Regional Lung Function Study Using $^{133}$Xe Gas in a Case of Chronic Heart Failure and Co-existent Chronic Obstructive Pulmonary Disease (COPD): Case Report†

Akiyoshi KAJITA, Isamu NARABAYASHI*, Osamu ISHIDA* and Takeo HAYASHI**
Department of Radiology, The Center for Adult Diseases, Osaka, 3 Nakamichi 1-chome Higashinari-ku, Osaka 537
*Department of Radiology, Kinki University School of Medicine, Nishiyama Sayama-cho, Minamikawachi-gun, Osaka 589
**First Department of Internal Medicine, Kinki University School of Medicine, Osaka, Japan
Received July 19, 1977

In a patient with a clinical history highly suggestive of chronic heart failure, a radioisotopic lung study with the combined use of $^{133}$Xe gas and $^{99m}$Tc-MAA was performed to determine regional lung function$^{11-15}$. This technique made it possible to prove that the patient had chronic heart failure and co-existent COPD.

When these conditions coexist the pathophysiological processes usually interact to conceal the characteristic signs of each disease$^{5,6)}$. A ventilation/perfusion lung study with the combined use of $^{133}$Xe gas and $^{99m}$Tc-MAA will help to establish the correct etiologic diagnosis$^{11)}$.

1. Case Report

A 54-year-old male was admitted to Kinki University Hospital complaining of severe exertional dyspnea, cough and sputum. Twenty years prior to admission he had been diagnosed as having chronic heart failure, class 3 or 4 of the New York Heart Association classification system.

Results of physical examination liven upon admission: The thorax expanded well but there was diminution in the descent of the diaphragm. On inspiration medium rales were heard over both lung bases. A grade 3-4 systolic murmur and a grade 2-3 diastolic murmur were audible in the apex of the heart. There was marked clubbing of the fingers, but no edema was found.

Laboratory data: An ECG showed atrial fibrillation and incomplete RBBB. An echocardiogram (UCC) showed marked sclerotic change in the mitral valves.

X-ray report: The heart was considerably enlarged (CT=0.7), particularly in the area of the left ventricle. The shadow of the main pulmonary artery was quite prominent, and the left atrium was also enlarged. However, there was no evidence of septal sign in either of the lung bases (Fig. 1).

Pulmonary function tests: (Table 1) The findings suggested chronic bronchitis following upon an existing condition of MSI, indicating a need for the performance of radioisotopic studies (Fig. 2) and cardiac catheterization (Table 2).
Eq. 1 PA chest. The hilar pulmonary arteries are prominent with marked tapering as they proceed distally. The lung fields are overinflated, especially in the right lower region.

### Table 1 Pulmonary function tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
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<tbody>
<tr>
<td>VC(%)</td>
<td>68%</td>
</tr>
<tr>
<td>FEV 1.0 (%)</td>
<td>41%</td>
</tr>
<tr>
<td>RV (%)</td>
<td>44%</td>
</tr>
<tr>
<td>Pao2</td>
<td>64.8 mmHg</td>
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<tr>
<td>PacO2</td>
<td>53.0 mmHg</td>
</tr>
</tbody>
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Fig. 2 Computer processed single breath, equilibrium and washout scintiphotograms following inhalation of 133Xe gas are illustrated. #1=210°-255° #2=375°-435°

### Table 2 Cardiac catheterization studies

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right atrium</td>
<td>1/5/3 (mmHg)</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>56/0/4</td>
</tr>
<tr>
<td>Pulm. artery</td>
<td>57/32/42</td>
</tr>
<tr>
<td>Pulm. art. wedged</td>
<td>+/-18/15</td>
</tr>
<tr>
<td>C.O. (1/min)</td>
<td>2.6</td>
</tr>
<tr>
<td>C.I. (1/min/M²)</td>
<td>2.1</td>
</tr>
<tr>
<td>R-L time*</td>
<td>13°</td>
</tr>
</tbody>
</table>

* Radiocardiogram

2. **Method**

The 133Xe ventilation study system (VSS) consists of a sealed plastic tube containing 10 mCi±20% of xenon gas at calibration time (Nihon Medi-Physics Inc., Hyogo, Japan). 133Xe gas was administered by inhalation through a xenon VSS. The patient was imaged in a sitting position in a positerior projection using a Toshiba GCA-202 gamma camera equipped with a parallel collimator. These images were aquired on a 64×64 matrix under computer control (DAP 5000N, 32 KB) and stored on a magnetic disc for subsequent computer analysis.

Using the 133Xe VSS it was possible to perform single breath study with a sharp 133Xe bolus. Following the single breath study, a rebreathing study was performed by the patient breathing back and forth through the system until equilibrium was achieved. Evaluation of 133Xe washout was obtained by sequential scintigraphy while the patient breathed normally.

Subsequently, one mCi of 99mTc-MAA was injected intravenously with the patient in a sitting position. The computer routinely divided each lung into 6 regions. Ventilation indices (V), perfusion indices (Q), ventilation/perfusion ratios (V/Q), and clearance times (T½) were obtained for each region of the lung.

3. **Results**

Serial scintiphotograms following inhalation of 133Xe showed an uneven distribution of the tracer, particularly in both lung bases (Fig.2). The computer processed initial scinti-
The posterior lung perfusion image obtained after $^{99m}$Tc-MAA injection shows decreased perfusion to the upper third of the left lung compared with the base (Fig. 4). On the other hand there was uniform distribution of the tracer in the left lung. The uneven distribution of ventilation/perfusion ratios is shown in Fig. 5.

4. Discussion

Chronic heart failure is a frequent manifestation of severe respiratory insufficiency. A ventilation/perfusion lung study with the combined use of $^{133}$Xe gas and $^{99m}$Tc-MAA will help to establish the correct etiologic diagnosis.

$^{133}$Xe can be inhaled directly as a gas or can be injected intravenously when dissolved in saline. A comparative study was performed between washout curves of inhaled vs. injected $^{133}$Xe in a normal subject and in a patient having COPD. The washout of inhaled $^{133}$Xe was much faster than that of injected xenon. This finding suggested a marked abnormality in the distribution of the individual alveolar $V/Q$ ratios, ventilation occurring predominantly in the poorly perfused alveoli and perfusion of the injected xenon occurring predominantly in the poorly ventilated alveoli.

At the beginning of the lung function study it would have been natural to assume that the patient had chronic bronchitis (COPD type B) resulting from a prior condition of chronic heart failure. The xenon ventilation study revealed that there were markedly prolonged washout curves and an uneven distribution of ventilation ratios suggesting the combined conditions of emphysema (COPD type A) and cardiac failure.

In patients with either chronic bronchitis or emphysema located selectively in the lower lobes of both lungs, the perfusion shift is accompanied by a ventilation shift. However, the two are not proportionate. The perfusion shift is usually greater than the ventilation shift, causing a ventilation to perfusion abnormality.
5. Conclusion

The $^{133}$Xe ventilation study system is simple and rapid. This technique is especially useful for performing lung function analysis on patients having chronic heart failure and co-existent COPD.

Acknowledgement

The assistance of Mr. T. Sakashita and Mr. T. Funakoshi in the completion of this work is gratefully acknowledged. Thanks are also extended to Nihon Medi-physics for providing us with the Xe-133 gas.

References

3) Krishnamurthy, G. T., et al.: *ibid.*, 13, 604-10 (1972)