Technology innovation to overcome the cancer care and radiological security challenges in Africa

Manjit Dosanjh, 17.02.2021

Linac-based RT coverage in Africa
Cancer is growing global challenge

- Globally 18 million new cases per year diagnosed and 9.6 million deaths in 2018
- Will increase to 27.5 million new cases per year and 16.3 million deaths by 2040
- 70% of these deaths will occur in low-and-middle-income countries (LMICs)

**Radiation therapy** is a key tool for treatment for over 50% patients and number of patients is increasing

LMICs have limited radiotherapy access: Only 10% of patients in low-income and 40% in middle-income countries have access to RT
Every year, 2 million women worldwide are diagnosed with breast or cervical cancer:

- 7 of 10 breast cancer deaths occur in low-middle income countries
- 9 of 10 cervical cancer deaths occur in low-middle income countries

SDG Goals and Maternal mortality: These breast and cervical cancer deaths also have a huge impact on child mortality, for every 100 women about 14-20 children die
Radiation Therapy is a key tool in treatment and includes:

- Cobalt 60 machines
- Linear accelerators (Linacs)
- Brachytherapy
- Image-guided radiotherapy (IGRT)
- MR-guided Linacs
- Particle therapy (proton and carbon)
- FLASH therapy (emerging technology)
World-wide radiotherapy coverage
Dramatic Disparity in Access to LINACs

- 28 countries have LINAC-RT facilities
- 12 countries only one facility
- 27 no LINACs for RT
- 385 RT-LINACs for > 1 billion people
- Nigeria had 85 radiation and clinical oncologists and only a couple of trained linear accelerator maintenance engineers for its nearly 200 million people
Africa’s Radiation Therapy Status

- **Acute shortage of RT** services both in quantity and quality
- **385 LINAC-RT** machines for more nearly **1.2 billion** inhabitants
- If current trends persist, GLOBOCAN forecast
  - By 2030, there will be **1.4 million** new cases of cancer
  - and there will be **1 million** deaths in Africa
- Only **28 countries** have RT facilities **27** have none
- Over **60% located in just 3 countries**: South Africa, Egypt and Morocco
- **12 countries** only one facility
- More than **18 countries** have Cobalt machines
- Africa has around **88 Co-60** machines (half of which are over 20 years old) proportionally more than any other continent
- Some of the **27 African countries lacking a Linac-RT** will consider buying Co-60 machine they are currently cheaper and easier to use
## Treatment Comparison: Co and Linac machines

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Cobalt</th>
<th>Linac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penumbra of photon beam</td>
<td>Large due to physical size of Co source</td>
<td>Small</td>
</tr>
<tr>
<td>Radiation dose distribution from machine to tumor</td>
<td>Less well formed</td>
<td>well-defined radiation dose distributions from</td>
</tr>
<tr>
<td>Energy of photons from machine</td>
<td>Low (1.17 and 1.33 MV), produce max radiation dose at depth of 0.5 cm in tissue</td>
<td>High (6 MV), produce max rad dose at depth of 1.5 cm in tissue</td>
</tr>
<tr>
<td>Patient treatment capacity</td>
<td>Dose rate decreases by half every five years, treatment time doubles</td>
<td>does not decrease with time</td>
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</table>
# Cost and Operational Needs

<table>
<thead>
<tr>
<th>Cobalt-60</th>
<th>Linac</th>
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</thead>
<tbody>
<tr>
<td>Widely used for treatment in poorer countries</td>
<td>Have greater infrastructural demands</td>
</tr>
<tr>
<td>Less costly</td>
<td>Require stable power grid and access to clean water</td>
</tr>
<tr>
<td>More reliable in challenging environments</td>
<td>Power interventions include: battery backups, solar arrays, diesel generators</td>
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<tr>
<td>Locally available spare parts</td>
<td>Higher operational costs</td>
</tr>
<tr>
<td>Lower operational and maintenance cost</td>
<td>Necessary service and maintenance contracts are costly</td>
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<tr>
<td>Less down time</td>
<td>Enough spare parts are not on hand</td>
</tr>
<tr>
<td>Available engineers locally</td>
<td>Downtime can range from weeks to months</td>
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Co-60 Machines

- Recent problem: there is a large expense associated with the return of used, but still highly radioactive sources, to their manufacturer, which should occur about every six years
  - often not included in the initial purchase price

- Many LMIC countries have legacy sources
  - lack adequate disposal facilities, or
  - they simply cannot afford to return disused sources,
  - leaving them vulnerable to theft or loss, security issue
LINAC-based Machine

- X-ray beam from a LINAC can be programmed to deliver high radiation doses that conform more closely to the specific size, shape and location of a tumor in a patient’s body.

- LINAC’s therefore minimizes the exposure of normal surrounding tissues and organs at risk.

- No security risks with LINACs, but requires a reliable and more stable electricity supply, including air conditioning, to operate.
Current status

• The burden of cancer is increasing globally

• Large shortfall in LIC and LMIC RT systems that are needed for effective cancer care

• LINAC-based RT is the current technology of choice

But LINAC technology is complex, labour intensive, and high cost to acquire, install, operate and service.

Can we use technology developments to address the current challenges and make RT more widely available?
1st workshop on:
“Design Characteristics of a Novel Linear Accelerator for Challenging Environments”

Norman Coleman (ICEC) David Pistenmaa (ICEC) Manjit Dosanjh (CERN)

http://indico.cern.ch/event/560969/
Medical Linacs for challenging environments

- 1st Design Characteristics of a Novel Linear Accelerator for Challenging Environments, November 2016, CERN
- 2nd Bridging the Gap Workshop, October 2017, CERN
- 3rd Burying the Complexity Workshop, March 2018, Manchester

- 4th Accelerating the Future Workshop, March 2019, Gaborone
Questionnaire

• We asked the range of questions

• Questions included the LINAC model, local environment, availability of services, subsystems, treatment and imaging.

• Which factors are responsible for machine downtime?

• Input for future machine

Received input from all African countries that have LINAC-based RT

Thank you to Dr Taofeeq Ige, Nigeria
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- Thank you to Taofeeq Ige for leading data gathering in Africa and Hubert Foy who made the first contacts

Thank you for listening