SPECIAL ARTICLES

HISTORY OF DIAGNOSTIC RADIOLOGY IN GHANA

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Summary

The history of Radiology in Ghana which began in 1951 has not been fully documented. The establishment of the Ghana College of Physicians and Surgeons, of which the Faculty of Radiology is a part, the West African College of Surgeons, as well as other institutions for radiography training, have played a major role in improving the Radiologist/Population-, Radiologist/Radiographer- and Radiographer/Population ratios in the country.

Credence has also been given to a number of aims and objectives of the Faculty of Radiology of the Ghana College of Physicians and Surgeons such as a) The turning out of Radiologists for 9 out of the 16 regions of the country. b) A vast improvement in the quality and quantity of radiological services to the citizenry by the provision of modern radiological equipment, as well as increased manpower for the various diagnostic procedures. c) The establishment of subspecialties such as Interventional radiology, Neuroradiology and Paediatric radiology.

The article seeks to highlight some of the major achievements and challenges in the delivery of radiological services to the citizenry of Ghana. Some of the challenges facing the specialty such as inadequate equipment in some public hospitals and the lack of maintenance of same are discussed. There is also inequitable distribution of radiologists across the country. Recommendations in the area of increased number of resident's slots for postgraduate training by the Ministry of Health, as well as the reestablishment of external exposure for trainers to deepen their knowledge for the training of residents have been mentioned.

Key words: *Ultrasonography, Computerized Tomography, Magnetic Resonance Imaging, Radio-isotope imaging, Mammography*

Introduction

X-rays were first discovered by a German professor of physics by name Wilhelm Conrad Roentgen on November 8th, 1895, in Wurzburg. He obtained a Nobel Prize in physics for his discovery in 1901. One of the earliest photographic plates from his experiments was a film of his wife's hand with a ring on it produced in 1896. His publication was entitled 'A new Kind of Rays' and this sparked an interest in X-rays throughout the scientific world. A year after his discovery, in Menlo Park, New Jersey, Thomas Alva Edison invented the fluoroscope in 1896. Following the discovery of X-rays, several applications of it and other forms of diagnostic methods have been developed to widen the scope and role of radiology in Medicine. Such applications and methods include the use of Ultrasonography (USG), Computerized Tomography (CT), Magnetic resonance imaging (MRI), Radio-isotope imaging, namely Single Photon Emission Computerized Tomography (SPECT) and Positron Emission Tomography (PET), digital radiography (DR) and mammography.[1,2] Ian Donald invented the foetal ultrasound in 1958 after the piezoelectric effect of a quartz crystal under mechanical vibration had been noted in 1880 by the brothers Jaques and Pierre Curie to produce electricity. Following that event several further developments in the commercial use of ultrasound have taken place dating back to 1963 and culminating in devices such as real time, colour Doppler and Spectral Doppler, 3D and 4D foetal ultrasound, the latter two in the 1980s and 1990s respectively as well as several other areas of utility. The first commercially available CT scanner was created by a British Engineer named Godfrey Hounsfield of EMI Laboratories in 1972. He co-invented the technology with physicist Dr. Allan Cormack and both researchers were later jointly awarded the 1979 Nobel Prize in Physiology and Medicine. MRI started in early 20th century. MRI was invented by Paul Christian Lauterbur, an American chemist who shared the 2003 Nobel prize in Physiology or Medicine with Peter Mansfield.

PET was discovered by Edward J. Hoffman, professor of nuclear medicine, together with Michael E. Phels in 1974 while the first whole body PET scanner appeared in 1977. The first completely dedicated mammography unit was developed by Gros in France in the middle 1960s. Digital radiography (DR) was introduced in the mid-1980s precisely in 1987 with Dr. Francis Mouyen launching the first digital radiography system[1,2]. Medical imaging has improved immensely since the discovery of the first X-rays over 120 years ago. There is much more accuracy in diagnosing a

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medical problem and because of these advances, there is also much less need to perform exploratory surgery.

Historical Background

It all started in 1951 when one expatriate radiologist by name Dr. Ali and four expatriate radiographers arrived in the country and were posted to the Korle-Bu Hospital with one of the latter four by name John Moss taking up the position of chief radiographer. The team had a supportive staff of eight x-ray operators who had undergone a 3-year training in radiography at the Ministry of Health X-ray Training School. The pioneer and first Ghanaian radiologist by name, Dr. Ferdinand Christian of blessed memory arrived in Ghana after the departure of the expatriate personnel and was posted to the Korle-Bu Hospital in 1964. He had a supportive staff of 12, out of which 4 had been trained as Radiographers in Great Britain. Other X-ray operators were posted to the 'G' Hospital in Kumasi now the Komfo Anokye Teaching Hospital in the Ashanti region, and other regional hospitals, namely Central, Western, Eastern, Volta and Northern, totalling in all 70. This gave a radiologist/radiographer ratio of 1/70 and a radiologist/population ratio of 1/7,739,473.

