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Clinical, Electrocardiographic and Morphologic Features of Massive Fatty Deposits ("Lipomatous Hypertrophy") in the Atrial Septum

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Objectives. **This study examined the morphologic features and the clinical significance of massive fatty deposits in the atrial septum of the heart.**

Background. **Large deposits of adipose tissue in the atrial septum were first described in 1964 and have been referred to as "lipomatous hypertrophy" of the atrial septum. A relation between these fatty deposits and atrial arrhythmias has been suggested.**

Methods. **The thickness of the atrial septum cephalad to the fossa ovalis ranged from 1.5 to 6 cm in 91 patients and was ≥2 cm in 80 patients. This report focuses primarily on the latter 80 patients.**

Results. **The thickness of the atrial septum in the 80 patients correlated with body weight and the thickness of the adipose tissue in the atrioventricular groove and that covering the right ventricle. In 53 patients (67%), one or more of the four major epicardial coronary arteries were narrowed >75% in cross-sectional area by atherosclerotic plaque. Atrial arrhythmias were present in 31 patients (40%). Patients with larger deposits of fat (atrial septal thickness ≥3 cm) had a higher frequency of atrial arrhythmias (60% vs. 34%, $p < 0.01$). The atrial septum was significantly thicker in patients with atrial arrhythmia compared with those without atrial arrhythmias (2.9 vs. 2.3 cm, $p < 0.01$). Of the 28 patients with available electrocardiograms, 20 (71%) showed atrial arrhythmias (nine atrial premature complexes, seven atrial fibrillation, three atrial tachycardia, one ectopic atrial rhythm and one junctional rhythm).**

Conclusions. **Massive fatty deposits in the atrial septum are associated with large deposits of fat elsewhere in the body and other parts of the heart. They are frequently associated with atrial arrhythmias and atherosclerotic coronary artery disease.**

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In the western world there is an expectation among many that people gain weight with age. The increase in weight is primarily due to the deposition of fat in various locations in the body. The heart is not spared from the fatty deposits. Most often the fat in the heart is in the subepicardial adipose tissue, particularly in the areas where the epicardial coronary arteries are located. Another location for fatty deposits in the heart is the atrial septum. When the fatty deposits in the atrial septum are large, such deposits have been called "lipomatous hypertrophy of the atrial septum." Since the initial description of this entity in 1964 (1), several reports (2–20) describing relatively few cases have appeared. Some reports (2–4) have suggested that some cardiac arrhythmias, particularly those of atrial origin, may be a consequence of this fatty deposition in the atrial septum. This report analyzes a large group of patients with massive infiltration of the atrial septum by fat to discern if there were specific clinical or electrocardiographic features that could be attributed to these fatty infiltrates.

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Methods

Sources of patients. The files of the Pathology Branch, which include essentially only cases with cardiovascular disease, were searched for cases coded as "lipomatous hypertrophy of the atrial septum" or "atrial septal lipoma." Although the files include cases entered as early as 1953, the first case of lipomatous hypertrophy of the atrial septum was not coded until 1975. Since that time, 91 cases have been so coded and approximately 7,000 cases >15 years of age were accessioned in the Pathology Branch from 1975 to July 1992.

The hearts from all 91 patients were originally examined and coded by one of the authors (W.C.R.) and subsequently 74 of the 91 hearts were examined by the other author (J.S.). The hearts in the 91 cases were submitted by 19 different medical centers, including 26 from Suburban Hospital (Bethesda, Maryland), 14 from the District of Columbia Veterans Affairs Hospital, 11 from the National Naval Medical Center, 9 from Georgetown University Medical Center, 9 from the District of Columbia Medical Examiners' Office, 5 from the Washington Hospital Center, 3 from Franklin Square Hospital (Baltimore, Maryland), 2 from the Clinical Center of the National Institutes of Health, 2 from Sibley Hospital (Washington, D.C.) and 1 each from each of 10 other medical centers. The medical records from each of the 91 cases were reviewed and the actual electrocardiograms were obtained in 29 cases.

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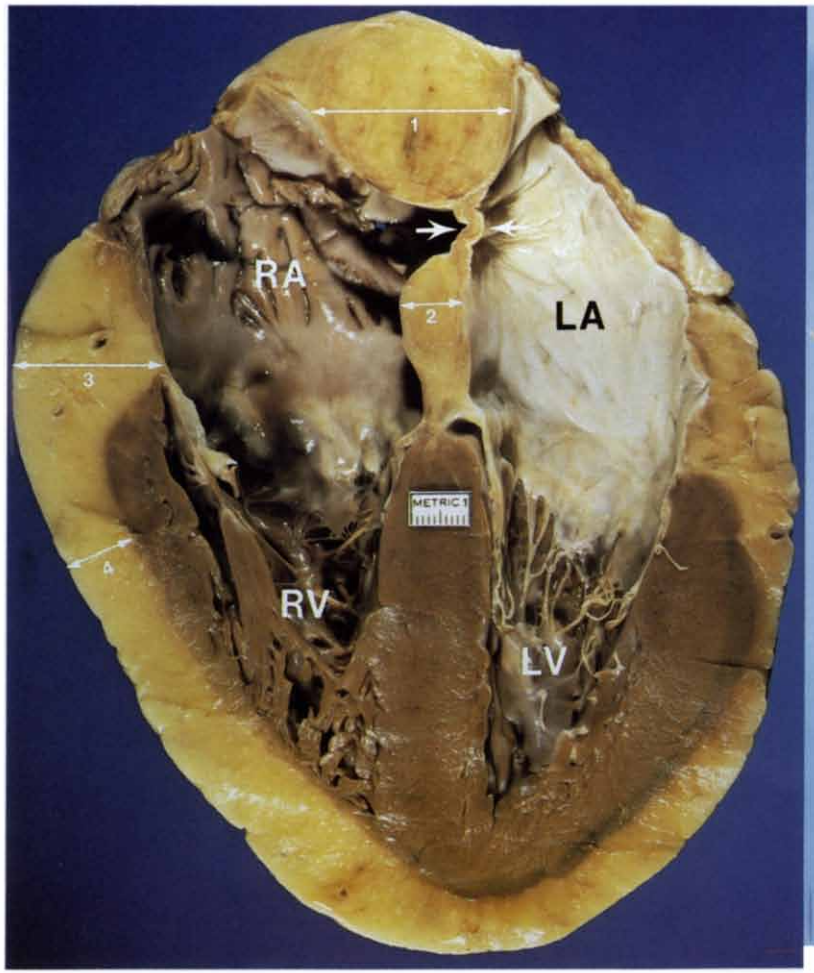


