International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Estimation of Dose Received by Sensitive Organs in External Radiation Therapy of Cervical Carcinoma

Mohamed E. M. Gar-Alnabi[1], Enaam A. Mohamed[2], Mohamed A. Ali Omer[3], Ghada A. E. Sakin[4], Mohammed Farahna[5]

[1, 2, 3, 4] College of Medical Radiologic Science, Sudan University of Science and Technology, Khartoum-Sudan

[3, 5] Radiologic Technology Department, College of Applied Medical Science, Qassim University, Buraidah-KSA

Abstract: ***The main objective of this study was to estimate dose received by sensitive organs in cervical carcinoma irradiation, out of 200 patients referred to Radiation and Isotopes Center of Khartoum (RICK). After successful investigations, the patients were decided to receive a radical radiotherapy course for stage I and II without hematologic spread. The collected variables were the organs position and depth, patient's separations, equivalent field size, percentage depth dose DD% and back scatter factor. The graphs and correlation were carried out using EXCELL software and the analysis of results showed that: the bladder, cervix and rectum were situated parallel to each other from anterior to posterior respectively and they have linear correlation in depth wise with patient separation based in equation:*** $y = 0.38x + 5.56$, $y = 0.39x + 1.82$, $y = 0.4x - 1.74$ ***respectively, where y refers to organ depth and x refers to patient separation in cm with a significant correlation at*** $R^2 = 0.8$. ***The DD% for the tumor (cervix), Bladder, head of femur and the rectum were 89.6%, 61.2, 50.2% and 38.1% respectively. The back scattered radiation increases as the tissue volume increases leading to increment of DD% and the back scatter factor increases exponentially with field size increment based on the following equation:*** $y = 0.022\ln x + 0.98$, ***which is so significant at*** $R^2 = 0.7$, ***where y refers to BSF and x refers to equivalent field size in cm.***

Keywords: External radiation, cervix, cancer, toxicity, estimation

1. Introduction

The cancer has been defined as an abnormal cell growth, the growth of which is uncoordinated with the normal one and persists with same excessive manner after the cessation of the stimuli that evoke it, with a tendency to metastasize to other vital organs via circulatory system, lymphatic system and direct invasion [1]. Such fatal disease could involve most of the human tissue and organs depending on specific induction carcinogenic factors or agents, such as physical factors (ionizing radiation, ultraviolet), chemical factors (Benzo [a] pyrene which cause characteristic point mutation in the p53 gene, Ethyl alcohol, Heterocyclic amine in overcooked meat/fish, Biological factors as viruses, Rb1 gene which is responsible for retinoblastoma… etc [2], one of these organs is the cervix. Cervical carcinoma represents a second commonest gynecological malignancy in Sudan with an incidence about 12 –15.5% of whole cancer and the risk factors include age (the highest risk occurs between late teens and mid-thirties), early age at first sexual intercourse, multiple sexual partners, certain strains of the Human Papilloma Virus (HPV, a sexually transmitted disease), smoking, and daughters of women who took DES (hormonal drug) [3]. As well it represents the most common cause of cancer deaths among women in developing countries, despite the fact that cervical cancer is preventable due to screening program. However approximately 80% of all cases of cervical cancer worldwide occur in less-developed countries, because prevention programs are either nonexistent or poorly executed [4]. It represents the second most common cancer diagnosed in women worldwide after breast cancer and as a third most common cause of death from cancer in women after breast and lung cancer which leads to more than 273,000 as mortality annually and higher in eastern and southern Africa relative to developed world due to screening programs in the developed countries [5].