Dr. W. O. Brakohiapa, the principal author (present author) arrived in Ghana in February 1975 as a radiologist, after undergoing a four-year training in radiology at the Justus-Liebig University in Giessen, Western Germany. He was posted to the Korle-Bu Hospital X-ray department in February 1975, and thus became the second radiologist at that hospital. Later on, Dr. Mrs. Kuffuor, an expatriate radiologist, was posted to the Komfo-Anokye Teaching Hospital in the late 70's. The Radiologist/Population ratio increased to 3/ 10,395,452 i.e., 1/3,465,150 in 1977 from 1/7,739,473 in 1965. Special mention should be made of the role played by Mr. John Quaye of blessed memory, a principal radiographer, in assisting the present author in the performance of all the angiograms (renal, celiac and peripheral) between February 1975 and February 1981.These specialized examinations were later on carried out by Prof. Boateng-Jumah, Dr.Chris Kotei, both of blessed memory, (as well as the present author).

Prof. Boateng-Jumah and the present author taught residents in training under supervision, namely Drs. S. Asiamah, E. K. Brakohiapa, A. Kaminta and E. M. Ogoe and many others from 1999 to the mid-2000. Prof. Boateng-Jumah and Dr. Chris Kotei joined the Radiology department of the Korle-Bu Teaching hospital in the early 80's, further increasing the radiologist-radiographer ratio. By 1996 the number of radiologists in the country had increased to 7 made up of Prof. Boateng-Jumah, Dr. Chris Kotei and the present author of the Korle-Bu Teaching Hospital. Dr. Mrs. Kuffuor, a British born radiologist, Prof. Genny Scarisberg, at the Komfo Anokye Teaching Hospital (KATH), Dr. Kutin Nuamah at the 37 Military Hospital and Dr. Mrs. Ibukun Olubanke Ahove of the Social Security and National Insurance Trust Hospital (SSNIT), further increasing the Radiologist/Population ratio to 7/17,462,496, i.e.,1/2,494,642.[3] Mr. Smith Kumordjie Ocansey of blessed memory was the first Ghanaian chief radiographer at the Korle-Bu Teaching Hospital after the departure of the expatriate staff in the mid 60's till his retirement in the mid 80's. He was followed by Mrs. Dorothy Mills, from the mid 80's to the early 90's. Mrs. Agnes Odonkor of blessed memory succeeded as the head till the year 2000 and was followed by Miss Harriet Ankrah (later Mrs. Harriet Duah) in 2000 till 2005. Mr. Steven Boateng succeeded Mrs. Duah in 2005 and is the current Chief radiographer of the same institution.

Human Resource Development- (Teaching Programmes)

As with the training of anesthetists and nurse anesthesists in Ghana, the training of radiologists and radiographers began with The West African College of Surgeons and the Ghana College of Physicians and Surgeons for radiologists, and the Ministry of Health training school for X-ray operators.[4] Training for x-ray operators continued with an intake of 10 trainees every 2 years. Mr. Ephson of blessed memory, (who gave all the historical information about radiology in Ghana verbally) to the present author in the period preceding the arrival of the latter in Ghana in 1975, was the sole graduate tutor. He was joined by Messrs. John Quaye and Boadi of blessed memory, John Gagbetor, Mrs. Harriet Duah and Mr. K. Arthur as teaching staff. Mr. Ephson was the first principal of the Ministry of Health X-ray Training School for X-ray operators from 1964 to 1982, followed by Mrs Harriet Duah from 1982 to 1986. Mr. Boadi was the principal from 1986 to 1988 but was succeeded again by Mrs Duah from 1988 to 2004. Mr. K. Arthur succeeded Mrs. Duah from 2004 to 2006. The X-ray operators of The Ministry of Health X ray Training School were later designated as X-ray technicians. The school folded up in 2006 because the School of Biomedical and Allied Health Sciences (SBAHS) of the College of Health Sciences, University of Ghana had started it's radiography BSc degree training already in 2002-2003 academic year, and taken over the further training of radiographers in the country.

