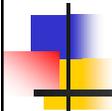


# **HOW RADIOTHERAPY WORKS**

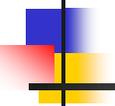
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Peter Kirkbride



# **RADIOTHERAPY WORKS**

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# RADIOTHERAPY WORKS

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## BRILLIANTLY

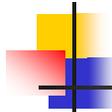
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- ## Overview
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- Origin of Radiation
  - Production of X-Rays
  - What is Radiotherapy?
  - How Does Radiotherapy Work?
  - Factors Affecting Radiation Effects
  - Radiosensitivity
  - Types of Radiotherapy
  - 'The Age of Radiotherapy'



## The Origin of Radiation

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- X-rays were discovered by Roentgen in 1895
- The development of the x-ray tube rapidly led to clinical applications, first as a diagnostic tool and later for therapy
- In 1898 Marie and Pierre Curie discovered radium
- This resulted in the use of radioactive materials for cancer treatment



## Production of X-rays

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- Passing a current through a filament releases electrons
- In radiotherapy, X-rays are produced when the electrons, travelling at the speed of light, are focused onto a Tungsten target within the Linear Accelerator; the machine used to deliver radiotherapy



## What is Radiotherapy?

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- ***The use of ionising radiation to treat mainly malignant disease***
- High-energy X-rays, (*waves of electromagnetic radiation*) cause ionisation (*making atoms electrically charged*)
- Ionisation causes damage to DNA in 2 major ways-
  - Direct Action
  - Indirect Action



## How Does Radiotherapy Work?

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- Direct action has a direct effect on the DNA, by ionising and damaging atoms within the cell nucleus.
- Indirect action affects the cell's environment; reactions with water molecules in the cell produce free radicals (*very reactive particles*) which damage the DNA. This is the dominant action for radiotherapy



## How Does Radiotherapy Work?

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- Radiotherapy cannot differentiate between normal and tumour cells, so all cells will be affected in the same way
- The basis of radiotherapy for treating malignant conditions depends on the good repair and recovery capacity of normal tissue compared to the poor rate of cancer cells
- The dose given can destroy the cancer by stopping it from repairing whilst leaving enough power in the normal tissue for repair and recovery



## Factors Affecting Radiation Effects

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- Side-effects depends on area irradiated,
- Higher total dose increases acute side-effects
- Higher daily dose (fraction size) causes higher risk of late permanent side-effects
- Acute effects common, almost always resolve
- Late effects rare, takes months/years to develop, and are permanent



## Types of Radiotherapy

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- External Beam Treatment-the type used in the radiotherapy department
- Intracavitary- a radioactive source is placed into a body cavity, e.g. cervix
- Interstitial- radioactive source implanted into tissue in the form of a needle or seed, e.g. prostate, tongue



## External Beam Radiotherapy

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- Patients are 'simulated' prior to treatment exposure
- Can use CT or conventional diagnostic x-ray simulator (latter falling out of fashion)
- Treatment is planned to maximise dose to tumour and minimise dose to normal tissue
- Delivery of radiation is accurate within mm. – may need immobilisation devices to minimise patient movement during treatment

# Simulator



# CT-Simulator



## Immobilisation Shell



## External Beam Radiotherapy

- X-rays and electrons can be used at different energies depending on the individual case
- Different machines are used according to the tumour site, depth and surrounding anatomy to be avoided
  - Superficial- used for skin tumours, e.g. BCC and SCC
  - Orthovoltage- used to treat some bone metastases (rarely used now)
  - Megavoltage- for deep seated tumours in any part of the body
  - Electrons