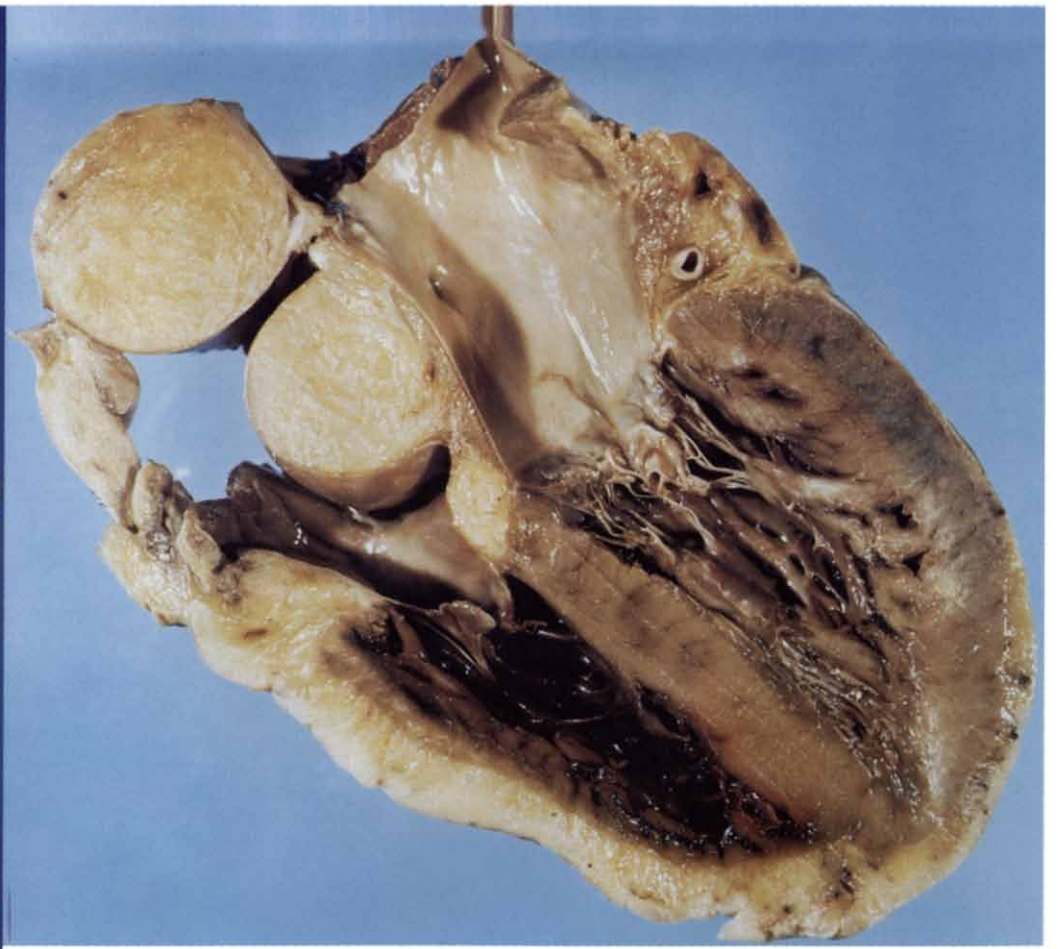


Figure 1 (left). Four-chamber view of the heart of a 70-year old man (NNMC# A86-42), showing the method used to measure the thickness of the cephalad portion of the atrial septum [1], the caudal portion of the atrial septum [2], the fat in the right atrioventricular groove [3] and the fat overlying the right ventricular wall [4]. LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle. The double arrowheads point to the fossa ovalis.

Figure 2 (right). Four-chamber view of the heart of a 74-year old woman (GT# 774-42). The caudal portion of the atrial septum is thicker than that in any of the other 90 cases.

JACC Vol. 22, No. 1
July 1993:226–38

Table 1. Clinical and Morphologic Findings in 11 Patients With Fatty Deposits in the Atrial Septum and an Atrial Septal Thickness <2 cm

Pt No.	Age (yr)/ Gender	HD in Life	AP	AMI	AA*	Htn	DM	Fatal CAD	HW (g)	Heart Floats	Thickness of Atrial Septum (cm)	≥1 CA With >75% ↓ in CSA by Plaque	LV Fibrosis	LV Necrosis
1	49/M	+	0	0	0	+	0	0†	580'	0	1.6	0	0	0
2	53/F	0	0	0	0	0	0	0	300‡	+	1.7	0	0	0
3	57/M	0	0	0	0	+	0	+	355	+	1.8	+	0	0
4	67/M	+	+	+	+	+	0	+	530	+	1.8	+	0	+
5	71/M	0	0	0	0	0	0	0	465	+	1.8	+	0	0
6	72/M	+	+	+	+	0	+	+	555	0	1.7	+	+	0
7	76/F	+	0	+	+	0	0	+	610	+	1.8	+	0	+
8	79/M	+	+	+	+	0	0	+	410	+	1.5	+	0	+
9	79/F	0	0	0	0	+	0	0	420	+	1.5	+	0	0
10	80/F	0	0	0	0	+	0	0	425	+	1.5	0	0	0
11	89/F	+	+	+	+	0	+	+	520	+	1.8	+	+	0
Total or mean value	70	6	4	5	5	5	2	6	470	9	1.7	8	2	3

*None had ventricular arrhythmias. †Died of aortic valve infective endocarditis. ‡Patient had cachexia and died of metastatic breast cancer. AA = atrial arrhythmia; AMI = acute myocardial infarction; AP = angina pectoris; CA = coronary artery; CAD = atherosclerotic coronary artery disease; CSA = cross-sectional area; DM = diabetes mellitus; F = female; HD = heart disease; Htn = systemic hypertension; HW = heart weight; LV = left ventricular; M = male; Pt = patient; 0 = absent; + = present; ↓ = decrease.

Methods of examining the hearts. Each heart was weighed on very accurate scales after fixation in formalin from 3 to 14 days and after carefully removing all portions of parietal pericardium and after removing the pulmonary trunk and ascending aorta by transverse incisions approximately 2-cm cephalad to the sinotubular junctions. Hearts received completely intact were placed in a large container of water to see whether or not they floated. (A floating heart is indicative of a very fatty heart [21].)

Each of the four major coronary arteries (right, left main, left anterior descending, left circumflex) was examined by transverse incisions, each about 5 mm apart, and the maximal degrees of cross-sectional area narrowing of each was recorded (0% to 25%, 26% to 50%, 51% to 75%, 76% to 100%). The cardiac ventricles were not opened in an entirely uniform fashion; they were opened by coronal, sagittal or transverse incisions, or a combination of these incisions. The maximal thickness of the fat in the right atrioventricular (AV) groove and that covering the right ventricular myocardium was measured as illustrated in Figure 1.

The atria were opened by a coronal incision, such that the midportion of the fossa ovalis of the atrial septum was incised. Measurements of the maximal thicknesses of the atrial septum both cephalad and caudal to the fossa ovalis were made after the incision through the midportion of the fossa ovalis (Fig. 1).

Statistical analysis. For each variable, the mean value and standard deviation was determined. Correlations were calculated between the thickness of the atrial septum and body weight, 12-lead QRS voltage and thickness of adipose tissue inferior to fossa ovalis, in the AV groove and overlying the right ventricular wall. Statistical analysis of the noncontinuous variables was done by the chi-square method. Continuous data were analyzed by the Student *t* test. A probability < 0.05 was considered significant.

Results

Atrial septal thickness cephalad versus caudal to the fossa ovalis. In all 91 patients, the thickness of the atrial septum cephalad to the fossa ovalis was always greater than that of the atrial septum caudal to the fossa ovalis. Either none or only minimal amounts of adipose tissue were present in the fossa ovalis. The maximal thickness of the cephalad portion of atrial septum ranged from 1.5 to 6 cm (mean 2.4) and that of the caudal portion of septum from 0.3 to 2.4 cm (mean 0.9). The 91 cases were divided into two groups on the basis of the maximal thickness of the cephalad portion of the atrial septum. One group consisted of 11 patients in whom the maximal atrial septal thickness ranged from 1.5 to 1.8 cm, and pertinent clinical and morphologic findings in these patients are detailed in Table 1.

The other group consisted of 80 patients in whom the maximal right to left thickness of the cephalad portion of atrial septum ranged from 2 to 6 cm (mean 2.5). The remainder of this report focuses on these 80 patients. Of the 80 patients, 69 (86%) had an atrial septum with a maximal thickness of 2 to 3 cm and 11 patients (14%) had an atrial septum with a maximal thickness >3 cm. Certain clinicopathologic findings in the patients with an atrial septum ≥2 cm are summarized in Table 2 and illustrated in Figures 1 to 11. The 80 patients (52 men, 28 women) ranged in age from 48 to 91 years (mean 69). Only 1 patient was <50 years of age and only 1 was >90 years of age; 12 patients were aged 51 to 60 years, 5 patients 81 to 90 years and 61 patients (76%) 61 to 80 years of age.

