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Intracardiac Phonocardiography in Subaortic Stenosis

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The purpose of this study is to explore the value of intracardiac sound recordings for the verification of subaortic stenosis. Intracardiac sound was measured in ten patients with subaortic obstructions. Seven had idiopathic hypertrophic subaortic stenosis, two had a subvalvular membrane, and one had a subvalvular tunnel. In each patient, a systolic murmur was recorded within the left ventricle distal to the obstruction. The murmur was of lower amplitude distal to the aortic valve, and it was of even lower amplitude or absent proximal to the obstruction. In the presence of entrapment, no intraventricular murmur occurred although an apparent subvalvular pressure gradient was observed. The identification and localization of the maximal intensity of a systolic murmur in the ventricular outflow tract may assist in the verification of a subvalvular obstruction and help distinguish between artifactual pressure gradients and gradients indicative of subvalvular stenosis.

Introduction

THE interpretation of an apparent intraventricular pressure gradient in subvalvular stenosis sometimes may be difficult because of the possibility of catheter whip or, in rare instances, entrapment of the tip of the catheter.[1] Many diagnostic tests are usually required to diagnose various types of subaortic stenosis, including clinical features,[2] the ventriculogram,[2,3] and the echocardiogram.[4,5] No single diagnostic procedure has been found to be adequate for all patients. The clinical features may be nonspecific[2] and the ventriculogram may be misinterpreted if it simulates an obstructive defect by showing an hour-glass silhouette during early diastole.[1] The echocardiogram has several limitations. In idiopathic hypertrophic subaortic stenosis (IHSS), it may fail to show systolic anterior motion of the mitral valve if there is no significant subaortic obstruction during the time of study.[5] Asymmetric septal hypertrophy may also be present without obstruction.[5,6] In addition, membranous subaortic stenosis or tunnel subaortic stenosis sometimes may not be apparent on echocardiograms.[7,8] Therefore, the diagnosis of a subvalvular obstruction, even during cardiac catheterization, may pose a problem. Any ancillary or supportive information would be of value. The purpose of this study is to determine if intracardiac phonocardiography may assist in verifying the presence of a subvalvular obstruction.

Methods

Pressure and intracardiac sound were measured during cardiac catheterization in ten patients with left ventricular outflow tract obstructions (see the accompanying table). Seven patients had IHSS as shown by echocardiography, ventriculograms, and pressure gradients across the outflow tract of the left ventricle. Two of these were treated surgically. Two of the ten (Patients 6 and 10) had a subvalvular membrane, and their diagnosis of subaortic stenosis was confirmed at surgery. In the one case of tunnel subaortic stenosis (Patient 7), the resected muscle showed normally arranged cardiac muscle with no fibrosis or disorganization.

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DIAGNOSTIC INDICATIONS OF LEFT VENTRICULAR OUTFLOW TRACT OBSTRUCTIONS

Patient	Diagnosis	Echocardiogram	Resting Pressure Gradient Across Outflow Tract (mm Hg)	Pressure Gradient Following Isoproterenol (mm Hg)	Ventriculogram	Findings at Surgery
1	IHSS	ASH, SAM	88	—	Outflow obstruction by MV and septum	IHSS
2	IHSS	ASH, SAM	48	—	Hyperkinetic ventricle	not done
3	IHSS	ASH, SAM	42	192	Outflow obstruction by MV and septum	not done
4	IHSS	ASH, SAM	8	50	Outflow obstruction by MV and septum	not done
5	IHSS	ASH, SAM	100	—	Thickened septum	IHSS
6	Membranous subaortic stenosis	Not diagnostic	32	—	Discrete subaortic stenosis	Subvalvular membrane
7	Tunnel subaortic stenosis	Not diagnostic	29	36	Subaortic tunnel	Subvalvular tunnel
8	IHSS	ASH, SAM	20	80	Thickened septum	not done
9	IHSS	ASH, SAM	120	—	Outflow obstruction by MV and septum	not done
10	Membranous subaortic stenosis	Early AV closure	20	—	Discrete subaortic stenosis	not done

ASH = asymmetric septal hypertrophy
SAM = systolic anterior motion of the mitral valve
MV = mitral valve
IHSS = idiopathic hypertrophic subaortic stenosis
AV = aortic valve

Entrapment of the catheter occurred in one patient who was catheterized because of symptoms of angina. This resulted in an apparent pressure gradient across the outflow tract even though he had no clinical, echocardiographic, or ventriculographic evidence of outflow tract obstruction.

