《招待講演》

Nuclear Medicine Cyclotrons

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Interest in the utilization of cyclotrons in medicine is relatively old. Almost twenty five years having passed since the medical research council established at Hammersmith Hospital in London a machine essentially for medical applications. A machine which is still working today. There were two potential avenues of application. One was utilization in radiotherapy of neutrons beams of conventional energy, giving much less oxygen effect than electromagnetic radiation, which led to expectation of great success in the treathent of certain types of tumors. The other, more properly within the bounds of nuclear medicine, was the production of radionuclides of major interest for pathophysiologic or diagnostic purposes, which could not be obtained by other methods, such as nuclear fission and activation by thermal neutrons.

The first route has been employed for some years in various centers in England, the United States, Japan and the Federal Republic of Germany. In balancing what one can conclude today from the results obtained and the interest expressed, we still have to wait to know whether neutrons will become an integral part of the radiotherapeutic arsenal.

The second route opens the very considerable possibility of rejuvenating nuclear medicine. In effect, the only radionuclides of the four fundamental elements of living material, Carbon, Hydrogen, Nitrogen and Oxygen which are susceptible of being detected from the exterior of the organism by virtue of the annihilation radiation, are Carbon 11 (20' half-life), Nitrogen 13 (10′ half-life) and Oxygen 15 (2′ half-life). In spite of the short half-life of ^{11}C and the even shorter one of ^{13}N we can conceive of labelling, without modification of their metabolic characteristics, a number of molecules of physiological and pharmacological interest. However, these 3 isotopes, because of their short half-life, presuppose that the cyclotron be located at the place of utilization, that is to say in the hospital environment. Seen fron this aspect the use of the cyclotron opens to nuclear medicine the possibility of exploring in man, in a non-invasive way, a number of physiologic, metabolic and pharmacologic processes which will lead to increase knowledge of human pathophysiology.

Three areas need to be considered in the development of such a program:

1) The Cyclotron.

Working in a hospital environment, it should be the simplest, most reliable and the easiest to use. Progress in recent years in the realm of small compact isosynchronous cyclotrons has led to machines meeting these criteria which are in the process of development in Japan, the United States and France.

2) Chemistry.

This is the most important part of the program and at the same time the point at which the greatest difficulties are encountered.

Concerning specifically the production of radioelements, notably that of ^{11}C, the most difficult aspect is that of obtaining sufficiently high specific activity.

But it is at the level of synthesis of the specific molecules where the most severe problems occur. One is faced in effect with conditions completely different from those of classical chemistry, for two major reasons: The time available for the synthesis is limited (3 half-lives, or about 1 hour at the most for ^{11}C); and the quantities of material used in the course of the reaction are infinitesimal. In accordance with the short times available for synthesis, the yields of labelling are low and necessitate the manipulation of considerable radioactivity, up to 1 curie or more in the case of ^{11}C. Radioprotection of personnel demands the complete automatization of each synthesis, which is very difficult and expensive. Finally, the last condition imposed by the short half-life of ^{11}C is the purification and the preparation of an injectable solution for use in man of a labeled producut.

3) The detection device.

The conventional cameras are not appropriated for imaging with the annihilation radiation of 511 Kev. The various positron tomographic cameras already developed in the United States now allow us to obtain practical and useful images. Nevertheless, to be able to exploit these capabilities completely, it is necessary to be able to quantitate the images to obtain useful physiologic and metabolic data. In the area of image quantification important progress needs to be made. Furthermore the acquisition times of the images are still too long to follow a number of physiologic and metabolic processes.

Nevertheless interesting results have already been obtained with short lived isotopes, notably ^{11}C, concerning:

The perfusion, ventilation, the water content and permeability of capillaries at the level of the lung:

The visualization and the functional state of the pancreas:

The fixation of fatty acids in the myocardium.

But it is in the brain that we expect the most promising results. Thus, we have as examples that have already been studied:

The blood flow and regional oxigen consumption:

The cerebral distribution of various psychotropic drugs:

The permeability of the blood-brain barrier to methionine:

And very recently for the first time specific receptors for valium have been demonstrated in the brain in vivo.