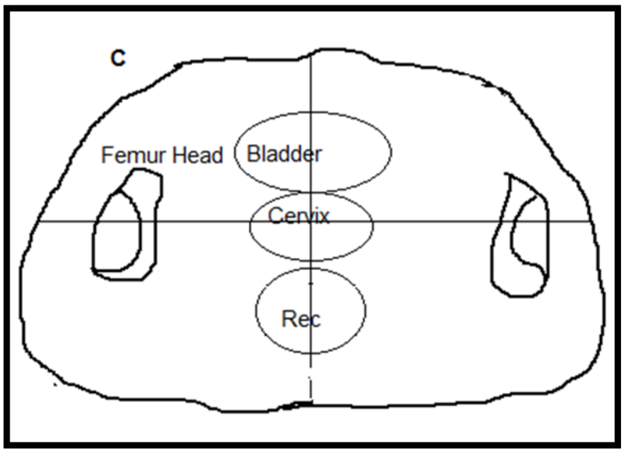
The effort of radiotherapy equipments manufacture's, Medical physicists, physicians, and radiation technologists have been directed to optimize the radiation therapy dose that should not exceed ± 5% of the prescribed tumor dose [6] or as mention by ICRU, [7] that: the error should not exceeds 3-5%, with critical consideration to the normal tissue dose and the adjacent vital organs. The models of treatment for cervical cancer irradiation vary according to types of cancerous tissue and stage of disease, thus for the majority of patients present with organ-confined disease, surgery is the primary treatment. Adjuvant radiotherapy is only indicated for patients at high risk of recurrence [8]. Patients treated with daily fractions of 1.8-2.0 Gy to a total dose of 45-46 Gy over 4.5-5 weeks show an acceptable level of toxicity in prospective studies [9; 10]. Selected patients may receive a brachytherapy boost to the vaginal vault using low, medium or high dose rate after loading radioactive sources.
The planning target volume for treating pelvic malignancy normally encompasses the whole of the true pelvis and may be extended further, depending on the extent and type of malignancy to include the para-aortic nodes, the inguinal nodes or the vagina. This volume necessarily includes a large volume of small and large bowel. Although beams eye view planning allows increased accuracy in shielding the bowel in uninvolved areas of the pelvis, [11] the tolerance of the sensitive organs (Rectum, bladder, hip joints and bowels) determines the dose and fractionation in treating gynecological cancer.

Therefore the focus of this study is to estimate the tumor dose (TD) in cervical cancer irradiation as well as the doses at critical organs such as bladder, rectum and the hip joints using brick technique (4 fields-box technique) relative to the applied given dose GD in external radiation therapy by Co-60 teletherapy machine. Since the conventional radiotherapy commonly used in developing countries rather than the most recent equipments and techniques like intensity modulated radiation therapy IMRT and remote after loading radiotherapy; the radiation risks have been as common. In this realm; [12] found that in external beam radiation therapy EBRT, the biologically equivalent dose for 2Gy fractionation as 2 cc (centimeter cubic) of the bladder wall, rectal wall and sigmoidal wall ranged from 39.47 to 57.12 Gy (median 55.10 Gy); 38.86-54.21 Gy (median 49.83 Gy); and 37.06-51.36 Gy (median 48.67 Gy), respectively. And the attempt reported by ICRP, [13] to manage the fluctuation of dose received by critical organs and target volume was the addition of margin to compensate the internal margin motion and the variation in patient position, however also this idea will induce adverse effects by either increasing the dose to rectum and bladder or giving insufficient carcinocidal dose to the tumor. While Elisabeth et al, [14], reported that: no effect in the dose received by the bladder and rectum when the patient position changed from supine to prone.

One method used to determine the dose at off axis, where the critical organs lie is the utilization of a 3D treatment planning systems (3DTPS) as has been stated by Sethi et al, [15] in which a designed compensating filters and a missing tissue compensation, can account for tissue in-homogeneities for radiotherapy beams. Such in-homogeneity in dose distribution commonly related to curved patients contour and the dose histogram could be derived from CT or MRI images that have to be fed to the TPS.

2. Methodology

200 patients of cervical cancer have been referred to Radiation and Isotopes Center of Khartoum (RICK) for radiation therapy course. After successful investigations as chest x-ray CXR, ultrasound, Lab. test, histopathology and bone scan, the patients were decided to receive a radical radiotherapy course i.e. they were in stage I and II without hematologic spread. The radiotherapy planning carried out using conventional simulator, by which the four radiation fields have been determine as well as the radiation field boarders (Anterior, posterior, and two lateral) together with the beam entrances as proposed by Finlay et al, [16] and as shown in Figure (1). Then the patients' contours (Figure 2) have been taken by using pantograph and the position of target volume and the critical organs (bladder, rectum and hip joints) were labeled and the patient's separation from anterior-posterior and lateral were measured



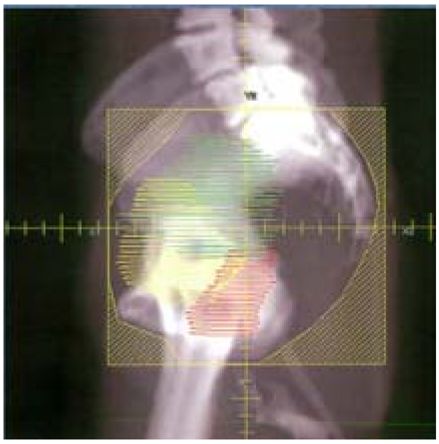


Figure 1: shows the conventional boarders of radiation therapy field: Superior L4/5 or 5/S1, inferior at edge of ischial tuberosity, anterior at symphysis pubis, posterior at post edge sacrum and laterally at 2 cm lateral to bony pelvis [17].

