 54-year-old male patient in this study. These results suggest that an increase in the peak diastolic velocity (E) or time velocity integral of the E wave is directly related to the increase in preload. By the nature of its clinical setting, this study presupposes multivariate factors in the interpretation of Doppler patient profiles since, in contrast to experimental evaluation, codeterminant factors were not constrained by an intervention procedure. On the contrary, all results were the natural outcome of the patient's response to treatment.

Without pharmacological or mechanical intervention, increased preload was evidenced postsurgically by increased end-diastolic LV diameter and left atrial diameter. After tumor resection, both the systolic function and the dynamics of LV diastolic filling showed marked improvement: With peak late filling velocity (A) remaining unchanged, peak early filling velocity (E) increased, resulting in normalization of the E/A ratio and agreeing with normal values reported previously ($E=61 \pm 9$ SD cm/sec; $A=46 \pm 10$ cm/sec)⁸. Although improved cardiac function may be the expected outcome of removal of an obstructing myxoma, the present case is perhaps the first report of a right atrial myxoma with documented by preload normalization by M-mode and Doppler echocardiography. Moreover, without experimental intervention, the naturally restored preload had favorable effects on both LV filling dynamics and systolic function.

To date, right atrial myxoma has been reported concomitant with first-degree AV block in 4 other clinical cases. In our patient, first-degree AV block resolved shortly after extirpation of the myxoma. Roberts and Ramsdale, reporting that conduction abnormality resolved within 3 months of successful surgical removal of a tumor, speculated that mechanical compression by the myxoma of either the underlying conduction tissue or the interventricular septum might account for the conduction disturbance.¹⁵ Our case supports their speculation.

Providing considerable sensitivity and specificity, Doppler echocardiography enables the serial investigation of left ventricular filling, which is often taken to reflect LV diastolic function.^{16,17} However, Doppler profiles possibly interpreted as diastolic dysfunction may, in fact, be affected by variations in preload, as suggested by the present study. Transmitral blood flow is determined by multiple factors, and Doppler transmitral velocity is subject to variations in ventricular preload,⁶⁻¹² afterload,^{18,19} heart rate,^{20,21} sympathetic tone²² and systolic function.¹⁹ In the present study, first-degree AV block was ruled out as the possible cause of impaired LV diastolic filling because peak early filling velocity is unaffected by sinus rhythm with varying PR intervals, as shown by Freedman et al.²³ A growing body of evidence supports the view that preload, which is extrinsic to the ventricle, plays a major role in LV diastolic function. According to several authors using either physiologic or pharmacological intervention in human studies, acute reduction of preload was accompanied by a decrease in peak early filling velocity (E) independent of any change in peak late filling velocity (A).⁶⁻¹² However, based on transient occlusion of the inferior vena cava in canine models, Courtois et al.¹³ reported decreases in both E velocity and A velocity resulting from preload reduction, which underscores the need to consider left atrial loading conditions when using Doppler profiles to assess LV diastolic function. In contrast to a reduction in preload, an increase in preload has been shown to produce the converse pattern in transmitral flow, ie, an increased E velocity with minimal⁹ or no change^{7,12} in A velocity.

In some reports on preload variation,

decreased preload was attributed to a compensatory acceleration of heart rate.^{6-8,10} This gives rise to the possibility that the pattern of transmitral blood flow may be more adversely affected by accelerated heart rate than by decreased preload. However, Takahashi et al.⁹ and Downes et al.¹² reported that decreased preload reduced the early diastolic filling velocity (E) independent of any change in peak late filling velocity (A), despite the absence of any significant increase in heart rate.

More recently, Courtois et al.¹⁹ found that systolic function was an important determinant of E velocity in intact dogs, as reflected by a significant correlation between E velocity and LV contractility (dP/dt) and afterload (aortic diastolic pressure) ($r=0.906$, $p<0.001$). However, they postulated that contractility and afterload may be determinants of other factors affecting E independent of end-systolic volume, such as variations in ventricular shape and torsion.²¹ Although preload was deemed unimportant in experiments by Courtois et al.,⁹ they acknowledged a strong likelihood of limitation posed by the substances employed, particularly morphine sulphate, which is known to increase venous capacitance and thereby reduce preload.