Pressure and intracardiac sound were measured with a catheter-tip micromanometer (Millar instruments, Houston, TX) and recorded on a VR-6 photographic recorder (Electronics for Medicine, White Plains, NY), at paper speeds of 25 to 200 mm/sec, during multiple pullbacks of the micromanometer from the apex of the left ventricle to the aorta. Particular care was taken to keep the gain of the sound amplifier constant during all recordings in order to compare the amplitude of murmurs recorded in various regions of the heart.

Ventriculograms in the right anterior oblique projection were obtained on 35 mm cine in all patients; in nine cases, both the left anterior oblique and right anterior oblique views were obtained. In three of these patients, a simultaneous injection was made in the left and right ventricles to show the thickness of the septum; none showed mitral regurgitation on the ventriculogram.

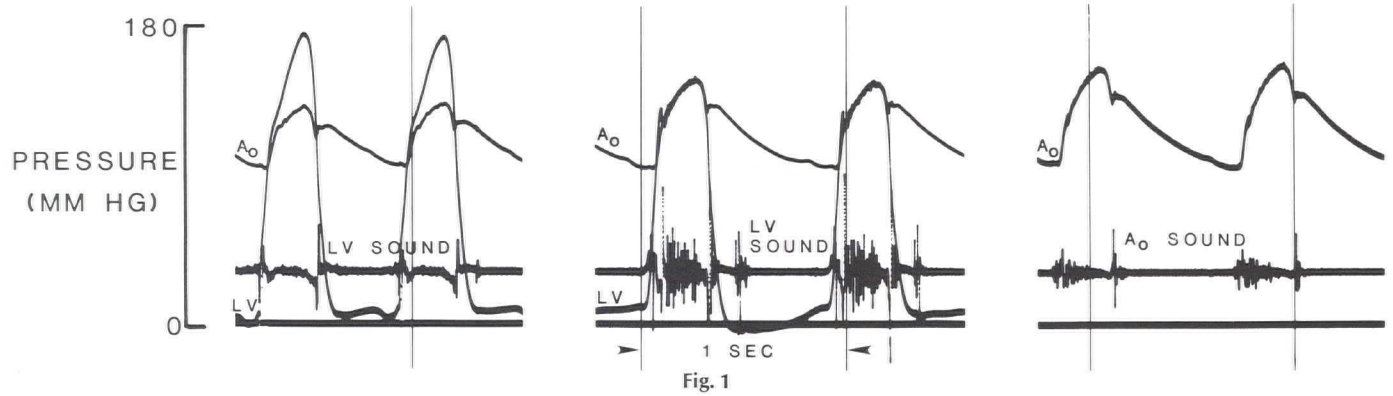

Fig. 1

Intracardiac sound, aortic (Ao) pressure, and left ventricular (LV) pressure in a patient with IHSS (Patient 3). Left: LV catheter was in the apex. Center: LV catheter was within the outflow tract. Right: Both micromanometers were within the aorta. The maximal intensity of the murmur occurred within the outflow tract.

