

History and Present of Radiation Oncology Services and Practice in Jordan

Jamal Khader^{1*}, Abdelatif Al Mousa¹, Samir Al-Kayed², Sondos El Khatib¹, Hana Mahasneh³, Rasmi Mubaidin⁴, Nabeel Al Nassir⁵, Sami Khatib⁵, Adnan Qasem⁵, Inad Haddadin⁶ and Elayan Elayan⁵

¹Radiation Oncology Department, King Hussein Cancer Center, Amman, Jordan

²Al Afia Radiotherapy & Nuclear Medicine Center, Amman, Jordan

³Radiation Oncology Department, Queen Alia Hospital, Royal Medical Services, Amman, Jordan

⁴Radiotherapy Department, Al Basheer Hospital, Ministry of Health, Al Taj Street 261, Amman, Jordan

⁵Al Afia Radiotherapy & Nuclear Medicine Center, Amman, Jordan

⁶Medical Physics Section, Radiation Oncology department, King Hussein Cancer Center, Amman, Jordan

Abstract

Radiation therapy for cancer patients in Jordan began with a small individual effort and has now grown to be one of the most prominent in the Middle East. Currently, there are four different centers that provide radiation treatment not only for the people of Jordan but also to other Arab neighboring countries. Naturally, Jordan being a developing country still faces a problem in the number of available radiotherapy machines and their supporting staff (physicists, technologists, etc.). In this paper we shed a light on the history and current status of radiation oncology in Jordan and discuss the challenges that faces us.

Keywords: Cancer; Radiation; Physicists; Treatment

Introduction

Jordan is a Middle Eastern country with limited resources and economic constrains. Jordan is divided into twelve governorates that occupies an area of 89,000 km² with a 2018 estimated population of 10 million [1]. Cancer is the second leading cause of death in Jordan after cardiovascular disease [2]. Cancer care is delivered through a combination of government, non- government, academic and private sectors without any national guidelines concerning treatment protocols or quality assurance. Despite several initiatives, Jordan does not have a national cancer control plan. In countries where cancer control programs have been implemented, the burden of cancer is decreasing and treatment outcomes are improving, supporting the need for Jordan to pursue this strategic goal [3]. In Jordan, the government bears the cost of cancer treatment. Cancer treatment is offered to Jordanians at no cost through government hospitals including the Ministry of Health (MOH), Royal Medical Services (Military), University hospitals and King Hussein Cancer Center, which is a non-governmental facility. Small minority travel for treatment in Europe or USA. According to Jordan Cancer Registry data in 2015, 8400 patients were diagnosed with cancer, 5556 Jordanians and 2844 non-Jordanians [4]. Cancers of the colon were the most common cancers in men and cancers of the breast were the most prevalent among women. It is estimated that 50-60% of cancer patients will need radiotherapy as part of their treatment. The practice of radiotherapy in Jordan has gone through many milestone steps (Figure 1).

Literature Review

The first treatment machine in Jordan

Jordan's first national hospital was established by a physician named Qasem Malhas in 1945 [5]. A few years later that hospital acquired Jordan's first radiation machine (10-100 Kilovoltage) which was used for treatment of superficial tumors. Radiologists then used to treat with the help of radiology physicists & technologists. No single radiation oncologist was available in Jordan at that time. Doctor Malhas then gifted the Jordanian Ministry of health the machine in 1962. The machine was then transferred to Al-Basheer general hospital

which is the main governmental hospital in Amman, the Capital. The hospital used the machine for the management of superficial tumors until the MOH managed to acquire in 1964 an Ortho-voltage machine (300 Kilovoltage, Maxi mar X-ray). At this point Nuclear Medicine specialists along with radiology physicists & technologists began to take part in patient management. A few years later in 1967, the radiology department at the hospital was expanded once more with the arrival of its and Jordan's first Cobalt machine (1.2 Megavoltage).

The first radiation oncologist in Jordan

The MOH had no qualified radiation oncologists until 1974 when the International Atomic Energy Agency (IAEA) hired a Polish Radiation Oncologist to work at Al-Basheer hospital. He contributed to the creation of a separate Radiation oncology department in 1978 and ran the cancer radiotherapy treatment services at the hospital till 1987.

The need for graduated and qualified radiation oncologists led to the creation of the first residency program in Jordan. This began in 1987 when the first resident joined the newly created Radiation Oncology residency program at Al-basheer hospital. The program is the oldest in Jordan. The program graduates two to three residents every year. Residents attend weekly and monthly lectures and are evaluated annually and at the end of residency by the medical council board exam.

