VII. 5 Production of Positron Emitting Radioisotopes for Medical Use

Fukuda H., Endo S., Kubota K., Abe Y., Hatazawa J., Sato T., Matsuzawa T.,
Tada M.* and Ido T.**
Department of Radiology and Nuclear Medicine, Research Institute for Tuberculosis
and Cancer, Tohoku University
Department of Pharmacology, Research Institute for Tuberculosis and Cancer,
Tohoku University*
Cyclotron and Radioisotope Center, Tohoku University**

Short-lived positron emitting radioisotopes have definite advantages for
medical use in several points. Firstly, irradiation dose is much lower than in
conventional nuclear medicine. Secondly, quantitative measurement is possible
by annihilation coincidence detection. Thirdly, the biochemical metabolism in
living body can be measured by using some organic compounds which were labeled
with physiological elements such as C-11, N-13, O-15, and F-18. In order to
develop these techniques, we have produced C-11, made $^{11}$C-glucose and applied it
to a tracer of glucose metabolism in tissue.

Fig. 1 shows the schematic diagram of C-11 production and photosynthesis
system. Carbon-11 was produced by bombarding a $^{14}$N$_2$ target with 12 MeV protons
at the intensity of 10 uA in the Tohoku University Cyclotron. The formed C-11
combined immediately with traces of oxygen in the target to give $^{11}$CO$_2$. The
$^{11}$CO$_2$ was trapped with molecular sieve 4A at room temperature, released by heating
the sieve more than 220°C and was flushed into a reaction vessel which contain
small pieces of spinach leaves. Production of $^{11}$C-glucose was employed by
photosynthesis method which Lifton and Welch have reported. 1) The $^{11}$CO$_2$ labeled
leaves were irradiated by day light white lamps, keeping the temperature less
than 35°C by air cooling. After 10 minutes illumination, the leaves were removed
from the vessel and placed in a beaker. Ninety-percent of ethanol was added to the beaker and the leaves and ethanol were boiled in order to extract sucrose.
After the extraction, 2N hydrochloric acid was added to the mixture and boiling
was continued to hydrolyse the sucrose to glucose and fructose. The organic
pigment was extracted by using chloroform. Then the products were passed through
anion exchange column to be neutralized. In these procedure, 20.8 mCi of $^{11}$CO$_2$
was mixed with the leaves and 1.04 mCi of the $^{11}$C-glucose and fructose mixture
was formed after one-hour purification steps. Therefore, chemical and radio-
chemical yield were 38.4 % and 5 %, respectively. These values were slightly
lower than ever reported data.1,2)

After sterile filtration, 50 uCi of the mixture was injected intravenously
into Donryu rats, some of which bearing subcutaneously growing AH 109A ascitic
hepatoma. The rats were sacrificed in series of time and the radioactivities of
blood, organs and tumor were measured by well scintillation counter. The distribu-
tion of radioactivities for selected organs were shown in Table 1. The result
shows that no specific organ can be seen except for relatively high concentration in the kidney and small intestine. Although there is a report that $^{11}$C-glucose accumulated in human lung cancer$^3$), our data shows no specific uptake in tumor tissue. Further experiments are needed to make sure of it.

Injected $^{11}$C-glucose in blood is quickly get into tissues, utilized for energy production by glycolysis and finally become $^{11}$CO$_2$, so that the measured activities represents a whole sum of these processes. Therefore, it is necessary to decide the ratio of each metabolic steps of glycolysis and to measure $^{11}$CO$_2$ in aspiratory air in order to know glucose metabolism. On the other hand, $^{18}$F-deoxy-D-glucose is a metabolic trapping agent and do not go further passway of glycolysis$^4$), so that we shall obtain a glucose demand of each organs. By using these two compounds, we may obtain further informations on glucose metabolism, though there are some problems to be solved.

References


Table 1. Distribution of $^{11}$C-glucose and fructose in Donryu rats

<table>
<thead>
<tr>
<th>Time after injection</th>
<th>Tissue Uptake (% injected dose/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blood</td>
</tr>
<tr>
<td>10 min.</td>
<td>2.72</td>
</tr>
<tr>
<td>30 min.</td>
<td>0.73</td>
</tr>
<tr>
<td>60 min.</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Fig. 1. Schematic diagram of C-11 production and photosynthesis system.