Table 2. Clinical and Morphologic Findings in 80 Patients With Massive Fatty Deposits in the Atrial Septum

	All Patients (n = 80)	Men (n = 52)	Women (n = 28)
Age (yr), range (mean)	48–91 (69 ± 9)	48–91 (68 ± 9)	53–86 (71 ± 9)
White/black	72/3	47/5	25/3
Heart disease in life	47/77 (61%)	30/49 (61%)	17 (61%)
Angina pectoris	19/77 (25%)	16/49 (33%)	3 (11%)
Myocardial infarction	20/77 (26%)	14/49 (29%)	6 (32%)
Congestive heart failure	21/77 (27%)	11/49 (22%)*	10 (36%)*
Sudden death	26/79 (33%)	21/51 (41%)*	5 (18%)*
Arrhythmias			
Supraventricular	31/77 (40%)	18/49 (37%)	13/28 (48%)
Ventricular	6/78 (8%)	6/50 (12%)	0 (0%)
Systemic hypertension	46/77 (60%)	31/49 (63%)	15 (54%)
Habitual alcoholism	10/76 (13%)	9/48 (19%)	1 (4%)
Diabetes mellitus	19/77 (25%)	15/49 (31%)	4 (14%)
Corticosteroid therapy	10/76 (13%)	6/48 (13%)	4 (14%)
Cancer			
All	28/78 (36%)	17/50 (34%)	11 (39%)
Fatal	22/28 (79%)	15/17 (88%)	7/11 (64%)
Body weight (kg), range (mean)†	55–125 (79 ± 14)	57–118 (82 ± 13)	55–125 (75 ± 16)
Height (cm), range (mean)†	145–193 (168 ± 12)	150–193 (173 ± 10)*	145–193 (162 ± 12)*
Cause of death			
Cardiac	37 (46%)	27 (52%)	10 (36%)
Vascular	10 (13%)	6 (11%)	4 (14%)
Noncardiovascular	33 (41%)	19 (37%)	14 (50%)
Death outside hospital	13/75 (17%)	10/47 (21%)	3 (9%)
Heart weight (g), range (mean)	300–915 (545 ± 125)	345–915 (566 ± 118)	300–880 (505 ± 134)
Heart floats in water	52/69 (75%)	35/48 (73%)	17/21 (81%)
No. of coronary arteries with >75% ↓ in CSA by plaque			
4	3 (4%) }	2 (4%) }	1 (4%) }
3	13 (16%) } 53 (67%)	9 (18%) } 41 (80%)*	4 (14%) } 12 (43%)*
2	18 (23%) }	16 (31%) }	2 (7%) }
1	19 (24%) }	14 (27%) }	5 (18%) }
0	27 (33%)	10 (20%)	16 (57%)
Coronary arteries with >75% ↓ in CSA by plaque			
Left main	4 (5%)	2 (4%)	2 (7%)
Left anterior descending	47 (59%)	38 (73%)*	9 (32%)*
Left circumflex	21 (26%)	14 (27%)	7 (25%)
Right	34 (43%)	27 (52%)*	7 (25%)*
Left ventricular fibrosis	22 (28%)	18 (35%)*	4 (14%)*
Left ventricular necrosis	15 (19%)	10 (19%)	5 (18%)
Mitral annular calcium	21 (26%)	14 (27%)	7 (25%)
Thickness of atrial septum (cm), range (mean)			
Cephalad portion	2–6 (2.5 ± 0.7)	2–5 (2.4 ± 0.5)*	2–6 (2.8 ± 0.9)*
Caudal portion	0.3–2.4 (1.0 ± 0.3)	0.4–1.5 (0.9 ± 0.2)	0.3–2.4 (1.0 ± 0.5)
Thickness of fat in atrioventricular groove, range (mean) (cm)	0.7–2.6 (1.7 ± 0.5)	0.7–2.6 (1.6 ± 0.5)	0.7–2.5 (1.8 ± 0.6)
Thickness of fat over the right ventricle, range (mean) (cm)	0.2–1.5 (0.7 ± 0.2)	0.3–1.5 (0.7 ± 0.2)	0.2–1.3 (0.7 ± 0.3)

*$p \leq 0.05$. †Data available in 40 patients. Abbreviations as in Table 1.

Small versus large septum. Comparison of the 59 patients with a smaller septum (2 to 2.9 cm) with the 21 patients with a larger septum (≥3 cm) disclosed significant differences in the frequency of male gender (73% vs. 43%), atrial arrhythmias (34% vs. 60%), systemic hypertension (71% vs. 55%), mean heart weight (520 vs. 565 g) (despite the smaller percent of men in the group with a larger heart) and a smaller quantity of cardiac fat overall as evidenced by the percent of hearts that floated in water (70% vs. 94%) (Table 3). Neither diabetes mellitus nor corticosteroid therapy had an effect on the thickness of the atrial septum. The average thickness of the septum in the 19 patients with diabetes mellitus was 2.4 cm and that in the 58 patients without diabetes was 2.6 cm. The mean thickness of the septum was 2.8 cm in the 10 patients on corticosteroid therapy and 2.5 cm in those not receiving corticosteroid therapy.

Coronary artery disease. Comparison of the 53 patients with significant coronary artery disease (one or more major epicardial coronary arteries narrowed >75% in cross-sectional area by atherosclerotic plaque at necropsy) with

JACC Vol. 22, No. 1
July 1993:226–38

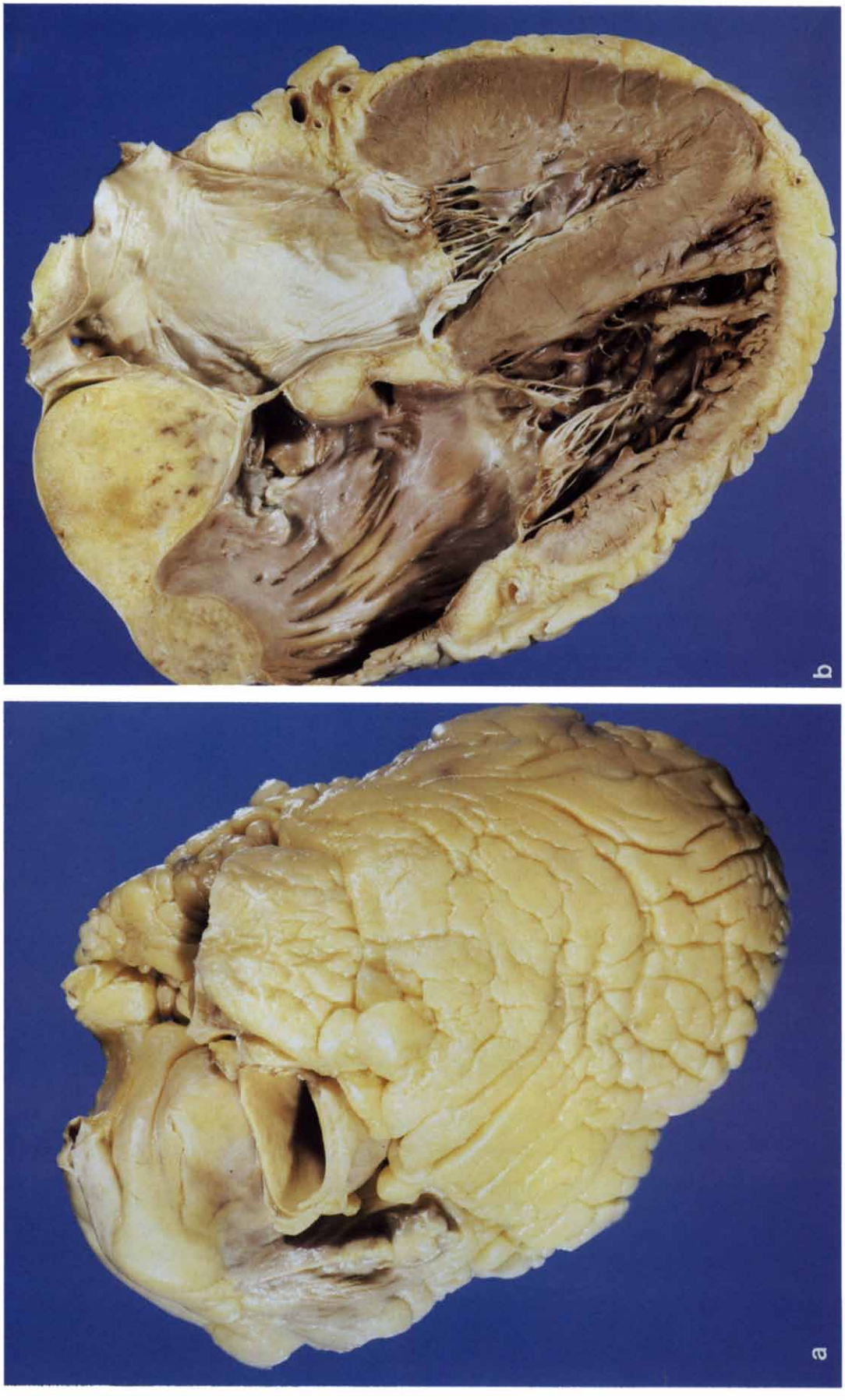


Figure 3. Exterior (a) and four-chamber (b) view of the heart of an 83-year old woman (NNMC# A88-43), showing massive amounts of epicardial adipose tissue covering the entire surface of both ventricles.