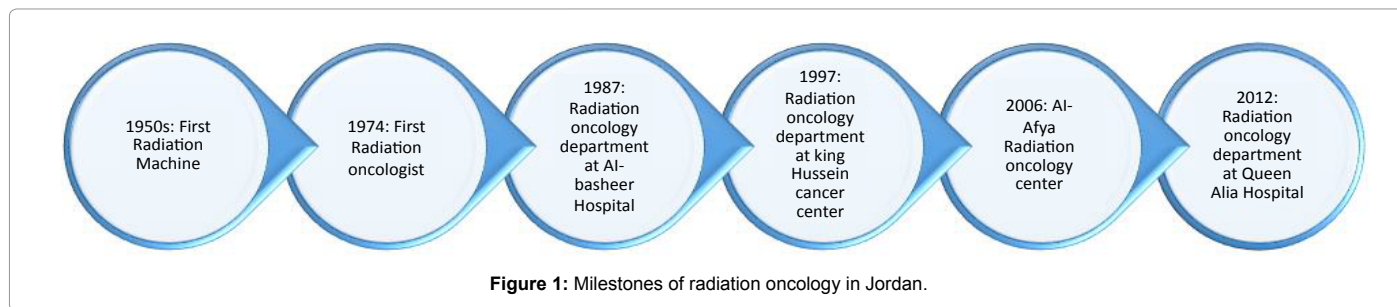
By 1987, six new qualified radiation oncologists who spent their residency training abroad in Russia, United Kingdom, and Spain

***Corresponding author:** Jamal Khader, Radiation Oncology Department, King Hussein Cancer Center, Amman, Jordan, Tel: +962796575553; E-mail: jkhader@khcc.jo

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returned to Jordan. Three of them joined the MOH department of radiation oncology and two joined the Royal Medical Services. The remaining radiation oncologist worked at the private sector mainly as a clinical oncology practitioner.

In 1987, the radiotherapy services at the hospital was expanded once more by the addition of its first linear accelerator machine (Varian). Two new cobalt machines were also installed at Al-Basheer hospital.

King Hussein cancer center

The Inauguration of the King Hussein Cancer Center (KHCC) in 1997 presented a major boost to the already rising radiation oncology practice in Jordan. KHCC was accredited by center by the Joint Commission International Accreditation, Disease-Specific (Oncology) Certification (JCI-DSC) [6]. The newly created radiation oncology department at the center had four new state-of-the-art Linear Accelerators and a CT simulator for treatment planning. The center was also the first to introduce brachytherapy radiotherapy system in Jordan by acquiring a high dose iridium brachytherapy machine. At that time, the department had three radiation oncologists with other supporting staff (physicists, technologists, medical engineers, etc.). But by 2004, the need arose for a complete residency program that was up to standards with its peers in the developed world. This was accomplished by the creation of the KHCC radiation oncology residency program. The faculty size of KHCC increased from three senior radiation oncologists in 2004 to 17 in 2018 by implementing its own residency program that adheres to the tenets of competence-based medical education. The four-year residency program at KHCC is complemented by a 3-month externship at a partner cancer center in USA or UK. Residents are required to sit for the American College of Radiologists (ACR) examinations every year and have to take the medical council board exam at year two and four of their residency. 41 Jordanian and non-Jordanian residents have successfully completed their residency program by 2019. Currently, there are 17 radiation oncologists and 13 residents at KHCC [7].

New centers enter service

In 2006, Al-Afia Radiotherapy and nuclear medicine center (a private radiation oncology facility) was established in Amman. The center started its treatment services with one linear accelerator and a CT simulator. Its staff consisted of three radiation oncologists, two physicists, and two technologists. In 2008, another linear accelerator was added and the number of technologists rose to six.

The Jordanian Royal Medical Services (RMS) have expanded its efforts from providing medical services to the Jordanian military to include the civilian sector and provide them with high quality medical service. In 2012, a new radiation oncology department was established at RMS Queen Alia Hospital. The newly created department has two

linear accelerators and a CT simulator. In 2014, High Dose Rate (HDR) Brachytherapy radiation system was installed.

The department had at its creation three radiation oncologists, six technologists, two physicists, and one medical engineer. The Residency Program at Queen Alia military hospital started in 2014. The program graduates two to three residents every year. Residents are required to attend weekly and monthly lectures by the department faculty and sits for annual examinations. By 2019, the department staff had rose to nine radiation oncologists, fourteen technologists, nine physicists, and one medical engineer making it one of the biggest in Jordan.

Current state and challenges of radiation oncology in Jordan

Cancer in Jordan has been on the rise steadily in the past 15 years. A 2018 epidemiological study reported a 60% overall increase in the incidence of cancer cases for the period of (2000-2013) [8]. Currently, there are four centers that provide radiation therapy treatment in Jordan. These centers are: (1) Al Basheer hospital, (2) Queen Alia hospital, Royal Medical Services, (3) King Hussein Cancer Center (KHCC), and (4) Al-Afia radiotherapy and nuclear medicine center. A List of the staff and available equipment are presented in Tables 1 and 2.