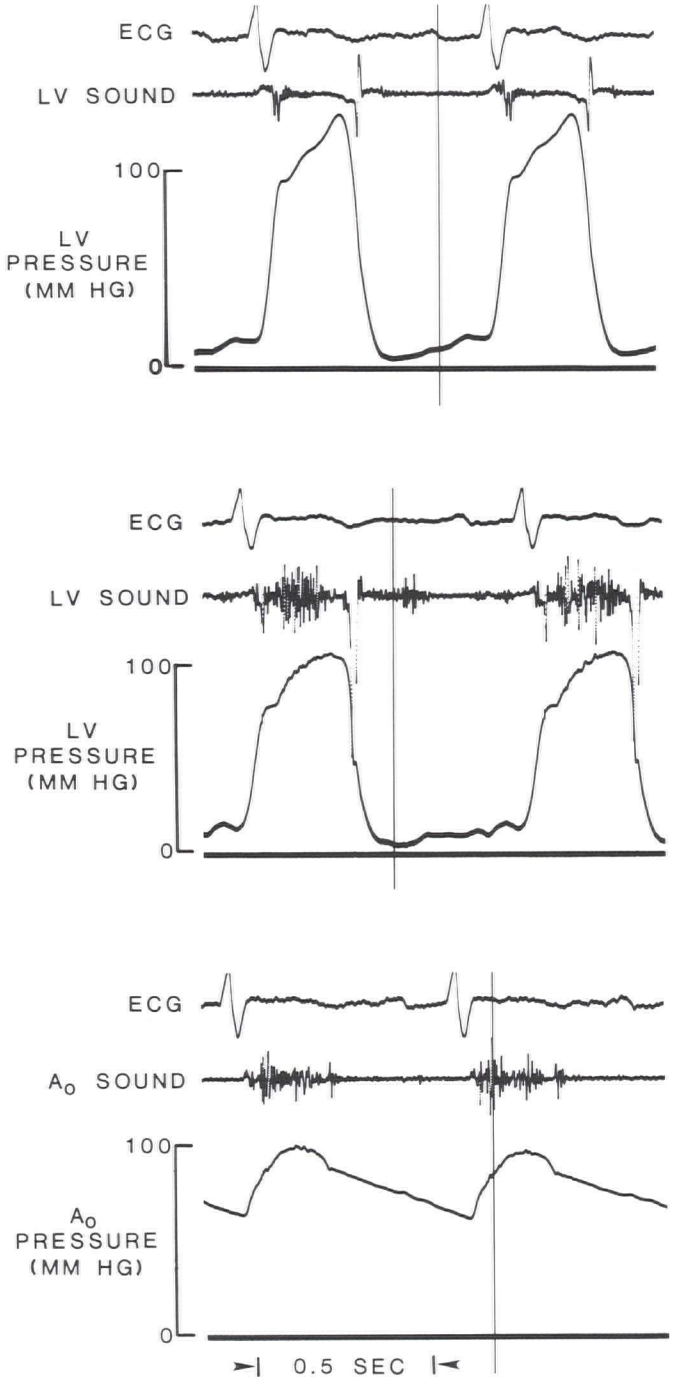

Fig. 2

Intracardiac pressure and sound in a patient with tunnel subaortic stenosis (Patient 7). Top: Left ventricular (LV) pressure and sound recorded proximal to the obstruction. Center: Pressure and sound recorded within the outflow tract, distal to the obstruction. Bottom: Aortic (Ao) pressure and sound. The murmur was of greatest amplitude within the outflow tract.

Results

In all patients with subaortic obstruction, irrespective of the cause (IHSS, a subvalvular membrane, or subvalvular tunnel), a systolic murmur of greatest amplitude was recorded within the outflow tract of the left ventricle (Figures 1-3). The murmur was of lower amplitude distal to the aortic valve and even lower or absent proximal to the obstruction.

One patient with IHSS (Patient 1) was catheterized before and after surgical correction. Prior to surgery, a pressure gradient was measured across the left ventricular outflow tract, and the ventriculogram and echocardiogram showed evidence of an intraventricular obstruction. A systolic murmur was shown in the outflow tract of the left ventricle. After surgical correction, intracardiac sound showed no murmur within the left ventricle during multiple withdrawals of the micromanometer from the apex of the left ventricle to the aorta. No pressure gradient was measured across the outflow tract, and the ventriculogram and echocardiogram showed no evidence of obstruction. The patient with entrapment of the catheter showed no systolic murmur within the outflow tract of the left ventricle (Figure 4).