Undergraduate and Graduate Training of Radiographers

Masters, Bachelors and PhD Degrees: The School of Biomedical and Allied Health Sciences (SBAHS) of the College of Health Sciences, University of Ghana continued with the training of radiographers, offering a 4-year diagnostic and therapeutic radiography Bachelor of Science, BSc. degree and an MSc. degree in medical ultrasonography. Also under review in the same facility is the MSc in medical imaging and radiotherapy.

The School of Allied Health Sciences (SAHS) of the University of Cape Coast (UCC) offers a BSc. Degree course in Diagnostic Imaging Technology for Radiographers. The University of Health and Allied

Sciences (UHAS), Ho, also offers a Bachelor of Diagnostic Imaging (radiography), Master of Philosophy in Medical Imaging, and Doctor of Philosophy for radiographers, sonographers, radiotherapists, medical physicists and radiologists. The Kwame Nkrumah University of Science and Technology (KNUST) offers a four-year BSc degree course in ultrasonography for radiographers.[5]

Diploma certificate: There is a 3-year diploma training program for radiological technicians started 5 years ago at the College of Health and Well-being, in Kintampo, ran by the Ministry of Health.

Training of Radiologists: West African College of Surgeons (WACS)

The postgraduate training program of the West African College of Surgeons (WACS) was inaugurated in January 1975. Prof. Boateng-Jumah, Dr. Chris Kotei and the present author were external examiners as well as lecturers of the faculty of radiology of the college. Despite the early start of the postgraduate training program of the West African College of Surgeons in 1975, it was not until 1999 that the residency program of the Ghana College of Physicians and Surgeons started in Ghana. Drs. Samuel Asiamah, Edmund Brakohiapa and Edwin Ogoe of the Korle-Bu Teaching Hospital and Dr. Andrew Kaminta of the 37 Military Hospital enrolled as the first group of radiology residents.

These pioneer residents had to do a lot of travelling to Nigeria for multiple radiology update courses with the support of the Ministry of Health. Prof. Boateng-Jumah and the present author asked then Dr. Millicent Obajimi (now Prof. M. Obajimi) of Ibadan University College Nigeria to assist as a visiting lecturer in the training of the first group of residents in the year 2000 followed by Dr. Alex Akoto Yeboah to beef up the faculty. The first Ghanaian fellows of the West African College of Surgeons in radiology by examination were Drs. Samuel Asiamah, Edmund Brakohiapa and Edwin Ogoe (2003), followed a year later by Dr. Andrew Kaminta (2004). Thereafter Dr. Vincent Hewlett and Dr. Mrs. Klenam Dzefi-Tettey in 2005 with Dr. Mrs. Klenam Dzefi-Tettey becoming the first female Ghanaian radiologist to qualify from the WACS. Other fellows from the WACS were Drs. Eric Otu-Danquah, Mrs. Augustina Badu-Peprah, Adu Tutu Amankwah, Margaret Twum, Yaw Mensah-Boateng, Benjamin Dabo Sarkodie, Jared Oblitey, Hafisatu Gbadamosi, Rosemond Aboagye, Andrea Appau, Mary Oblitey and Yaa Achiaa Afreh, making a total of eighteen (18) Ghanaian Fellows to date. The current Ghanaian examiners of WACS are Drs. Samuel Asiamah, Edmund Brakohiapa, Vincent Hewlett, Klenam Dzefi-Tettey, Augustina Badu-Peprah,and Yaw Mensah-Boateng.

History of the Establishment of the Ghana College of Physicians and Surgeons (GCPS)

It all started in a small hotel in New Achimota in 2002 when the then Acting Rector of the College, Prof P. K. Nyame, called a meeting of heads of Faculties and their deputies to start drawing up their curricula for the establishment of the Ghana College of Physicians and Surgeons. Prof. Boateng-Jumah and the present author attended that meeting and started immediately thereafter to work on the curriculum for the Faculty of Radiology. Others who played a role were the British born Radiologist Dr. Genny **S**carisburg from the KATH and Dr. Alex Akoto Yeboah with the help of the newly qualified fellows of WACS. Eventually the GCPS was inaugurated in 2003 with Prof. P. K. Nyame as the first rector of the college, and Prof. Boateng-Jumah as the first chairman of the Faculty of Radiology, followed by Dr. Alex A. Yeboah and the present author; the latter in 2006.