Jordan's total surface area is 89.320 Kilometers putting the coverage per surface area at 22,230 km²/center. Unfortunately, all four centers are present in Amman in central Jordan. Amman is home to about 4.2 Million people. This creates a peculiar problem where about 6 Million people of the population of the north and south governorates of the country are not covered and have to travel long hours to receive treatment. Figure 2 shows a map of Jordan. Distribution of Population in Jordan in different governorates are presented in Table 3.

Radiotherapy (RT) machines are highly complicated technological equipment that are both expensive and difficult to operate. External beam radiotherapy or teletherapy is the most frequently used form of RT. The traditional cobalt machine was the main teletherapy equipment until recently when Linear accelerators (Linac) took over. Linacs enables us to modify the shape and intensity of the produced beam by various means. This enables us to produce different types (conventional, conformal, intensity-modulated, tomographic and stereotactic) of radiotherapy according to the patient needs [9]. Currently, the total number of Linear accelerators in Jordan is 12 (6 at KHCC, 2 at Al-basheer hospital, 2 at Al-Afia center, and 2 at Royal medical services) with a population coverage of 830 thousand/megavolt. The low number of machines per population combined with the high load of patients causes the frequent breakdown of machines experienced in all four centers. KHCC radiotherapy department receives 2300 patients every year, while the MOH Al-basheer hospital receives 1500 patients. This puts the machines present MOH at a serious strain where every 750 patient has to be treated with one machine compared to KHCC's 384 patient per machine which is still also a

Institution	Radiation oncologists	Radiation oncology residents	Physicists	Dosimetrists	Technologists	Oncology nurses	Engineers	Data managers
KHCC (NGO)	17	13	9	5	32	10	Biomedical Engineering Department support	6
Queen Alia Hospital, (Royal Medical Services)	9	10	9	0	14	4	1	0
Al Basheer Hospital (JMOH)	8	11	4	0	12	5	Biomedical Engineering Department support	0

Table 1: Staffing at the cancer facilities in Jordan.

Radiation Therapy Facility	Treatment Techniques	X-ray Beam Energy	Electrons Energy	Brachytherapy System	Simulation Equipment	Treatment Planning System	IGRT	Special Techniques Capabilities
KHCC (NGO)	3D CRT IMRT VMAT	6, 10, 15 MV	6, 8, 10, 12, 15 MeV	HDR Ir-192 Nucletron Intracavitary brachytherapy for gynecological malignancies. LDR Plaque therapy for orbital tumor	2 CT SIM with MRI and PET image fusion and CT images capability	Pinnacle, Monaco, Brainlab, and Oncentra	CBCT, iView GT and Clarity IGRT for prostate and breast tumors	SRS, SFRT, TBI, TSI, TLI, SBRT, ABC
Queen Alia Hospital (Royal Medical Services)	3D CRT	6, 15 MV	8, 10, 12, 15 MeV	HDR Ir-192 Nucletron Intracavitary brachytherapy for gynecological malignancies	1 CT SIM with MRI and PET image fusion and CT images capability	Xio	No	No
Al Basheer Hospital (JMOH)	3D CRT	6, 15 MV	6, 9, 10, 12, 15, 21 MeV	No	1 CT SIM with MRI and PET image fusion and CT images capability	Eclipse	No	No
Al-Afia Radiotherapy and Nuclear Medicine Center (Private Sector)	3D CRT IMRT	6, 10, 15 MV	8 MeV	No	1 CT SIM with MRI and PET image fusion and CT images capability	Monaco	No	No

3D CRT - three dimensional conformal radiation therapy, IMRT - intensity-modulated radiation therapy, VMAT - volumetric arc therapy, MV - megavoltage, MeV - million electron voltage, HDR high dose rate, Ir - iridium, LDR - low dose rate, CT - computed tomography, SIM - simulator, MRI - magnetic resonance imaging, PET - positron emission tomography, CBCT - cone beam computed tomography, GT - gated therapy, IGRT - image-guided radiation therapy, SRS - stereotactic radiosurgery, SFRT - stereotactic fractionated radiation therapy, TBI - total body irradiation, TSI - total skin irradiation, TLI - total lymphoid irradiation, SBRT - stereotactic body radiation therapy, ABC - active breathing coordination

Table 2: Current technologies used at different radiation therapy facilities in Jordan.