Then the treatment planning system TPS has been fed with the labeled patient's contours for each individual patient, and the final dose histogram was carried out and from which the percentage depth dose DD% at the tumor and critical organs have been determined as determine by Podgorsak et al, [18]. The patient position was supine and using box technique to irradiate the tumor with radical gamma radiation dose of 4500 cGy.

Figure 2 shows the patient contour with labeled target volume and the critical organs as well as the patient separation from anterior-posterior and lateral aspects.

3. Results

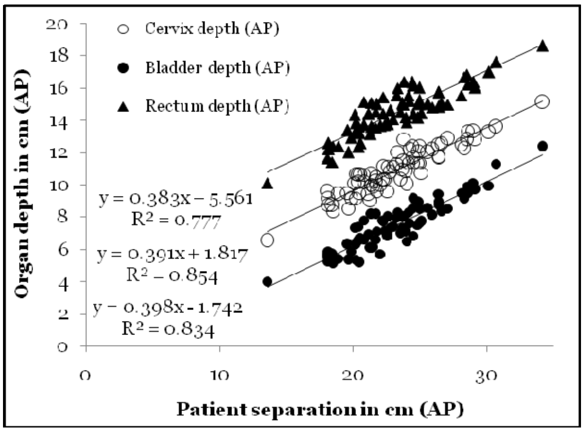


Figure 1: shows the female pelvic organs depth from anterior aspect (AP-view) correlated versus patient AP separation.

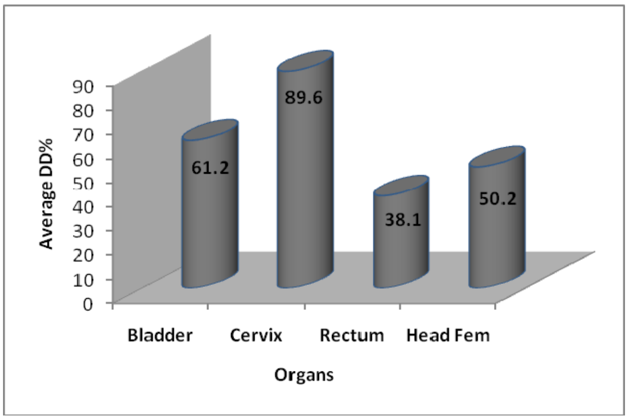


Figure 2: shows the radiation percentage depth dose DD% for female pelvic organs receiving radiotherapy course for cervical carcinoma using box technique.

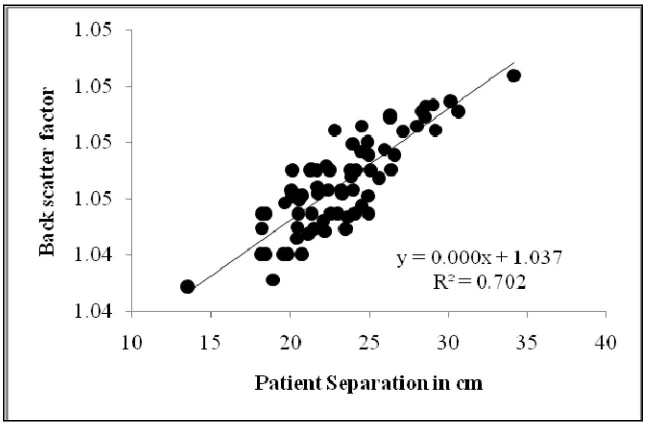


Figure 3: shows the correlation between the back scatter factor and patients separation in cm

