JACC Vol 7, No 3
March 1986 693-5

Atrial Contraction Is an Important Determinant of Pulmonary Venous Flow

GAD KEREN, MD,* ALAN BIER, MD,† JACK SHEREZ, MsC,* DENNIS MIURA, MD,† DEBORAH KEEFE, MD, FACC,† THIERRY LEJEMTEL, MD†

Bronx, New York and Tel Aviv, Israel

Pulmonary venous flow has two phases (systolic and diastolic) in normal subjects when studied by pulsed Doppler echocardiography. Only one phase of pulmonary venous flow (diastolic) was observed in six patients without synchronous atrial contraction (four patients with atrial fibrillation and two with complete atrioventricular [AV] block). This pattern reversed to normal (biphasic) when AV synchrony was reestablished by cardioversion to sinus rhythm in patients with atrial fibrillation and by AV sequential pacing in patients with complete AV block. Thus, both atrial and ventricular contraction and relaxation are important determinants of pulmonary venous flow.

(J Am Coll Cardiol 1986;7:693–5)

Pulmonary venous flow in normal individuals is biphasic (Fig. 1) (1,2). The first phase of flow occurs in systole and the second phase in diastole. The ability to record this flow by pulsed Doppler echocardiography was demonstrated in a recent study (2), which suggested that a lack of synchronized atrial contraction and relaxation in patients with atrial fibrillation or sinoatrial block results in elimination of the normal biphasic pattern of pulmonary venous flow. Instead, a monophasic diastolic flow pattern was noted in these patients with little or no systolic phase.

To assess the reversibility of this abnormal pattern when atrioventricular (AV) synchrony was reestablished, we studied three patients with isolated atrial fibrillation and one patient with mitral stenosis and atrial fibrillation before and after cardioversion (Table 1). We also studied two patients with a dual chamber AV sequential (DDD) pacemaker to determine whether introduction of synchronized atrial stimulation (DDD mode) and its elimination (VVI mode) resulted in similar changes in pulmonary venous flow.

Methods

Two-dimensional and pulsed Doppler echocardiography were performed using a Hewlett-Packard ultrasound imaging system (77020AC). The system has a phased array sector scanner and a movable Doppler cursor that allows sampling along a line within the image when the system is in pulsed Doppler mode. Images were obtained using either a 2.5 or a 3.5 MHz transducer, whichever provided optimal visualization of the endocardium.

For recording mitral valve and pulmonary venous flows, the apical four chamber view was used. To obtain mitral flow velocity, the sampling volume was positioned between the tips of the mitral leaflets in the left ventricle, whereas to obtain pulmonary venous flow, the transducer had to be rotated, sometimes only slightly, so that the orifices of the pulmonary veins into the left atrium were well visualized and the sampling volume was positioned in place (Fig. 2). The right upper pulmonary vein was most frequently used for flow velocity recording. Echocardiographic and Doppler flow studies were recorded on a black and white hard copy recorder.

Results

Atrial fibrillation. Figure 3A shows the pattern of pulmonary venous flow in a patient with atrial fibrillation before cardioversion. The only prominent pulse of flow occurs during diastole with a slow deceleration in the beginning of systole. After cardioversion, the biphasic pattern of pulmonary venous flow reappears (Fig. 3B) with the first phase occurring in systole and the second in diastole. Atrial contraction resulted in an abrupt deceleration of the second phase of flow.

From the †Department of Medicine, Division of Cardiology, The Albert Einstein College of Medicine, Bronx, New York and *Department of Cardiology, Tel Aviv Medical Center and University, Tel Aviv, Israel

Manuscript received May 28, 1985; revised manuscript received October 8, 1985, accepted October 23, 1985.

Address for reprints: Gad Keren, MD, Department of Cardiology, Tel Aviv Medical Center, Weizman Street No. 6, Tel Aviv, Israel

