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Increased FDG uptake in the wall of the right atrium in people who participated in a cancer screening program with whole-body PET

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The purpose of this study was to evaluate the characteristics of patients who showed increased FDG uptake in the wall of the right atrium.

We have encountered 10 patients with increased activity in the wall of the right atrium among a total of 2,367 examinees who participated in our cancer screening program with whole-body PET. The mean age of these examinees was 62.9 yr, higher than that of the total population. All suffered from cardiac disorders, especially atrial fibrillation. FDG accumulated almost exclusively in the wall of the right atrium, whereas only slight activity was seen in the wall of the left atrium. Although the average size of the right atria was significantly enlarged, left atria were more severely dilated than right ones. Therefore overload does not seem to account for the FDG accumulation in the wall of the right atrium.

In conclusion, the increased activity in the wall of the right atrium was a rare finding that was made in older people who suffered from cardiac disease. Although the mechanism of induction of the high metabolic state of glucose in the wall of the right atrium remains unclear, this unusual activity would be another false positive finding in cancer screening with whole-body FDG PET.

Key words: fluorine-18 fluorodeoxyglucose (FDG), right atrium, atrial fibrillation

INTRODUCTION

THE ENERGY METABOLISM of cardiac ventricles, especially the left ventricle, has been extensively studied and the main source of energy is fatty acid and glucose.[1] Since normal myocardium with sufficient blood perfusion produces energy mainly by metabolizing fatty acids in a fasting state, the myocardium would not show any marked F-18 fluorodeoxyglucose (FDG) uptake, and the heart is usually only faintly visualized if FDG is administered during a fasting state.

When cancer screening tests are performed with FDG PET, cancer lesions may be detected if the physiological accumulation of FDG in normal organs is kept as low as possible. We therefore performed the whole body FDG tests during a fasting state of at least four hours to suppress FDG uptake in the heart.[2]

So far we have examined over 2,000 cases in the fasting state, and we have sometimes experienced cases that show increased activity in the walls of the cardiac chambers. Although left ventricular walls were visualized in most of these cases, we occasionally encountered cases with high FDG uptake in the walls of the right atria.[3]

It is known that FDG accumulation in the left ventricular walls are facilitated in the ischemic condition even if the examinee were in a fasting state,[4] but, because accumulation in the walls of the right atria has not been investigated until now, we evaluated the clinical characteristics of these rare cases.

MATERIAL AND METHODS

Subjects

We examined 2,367 cases (1,523 men, 844 women, male : female, 0.64 : 0.36; age, mean ± SD, 52.4 ± 10.2 yr)

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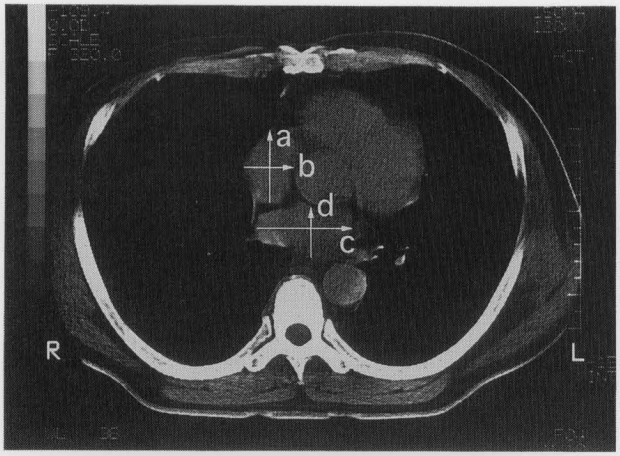


Fig. 1 Atrial size on CT image.
right atrial size: a × b, left atrial size: c × d

Table 1 Cardiac disease and medication

No.	age, sex	cardiac disease	cardiac medication
1	64 M	Af (chronic)	verapamil, pilsicainide
2	59 M	HF, TR, MR, complete AV block	nifedipine
3	57 M	Af (chronic)	metildigoxin, disopyramide
4	68 M	Af (chronic)	carvedilol
5	50 M	Af (paroxymal)	pilsicainide, disopyramide
6	48 F	Af (chronic)	metildigoxin, disopyramide
7	75 M	ASD	metildigoxin, nifedipine
8	72 M	MSR, Af (chronic)	none
9	70 M	Af (chronic)	atenolol
10	66 M	OMI (A-S), Af (chronic)	metildigoxin, diltiazem