## Superficial Treatment



## Orthovoltage Treatment

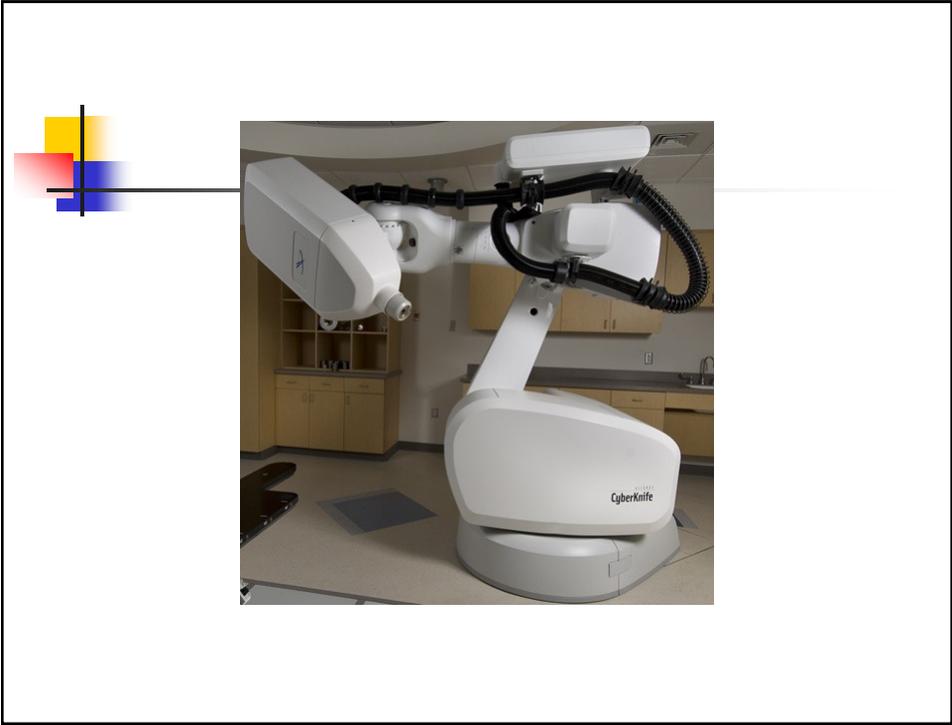


## External Beam Radiotherapy

- Megavoltage RT has advantage of skin-sparing
- When beam impacts on surface full dose of radiation not delivered
- Dose builds up over first 0.5-1cm under skin
- Therefore most modern megavoltage RT does NOT cause 'burns'

## Megavoltage Treatment







## Brachytherapy

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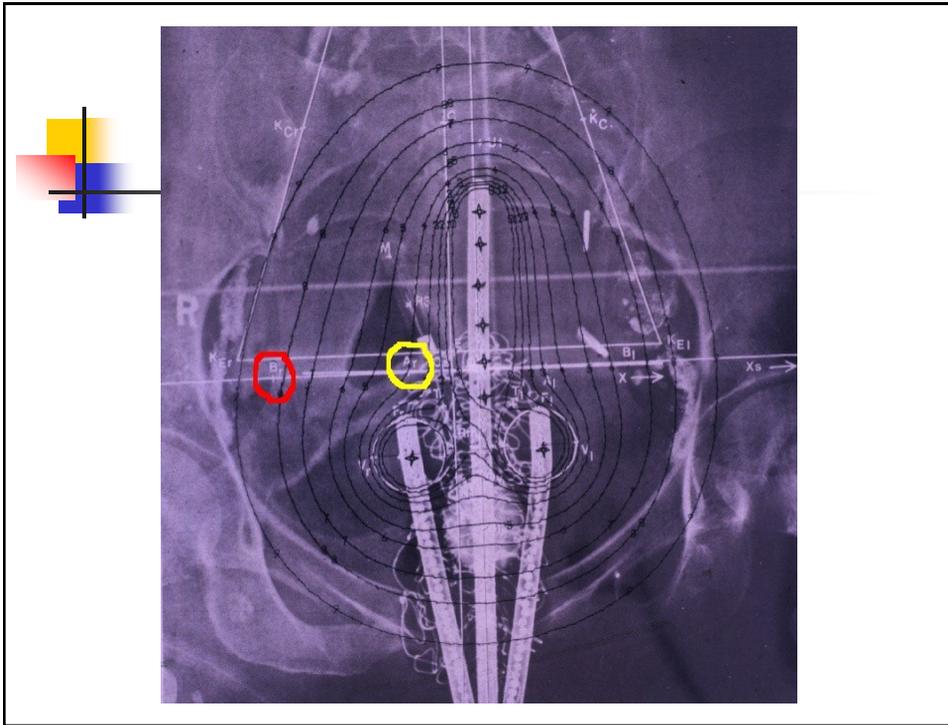
- A technique where radioactive sources placed in or near tumour
- Relies on 'inverse square law' of physics - radiation falls off dramatically with distance
- Commonly used in pelvic cancers (gynae, prostate)



