A Century of Radiation Medicine

A hundred years of diagnostic imaging

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Röntgen’s discovery of the X-ray 100 years ago began a period of rapid change in medical technology which shows no sign of slowing down today.

At the end of the nineteenth century hopes for progress in health were focused on microbiology and biochemistry. Few people expected that the next great advance would come from physics, but as things turned out physics had some spectacular successes during this period, some of which were to change the world in the twentieth century.

1895–1898: years of discovery

Four consecutive years were particularly important. At the end of 1895 Wilhelm Conrad Röntgen discovered the X-ray while experimenting with cathode rays, and during that same week the Lumière brothers introduced cinematography, and made the first film. The age of the image had begun. In 1896 Henri Becquerel discovered radioactivity, in 1897 J.J. Thomson discovered the electron, and in 1898 Pierre and Marie Curie isolated radium. Rutherford, Planck and Einstein were to build the foundations of modern physics and its applications in less than a decade.

When considering this period it is hard to decide which is more remarkable: the creative genius of the biologists and physicists, or the rapidity with which their discoveries accumulated and became widely known. Two or three weeks after the discovery of X-rays, radiological pictures of patients were being taken in Vienna, Paris and London. While examining one of these pictures in January 1896, Becquerel started wondering about the mechanism by which the rays were produced. As a specialist in fluorescence, he concentrated on the links between fluorescence and X-rays. After three months of investigation he discovered that a natural element, uranium, spontaneously emitted rays that closely resembled the X-ray.

The twentieth century

This discovery of natural radioactivity led to the discovery of radium with its medical applications, a new understanding of the structure of the atom, radiochemistry, the discovery of artificial radioactive isotopes by Irène and Frédéric Joliot-Curie in 1934 and, finally, atomic energy. Meanwhile Thomson’s discovery of the electron was leading to the development of modern electronics and its medical applications as we know them today.

At the beginning of the twentieth century hundreds of doctors around the world were devoting themselves to the use and improve-
ment of these new technologies from the realm of physics. The first images obtained from radiology were of poor quality, but sensitivity and resolution were gradually improved. At first, fluoroscopy was often used because it could show how the organs moved, particularly the lungs and the heart. However, this was gradually replaced by techniques which produced more accurate images and delivered fewer rays to the patient and the radiologist. The use of substances for increasing contrast had started in 1897, and in 1930 tomography came into use – a technique which focuses on the main object to be imaged and not on the surrounding tissues through which the X-ray passes.

During this last third of the twentieth century the advances made in medical imaging have come from the alliance between radiology and computer science. In 1970 Godfrey Hounsfield built the first scanner, which works by means of computerized image reconstruction. Computers also make it possible to use the recent discovery of nuclear magnetic resonance for medical imaging.

After the Joliot-Curies’ discovery of radioisotopes it became possible to make these for most natural elements. Thanks to G. von Hevesy’s development of the tracer method and Lacassagne’s work on autoradiography, onwards it was possible to measure thyroid activity and make morphological studies by tracing the distribution of iodine in the gland. The first mappings were quickly made obsolete by the discovery of scintigraphy and the scintillation camera, which produce clear and precise images. The qualitative and quantitative analysis of these images makes it possible to measure the functional activity of the different parts of an organ. Scintigraphy quickly became an essential diagnostic tool.

**Medical imaging from yesterday to tomorrow**

It could be said that modern medicine began in 1800 with the systematic performance of autopsies to study the internal lesions which were the cause of death. This practice, which had become well established by 1895, was transformed in less than a decade by the advent of diagnostic imaging: it was now possible to study the lesions inside a living body, and thus take precise curative action. Today medical imaging has achieved a perfection that was unimaginable even only 20 years ago, but this is probably only the beginning. During the next decade we can expect a number of important developments. Dynamic imaging will show not only the movement of organs but the flow of blood, lymph and other fluids. Widespread use will be made of techniques such as three-dimensional imaging, functional imaging of quantitative data, and biochemical imaging which distinguishes between tissues according to their chemical composition.

Such facilities will open up vast new horizons for research. To take but one example, they will transform the study of neuroscience. The observation of internal lesions led to dramatic progress in treating somatic diseases but was of little use for the study of mental illnesses not caused by visible brain damage. With the new technologies, however, it will be possible to observe the functional activity of different
regions of the brain by using simple criteria such as vascularization rates, or the amounts of oxygen or glucose consumed.

It will be possible to examine the different working zones of the brain, for instance when the subject is listening, speaking or making various kinds of intellectual effort. Already the activity of the brain during hallucinations or delirium is being studied, and in the near future we will know which parts of the brain are not functioning normally in a number of psychiatric conditions. For example, what is the difference between the mental functions of someone who cannot distinguish between hallucination and reality and of someone who can? The new technologies offer the prospect of precise answers.

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**Cost-effectiveness analysis**

Cost-effectiveness analysis is a technique to assist you in decision-making. It is one of the tools available to help you to identify areas of your health programme that are inefficient and to help you to design a better programme. A cost-effectiveness study involves assessing the gains (effectiveness) and resource input requirements (costs) of alternative ways of achieving a specified objective. The results are usually expressed in terms of cost per unit of effectiveness for each alternative. The alternative with the lowest cost per unit of effectiveness is the most cost-effective and is generally to be preferred on grounds of economic efficiency. ... A cost-effectiveness study should be done, if possible, whenever you are faced with a choice of options.