M: male, F: female, Af: atrial fibrillation, HF: heart failure, TR: tricuspid regurgitation, MR: mitral regurgitation, AV: atrioventricular, ASD: atrial septal defect, MSR: mitral stenosis and regurgitation, OMI: old myocardial infarction, A-S: anteroseptal area

by whole-body FDG PET for cancer screening between October, 1994 and January, 1998. We reviewed the findings of their whole-body FDG PET tests and selected the cases with increased activity in the wall of the right atrium. The selected cases were examined for the presence of cardiac disorders, and ECG findings and cardiac medication were recorded. Their atrial size on chest CT was calculated. The blood sugar level, the serum concentration of free fatty acid and the percentage of hemoglobin A_{1C} (HbA_{1C}) were also measured. The sampling of blood was performed just before the emission scans of FDG PET tests. Our cancer screening protocols have been approved by the Ethical Committee of HIMEDIC Imaging Center at Lake Yamanaka, and informed consent was obtained from all examinees.

FDG PET studies

A PET study was carried out 45 to 60 minutes after the administration of 260 to 370 MBq of FDG during a fasting state of at least four hours. PET images were obtained with ECAT EXACT47 whole-body scanners (Siemens/CTI, Knoxville, TN). Emission scannings were performed from the level of the pelvis to the level of the maxilla, divided into 4 or 5 bed positions. No transmission scan for attenuation correction was performed to save imaging time.[5] Coronal and transaxial images of the whole body of each patient were reconstructed. The activity of the walls of cardiac chambers was visually evaluated by observing both coronal and transaxial images.

Chest CT studies

CT images of the chest were obtained with Super Helix TCT 900S (Toshiba, Tokyo, Japan). The atrial size was calculated by the product of the long axis (cm) and the short axis (cm) measured on the slice at the level of the aortic valve (Fig. 1). The normal atrial size was calculated with the data for 50 healthy Japanese subjects.

Statistical analysis

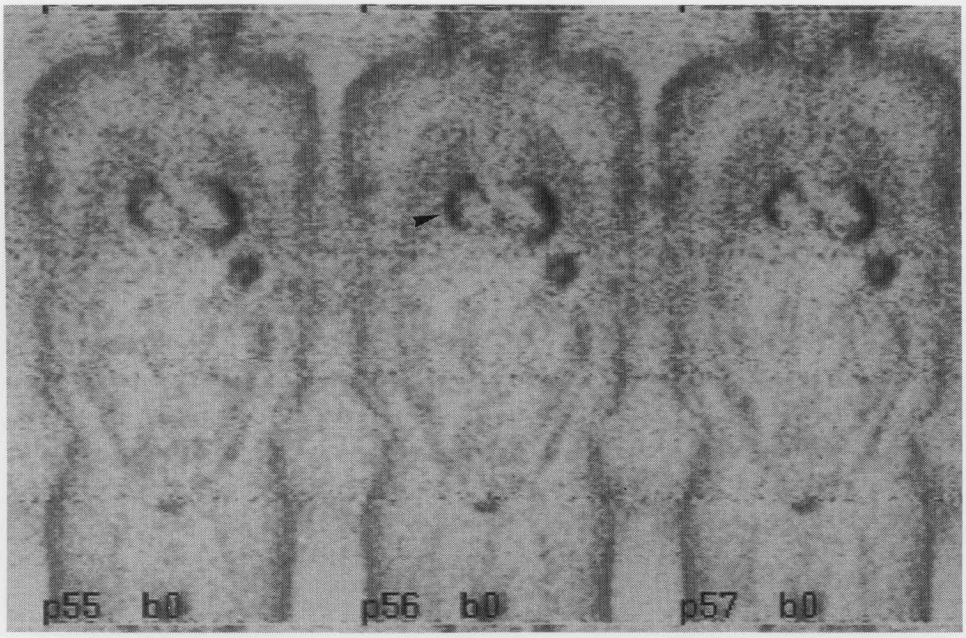
The male to female ratio of selected cases was compared with that of our screening population by the test for the proportion according to binominal distribution. The mean age and the results of blood chemistry tests were compared with those of the total population by the test for the mean. $P < 0.05$ was considered significant. Data were expressed as the mean ± SD.