## History of Brachytherapy

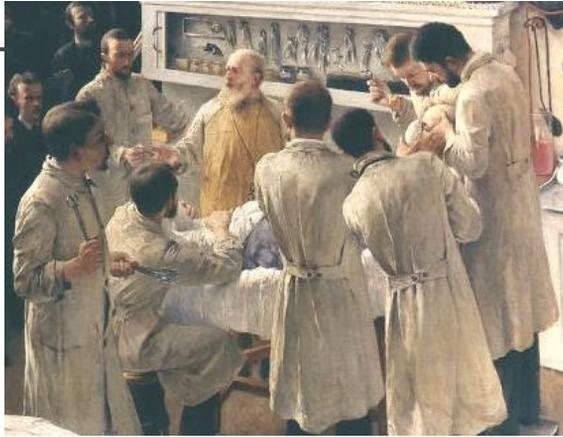
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- 1960's Radium tubes 50 hours
- 1970's Caesium 25 hours
- 1980's Selectron 15 hours
- 1990's High Dose Rate 'minutes' (fractionated into 3-5 doses)
- Pulsed Dose Rate (allows Image Guided BT, and safer for terrorists!)



## Role of radiotherapy

- CURE
  - Surgery cures 50+% of all cured cancers, radiotherapy 40-45%, chemotherapy 5-10%
  - High dose, long courses required (4-7 weeks)
- PALLIATION
  - Highly effective in reducing symptoms, esp. pain and bleeding.
  - Short course only required (1-5 fractions)



## The Age of Surgery

- Traditionally, the best way to get rid of a cancer has been to cut it out.
- For many decades surgery was the only treatment for cancer.
- First cancer operation took place in 1846, since then surgery has understandably and rightly been the mainstay of cancer treatment.
- Even today, of all cancers that are cured, most are cured surgically.
- Mid-19th century until recently was *'the age of surgery'*



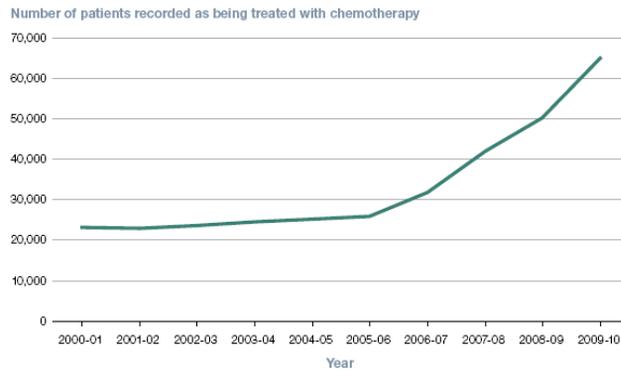
## The Age of Chemotherapy

- In 1971, declaration of the “war on cancer”,
  - President Nixon signed the National Cancer Act
- Since then, billions of dollars expended on that ‘war’.
  - Explosion of cancer research
  - Screening programmes developed
  - Risk factors identified
  - But largest expenditure has been on treatment, particularly drugs to treat cancer, (“chemotherapy”).
- Spending on chemotherapy has remained unchecked and unquestioned
- In 2010 concerns that the United Kingdom was not been spending enough on cancer drugs compared to the rest of the world.
  - Mr Cameron’s election pledges led to creation of £200 million ‘cancer drugs fund’.