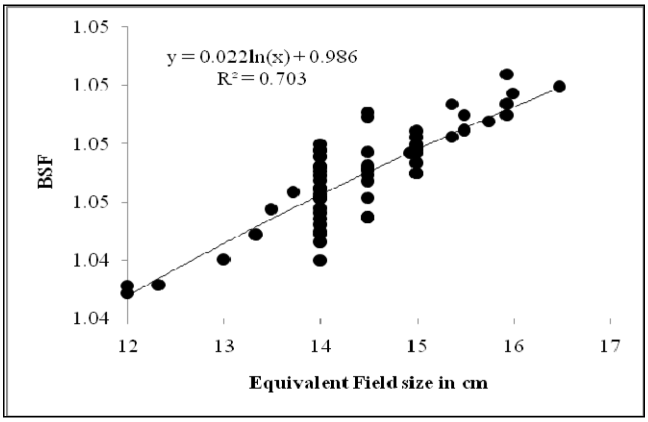


Figure 4: shows the correlation between the equivalent field size and the back scatter factor

4. Discussion and Analysis

Figure 1 shows the female pelvic organs depth from anterior aspect (AP-view) correlated versus patient AP separation. It confirms that: anatomically the rectum situated at most deep to posterior aspect, followed by the cervix and the most anterior organ was the bladder [19]. These organs position have a correlation with patient separation in a linear form of the following equations: y = 0.38x +5.56, y = 0.39x + 1.82 and y = 0.4x -1.74, respectively, where y refers to organ depth and x refers to patient separation in cm with a significant correlation at R2 = 0.8. The data from CT images prove that the cervix is not situated at the mid of patients from AP aspects, this fact should be considered seriously in manual planning of radiation therapy in which they assume that the cervix is a mid-positioning organ leading to overdose in rectum and may give insufficient dose to tumor (cervix).

Figure 2 shows the radiation percentage depth dose DD% for female pelvic organs receiving radiotherapy course for cervical carcinoma using box technique. It revealed that the DD% for the tumor (cervix), Bladder, head of femur and the rectum were 89.6%, 61.2, 50.2% and 38.1% respectively, which were equivalent to 4032, 2308.2, 2333.6 and 2225.6 cGy respectively. The received dose by tumor does not concise with the concept of ICRU, [7] and Zhu, [6] which stated that: the tumor dose has to be ±5% from the prescribed dose, as well Withers et al., [20] stated that: 50 Gy can get 90% probability for local control, even if there are microscopic diseases in pelvic lymph nodes. Therefore such planning would results in ±10.4% as loss of dose, hence leading to recurrence or treatment relapse due to insufficient tumor dose or inadequate pelvic radiation coverage for the draining lymph nodes [21]. Also there were wide variations have been reported in the pelvic anatomy of individual patients, which implies the different levels of aortic bifurcation, altered sacral curvature, and varying course of pelvic vessels [22-24]. These have raised concerns over the adequate coverage of the target volume with conventional two dimensional fields based on standard bony landmarks. The DD% received by these organs usually showed to be considerable due to back scattered radiation which is influenced by the field size and tissue volume [25].

Figure 3 shows the correlation between the back scatter factor (BSF) and patient's separation in cm. it indicates that the back scattered radiation increases as the tissue volume increases leading to increment of DD% for all organs at the target volume. The correlation between patient separation and the back scatter could be fitted in the following equation: $y = 0.000x + 1.037$, which is significant at $R^2 = 0.7$, where y refers to BSF and x refers to patient separation in cm such proportional relationship has been mention by Khan, [25]; Hassan et al, [26], Grosswendt, [27].

Figure 4 shows the correlation between the equivalent field size and the back scatter factor. It reveals that there is proportional exponential relationship between equivalent field size in cm and the back scatter factor BSF in a form of equation: $y = 0.022 ln x + 0.98$, which is so significant at $R^2 = 0.7$, where y refers to BSF and x refers to equivalent field size in cm. Such proportional relationship has been mention by Khan, [25], which is so indicative that: the field size is influencing factor in the BSF as well as in the DD%.

References

[1] Yin, B.W., Lloyd, K.O. (2001). Molecular cloning of the CA125 ovarian cancer antigen: Identification as a new mucin, MUC16. J. Biol. Chem. Vol. 276, P: 27371-27375.

[2] Hiroshi Saeki and Keizo Sugimachi. (2001). Feature: Prevention and Early Detection for Cancer: Carcinogenic Risk Factors. Journal of the Japan Medical Association, Vol. 125, (3), P: 297-300.

[3] Miller, Bomford and kunkler. (2004), Text book of Radiotherapy, 6th. editions Churchill living stone, London England.