Discussion

Identification of an ejection murmur within the left ventricular outflow tract and of an absent or lower amplitude murmur at the apex and distal to the aortic valve implies the presence of an intraventricular obstruction sufficient to cause a disturbance of flow. Turbulent eddies picked up by a phonocatheter do not propagate well upstream from a stenotic orifice.[9] Therefore, no murmur or only a faint murmur would be expected within the ventricle proximal to the subaortic obstruction. Within the outflow tract, an ejection murmur would be expected due to the local occurrence of a turbulent jet.[10] Distal to the point of peak turbulence, the murmur would gradually diminish in intensity as the magnitude of turbulence diminished.[10,11]

In spite of the reliable nature of cardiac catheterization for the diagnosis of subaortic stenosis, there frequently is an element of uncertainty about the validity of an apparent pressure gradient measured across the ventricular outflow tract. Entrapment of the catheter or catheter whip may simulate a pressure gradient. Measurement of intraventricular sound may validate the authenticity of a subvalvular gradient. The demonstration of an intracardiac murmur may also call attention to a subvalvular obstruction which is not severe enough to cause a prominent gradient.

Intracardiac phonocardiograms in patients with IHSS have been recorded by other investigators,[1,12] although their interpretation of the significance of the intracardiac murmur differed. Some believe, as we do, that a murmur of maximal

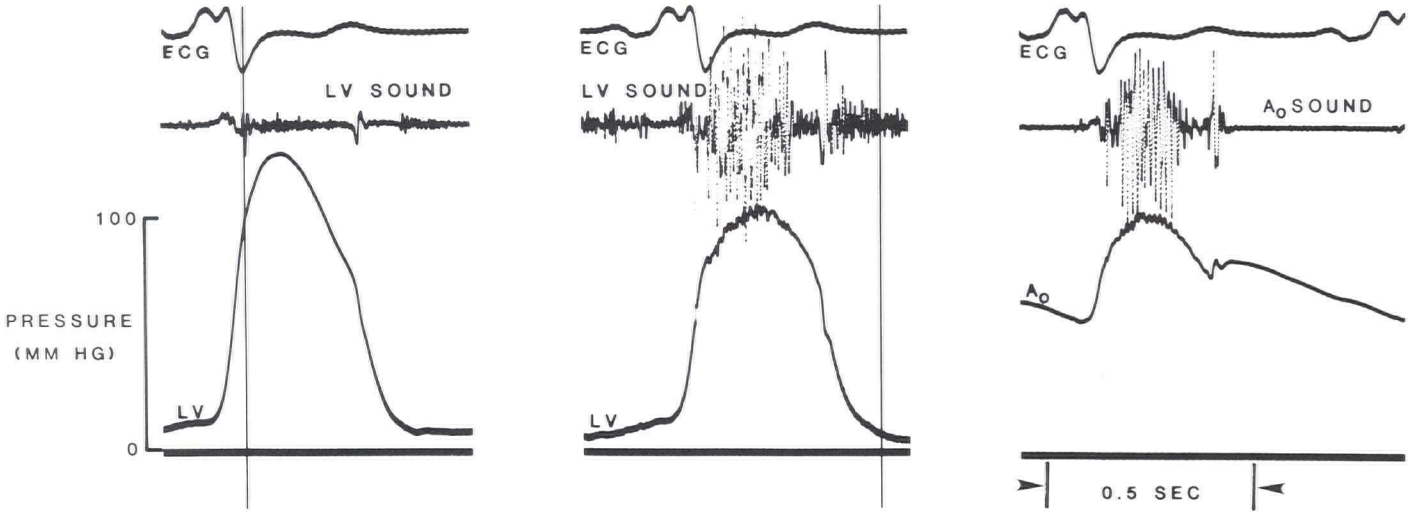

Fig. 3
Intracardiac pressure and sound recorded in a patient with a subvalvular membrane (Patient 6). Recordings are from the apex of the left ventricle (LV) (left), outflow tract (center), and aorta (Ao) (right), just distal to the aortic valve. The murmur was of greatest amplitude within the LV outflow tract.