# Chemotherapy

**Figure 4**

Number of patients recorded as being treated with chemotherapy



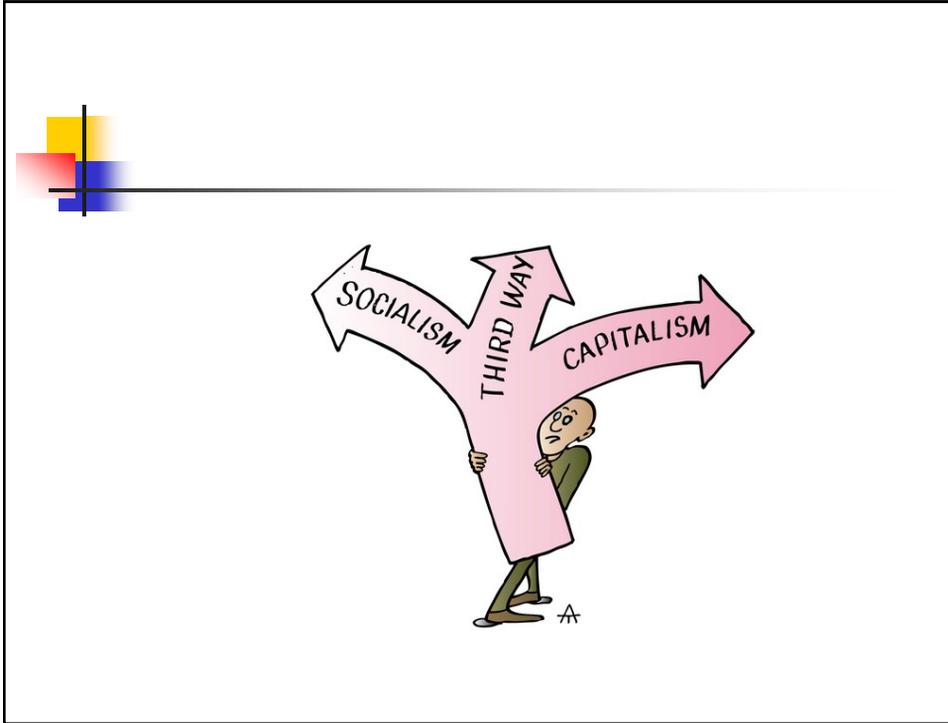
**NOTE**

1 The figure presented for 2009-10 is extrapolated from data for the first three quarters.

Source: National Audit Office analysis of Hospital Episode Statistics

# The Age of Chemotherapy

- 40 years of 'war' = *'the age of chemotherapy'*.
- BUT not been a great success.
  - Vast majority of cancer drugs do not cure patients;
  - Instead may shrink tumours and prolong life, but often only by a few months.
  - International panel of cancer specialists voiced concerns that the huge amounts of money being spent on new cancer drugs make very little difference to the outcomes of individual patients. (Lancet Oncology 2011)
  - This report actually says that, in many cases, the use of these expensive drugs is 'futile'.



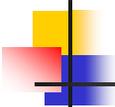
## The 'Third Way'

- 'Slash, burn, poison' – **radiotherapy**, as well as surgery and drugs
- X-rays as treatment for cancer has been around almost as long as surgery and contributes to about 40% of all cancer cures.
- However, compared to its cancer treatment counterparts, very much 'Cinderella' to two (?ugly) sisters.
- 2011 was the 'Year of Radiotherapy':
- ***Perhaps 2012 marks the beginning of 'the age of radiotherapy'.***



## The Age of Radiotherapy

- New technology has large up-front costs,
- Governments and health care funding agencies reluctant to invest
- But these sums of money are dwarfed by amount of money spent in other areas, especially chemotherapy.



## The Age of Radiotherapy

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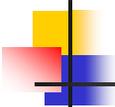
- For example, 30,000 patients per year in the UK should receive IMRT
- At present figure is about one-sixth of that
- Yet amount of money required to enable all patients needing IMRT to have it would be **<5% of the cancer drugs fund annual budget!**
- For same price as **30,000** patients' IMRT, just **30** would receive full courses of Ipiluminab (new melanoma 'wonder drug' which extends survival by just two months!)



## The Age of Radiotherapy

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- Represents opportunity which should be taken.
- In a decade, could most cancers be cured, not by in-patient-requiring surgery, but by radiation treatments using sophisticated, high-technology equipment requiring no more than 5 or 6 out-patient visits?



## The Age of Radiotherapy

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- Because of need to be encased in concrete and lead, radiotherapy departments traditionally set away in basements of hospitals and clinics.
- Time for radiotherapy to come out of hiding, and take rightful 'place in the sun'