[4] Ferlay J, Bray F, Pisani P, Parkin DM. (2004). GLOBOCAN 2002: Cancer incidence, mortality and prevalence worldwide. IARC Cancer Base No. 5, Version 2.0. IARC Press, Lyon - France.

[5] Nyasha Chingore-Munazvo, Priti Patel, Melody Kozah and Caroline James. (2012). Tackling Cervical Cancer: Improving Access to Cervical Cancer Services for Women in Southern Africa. Southern Africa Litigation Centre (SALC), Johannesburg, South Africa.

[6] Zhu X R. (2000), Entrance dose measurements for in-vivo diode dosimetry: Comparison of correction factors for two types of commercial silicon diode detectors, Journal of applied clinical medical physics, Vol. 1 (3), P: 100-107.

[7] ICRU (1976). Determination of absorbed dose in a patient irradiated by beams of x-ray or gamma rays in radiotherapy procedures. ICRU report 24, Bethesda, Maryland.

[8] Creutzberg CL, van Putten WL, Warlam-Rodenhuis CC, (2004); Postoperative Radiation Therapy in Endometrial Carcinoma Trial. Outcome of high-risk stage IC, grade 3, compared with stage I endometrial carcinoma patients. J. Clin. Oncol, 22, P: 1234-1241.

[9] Creutzberg CL, van Putten WL, Koper PC. (2001). Portec Study Group. The Postoperative Radiation Therapy in Endometrial Carcinoma Trial. The morbidity of treatment for patients with Stage I endometrial cancer: Results from a randomized trial. Int J Radiat Oncol Biol Phys, 51, P: 1246-1255.

[10] Churn M, Jones B. (1999). Primary radiotherapy for carcinoma of the endometrium using external beam radiotherapy and single line source brachytherapy. Clin Oncol, 11, P: 255-262.

[11] Gerstner N, Wachter S, Knocke T. H. (1999). The benefit of beams eye view based 3-D treatment planning for cervical cancer. Radiotherapy Oncology Vol. 51, P: 71-78.

[12] Beth M. Beadle, Anuja Jhingran, Mohammad Salehpour, Marianne Sam, B.S., Revathy B. Iyer, and Patricia J. Eifel. (2009). Cervix regression and motion during the course of external beam chemoradiation for cervical cancer. Int. J. Radiation Oncology Biol. Phys., Vol. 73, No. 1, P: 235–241.

[13] ICRU. (1999). Report 62: Prescribing, recording and reporting photon beam therapy (supplement to ICRU report 50). Bethesda: International Commission on Radiation Units and Measurements.

[14] Elisabeth Weiss, Susanne Richter, Clemens F. Hess. (2003). Radiation therapy of the pelvic and paraaortic lymph nodes in cervical carcinoma: a prospective three-dimensional analysis of patient positioning and treatment technique, Radiotherapy and Oncology, vol. 68, P: 41-49.

[15] Sethi, A., Leybovich, L., Dogan, N., and Glasgow, G. (2003). Effectiveness of compensating filters in the presence of tissue in homogeneities. J. Appl. Clin. Med. Phys., Vol. 4, P: 209-216.

[16] Finlay, M.H., Ackerman, I., Tirona, R.G., Hamilton, P., Barbera, L., Thomas, G., 2006. Use of CT simulation for treatment of cervical cancer to assess the adequacy of lymph node coverage of conventional pelvic fields based on bony landmarks. Int. J. Radiat. Oncol. Biol. Phys., 64 (1), P: 205-209.

[17] Michelle F. Benoit, M. Yvette W. Brown, Creighton L. Edwards. (2013). Gynecologic Oncology Handbook: An evidence Based Clinical Guide. Demos Medical Publishing LLL-USA.

[18] Podgorsak E. B., William Parker and Horacio Patrocinio. (2005). Radiation Oncology Physics: A handbook for Teachers and Students, IAEA-Vienna.

[19] Valerie C. Scanlon and Tina Sanders. (2007). Essential of Anatomy Physiology, 5th. edition. published by F. A. Davis company, Philadelphia – USA.

[20] Withers, H.R., Peters, L.J., Taylor, J.M., (1995). Dose-response relationship for radiation therapy of subclinical disease. Int. J. Radiat. Oncol. Biol. Phys., Vol. 31 (2), P: 353-359.

[21] Perez, C.A., Kuske, R.R., Camel, H.M., Galakatos, A.E., Hederman, M.A., Kao, M.S., Walz, B.J., (1988). Analysis of pelvic tumor control and impact on survival in carcinoma of the uterine cervix treated with radiation therapy alone. Int. J. Radiat. Oncol. Biol. Phys., Vol.14 (4), P: 613-621.