Aims and Objectives

The aims and objectives of the faculty of Radiology in line with those of the Ghana College of Physicians and Surgeons are basically to increase the overall manpower in the delivery of radiological services to the citizenry of Ghana and beyond.[6]

Accreditation of Teaching Hospitals

The KBTH in Accra and later the KATH in Kumasi were giving full accreditation whereas the 37 Military Teaching Hospital in Accra was given partial accreditation according to specific criteria of the college. Upon the acquisition of an MRI machine, the 37 Military Teaching Hospital was also given full accreditation while the University of Cape Coast Teaching Hospital was given partial accreditation in 2018. A final curriculum was drawn up in 2007 by Dr. Samuel Asiamah and the present author both of the Korle-Bu Teaching Hospital as well as Dr. AduTutu Amankwah of the Komfo-Anokye Teaching Hospital based mainly on the Australian model, while the ultrasound portion of the curriculum was based on the model of the Jefferson Ultrasound Radiology Education Institute (JUREI) at the Thomas Jefferson University Hospital in Pennsylvania USA. A review of the curriculum including a new system of fellowship has been drawn up by Drs. S. Asiamah, Mrs. Ewurama A.Idun, Mrs. Klenam Dzefi-Tettey and Adu Tutu Amankwaa in November 2021.

Human Resource Development - (Training Programme)

The radiology postgraduate program of the GCPS started at the KBTH and Dr. C. Tasiame after passing a written and oral examination in March 2004 was admitted into the program in September of the same year. Later Drs. A. Ankrah, Ewurama A. Idun, Alhassan, E. M. K. Edzie, K. Amedi, H. Afachao and Adu-Gyimiri joined him for the membership program, with the residents of the 37 Military Hospital receiving part of their training at the KBTH. The faculty examiners comprised the present author as chief examiner and others namely Drs. Samuel Asiamah, Edmund

Brakohiapa, Mrs. Augustina Badu-Peprah, Andrew Kaminta, Mrs. Klenam Dzefi-Tettey and Vincent Hewlett with Dr. Yaw Mensah-Boateng as the invigilator, and Professor Donald Amasike Nzeh of Nigeria as the external examiner. The heads of Departments of Radiology in the teaching hospitals later became designated as examiners. The total number of residents in the Teaching Hospitals at the end of February 2022 is 68 comprising 30 at the Korle-Bu Teaching Hospital, 17 at the 37 Military Teaching Hospital and 21 at the Komfo Anokye Teaching Hospital and there are 6 fellows of GCPS by examination to date.

The Role of the Teaching Hospitals

The heads of the teaching hospitals and their supporting colleagues have played a vital role in the training of residents for the postgraduate program, namely Dr. A. Kaminta, who played a vital role in the training of his residents and was an examiner till his retirement with Drs. Alhassan, Mrs. E. A. Idun and currently Dr. K. Amedi as the next head of department supported by Dr. Janet Bamfo-Addo, Dr. Lulu (a visiting Cuban radiologist), and three other radiologists of the 37 Military Hospital; Prof.Boateng-Jumah, Drs. Alex Akoto Yeboah, Vincent Hewlett, Yaw Mensah-Boateng and Mrs. Klenam Dzefi-Tettey as successive heads of the department of radiology of the Korle-Bu Teaching Hospital, supported by Dr. Chris Kotei, the present author, Drs. Samuel Asiamah, Edmund Brakohiapa and Edwin Ogoe of the Korle-Bu Teaching Hospital; as well as Dr. Mrs. Augustina Badu-Peprah and Dr. Adu Tutu Amankwah, supported by Drs. Ato Quansah, George Asafu Adjayi Frimpong and a visiting Nigerian Radiologist, Dr. Adeyinka (now Prof.) of the KATH. The head of the Radiology Department of the School of Medical sciences of the University of Cape Coast, Dr. E. K. M. Edzie and Prof. P. N. Gorleku are yet to begin the training of residents.