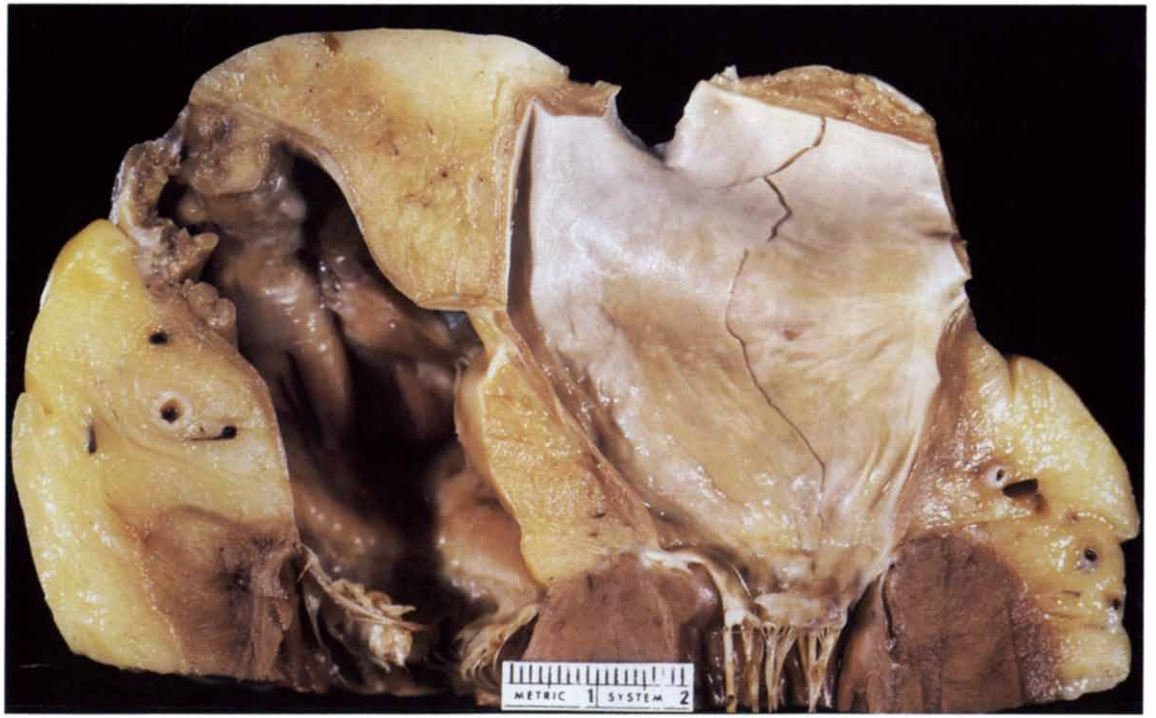


Figure 4 (left). Coronal section of the right and left atria and the atrial septum of the heart of a 71-year old woman (SV# 7/78).

Figure 5 (right). Four-chamber view of the heart of a 77-year old woman (NNMC# A89-33). The coronal section through the atrial septum is made slightly anterior to the fossa ovalis.

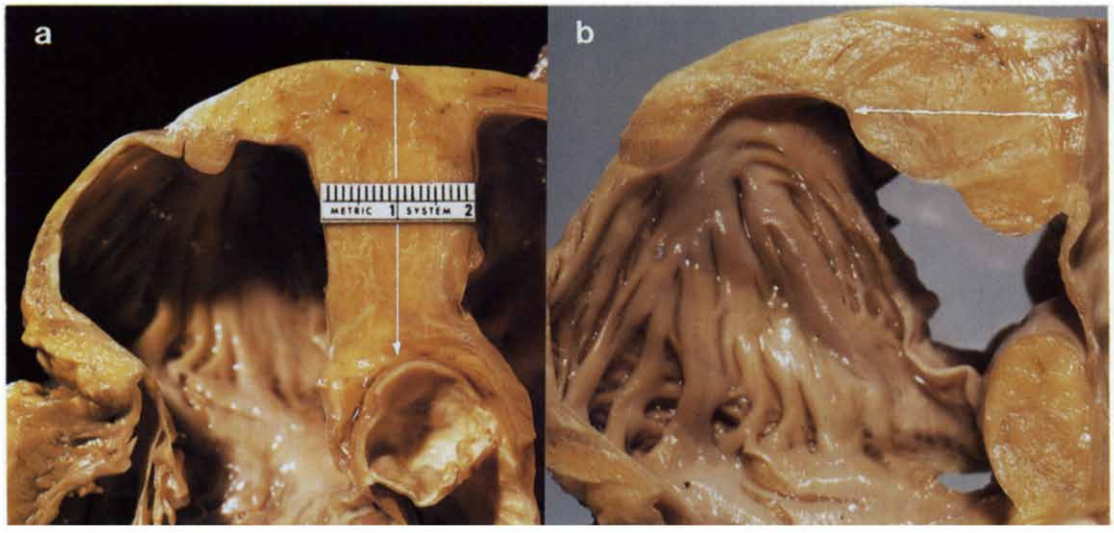


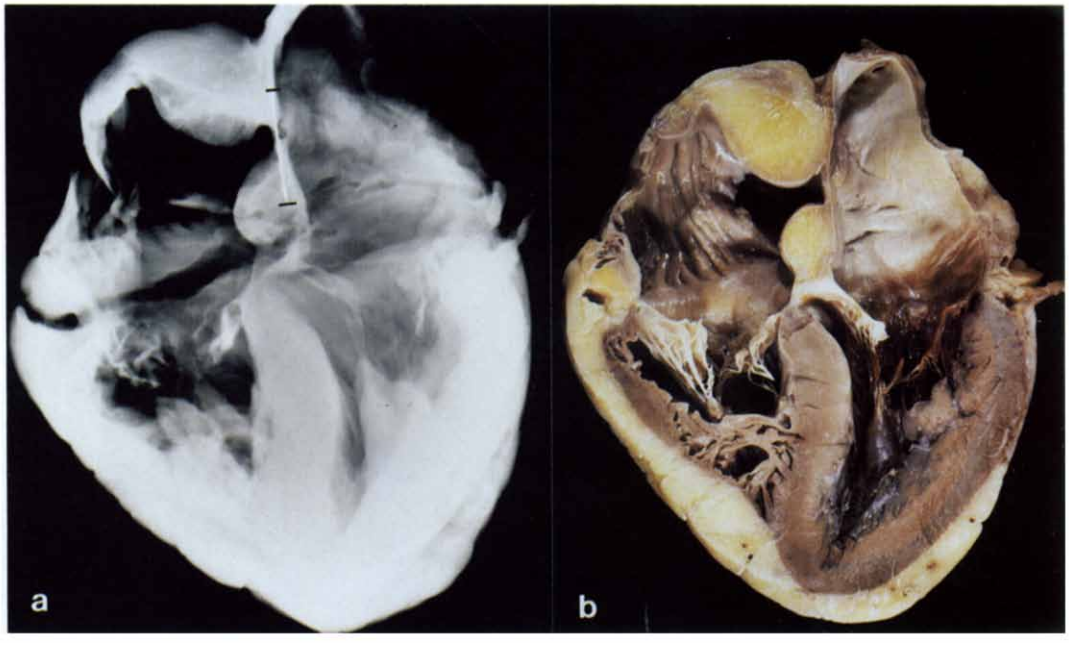
Figure 6. Close-up of the right atrium and atrial septum in a four-chamber view of the heart of a 76-year old woman (NNMC# A75-32). The coronal section is anterior to the fossa ovalis in **a** and at the level of the fossa ovalis in **b**. If the atrial septum is measured from its cephalad to its caudal extension as shown in **a (between the arrows)**, the thickness of the septum would be nearly twice that of the cephalad portion at the level of the fossa ovalis as shown in **b**. Measurements in the present study were all done as shown in **b**.

the 27 patients with insignificant coronary narrowing disclosed a significantly higher proportion of men (77% vs. 41%), a lesser frequency of fatal cancer (21% vs. 42%) and a smaller mean thickness of the atrial septum (2.4 vs. 2.9 cm). No significant difference in the frequency of atrial arrhythmias between the two groups was observed (41% vs. 38%).

