Radiotherapy and Oncology xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Perspective

Changing the global radiation therapy paradigm

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ARTICLE INFO

Article history:
Received 5 March 2018
Received in revised form 23 May 2018
Accepted 23 May 2018
Available online xxxx

Keywords:
Global health
Radiation therapy
Linear accelerators
Cancer health disparities
Radiological/nuclear security
Reverse innovation

Filling the gap in cancer care in underserved regions worldwide requires global collaboration and concerted effort to share creative ideas, pool talents and develop sustainable support from governments, industry, academia and non-governmental organizations. Comprehensive cancer care, which fits within and strengthens the broader healthcare system, ranges from prevention to screening, to curative treatment, to palliative care and to long-term follow-up. Radiation therapy is an essential component for curative and palliative cancer care and can serve as a stable focal point physically and for personnel around which regional cancer and health care programs can be established. To build capacity with high quality capability and with the credibility to conduct research to understand specific diseases and treatment outcomes requires a complex systems approach toward both expertise and technology.

To move forward in the aspirational goal of substantially reducing the global burden of cancer as part of the Sustainable Development Goals of the United Nations [1], a workshop was convened on November 7–8, 2016 by the International Cancer Expert Corps (ICEC) [2] and hosted by CERN [3]. Entitled "Design Characteristics and Implementation of a Novel Linear Accelerator for Challenging Environments" a major focus was on innovative radiation oncology technology opportunities. Cobalt-60 units are still in use but, while newer units are increasingly sophisticated, they do not provide the full treatment capability of modern linacs and require ongoing security and ever-increasing costs for disposal of radioactive materials.

While there has been substantial progress in radiation oncology technology development, significant opportunity remains for improvement and innovation in the combination of technology and processes used to deliver basic and advanced radiation therapy in low- and middle-income countries. Most specifically, the adoption of a collaborative approach that ties together broad expertise and perspectives by connecting global need, oncology expertise, and deep capacity in technology innovation was reinforced by this workshop and subsequent efforts and has resulted in a framework for collaboration to address the unacceptable gap in global cancer care.

The magnitude of the problem

It is estimated that the annual global cancer incidence will rise from 15 million cases in 2015 to as many as 25 million cases in 2035, 65–70% of which will occur in low- and middle-income countries (LMICs) [4] where there is a severe shortfall in radiation

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https://doi.org/10.1016/j.radonc.2018.05.025
0167-8140/

treatment capacity. Cancer care is multi-modal, including pathology, imaging, the range of oncology expertise, nursing and support staff, with at least 50% of cancer patients benefiting from radiotherapy regardless of their geographic location [5]. Radiotherapy is an effective curative and palliative modality for a very broad range of tumors. Yap, et al. have estimated that, if the demand for radiotherapy is met in LMICs by 2035, each year an additional 1.3 million people would experience local disease control and over 615,000 patients would derive a survival benefit [6] with other estimates closer to 1 million per year [7–9]. For the advanced stages of cancer for which surgery is not feasible, radiotherapy can still be curative. Without radiotherapy, effective palliative care is often absent and particularly so in countries that limit the use of narcotics. When considering investment in overall global healthcare, the relationship between the etiology and management of the non-communicable diseases – cardiovascular, metabolic, respiratory, and oncologic – and the communicable diseases, particularly those for which screening and prevention are available (e.g., HPV related illness and hepatitis), gives cancer care an opportunity to be the focal point for coordination, collaboration and strengthening health systems networks.

A Lancet Oncology Commission, the Global Task Force on Radiotherapy for Cancer Control (GTFRCC) of the Union for International Cancer Control (UICC) [7], supported by additional recent data [10], documented the global demand for radiotherapy, the resources required and the economic and societal benefits that would be reaped by additional investment in providing such coverage. It was estimated that as many as 12,600 megavoltage treatment machines will be needed to meet the radiotherapy demands in LMICs by 2035. Using current staffing models, there will be an estimated need by that time for an additional 30,000 radiation oncologists, more than 22,000 medical physicists and almost 80,000 radiation technologists. The financial investment needed in LMICs is approaching $200B USD and the economic benefits demonstrate significant returns to those countries that choose to invest.