Teaching

Teaching continues to be enhanced in the form of 1) didactic lectures on the 10 organ systems by lecturers of the college, supported by daily presentations by residents on selected topics. 2) Constant online lectures by external lecturers on various topics through zoom, facilitated by Drs. E. A. Idun, A. Badu Peprah and Klenam Dzefi-Tettey. 3) Practical teaching of residents on various forms of imaging including USG, CT and MRI of the whole body as well as angiography, Barium studies, interventional radiological procedures, film viewing and reporting. The faculty chooses various topics of interest for continuing professional development (CPD) yearly at the Annual General Meeting of the College. The present author assumed the positions of chairman and chief examiner of the faculty of radiology in 2006 and played a major role in directing the affairs of the faculty as well as participating fully in the teaching of residents until his retirement in 2012. Mention should be made of Dr. Samuel Asiamah for his role in human resource development of the faculty of radiology of the Ghana college of Physicians and Surgeons, firstly as the former secretary and secondly, now chief examiner of the faculty, as well as his role in the teaching of residents in the theory and practice of MRI, CT, Ultrasound, angiography and core biopsy. Through Dr. Asiamah's tutorship and further attachment in the USA as an observer, a fellow of the college, Dr. Yaw Mensah-Boateng has acquired the skills in biopsy and drainage and has also trained Drs. Simpson Mensah and Hafisatu Gbadamosi in CT and ultrasound-guided biopsy and drainage as well as Drs. Andrea Appau and Dorothea Akosuah Anim in ultrasound-guided procedures. Dr. Mrs. Klenam Dzefi-Tettey, the current faculty secretary of the GCPS and head of the department of radiology of the Korle-Bu Teaching Hospital together with other fellows, namely Drs. S. Asiamah, Yaw Mensah-Boateng, B. D. Sarkodie, A. Appau, E. Jackson and Hafisatu Gbadamosi have also played and continue to play an important role in the teaching and training of residents assisted by 6 members at the Korle-Bu Teaching Hospital. Similar mention is made of Drs. Augustina Badu-Peprah, Adu Tutu Amankwah, Ato Quansah and George Asafu Adjayi Frimpong of the Komfo Anokye Teaching Hospital for their roles in the teaching of residents and other colleagues.

Pre- and Post-Fellowship Exposure

Some of the first to the fifth groups of fellows from the West African College of Surgeons have had postgraduate exposure in Radiology outside Ghana. Drs. Edmund Brakohiapa, Edwin Ogoe, Samuel Asiamah, Vincent Hewlett, Klenam Dzefi-Tettey, Eric Otu-Danquah, Augustina Badu- Peprah, Adu Tutu Amankwah, Yaw Mensah Boateng and Benjamin Dabo Sarkodie had attachments of varying periods at the Hospital of the University of Pennsylvania (HUP), USA. While at HUP they attended short term ultrasound courses of various types and duration such as breast core biopsy, Doppler, musculoskeletal, transvaginal, 2D and 3D OBGY USG at JUREI of the Thomas Jefferson University Hospital in Philadelphia, Pennsylvania. Dr. S. Asiamah also attended a 3-month course in interventional radiology (Angiography and core-biopsies) in Hungary before attending another 3-month course in the University of Pennsylvania in MRI. Drs. Augustina Badu-Peprah and Ato Quansah had courses of 6 months and 3 months duration respectively at the Academic Medical Centre (AMC) in Amsterdam. Dr. Kaminta had a 1 year, pre-fellowship attachment in Australia. These exposures have positively enhanced their knowledge and teaching capabilities in radiology to the advantage of the faculty of radiology of the GCPS.

Interventional Radiology

Interventional radiological procedures actually started when Prof. Boateng Jumah assisted in an

ultrasound–guided drainage of a liver abscess by a surgical specialist in 2001 while Dr. E. K. Brakohiapa assisted in an ultrasound-guided Nephrostomy tube placement by the urologist, Dr. J.Mensah (now Prof.) and also performed breast core biopsies in 2004 at the Radiology Department of the Korle-Bu Teaching Hospital.

Subspecialty Training

Dr. Benjamin Dabo Sarkodie of the Korle-Bu Teaching Hospital is the first accredited interventional radiologist in Ghana. Other subspecialty radiologists are Dr. Emmanuel K. Y. Jackson of LEKMA Hospital but now at the KBTH as a neuroradiologist and Dr. Rosemond Aboagye of the Greater Accra Regional Hospital as a pediatric radiologist. Special mention is made of Dr. B. D. Sarkodie for his role in the first treatment of cerebral aneurysm by coiling/stenting, hitherto unavailable in Ghana. He has since then, on his own, performed several cases of that kind as well as other procedures some of which are, the non-vascular interventions such as biliary drainage/stenting; nephrostomy; radiofrequency and microwave ablation of tumours; endovascular interventions: angioplasty and stent insertion; transarterial chemoembolization (TACE); neurointerventions: intracerebral aneurysm coiling/stenting; intra-arterial chemotherapy for retinoblastoma. There are currently 3 radiologists, namely Drs. Edmund K. Brakohiapa of the University of Ghana Medical School, Babatunde B. Jimah of the School of Medical Sciences, UCC and Dorothea Akosua Anim of the Radiology department of the Korle-Bu Teaching hospital undergoing training in his outfit.