0735-1097/86/$3 50

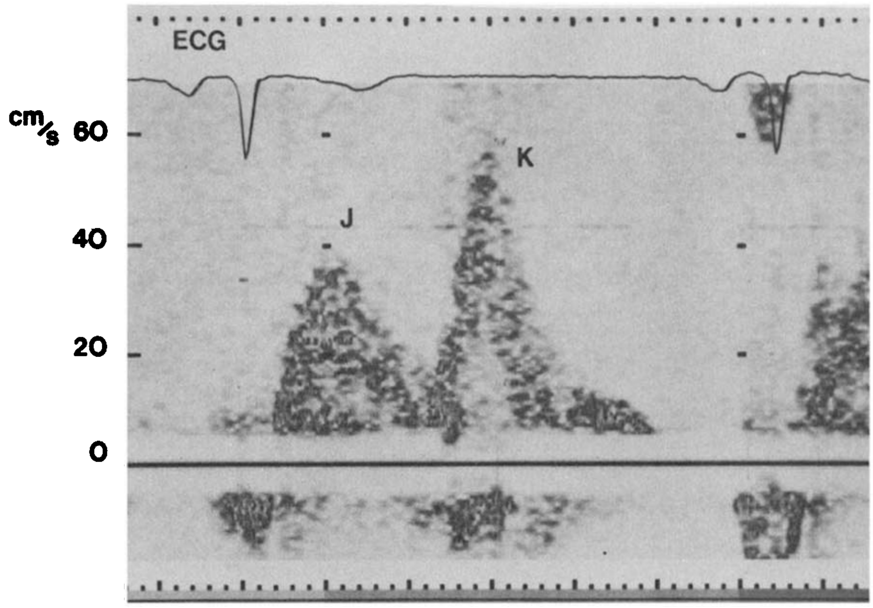


Figure 1. Pulmonary venous flow in a normal subject. ECG = electrocardiogram; J = systolic phase; K = diastolic phase.

Cardiac pacemaker. Figure 4 shows the pattern of pulmonary venous flow in a patient with a DDD pacemaker before and after a change from the VVI (Fig. 4A) to the DDD (Fig. 4B) mode. In Figure 4A, only one diastolic phase of flow is registered, whereas after initiation of the DDD mode and the introduction of an atrial stimulus, a biphasic pattern of systolic and diastolic flow pulses appeared.

Discussion

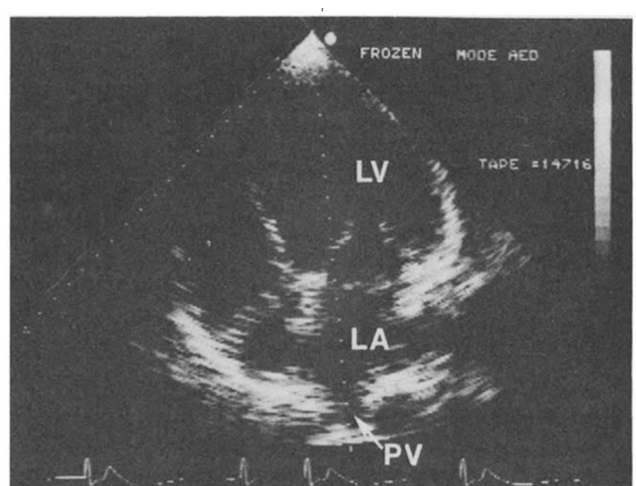
Our observations support the hypothesis that both left atrial and left ventricular contraction and relaxation are important determinants of pulmonary venous flow. They corroborate the studies by Sivacyan and Raganathan (3), who demonstrated a monophasic diastolic jugular venous flow in patients with atrial fibrillation. These authors suggested that the abnormality of flow may reflect the long-standing nature of the underlying condition and result from derangement in right heart hemodynamics, rather than from the arrhythmia itself. However, the immediate reversal of flow disturbance observed in our patients after cardioversion or the introduction of AV sequential pacing does not support this view. Rather, atrial relaxation, which occurs during ventricular systole, seems to be responsible for the first phase. Then, after left ventricular relaxation and pressure crossover, a transmitral rapid filling wave occurs and pulmonary venous flow resumes, generating a second phase of flow (1,2,4,5).

Table 1. Summary of Patients

Case	Age (yr) & Sex	Primary Diagnosis	Therapy*
1	65 M	AF	Digoxin
2	60 M	Hypertension; AF	Digoxin
3	55 F	AF	Digoxin
4	35 F	Mitral stenosis; AF	Digoxin
5	72 M	Moderate AS; CAVB	DDD
6	72 M	CAVB	DDD

*Medication before cardioversion. AF = atrial fibrillation; AS = aortic stenosis; CAVB = complete atrioventricular block; DDD = dual chamber atrioventricular sequential pacemaker; F = female; M = male.

Figure 2. Two-dimensional echocardiogram, four chamber view, showing the orifice of the pulmonary vein (PV) where the Doppler beam was positioned. LA = left atrium; LV = left ventricle.