In efforts directed toward elucidating the complex relationships between transmitral flow and the interrelationship of diastolic and systolic function, many approaches have been taken to mimic right atrial insufficiency, such as acutely reducing venous return or inhibiting end-diastolic pressure. The use of anesthesia, contrast agents, or other substances necessarily negates or minimizes the influence of codeterminants and presupposes that the researcher will take the unknown variables into account. Experimental investigation on canine models demonstrated that if atrial loading is reduced acutely, intraatrial forces that normally contribute to diastolic filling are attenuated and rapid ventricular filling may not be completed effectively.¹³

In contrast to subjects controlled in the laboratory, the present case enabled the study of right atrial impairment with no factor being deliberately controlled. Extirpation of the large right atrial myxoma produced not only normalization of preload but also resulted in improved systolic function, as verified by an increased percent fractional

shortening of the LV minor axis and by an augmented maximum velocity in both the left ventricular and right ventricular outflow tracts. Since multiple factors are inherently involved in total cardiac function, no factor may be singled out as the sole determinant responsible for improvement. However, preload is thought to play a paramount role because the principal hemodynamic change elicited by extirpation of an obstructive myxoma is theoretically the restoration of the potential of the heart to increase the preload.

The present case clarified that surgical correction of flow impairment associated with right atrial tumor results in stabilization of preload. In our patient, the peak early filling velocity (E) normalized as a consequence of natural recovery from the lesion without alteration of peak late filling (A) velocity and without drug intervention, which suggests a close relationship between diastolic performance and left ventricular preload. These results provide a strong argument that transmitral Doppler velocity profiles are load-sensitive and therefore reliable markers of diastolic function. To more fully evaluate the intricate relationships of preload and cardiac function, further investigation is warranted by comparing Doppler profiles of patients with and without pathological disturbance.

Acknowledgements

The authors thank Dr. Akihito Irisawa and Dr. Akira Ishiura of the Department of Thoracic Surgery, Kitasato University Hospital, for performing the operation. We also thank Professor Nell Kennedy for valuable advice in preparing this manuscript.