Fatal cancer. Comparison of the 22 patients with fatal cancer with the 56 patients without cancer disclosed a significantly lower frequency of coronary artery disease in the cancer group (50% vs. 73%) and a smaller mean heart weight among the women (405 vs. 545 g). The mean thickness of the atrial septum was similar between these two groups (2.5 vs. 2.6 cm).

Atrial arrhythmias and conduction disturbances. Comparison of the 31 patients with atrial arrhythmias with the 46 patients without such arrhythmias disclosed a thicker atrial

Figure 7. Postmortem radiograph (**a**) and four-chamber view (**b**) of the heart of a 73-year old man (SH# A92-12). The needle (enclosed by **perpendicular lines**) in the atrial septum (**arrows**) measures 2.8 cm in length.



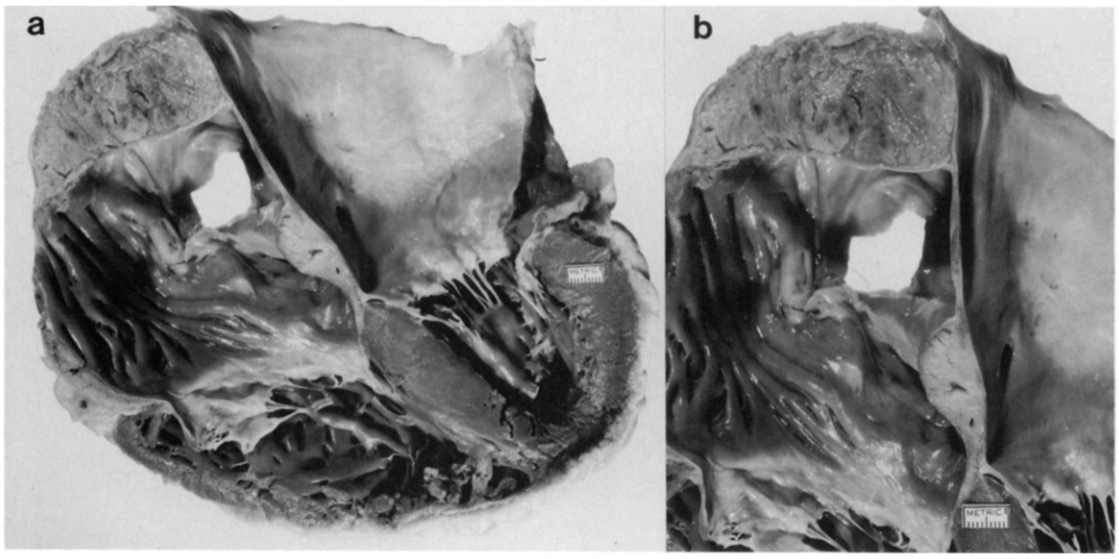
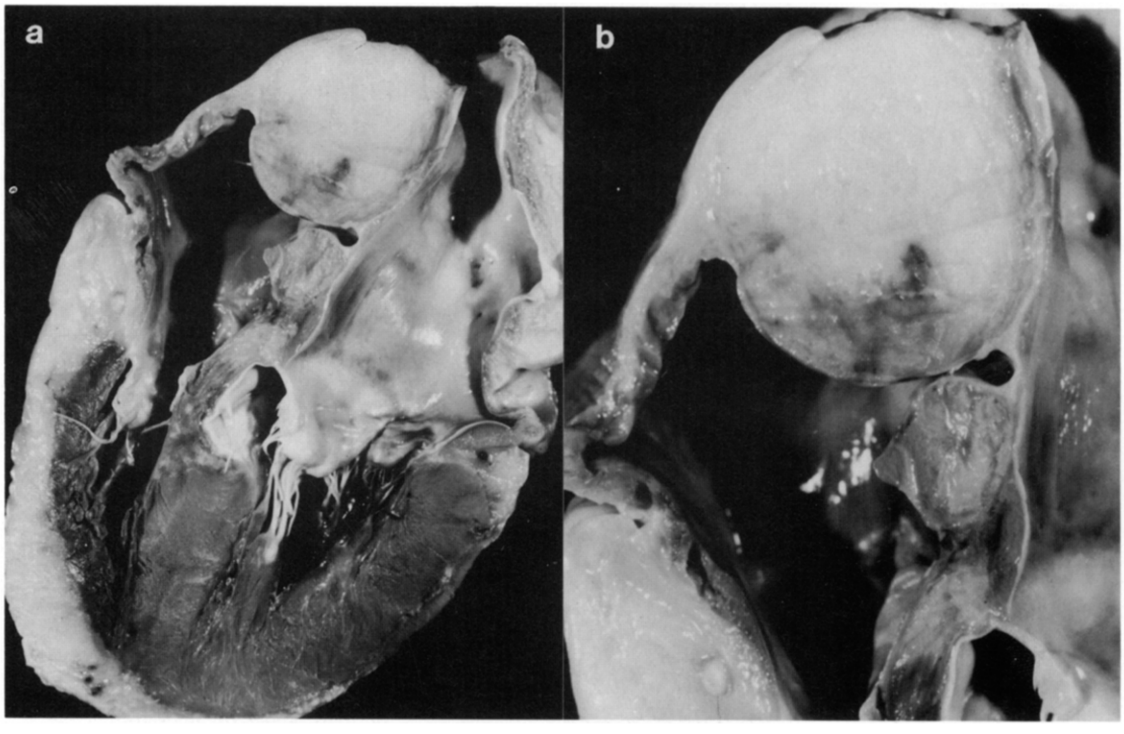


Figure 8. Four-chamber view of the heart of a 71-year old woman (**a**) and close-up of the right and left atria and atrial septum (**b**) (FSH# A-4088). Both atria are very dilated. The portion of the atrial septum cephalad to the fossa ovalis is 6 cm thick.

septum in the patients with arrhythmia (2.9 vs. 2.3 cm), a heavier heart in the women (545 vs. 470 g) and a higher frequency of signs and symptoms of congestive heart failure (42% vs. 17%) (Table 4). No significant differences occurred in the frequency of significant coronary artery disease (68% vs. 67%) or of myocardial infarction (45% vs. 37%) (Table 4).

Various electrocardiographic measurements were performed in 28 of the 80 patients with an atrial septum ≥2 cm in thickness (Table 5). Twelve (43%) of the 28 patients with an electrocardiogram had chronic atrial arrhythmias (atrial fibrillation in 8). Of the 18 patients with sinus, junctional or ectopic atrial rhythm, 9 (50%) had atrial premature complexes. Six patients (21%) had major conduction disturbances, but four of them had myocardial infarction. Total

Figure 9. Four-chamber view of the heart of a 78-year old man (**a**) and close-up of the right atrium and atrial septum (**b**).