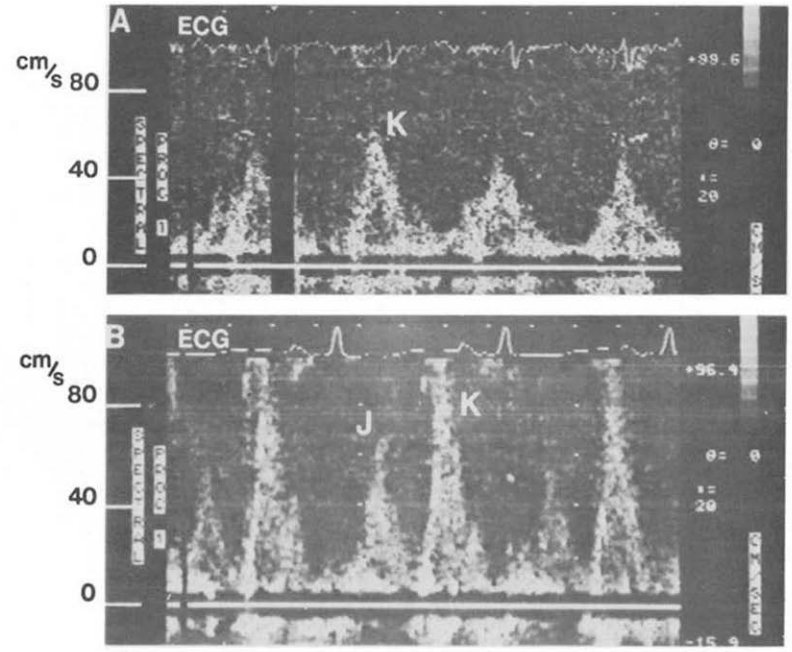


Figure 3. Patient 1. Pulmonary venous flow in a patient with atrial fibrillation. **A**, Before cardioversion. Only a diastolic (K) phase is observed. **B**, During sinus rhythm (after cardioversion). Both systolic and diastolic phases (J,K) are observed.

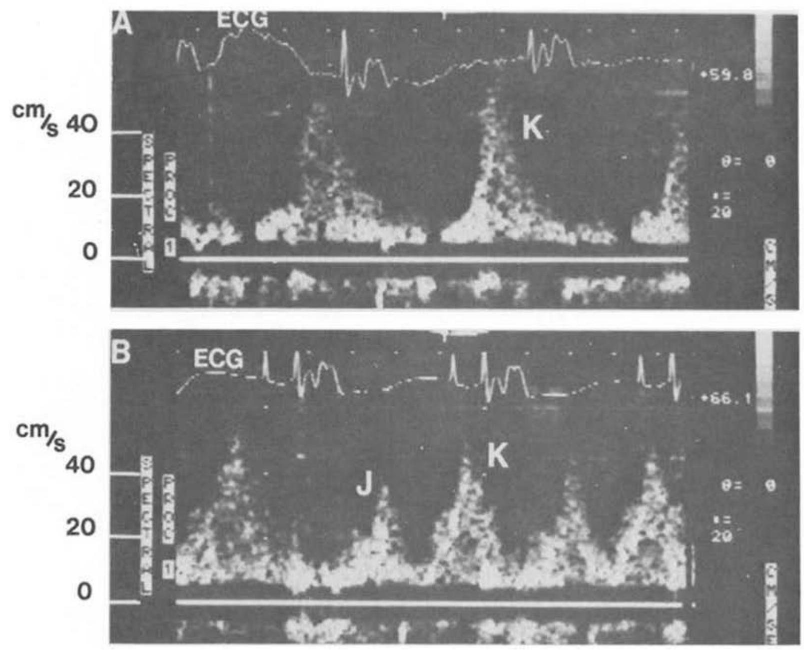


Figure 4. Patient 6. Pulmonary venous flow in a patient with an atrioventricular sequential pacemaker. **A**, Pacemaker in VVI mode. Only a diastolic (K) phase is observed. **B**, Pacemaker in DDD mode. Both phases (J,K) are observed.

References

1. Rajagopalan B, Friend JA, Stallard T, Lee GJ. Blood flow in pulmonary veins. I. Studies in dog and man. Cardiovasc Res 1979;13.667–76.
2. Keren G, Sherez J, Megidish R, Levitt B, Laniado S. Pulmonary venous flow pattern—its relationship to cardiac dynamics. Circulation 1985;71:1105–12.
3. Sivacyan V, Raganathan N. Transcutaneous jugular venous flow velocity recording: clinical and hemodynamic correlates Circulation 1978;57·930–9
4. Rajagopalan B, Friend JA, Stallard T, Lee GJ. Blood flow in pulmonary veins. II. The influence of events transmitted from the right and left sides of the heart. Cardiovasc Res 1979,13:677–83
5. Rajagopalan B, Bertram CD, Stallard T, Lee GJ. Blood flow in pulmonary veins. III. Simultaneous measurements of their dimensions, intravascular pressure and flow. Cardiovasc Res 1979;13.684–92.