REFERENCES

1. Heath D: Pathology of cardiac tumors. *Am J Cardiol* 1968; **21**: 315–327
2. Hall RJ, Cooley DA, McAllister HA, Frazier OH: Heart disease due to neoplasm. Neoplastic heart disease. In: Hurst JW, Schlant RC, Rackley CE, Sonnenblick EH, Wenger NK eds. *The Heart*, 7th Edition. New-York, McGraw-Hill Information Services Co., 1990, 1382
3. Depace NL, Soulen RL, Kotler MN, Mintz GS: Two-dimensional echocardiographic detection of intraatrial masses. *Am J Cardiol* 1981; **48**: 954–960
4. Sheiban I, Casarotto D, Trevi G, Benussi P, Marini A, Accardi R, Motta A, Brunelli M, Muneretto C, Tenuti A, Scuro LA: Two-dimensional echocardiography in the diagnosis of intracardiac masses: A prospective study with anatomic validation. *Cardiovasc Intervent Radiol* 1987; **10**: 157–161
5. Smith ST, Hautamaki K, Lewis JW Jr, Serwin J, Alam M: Transthoracic and transesophageal echocardiography in the diagnosis and surgical management of right atrial myxoma. *Chest* 1991; **100**: 575–576
6. Choong CY, Herrmann HC, Weyman AE, Fifer MA: Preload dependence of Doppler-derived indexes of left ventricular diastolic function in humans. *J Am Coll Cardiol* 1987; **10**: 800–808
7. Stoddard MF, Pearson AC, Kern MJ, Ratcliff J, Mrosek DG, Labovitz AJ: Influence of alteration in preload on the pattern of left ventricular diastolic filling as assessed by Doppler echocardiography in humans. *Circulation* 1989; **79**: 1226–1236
8. Shimizu M, Kuramochi K, Kitazumi H, Kawaguchi T, Niizuma K, Kawano M, Ogata N, Kawano T, Fukawa S, Noro C, Tsuyusaki T, Kikawada R: Evaluation of cardiac function at rest and under acute loading in patients with essential hypertension using pulsed Doppler echocardiography. *J Cardiol* 1990; **20**: 123–134 (in Japanese)
9. Takahashi T, Iizuka M, Sato H, Serizawa T, Momomura S, Mochizuki T, Kohmoto O, Aoyagi T, Matsuo H, Ikenouchi H, Sakamoto T, Sugimoto T: Doppler echocardiographic-determined changes in left ventricular diastolic filling flow velocity during the lower body positive and negative pressure method. *Am J Cardiol* 1990; **65**: 237–241
10. Berk MR, Xie G, Kwan OL, Knapp C, Evans J, Kotchen T, Kotchen JM, Demaria AN: Reduction of left ventricular preload by lower body negative pressure alters Doppler transmitral filling patterns. *J Am Coll Cardiol* 1990; **16**: 1387–1392
11. Triulzi MO, Castini D, Ornaghi M, Vitolo E: Effects of preload reduction on mitral flow velocity pattern in normal subjects. *Am J Cardiol* 1990; **66**: 995–1001
12. Downes Tr, Nomeir A, Stewartt K, Mumma M, Kerensky R, Little WC: Effect of alteration in loading conditions on both normal and abnormal patterns of left ventricular filling in healthy individuals. *Am J Cardiol* 1990; **65**: 377–382
13. Courtois M, Vered Z, Barzilai B, Ricciotti NA, Perez JE, Ludbrook PA: The transmitral pressure-flow velocity relation: Effect of abrupt preload reduction. *Circulation* 1988; **78**: 1459–1468
14. Sahn DJ, Demaria A, Kisslo J, Weyman A: Recommendations regarding quantitation in M-mode echocardiography: Results of a survey of echocardiographic measurements. *Circulation* 1978; **58**: 1072–1083
15. Roberts DH, Ramsdale DR: First degree atrioventricular block associated with right atrial myxoma. *Postgrad Med J* 1990; **66**: 140–141
16. Rokey R, Kuo LC, Zoghbi WA, Limacher MG, Quinones MA: Determination of parameters of left ventricular diastolic filling with pulsed Doppler echocardiography: Comparison with cineangiography. *Circulation* 1985; **71**: 543–550
17. Spirito P, Maron BJJ, Bonow RO: Noninvasive assessment of left ventricular diastolic function: Comparative analysis of Doppler echocardiograph-

- ic and radionuclide angiographic techniques. *J Am Coll Cardiol* 1986; **7**: 518–526
18. Choong CY, Abascal VM, Thomash JD, Guerrero JL, McGlew S, Weyman AE: Combined influence of ventricular loading and relaxation on the transmitral flow velocity profile in dogs measured by Doppler echocardiography. *Circulation* 1988; **78**: 672–683
 19. Courtois M, Mechem CJ, Barzilai B, Ludbrook PA: Factors related to end-systolic volume are important determinants of peak early diastolic transmitral flow velocity. *Circulation* 1992; **85**: 1132–1138
 20. Herzog CA, Elsperger KJ, Manoles M, Murakami MA, Asinger R: Effect of atrial pacing on left ventricular diastolic filling measured by pulsed Doppler echocardiography (abstract). *J Am Coll Cardiol* 1987; **9**(Suppl A): 197A
 21. Parker TG, Cameron D, Sena J, Morgan CD, Sasson Z: The effect of heart rate and A-V interval on Doppler ultrasound indices of left ventricular diastolic function (abstract). *Circulation* 1987; **76**(Suppl iv): 124
 22. Johannessen K, Cerqueira M, Veith RC, Stratton JR: Influence of sympathetic stimulation and parasympathetic withdrawal on Doppler echocardiographic left ventricular diastolic filling velocities in young normal subjects. *Am J Cardiol* 1991; **67**: 520–526
 23. Freedman RA, Yock PG, Echt DS, Popp RL: Effect of variation in PQ interval on patterns of atrioventricular valve motion and flow in patients with normal ventricular function. *J Am Coll Cardiol* 1986; **7**: 595–602