RESULTS

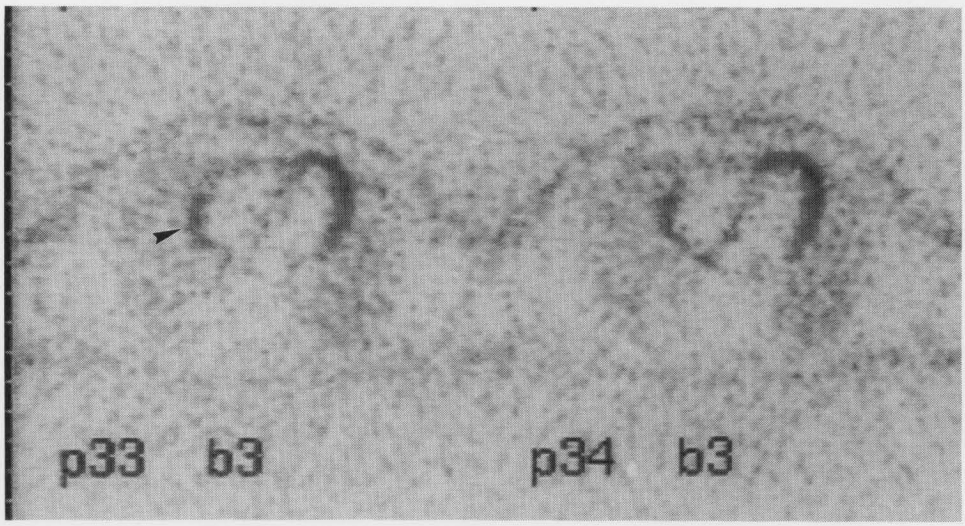
Increased activity in the right atrial wall was found in 10 (9 male and 1 female) of 2,367 cases. The male to female ratio was not significantly higher than that of the total population ($p = 0.07$). Their mean age was 62.9 ± 8.7 yr, which was significantly higher than that of the total population ($p < 0.01$). All 10 cases suffered from cardiac disorders (Table 1). Eight suffered from atrial fibrillation, one had congestive heart failure with valvular disease, and the other had atrial septal defect. Nine of 10 patients were receiving cardiac medical treatment. One patient suffering from atrial fibrillation had experienced an episode of myocardial infarction. No remarkable ischemic findings were recognized on the ECG tests of the others. The findings of atrial fibrillation were noted on the ECG tests in 11 cases from our screening population, therefore 73% (8/11) of cases with atrial fibrillation showed increased activity in the right atrial wall.

FDG PET studies

Accumulation in the wall of the right atrium was visualized in the shape of an arc in the right inferior mediastinum (Fig. 2). When compared with CT images taken on the same day, the activity was found to correspond to the lateral wall of the right atrium. In the ten patients with FDG accumulation in the wall of the right atrium, the left



a



b

Fig. 2 No. 2 (59 M). The coronal images (a) showed an arc shape of activity (arrowhead) in the mildly right aspect of the inferior mediastinum. This unusual activity (arrowhead) was located in the right posterior aspect of the left ventricular wall on the transaxial images (b). It corresponded to the wall of the right atrium.

atria were faintly visualized in only three cases (Table 2). None of the ten cases showed FDG accumulation in the right ventricular wall. FDG uptake in the left ventricular wall, however, was noted in eight patients although we tested them in the fasting state.

Size of cardiac atria

The results are shown in Table 3. The mean size of the right atrium was 22 ± 6 cm^2, which was significantly greater than that of a healthy Japanese population (10 ± 2 cm^2) ($p < 0.01$). The mean size of the left atrium was 42 ± 15 cm^2, which was also significantly enlarged compared to the data on healthy Japanese (14 ± 3 cm^2) ($p < 0.01$). Left atria, however, were more severely dilatated than right ones.

Blood chemistry studies

The results are shown in Table 4. The mean blood sugar level of the ten cases was 99 ± 19 mg/d*l*, which was significantly higher than in the general population (90 ± 8 mg/d*l*, $p < 0.01$). The mean serum concentration of free fatty acid was similar to that of the general population

Table 2 FDG uptake in the walls of the cardiac chamber

No.	RA	LA	RV	LV
1	+	±	−	+
2	+	−	−	+
3	+	−	−	−
4	+	−	−	−
5	+	±	−	+
6	+	±	−	+
7	+	−	−	+
8	+	−	−	+
9	+	−	−	+
10	+	−	−	−

RA: right atrium, LA: left atrium, RV: right ventricle, LV: left ventricle, −: no FDG uptake, ±: slight FDG uptake, +: FDG uptake

Table 3 The size of cardiac atria

No.	RA size (cm^2)	LA size (cm^2)
1	20	29
2	25	41
3	23	36
4	28	48
5	17	32
6	9	16
7	22	45
8	27	52
9	19	40
10	30	77

(0.34 ± 0.25 vs. 0.42 ± 0.14 mEq/*l*, respectively; $p > 0.05$). The mean HbA_{1C} concentration was $5.4 \pm 0.8\%$, significantly higher than in the general population ($4.9 \pm 0.5\%$, $p < 0.01$).