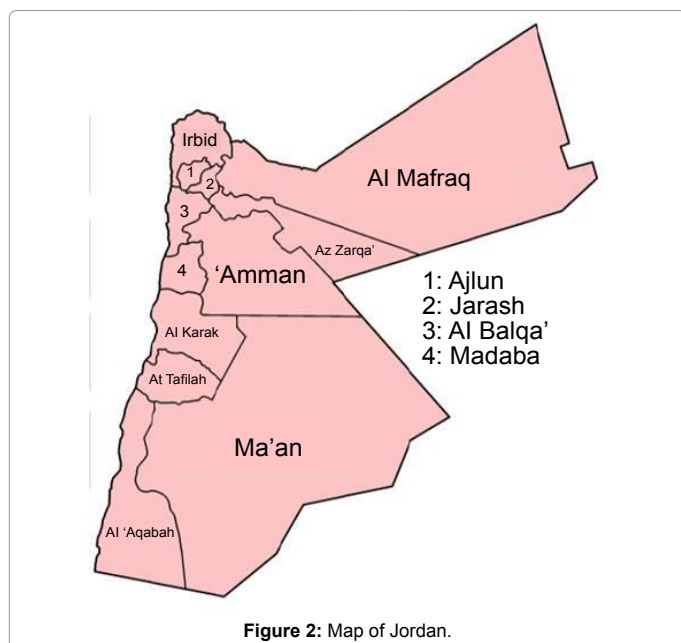


Figure 2: Map of Jordan.

Governorate	Total		Female	Male
	%	No.		
Amman	42.00	4327800	2004300	1323500
Irbid	18.50	1911600	923900	987700
Zarqa	14.30	1474000	694700	779300
Mafraq	5.80	593900	287700	306200
Balqa	5.20	531000	245900	285100
Karak	3.30	341900	163300	178600
Jarash	2.50	256000	122900	133100
Madaba	2.00	204300	69300	108000
Aqaba	2.00	203200	88300	114900
Ajlun	1.80	190200	92300	97900
Ma'an	1.70	171100	81800	89300
Tafila	1.00	104000	49600	54400
Total	100.00	10309000	4851000	5458000

Table 3: Estimated population by governorate and sex, at end of 2018.

the only center that provides this form of radiotherapy. KHCC provides intracavitary HDR brachytherapy radiotherapy for gynecological and nasopharyngeal malignancies, and LDR brachytherapy for tumors of the eye. Recently, a new brachytherapy system was installed at Queen Alia hospital of the Royal medical services.

Other sophisticated modalities that require high level of technical expertise include Three-dimensional Conformal Radiotherapy (3-DCRT), Intensity Modulated Radiotherapy (IMRT), Image Guided Radiotherapy (IGRT), and Stereotactic Radiosurgery (Gamma Knife) [11].

There is a lack of advanced radiotherapy modalities in Jordan. The main treatment modality present at the four centers is the 3D

conventional radiotherapy. Image modulated radiotherapy is only present in KHCC and Al-Afia center, while brachytherapy systems are present only in KHCC and Royal medical services.

KHCC leads the way in improving its inventory of these different systems. Advanced technologies have been acquired there and much experience has been harnessed for other centers to benefit from. KHCC currently have the only Image guided radiotherapy unit in Jordan. In addition, the center has other sophisticated modalities such as stereotactic radiosurgery, stereotactic body radiosurgery, total body irradiation, total skin irradiation, and active breathing control system for breast radiotherapy [12,13].

Future Plans

There has been a growing interest to solve the deficiency in equipment and trained personnel by the Jordanian government, royal medical services, and the private sector. Through increasing financial allocation, charity fundraising, and private sector contributions, radiation oncology has grown as a specialty in Jordan in the past 20 years.

The growing need for radiation treatment for different types of malignancies necessitates a greater effort to create new centers with latest state-of-the-art equipment and highly trained radiation oncologists and supporting staff. King Abdullah University hospital in Irbid (north Jordan) has taken the initiative. A new radiation oncology department will be created there to serve the local population and to increase the machines pool in Jordan overall. The new department will have two linear accelerators, one CT simulator, and one high dose rate Brachytherapy unit.

Similarly, the existing centers plans to expand and increase its equipment inventory and staffing capacity. KHCC intends to install two new linear accelerators and one MRI based simulator. Al-basheer hospital is expanding into a new building comprising two new linear accelerators capable of Intensity Modulated Radiotherapy and Volumetric arc therapy techniques. Queen Alia hospital will also install a new linear accelerator capable of both techniques.

Conclusion

Jordan, being a developing small country with a low GDP faces

a challenge to maintain a viable radiotherapy services. Efforts since 1945 have resulted in an ever growing service with a total of 4 centers. Problems of center distribution and low number of machines are currently the greatest obstacles to overcome. However, we aspire to maintain positively growing interest in providing an affordable and high quality radiotherapy service that is able to serve the Jordanian population and neighboring Arab countries.

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