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Overview

Is Africa a 'Graveyard' for Linear Accelerators?

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Abstract

Linear accelerator downtimes are common and problematic in many African countries and may jeopardise the outcome of affected radiation treatments. The predicted increase in cancer incidence and prevalence on the African continent will require, *inter alia*, improved response with regard to a reduction in linear accelerator downtimes. Here we discuss the problems associated with the maintenance and repair of linear accelerators and propose alternative solutions relevant for local conditions in African countries. The paper is based on about four decades of experience in capacity building, installing, commissioning, calibrating, servicing and repairing linear accelerators in Africa, where about 40% of the low and middle income countries in the world are geographically located. Linear accelerators can successfully be operated, maintained and repaired in African countries provided proper maintenance and repair plans are put in place and executed.

Key words: Africa; equipment maintenance and repair; linear accelerator; radiation therapy

Statement of Search Strategies Used and Sources of Information

This paper is based on about four decades of experience of Helmut Reichenvater in capacity building, installing, commissioning, calibrating, servicing and repairing linear accelerators in Africa. In addition, both authors have consulted the International Atomic Energy Agency (IAEA) Directory of Radiotherapy Centres (DIRAC) web page and conducted a literature study.

Introduction

Clinical linear accelerators (LINACs) are the battle horses of many radiation therapy facilities around the globe [1]. When no back-up is available, failure in using the treating LINAC for a couple of days can seriously compromise the treatment outcome of the patients under radiation treatment; therefore, long machine downtimes should be avoided. Due to its heavy mechanical and complex electronic components, highly qualified personnel are required for maintenance, comprehensive quality assurance, repair and successful operation of a LINAC [2–6]. In very complex cases, technical support from the vendor may be necessary [7,8]. Stable power and reliable cooling water supply systems are another requirement for sustainable operation of this type of equipment [7,9,10]. Maintenance and repair of LINACs in many African countries is a big challenge due to a variety of reasons, including limited government support, lack of qualified personnel with regard to repairs and maintenance, questionable assistance approach by manufacturers and their regional agents, inadequate storing of spare parts and poor management. Unfortunately these problems have not yet been properly addressed by competent local, national, regional and international bodies, and are part of the reasons that have led to the perception that LINACs cannot be successfully operated in

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Africa, where the income level of all countries varies between low and middle income (income level classification according to World Bank definitions for 2015). The relationship between the number of megavoltage teletherapy (LINAC and Co-60) machines per million population with the wealth of African nations has been presented elsewhere [11]. The obvious exceptions in maintaining LINACs are Egypt (lower middle income) and South Africa (upper middle income), who together hold about 60% of all LINACs available on the continent [1]. Most cancers in Africa can be managed with radiation therapy [12–14], which is used to manage about 50% of all cancer cases in high income countries (HIC) (income level classification according to World Bank definitions for 2015) [15,16]. Most causes of LINAC breakdown are common among African countries. Strategies to minimise these breakdowns could be shared among radiation therapy facilities in order to improve the dire situation of radiation therapy care in these countries. The problem in maintaining LINACs in Africa will probably become more evident in the near future when LINACs using advanced technologies are installed. Modern LINACs require information technology support and dedicated treatment planning systems; therefore, problems associated with information technology and treatment planning systems must be addressed in order to fully benefit from the advances in modern LINAC technology. The predicted cancer incidence increase on the continent over the next years [17] will require adequate maintenance, robust quality assurance and repair of LINACs in order to efficiently fight cancer using radiation.

Here we discuss some frequent and specific problems related to the operation of LINACs and propose possible alternative solutions relevant for local situations in African countries.

Background

The choice whether to operate a Co-60 machine or a LINAC requires careful consideration of the aim of the treatment [10,18], the cost of the megavoltage machine [6] and the available or planned radiation therapy infrastructure including physical, technical and clinical support [6,9,10]. There is an ongoing discussion about the costs and benefits of Co-60 machines and LINACs [6,9,10,18–22]. For simple treatments, similar treatment plans can be produced with either a Co-60 machine or a LINAC [18,19,21,22]; however, for complex treatments, LINACs are better suited [6,9,18]. The risk of the Co-60 machine radioactive source getting stolen for its potential use in dirty bombs may impose additional security costs. Maintenance costs, except source replacement, are cheaper for Co-60 machines in contrast to LINACs [6], which are technically more sophisticated and may require replacements of klystrons or magnetrons [10,22], which are major LINAC components. LINACs require robust and frequent quality assurance to ensure that the expected beam quality and dose rate are produced [3–5]. Although quality assurance and maintenance are simpler for Co-60 machines relative to LINACs [6,10], many African nations have chosen to operate LINACs instead of Co-60 machines upon upgrading or introduction of new radiation therapy facilities [1,23]; consequently, the number of LINACs on the continent in 1998 tripled to 189 units in 2010, whereas the number of Co-60 machines decreased from 93 to 88 units [23]. Notwithstanding the increase, the number of LINACs per million population in Africa remains low (0.2) in comparison to Asia (0.7), Europe (5.5), North America (7.5) and South America (1.5) [1,24]. This paper is based on about four decades of extensive experience in training local staff, installing, commissioning, calibrating, servicing and repairing LINACs in many African countries and presents an overview on typical LINAC problems and strategies on how to reduce their breakdowns in a resource-constrained setting.

Inadequate Repair Approaches and Qualifications of the Maintenance and Repair Personnel

The responsibility to operate, maintain and repair a LINAC pertains to the operator of the radiation therapy equipment. Specialised human and technical capacity is critical when a repairable breakdown is verified. Although maintenance and repairs in HIC are executed by the manufacturers or engineers employed by the hospitals, this is mostly not so in Africa, were government support to radiation therapy may be limited. Table 1 compares the most probable qualifications of personnel involved in maintenance and repair of LINACs between HIC and African countries.

The repair and maintenance plans recommended and prescribed by the suppliers and international bodies may not address the requirements of the operators in Africa. Table 2 shows a contrast of typical approaches to repair between HIC and African countries.

Due to poor remuneration, highly trained and specialised staff are not attracted; instead high staff turnover leads to inadequate operation, maintenance and repair work. Regulatory authorities should ensure that qualified personnel carry out the maintenance and repair of LINACs and that international assistance is sought if appropriate. In addition, governments in Africa should find ways to adequately reimburse personnel employed for the operation and upkeep of radiation therapy equipment for the services they render. Fortunately, some African governments are slowly introducing measures to alleviate these adverse conditions for specialist employees.

Prohibitive Training Course Prices Offered by Manufacturers

Most of the time, as part of the after sales services offered by the manufacturers, training courses are offered to counterpart institutions only when they have purchased new equipment. Even so, the prices for in-depth training amount to around $12 000 per trainee per week. It should

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