JACC Vol. 22, No. 1
July 1993:226–38

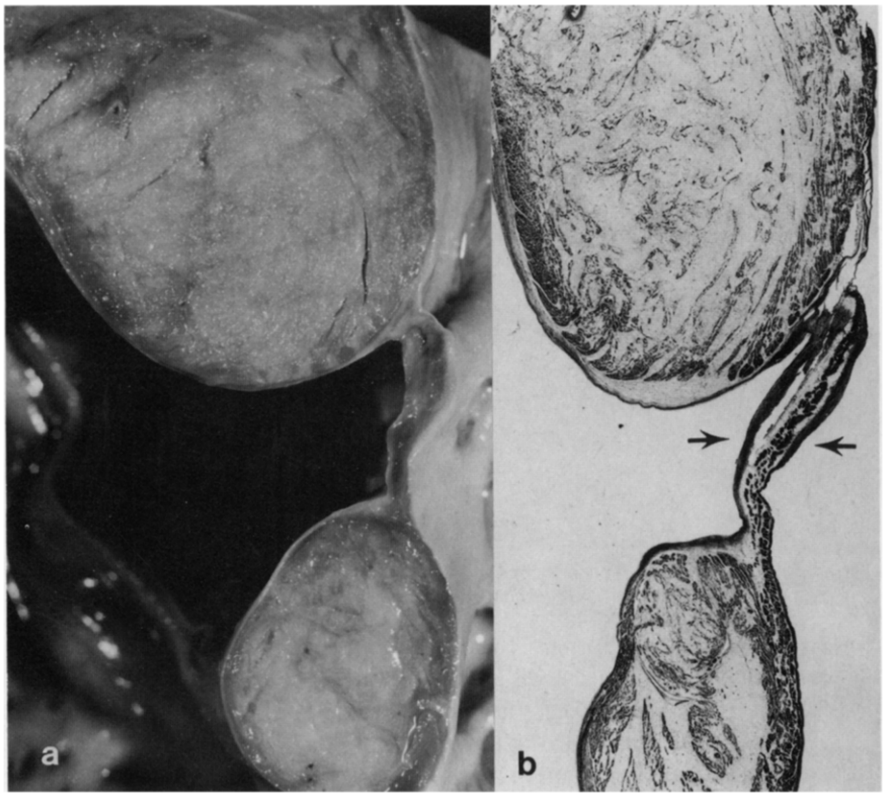


Figure 10. Gross (a) and histologic (b) section of the atrial septum of the heart of a 60-year old woman. Only minimal amounts of adipose tissue are present in the fossa ovalis (**arrows**). Movat stain ×25 (b).

12-lead QRS voltage measured by the method of Siegel and Roberts (22) ranged from 59 to 266 mm (mean 131 ± 51). Patients with an atrial septum ≥3 cm had a significantly higher frequency of atrial arrhythmias (75% vs. 18%) and larger total 12-lead QRS voltages (150 vs. 115 mm) than those of patients with an atrial septum <3 cm (Table 6).

Discussion

Measurement of atrial septal thickness. One difference in our study from those published previously on this subject is

Figure 11. Normal atrial septum (DCMEO 78-04-284) with a maximal thickness of 6 mm in its cephalad portion and no fatty deposit. The fossa ovalis membrane (**arrows**) measures <1 mm in thickness. LA = left atrium; RA = right atrium.

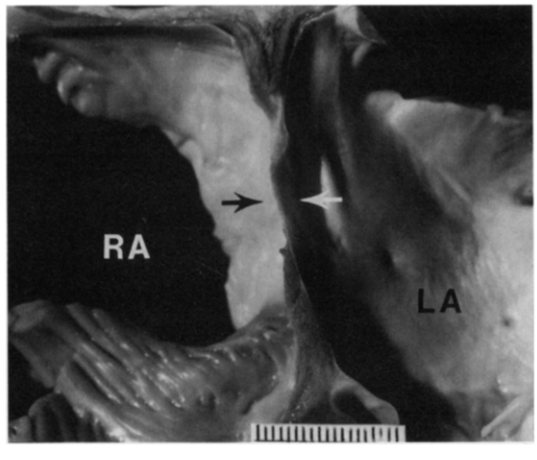


Table 3. Comparison of the Clinical and Morphologic Findings in Patients With Small (septal thickness <3 cm) and Large (septal thickness ≥3 cm) Fatty Deposits in the Atrial Septum

	Atrial Septal Thickness <3 cm (n = 59)		Atrial Septal Thickness ≥3 cm (n = 21)	
Age (yr), range (mean)	48–91 (68)		51–85 (71)	
Men	43 (73%)*		9 (43%)*	
Atrial arrhythmias	19/56 (34%)*		12/20 (60%)*	
Systemic hypertension	31/56 (55%)*		15/21 (71%)*	
Body weight (kg), range (mean)	55–95 (78)		55–125 (84)	
Heart weight (g), range (mean)	300–915 (520)*		335–880 (565)*	
Heart floats in water	37/53 (70%)*		15/16 (94%)*	
No. of coronary arteries with >75% ↓ in CSA by plaque				
4	2 (4%)	42 (71%)	1 (5%)	11 (52%)
3	10 (17%)		3 (14%)	
2	15 (25%)		3 (14%)	
1	15 (25%)		4 (19%)	
0	17 (29%)		10 (48%)	
LV fibrosis	17 (29%)		5 (24%)	
LV necrosis	12 (20%)		3 (14%)	
Thickness of atrial septum (cm) range (mean)				
Cephalad portion	2.0–2.9 (2.1)*		3.0–6.0 (3.6)*	
Caudal portion	0.3–1.3 (1.0)		0.6–2.4 (1.2)	
Thickness of fat in atrioventricular groove (cm), range (mean)	0.7–2.6 (1.7)		0.9–2.5 (1.9)	
Thickness of fat over the right ventricle (cm), range (mean)	0.2–1.3 (0.7)		0.4–1.5 (0.8)	

*$p < 0.05$. Abbreviations as in Table 1.

Table 4. Comparison of Patients With Massive Fatty Deposits in the Atrial Septum With and Without Atrial Arrhythmias

	Atrial Arrhythmia			
	Present (n = 31)		Absent (n = 46)	
Age (yr), range (mean)	52–84 (72)		48–91 (67)	
Male/female	18 (58)/13 (42%)		31 (67)/15 (33%)	
Systemic hypertension	18 (58%)		28 (61%)	
Angina pectoris	9 (29%)		10 (22%)	
Congestive heart failure	13 (42%)*		8 (17%)*	
Diabetes mellitus	9 (29%)		10 (22%)	
Corticosteroid therapy	5 (16%)		5/44 (11%)	
Cancer	14 (45%)		14 (30%)	
≥1 CA with >75% ↓ in CSA by plaque	21 (68%)		31 (67%)	
Heart weight (g), range (mean)				
Men	410–915 (605)		345–800 (585)	
Women	315–880 (545)*		300–680 (470)*	
Heart floats	17/25 (68%)		34/42 (81%)	
Maximal thickness of the atrial septum (cm)	2.0–5.5 (2.9)*		2.0–6.0 (2.3)*	
Mitral annular calcium	8 (26%)		12 (26%)	
Myocardial infarction				
Healed	8 (26%)	14 (45%)	9 (20%)	18 (40%)
Acute	4 (13%)		6 (13%)	
Both healed and acute	2 (6%)		3 (7%)	

*$p < 0.05$. Abbreviations as in Table 1.

the method chosen to measure the thicknesses of the atrial septum. In the present study, the atrial septum was incised in a coronal fashion, with the incision extending through the midportion of the fossa ovalis, which contains minimal amounts, if any, of fat and therefore is only ≈1 cm thick. By incising the atrial septum using the fossa ovalis as the landmark, the thickness of the cephalad portion was always greater than the thickness of the caudal portion of the septum. With this method of measuring the thickness of the atrial septum, 6 cm was the thickest and 1.5 cm was the thinnest atrial septum. Previous publications (5) have described larger atrial septa, but the method of measurement was never described precisely. If we had determined the thickness of the atrial septum by measuring, for example, the longitudinal thickness either anterior or posterior to the fossa ovalis, measurements two or more times as large as our maximal measurements would have resulted. The use of the fossa ovalis as the landmark for measuring atrial septal thickness also allows comparison of the necropsy measurements with those recorded by echocardiography-computed tomography and nuclear magnetic resonance (NMR) imaging.