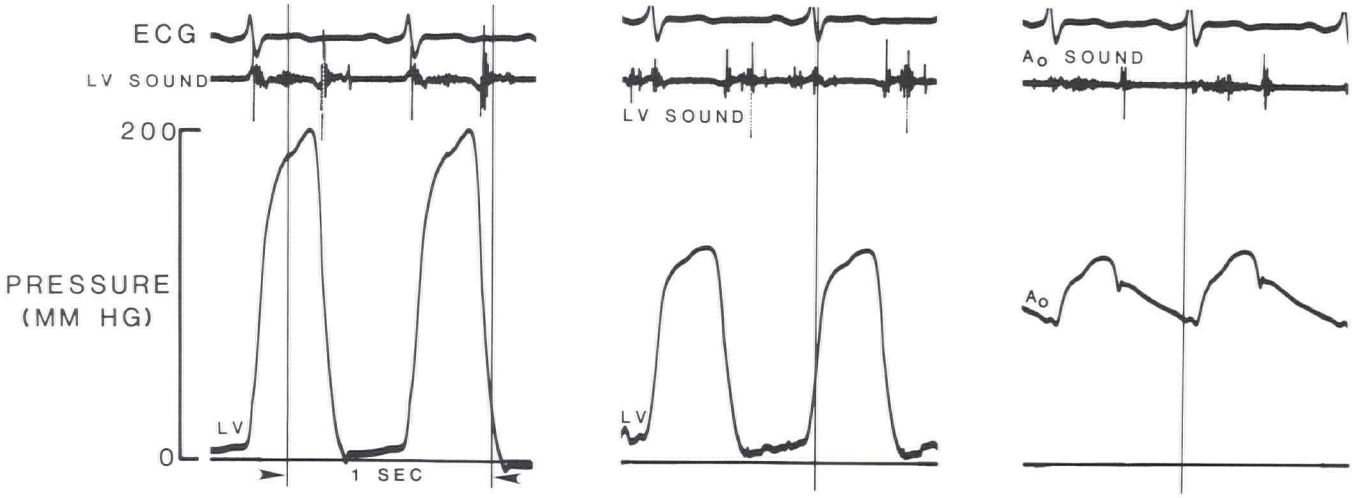

Fig. 4
Intracardiac pressure and sound in a patient in whom catheter entrapment occurred, resulting in an apparent intraventricular pressure gradient. No systolic murmur was recorded within the outflow tract of the left ventricle.

amplitude in the ventricular outflow tract and of lower amplitude in the aorta indicate that the murmur was ventricular in origin.[12] Others, whose patients with IHSS also had mitral regurgitation, indicated that the recorded intraventricular murmur was the regurgitant murmur, which was recorded with greater amplitude in the left atrium.

Despite these differing results, intracardiac phonocardiography has been shown to be a useful diagnostic technique in a variety of cardiac diseases, as it enables murmurs to be detected with greater intensity distal to a lesion.[13]

Summary

Intracardiac phonocardiograms were recorded in patients with various types of subaortic stenosis. In all cases, the systolic murmur was shown to be of greatest amplitude within the outflow tract of the left ventricle distal to the obstruction. Occasionally, such a murmur was recorded even in the absence of a prominent pressure gradient. In the presence of an apparent gradient caused by entrapment of the catheter, no murmur was recorded within the ventricular outflow tract. It appears, therefore, that intracardiac phonocardiography may assist in the verification of the presence of a subvalvular obstruction.

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