DISCUSSION

We observed unusual activity in the wall of the right atrium in 10 of 2,367 cases (0.42%). The mean age in the 10 cases with abnormal FDG uptake was significantly higher than the mean age of our screening population. All of them had cardiac disease, the majority (8/10) showing atrial fibrillation, and nine were on medication. Aging, cardiac disorders, and/or cardiac medication may have caused the changes in glucose metabolism in the wall of the right atrium.

Faint FDG uptake in the wall of the left atrium was noted in only three of the ten cases, so that FDG uptake in the atrial wall seemed to occur selectively in the right atrium. In experiments on dogs, it was reported that atrial perfusion and atrial oxygen consumption increase as a result of induction of atrial fibrillation,[6,7] and this overloading the atria may be related to the FDG uptake. We estimated atrial size on CT images because overloading the atria induce their dilation. Although the average size of both atria was significantly greater than atrial size data

Table 4 Blood chemistry

No.	Glucose (mg/d*l*)	FFA (mEq/*l*)	HbA_{1C} (%)
1	93	0.11	5.1
2	90	0.06	5.4
3	100	0.36	4.9
4	83	0.94	5.7
5	117	0.42	5.3
6	77	0.27	4.9
7	83	0.40	5.5
8	85	0.53	4.6
9	125	0.22	7.7
10	137	0.10	4.9

FFA: free fatty acid

obtained in healthy adult Japanese subjects, the left atria showed more marked enlargement than the right ones. These results indicated that the load was applied to the left atrium rather than the right atrium, and that the accumulation of FDG in the wall of the right atrium was not facilitated by atrial overload alone.

While FDG is known to accumulate in ischemic myocardium in the left ventricle,[4] only one of the ten cases had experienced an episode of myocardial ischemic change. Since none of the cases showed clear atrial ischemic findings on ECG tests such as deviation of STa segment and deformity of the P wave,[8] the unusual accumulation of FDG in the wall of the right atrium was not positively explained by atrial ischemic change. Other mechanisms may be responsible for the high FDG uptake in the wall of the right atrium. The incidence of FDG uptake in the left ventricular wall was also higher in these 10 cases than in the general population (unpublished data), although myocardial ischemic change was seen in only one case.

These cases may therefore have had some other common characteristics that facilitated the myocardial uptake of glucose. The results of blood chemistry studies revealed that the average blood sugar level and HbA_{1C} concentration of the cases were higher than those of our screening population. The high blood sugar level may facilitate the uptake of FDG by the walls of the cardiac chambers, but it could not explain the selective accumulation in the wall of the right atrium.

CONCLUSION

Abnormal FDG accumulation in the right atrial wall was found in older subjects with cardiac disease. FDG accumulation in the right atrial wall could not be explained only by atrial overload. Further investigation is required to clarify the mechanism of FDG accumulation in the right atrium. FDG accumulation in the right atrial wall is not evidence of malignancy, and would be another false positive finding for cancer screening by FDG PET.

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REFERENCES

1. Opie LH. The Heart: physiology, from cell to circulation. 3rd ed. Philadelphia, Lippincott-Raven, pp. 295–342, 1998.
2. Yasuda S, Ide M, Takagi S, Shohtsu A. Cancer screening with whole-body FDG PET. *KAKU IGAKU (Jpn J Nucl Med)* 33: 1065–1071, 1996.
3. Fujii H, Yasuda S, Ide M, Takahashi W, Shohtsu A, Kubo A. Increased fluorine-18 fluorodeoxyglucose uptake in the right atrial wall in a patient with atrial fibrillation. *Clin Nucl Med* 24, 1999 (in the press).
4. Tamaki N, Yonekura Y, Konishi J. Myocardial FDG PET studies with the fasting, oral glucose-loading or insulin clamp methods. *J Nucl Med* 33: 1263–1268, 1992.
5. Yasuda S, Ide M, Takagi S, Shohtsu A, Mitomi T, Kobayashi S, et al. Cancer screening with whole-body FDG PET images without attenuation correction. *KAKU IGAKU (Jpn J Nucl Med)* 33: 367–373, 1996.
6. White CW, Kerber RE, Weiss HR, Marcus ML. The effects of atrial fibrillation on atrial pressure-volume and flow relationships. *Circ Res* 51: 205–215, 1982.
7. McHale PA, Rembert JC, Greenfield JC. Effect of atrial fibrillation on atrial blood flow in conscious dogs. *Am J Cardiol* 51: 1722–1727, 1983.
8. Liu CK, Greenspan G, Piccirillo. Atrial infarction of the heart. Circulation 23: 331–338, 1961.