Normally the atrial septum both cephalad and caudal to the fossa ovalis is <1 cm thick. In the present study, we focused primarily on patients with a maximal atrial septal thickness ≥2 cm. Because previous reports have included cases with <2 cm atrial septal thickness, we also included cases with maximal septal thickness ranging from 1.5 to 1.9 cm, so that these cases could be compared with others previously reported (Table 1).

Adipose tissue in other portions of the heart. When the atrial septum is massively infiltrated by fatty deposits, the amount of adipose tissue is always increased in other portions of the heart, mainly the subepicardial adipose tissue, particularly over the right ventricular wall and in the AV sulci. The fatty deposits may be so extensive that every square centimeter of ventricular myocardium is covered by adipose tissue. The huge deposits of fat in all portions of the heart made the heart in many of our patients lighter than water, such that 75% (52 of 69) of the hearts floated in water. The actual weight of the fat, measured in five of our patients, constituted 32% to 52% (mean 41%) of the total weight of the heart. The maximal thickness of the atrial septum in our patients with septa ≥2 cm correlated with the thickness of the subepicardial adipose tissue over the right ventricular myocardial wall ($r = 0.61$) and that in the AV sulcus ($r = 0.79$). Among our 80 patients, the body weight was available in 40 and the maximal thickness of atrial septum in these patients correlated with body weight ($r = 0.84$).

The adipose tissue in the heart may be the last site to disappear with weight loss. Support for this view is gained by the presence of huge quantities of cardiac fat in the 22 patients with fatal cancer, a number of whom were cachectic at necropsy. The maximal thickness of the atrial septum in the 22 patients with cancer was similar to that in the 56 patients without known cancer (2.5 vs. 2.6 cm).

In addition to the constant association of the massive atrial septal fatty deposits with massive deposits of fat in other portions of the heart and usually in other portions of the body, there also was near universal increase in heart weight: 77 (96%) of the 80 patients had an increased heart weight (>350 g in women, >400 g in men). Systemic hypertension, as might be expected because of the high prevalence of obesity, was present in 46 (60%) of 77 patients (Table 2). Significant atherosclerotic coronary artery disease was also common. Of the 80 patients, 53 (66%) had >75% narrowing in cross-sectional area of one or more major epicardial coronary arteries by atherosclerotic plaque and 33 (62%) of the 53 patients died from consequences of coronary artery disease.

Presence of atrial arrhythmias. Whether the frequency of atrial arrhythmias is greater in patients with massive atrial septal fatty deposits than in patients of similar age and gender without these deposits has been controversial. Among 122 cases of atrial septal fatty deposits reported by others (1–20), atrial arrhythmias of some type, including atrial premature complexes, were present in 56 (45%). Among our 80 patients with septa ≥2 cm thick, 31 (40%) had supraventricular arrhythmias. (This number and percent excludes atrial premature complexes.) In our patients, the frequency of atrial arrhythmias increased with increasing thickness of the atrial septa, such that 60% of the patients with an atrial septum ≥3 cm had atrial arrhythmias com-

Table 5. Electrocardiographic Findings in 28 Men and Women With Lipomatous Hypertrophy of the Atrial Septum

Pt No.	Age at Death (yr)/Gender	Interval From ECG to Death (days)	Heart Rate (beats/min)	Heart Rhythm	Interval (ms)			Conduction Abnormality	QRS Voltage (mm)			APC	LAA	HW (g)	LV Fibrosis	LV Necrosis	Thickness of Atrial Septum (cm)	≥1 CA >75% ↓ in CSA by Plaque	Cause of Death
					PR	QRS	QTc		12-Lead	I,II, III,R, L,F	V_1–V_6								
								Men											
1	48/M	94	56	S	14	[illegible]	42	0	97	34	63	0	0	490	0	0	2.5	+	CAD
2	51/M	7	85	S	18	8	36	0	170	59	111	0	+	630	0	+	2.0	+	CAD
3	57/M	57	110	S	16	8	37	0	155	54	101	+	0	685	0	0	3.0	0	Cancer
4	64/M	23	82	S	15	9	28	0	139	59	80	+	+	470	0	0	2.5	0	Suicide
5	65/M	10	80	AF	—	12	—	Left BBB	241	95	146	–	–	450	+	+	3.0	+	CAD
6	68/M	1	56	S	18	10	44	0	93	34	59	+	+	490	0	0	2.0	+	CAD
7	70/M	3	72	J	17	14	44	Right BBB	118	53	65	0	+	520	0	+	2.5	+	CAD
8	70/M	1	124	AF	—	10	30	0	147	60	87	–	–	795	0	0	5.0	0	Infection
9	72/M	11	170	AT	—	11	26	IVCD	134	49	85	–	–	710	+	0	2.0	+	CAD
10	73/M	41	95	S	18	15	37	Right BBB,LPFB	94	49	45	+	+	690	+	0	2.9	+	Cancer
11	73/M	89	84	EA	22	13	41	Left BBB	112	50	62	+	–	550	0	0	3.4	+	AAA
12	84/M	5	120	AT	—	8	—	0	157	43	114	–	–	410	0	0	3.5	+	Cancer
Subtotal	67 ± 10/12M	29 ± 9	95 ± 30	6S	18 ± 2	10 ± 2	37 ± 6	5	140 ± 43	54 ± 17	87 ± 29	5 (63%)	6/7	576 ± 129	3	3	2.9 ± 0.9	9 (75%)	
								Women											
13	59/F	6	136	S	16	8	36	0	90	49	41	+	+	410	+	0	2.0	+	Cancer
14	60/F	1	125	S	16	9	36	0	91	20	71	0	0	680	+	+	3.0	+	CAD
15	70/F	41	82	S	17	10	44	0	127	60	67	+	+	550	0	+	2.0	+	CAD
16	71/F	9	89	S	18	9	38	0	125	52	67	0	+	630	0	+	2.2	+	CAD
17	72/F	15	85	S	20	10	40	0	93	23	70	0	+	330	0	0	2.0	0	Cancer
18	73/F	3	80	AF	—	9	40	0	158	52	106	–	–	680	0	0	2.7	+	CAD*
19	74/F	130	78	AF	—	9	—	0	133	51	82	–	–	540	0	0	3.5	0	Cancer
20	76/F	11	120	AT	—	8	—	0	266	80	186	–	–	450	0	0	3.0	0	—
21	77/F	6	146	AF	—	8	27	0	75	20	55	–	–	530	+	0	3.0	+	Infection
22	77/F	16	105	S	19	8	28	0	138	40	98	+	+	440	0	0	2.0	0	Leukemia
23	78/F	13	117	S	20	7	—	0	121	41	80	0	+	410	0	0	2.5	0	COPD
24	78/F	2	155	AF	—	10	—	0	110	34	76	–	–	540	0	0	3.3	0	Cancer
25	79/F	11	92	S	21	9	42	LAFB	88	50	38	0	+	420	0	0	2.0	+	COPD
26	79/F	455	100	S	20	8	38	0	217	71	146	0	+	500	0	0	3.5	0	Stroke
27	80/F	3	120	S	20	7	32	0	59	27	32	+	0	350	0	0	2.0	+	Cancer
28	83/F	39	132	AF	—	7	27	0	89	26	63	–	–	575	0	0	4.0	+	COPD
Subtotal	74 ± 7/16F	21 ± 16	110 ± 27	10S	19 ± 2	9 ± 1	36 ± 6	1	124 ± 53	43 ± 18	81 ± 39	4 (40%)	8/10	502 ± 108	3	3	2.7 ± 0.7	9 (56%)	
Total	70 ± 9/28	24 ± 9	103 ± 28	16S	18 ± 2	9 ± 2	36 ± 6	6 (18%)	131 ± 51	83 ± 36	47 ± 18	9 (50%)	14/17	545 ± 125	6	6	2.8 ± 0.7	18 (64%)	

*Died after mitral valve replacement for mitral regurgitation secondary to papillary muscle dysfunction. Subtotal and total values are presented as mean value ± SD or number (%) of patients. AAA = abdominal aortic aneurysm; AF = atrial fibrillation; APC = atrial premature complex; AT = (multifocal) atrial tachycardia; B = black; BBB = bundle branch block; COPD = chronic obstructive pulmonary disease; EA = ectopic atrial; ECG = electrocardiogram; IVCD = intraventricular conduction delay; J = junctional; LAA = left atrial abnormality; LAFB = left anterior fascicular block; LPFB = left posterior fascicular block; S = sinus; other abbreviations as in Table 1.