Workshop participants from global health, cancer care, and radiation technology fields addressed: (1) the role of radiotherapy in treating patients with cancer in the challenging environments of many LMICs, (2) the security concerns related to high-activity radiological sources in medical facilities, (3) the design characteristics of linear accelerators and related technologies for use in challenging environments, (4) the education, training and mentoring of the sustainable workforce needed to utilize novel radiation treatment systems and (5) the costs and financing of the implementation of the recommendations from the workshop.

The workshop agenda can be found online [9]. Issues raised there and at subsequent discussions during the International Conference on Advances in Radiation Oncology (ICARO2) [12] in June, 2017 and at a second workshop held at CERN on October 26 and 27, 2017 showed clear evidence that technological opportunities exist to improve global access to radiation treatment.

Focusing on the machine alone will not solve the problem

Numerous national scientific societies and non-governmental organizations (NGOs) provide training globally on a limited scale for radiotherapy professionals and allied health personnel. Radiating Hope, a US-based NGO, provides radiotherapy equipment, often refurbished, on a limited scale to regions that have limited or no capacity [13]. Successful approaches to peer-supported case-based education including pioneering work by Hardenburgh via Chartrounds [14] and the potential for use of highly interactive teleconferencing, such as TELESYNERGY®, developed by the National Institutes of Health for cancer disparities programs [15], are considered critical to education and mentorship. By far, the greatest body of effort and experience in developing radiation treatment capacity in LMICs resides with the International Atomic Energy Agency (IAEA). The aim of IAEA's program on Human Health (NAHU) [16] is to enhance the capabilities in Member States to address needs related to the prevention, diagnosis and treatment of diseases through the application of nuclear techniques. Their Human Health Campus [17] website posts extensive and detailed guidelines for the implementation of radiotherapy programs as well as education and training syllabi and course materials for the diverse professions involved in delivering radiotherapy. Through the IAEA Technical Cooperation Programme, including its Program of Action for Cancer Therapy (PACT) [18], the IAEA addresses the needs of IAEA LMIC Member States by supporting the implementation of radiotherapy programs and by expanding their efforts through cooperation with non-governmental donors.

Successful instances in which an optimal mix of local commitments was available were presented at the workshop [11] as examples of radiotherapy programs that have thrived and are expanding. On the other hand, the lack of secure resources, inadequate planning, the failure of local governments to keep commitments and political instability resulted in weak programs and lack of continuity. Among the current IAEA criteria for project support are: (1) political stability in the country or region, (2) local commitment and (3) political will for sustained ownership and long-term funding of the program. A typical project includes a medium-term plan for the establishment of the first radiotherapy department in a region and a long-term plan that includes adequate staffing and creation of a local training program that will allow the facility to become a nucleus for future regional expansion. Successful regional training centers are stabilizing factors that can mitigate the so-called "brain drain" pressures.

Among the major points of the discussions [11] were:

1. The importance of local champions [19] and local and regional investment in resources. Top-down solutions from upper-income countries contain useful tools and frameworks but the needs, solutions and time-tables should be driven by specialists in local communities and external experts who best understand the issues. Examples of guidelines being developed for LMICs that can be a useful starting point for program building are the National Comprehensive Cancer Network (NCCN) Harmonized Guidelines for Sub-Saharan Africa [20]. Purchase or donation of equipment to countries in which there is inadequate infrastructure and technical capability can result in money wasted or in technology not used appropriately and/or effectively.
2. The treatment capability must not be considered "second-rate" but should be on par with that generally available for cancer care in developed nations. (The highly innovative and expensive technologies, such as particle therapy, should be considered on a regional level, with appropriateness for treatment based on carefully defined criteria.)
3. Research is a key part of this overall enterprise including: (a) population studies to define the cancer problem locally or regionally, (b) biology and epidemiology investigations to understand how genes, environment, the microbiome and infectious agents impact cancer, (c) cancer treatment outcomes studies, (d) policy projects for access to healthcare including access to multiple specialists and supportive care and (e) economic analyses for balancing cost and resources and guiding future investment.
4. Technical programs that might bear on the development of a novel linear accelerator and treatment system are ongoing [11]. Subsequent meetings have addressed specifics of the linear accelerator design and implementation, including a "BOXCare" concept proposed by Jaffray [21].

Please cite this article in press as: Pistenmaa DA et al. Changing the global radiation therapy paradigm. Radiother Oncol (2018), https://doi.org/10.1016/j.radonc.2018.05.025