[22] Greer BE, Koh WJ, Figge DC, Russell AH, Cain JM, Tamimi HK. (1990). Gynecologic radiotherapy fields defined by intraoperative measurements. Gynecol Oncol; 38: 421-424.

[23] Zunino S, Rosato O, Lucino S, Jauregui E, Rossi L, Venencia D. (1999). Anatomic study of the pelvis in

carcinoma of uterine cervix as related to the box technique. Int J Radiat Oncol Biol Phys; 44, P: 53-59.

[24] Justino PB, Baroni R, Blasbalg R, Carvalho Hde A. (2009). Clinical tumor dimensions may be useful to prevent geographical miss in conventional radiotherapy of uterine cervix cancer: A Magnetic Resonance Imaging Based study. Int J Radiat Oncol Biol Phys; 74: 503-510.

[25] Khan M. Faiz. (2010). The Physics of Radiation Therapy, 4th. edition, Lippincott Williams & Wilkins, Minnesota-USA.

[26] Hassan M.A., M.H. Gaber, E. Esmat, H.I. Farag, H.M. Eissa. (2005). Standard water phantom backscatter factors for medium energy x-rays. Romanian J. Biophys., Vol. 14, (1–4), P: 69–79.

[27] Grosswendt, B., (1990). Dependence of the photon backscatter factor for water on source-to-phantom distance and irradiation field size. Phys. Med. Biol., Vol. 35, P: 1233–1245.

Author Profile

Mohamed Elfadil M. Gar-elnabi: received the B.Sc. in Radiotherapy and Nuclear Medicine, and M.Sc. degrees in Medical Physics from Sudan University of Science and Technology in 1995 and 2001 respectively. He has been working as medical physicist and radiation technologist at Radiation and Isotopes Center of Khartoum as well as a lecturer at College of Medical Radiologic Science, Sudan University of Science and Technology. He received a PhD. degree from Natal University South Africa-2007 in Medical physics as well he is working as a lecturer (Associate Prof.) at Sudan University of Science and Technology-Khartoum-Sudan.

Enaam Abdallah Mohammed Abdallah: Awarded B.Sc. in Radiotherapy and Nuclear Medicine from SUST-2005. Working in RICK as Radiotherapy Technologist from 2005 to 2009 in Sudan, part-timer in teaching at college of Radiologic science same duration and now as Radiology Technician (diagnostic department in Alarda General Hospital) at Jazan Ministry of Health Saudi Arabia since 2009

Mohammed Ahmed A. Omer: Award the B. Sc. -1. in Radiotherapy and Nuclear Medicine, B. Sc.-2 in Medical Equipments Technology and M.Sc. degrees in Medical Physics from Sudan University of Science and Technology in 1995, 1998 and 2001, respectively. He has been working as medical and radiation technologist at Radiation and Isotopes Center of Khartoum as well as a lecturer at College of Medical Radiologic Science, Sudan University of Science and Technology. And he received a Ph. D. degree from University Putra Malaysia - 2007 in Medical physics-Applied Radiation as well now working as a lecturer (Associate Prof.) at Qassim University-Buraidah-KSA.

Ghada A. E. Sakin: Awarded B. Sc. Degree in Nuclear Medicine in 2010 from National Ribat University-Sudan and M. Sc. from College of Medical Radiologic Science-Sudan University of Science and Technology 2013. She has been working as a lecturer (part timer) at Sudan University of Science and Technology-department of Radiotherapy and Nuclear Medicine as well as NM technologist at RICK since up to date. Now as a Ph. D. candidate in same field at Qassim University-Buraidah-KSA.

Mohammed F. Mohammed Manafal: received B.Sc. in Anatomy and Physiology-Al Azhar University (Egypt) 1995, MSc. in Human Anatomy-Khartoum University (Sudan) 1998 and PhD in Medical Anatomy-Delhi University (India) 2004. He has been working as Teaching Assistant, Faculty of Medicine, Upper Nile University (UNU)-Sudan (1995-1997), Lecturer 1997-2004 and Assistant Professor up to 2006. Assistant Professor at Faculty of Medicine, Sudan International University (2006-2008) and Assistant Professor at College of Applied Medical Science, Qassim University, Kingdom of Saudi Arabia (2008-2011).