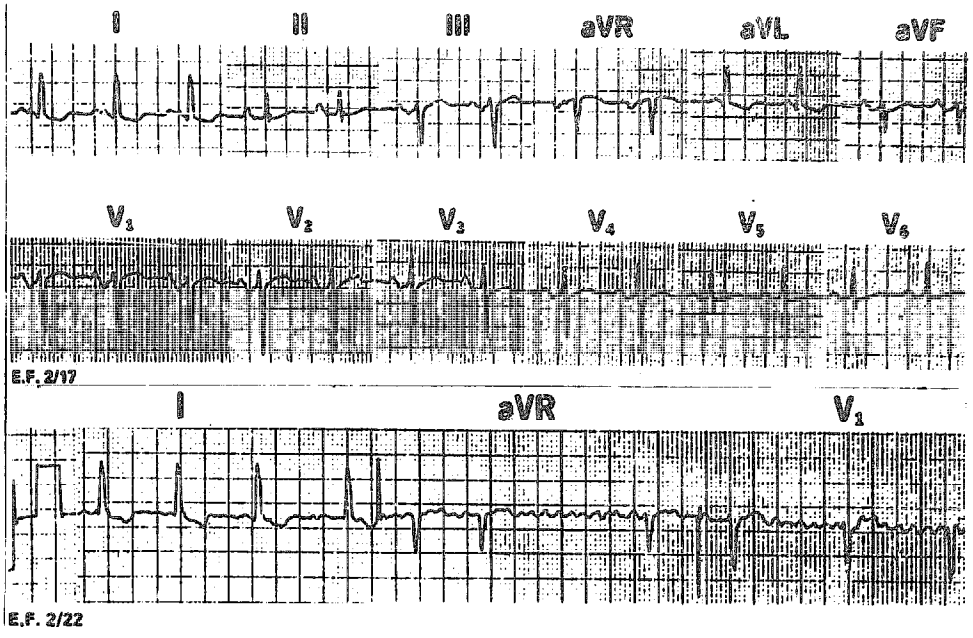


Figure 12. Electrocardiographic recordings obtained 5 days apart in a 74-year old white woman who died of lung cancer. At necropsy, the heart weighed 540 g, the atrial cavities were mildly enlarged and there were no scars in the left ventricular myocardium. The thickness of the atrial septum is 5.4 and 1.4 cm cephalad and caudal, respectively, to the fossa ovalis. **Upper two tracings,** Typical "dome and dip" P waves in sinus rhythm; **Lower tracing,** The rhythm is now atrial fibrillation.

pared with only 34% of the patients with an atrial septum 2 to 2.9 cm thick ($p < 0.01$). Furthermore, in the 31 patients with atrial arrhythmias the atrial septum was thicker than in patients without these arrhythmias (2.9 vs. 2.3 cm, $p < 0.01$) (Table 4). Finally, the similar frequency of significant coronary artery disease or myocardial infarction in the patients with and without atrial arrhythmias strongly supports the view that the atrial arrhythmias result in some way from the massive fatty deposits in the atrial septum.

Table 6. Comparison of the Clinical and Morphologic Findings in 28 Patients With Small (septal thickness <3 cm) and Large (septal thickness ≥3 cm) Fatty Deposits in the Atrial Septum in Whom a 12-Lead Electrocardiogram Was Available

	Atrial Septal Thickness <3 cm (n = 16)	Atrial Septal Thickness ≥3 cm (n = 12)
Age (yr) (mean)	(69)	(73)
Gender		
Men	7	5
Women	9	7
Systemic hypertension	10 (63%)	9 (75%)
Interval ECG to death (days)	19*	32*
Heart rhythm		
Sinus	13 (82%)*	3 (25%)*
Junctional	1 (6%)	0
Atrial tachycardia	1 (6%)	2 (17%)
Atrial fibrillation	1 (6%)	6 (50%)
Ectopic atrial rhythm	0	1 (8%)
Any atrial rhythm other than sinus	3 (18%)*	9 (75%)*
Conduction abnormality		
QRS voltage		
12-lead	115*	150*
Precordial leads	46	51
Limb leads	69*	99*
Heart weight (g)	515	520
LV fibrosis	3	3
LV necrosis	4	2
Thickness of atrial septum (cm)	2.2*	3.4*
≥1 CA with >75% ↓ in CSA by plaque	12 (75%)	6 (50%)

*$p = 0.05$. Abbreviations as in Table 1.

Kluge (2) was the first to mention a possible association between atrial arrhythmias and massive fatty deposits in the atrial septum. He described a 64-year old man with a 3-cm thick atrial septum and atrial tachycardia. The patient also had chronic obstructive pulmonary disease. Hutter and Page (4) described supraventricular arrhythmias in all 10 of their patients with an atrial septal thickness of 1 to 4 cm. Eight had premature atrial complexes that were often multifocal, three had wandering atrial pacemaker, three had multifocal atrial tachycardia and two had paroxysmal atrial tachycardia. One of the 10 patients had sick sinus syndrome and another 2 had atrial fibrillation. In five patients a peculiar P wave configuration (dome and dip P wave) was seen. We found similar P waves in 13 (67%) of our 16 patients in sinus rhythm (Fig. 12); 1 of our 13 patients had P waves suggestive of interatrial conduction block. At necropsy, the left atrium was dilated in only 1 (8%) of the 13 patients with sinus rhythm and an abnormal P wave configuration. Erhardt (15) speculated that the abnormal P waves in these patients result from normal downward activation of the right atrium from the sinus node, whereas the left atrium is electrically activated later in an upward fashion from the AV node. Four of the six patients reported on by Klein and Schaefer (17) with massive atrial septal fat diagnosed at necropsy had ECG abnormalities (intermittent sinoatrial block in two patients and atrial tachycardia and paroxysmal atrial fibrillation in one patient, and incomplete right bundle branch block and first degree

JACC Vol. 22, No. 1
July 1993:226–38

AV block in one). Only one patient had atherosclerotic coronary artery disease.

Other possible effects. Atrial arrhythmias appear to be the only functional consequence of massive fatty infiltrates in the atrial septum. Although other reports (6) have mentioned the possibility of obstruction to blood flow in the superior vena cava, coronary sinus, right pulmonary veins and right atrium, such obstruction has never been proved hemodynamically and none of our patients, even those with the thickest septa, had anatomic evidence of functional compression of adjacent vascular structures.

A potential danger of massive fatty infiltrates in the atrial septum is their confusion with neoplastic infiltration of the septum. Indeed, two patients have been reported (7,8) to have operative excision of the fatty mass in the atrial septum because cancer was suspected.

Diagnosis and nomenclature. In vivo diagnosis of massive fatty deposits in the atrial septum was reported first in 1982 with the use of computed tomography (13). Since then, a number of reports have described the diagnostic usefulness of echocardiography (8–12), computed tomography (11,12) and nuclear magnetic resonance imaging (8,10–12).

The best name for the massive fatty deposits in the atrial septum is still debated. We prefer the simple phrase "massive fatty deposits in the atrial septum" because it best describes the abnormality. The most common phrase is "lipomatous hypertrophy of the atrial septum," but the word "lipomatous" is incorrect because the fatty infiltrates are clearly not lipomas. In our view, the word "hypertrophy" should not be used to describe an infiltrate that should not be there in the first place. Thus, we suggest the simple descriptive phrase "massive fatty deposits in the atrial septum."

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