Particle physics on the cancer ward

By Professor Bleddyn Jones
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Techniques developed by atomic physicists are being used to develop the first of what promises to be a new generation of cancer treatments in place of conventional radiotherapy.

One day doctors could even be using anti-matter.

Recent announcements from the CERN laboratory in Geneva have aroused considerable interest in some medical circles.

Cancer cells were successfully targeted with anti-matter subatomic particles, causing intense biological damage leading to cell death.

These pilot experiments may have future potential. But applications borrowed from particle physics are already being used in cancer treatment to help avoid the major side effects of radiotherapy.

In conventional radiotherapy, X-ray beams pass through the entire thickness of the body, so that many organs and tissues receive unnecessary radiation.

Proton and ion therapy

Although beams of charged atomic particles act in the same way as X-rays - interacting with cellular DNA and causing chromosome breaks and cell death - most of their energy can be delivered at a particular point in the cancer.

Little or no energy is deposited beyond the cancer target.

PROTON BEAM THERAPY

Treatment of a spinal cancer using proton beam therapy
Concentrations of radiation are shown in color codes from high (red) to low (blue)
Most radiation is concentrated on the tumour
Pictures: Courtesy of Francis H. Burr Proton Therapy Center, Boston, Massachusetts

The amount of radiation affecting normal tissues can be reduced to half or even one tenth at the same time as delivering the same or higher dose to the cancer.

The more efficient treatments bring numerous benefits.

Reducing collateral radiation is particularly beneficial for patients whose cancers are close to the spinal cord, brain, heart, eye or ear.

Complications from irradiation of the lungs can cause shortness of breath.

While in bowels and kidneys, severe complications can require surgery.

Younger patients would have reduced risk of damage to their development and lower risks of future cancers.

Types of cancer which are resistant to existing treatments could be treated with higher doses than X-rays permit.
And complications from metallic hip replacements could be avoided, along with issues with bone marrow irradiation making for safer subsequent cancer chemotherapy.

In Japan, doctors have already been using particle beams (of carbon ions) for cancers of the eye, lung, prostate and liver.

They report needing only one to four carbon ion treatments compared to six to seven weeks with X-rays.

**UK facility**

The UK currently has only one treatment centre, a proton (hydrogen ion) facility at Clatterbridge Hospital, Liverpool, the first hospital based facility in the world.

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<th>X-RAYS</th>
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<td>Treatment of a spinal cancer using X-rays</td>
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<td>While most radiation is concentrated on the tumour, there are significant doses affecting the nearby kidneys (outlined) and other organs</td>
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It has treated over 1,000 patients and produced excellent results, but it can only treat eye tumours.

And two young patients with special treatment needs from Birmingham were referred for proton therapy in Boston, USA for tumours in the spinal column and lower skull.

They received a higher tumour dose than would otherwise have been possible, both with reduced risks of paralysis, a reduced lung dose in the first patient and of further deafness in the second.

Other proton and ion facilities are being built around the world, notably in Japan, the United States, Italy, Germany, Austria, Sweden and France.

Each centre requires a cyclotron or synchrotron, a particle accelerator from which the particle beam can be delivered to multiple treatment rooms.

In the UK, they would cost £70-100m, and each could treat around 2,000 patients a year. There is a strong case for providing them in all major UK cities.

Anti-matter treatment may still be a while off in the future but esoteric physics could be bringing major benefits to many more cancer patients today.

**Professor Bleddyn Jones is a Consultant in Clinical Oncology & Applied Radiobiology at University Hospital, Birmingham.**

He will be discussing issues raised in this article in BBC Radio 4's scientific discussion programme, Material World on Thursday 8 March at 1630GMT

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Story from BBC NEWS:
http://news.bbc.co.uk/go/pr/fr/-/2/hi/health/6403737.stm

Published: 2007/03/06 15:42:02 GMT

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