Dr. E. K. Y. Jackson (Neuroradiologist); some of the procedures being carried out by him are CT/Fluoroscopic- guided steroid injections, nerve root block, medial branch block and rhizotomy. Fluoroscopic guided ganglion impar block, vertebroplasty, intrathecal chemotherapy injection, CT guided synovial cyst rupture. Dr. Rosemond Aboagye (Pediatric Radiologist): apart from the routine procedures performed under fluoroscopy such as barium studies and others of the genitourinary tract, she performs specialized USG including Doppler studies, USG guided drainages and biopsies, as well as Specialized paediatric CT and MRI for all systems.

Ultrasound Training

The training for non-radiologist medical doctors in ultrasonography in Ghana earnestly began when Philips Engineering organized a 'Teaching the Teachers' program at their premises in 1997. The program was attended by 3 radiologists namely Prof. Boateng Jumah, Dr. Chris Kotei and the present author, as well as two gynaecologists, namely Dr. J. O. Armah of blessed memory and Prof Seffah of the University of Ghana Medical School. Following that event, the three radiologists participated in the training of more than 120 doctors in ultrasonography in Ghana[7]. This was followed by the Thomas Jefferson University Ultrasound Unit's 'Teaching the Teachers' program in which the present author was among eight African radiologists who underwent a 4 months' training program in ultrasound at the Ultrasound Unit of the Thomas Jefferson University in Philadelphia. Participants were given certificates of participation after the period apart from receiving 2 ultrasound machines each to use for teaching in 'Jefferson Ultrasound Affiliate Centres' in their various countries. He started the ultrasound training program successfully for radiologists and residents for some time at the Korle-Bu Teaching Hospital's Thomas Jefferson Ultrasound Affiliate Centre of which he was the director but had to curtail the program because of lack of cooperation.

Current Examinations in Teaching Hospitals

All the teaching hospitals carry out simple examinations of the chest, abdomen, skull, upper and lower extremities as well as the spine and mammography. **Special Examinations**: These include:

1) Fluoroscopy**:** Barium studies, namely barium meal, swallow and enema, distal loopogram, fistulogram, hysterosalpingography, urethrography, micturating cystourethrogram, sinography, retrograde cystourethrography.

2) USG: of the abdomen and pelvis, doppler and duplex ultrasound of the vessels, muskulo-skeletal USG and ultrasound of small parts such as breast, thyroid and scrotum.

3) CT scan of the brain, sinuses and orbits, chest abdomen and pelvis, spine, breast and prostate as well as CT urography, angiography and triple phase angiography of the liver.

4) MRI: Brain, sinuses, orbits, internal auditory meatus, abdomen, pelvis, spine, joints as well as Magnetic Resonance Cholangiopancreatography (MRCP) are performed at the Korle-Bu- and Komfo Anokye Teaching Hospitals, but not available at the 37 Military Hospital and the School of Medical Sciences of the University of Cape Coast.

5) Interventional radiological procedures are performed at the Korle-Bu Teaching Hospital, Komfo Anokye Teaching Hospital and the School of Medical Sciences, University of Cape Coast. In addition, the Korle-Bu Teaching Hospital offers dacrocysto/sialography, T-Tube intraoperative and postoperative cholangiography, Percutaneous Transhepatic Cholangiography (PTC) and Endoscopic Retrograde Cholecystopancreatography (ERCP).

Equipment-History

Initial Stage: The basic X-ray equipment at the Korle-Bu Teaching Hospital in the early to mid '70s were one MX-2, and one MX-4 machines, manufactured by Watson and Sons Ltd. for conventional radiography. There were also 2 General purpose machines from Philips and Siemens, one with linear tomographic attachment, and the other with attachment for

angiography. The fluoroscopic machine at that time was a fluorescent screen, for which the radiologist needed visual adaptation in the dark for 30 minutes before screening could begin. There was also a skull unit used by Dr. Mustapha, a renowned neurosurgeon of blessed memory, for performing ventriculography, pneumoencephalography and carotid angiography. Orthopantomography for dental radiography was also available at the X-ray department of the Korle-Bu Hospital.

Equipment for the middle stage, i.e. The mid-1970s to mid-1980s at the Korle-Bu Hospital continued as above until the late 1980s when a fluoroscopic machine with image intensifier and TV monitor was acquired. The first CT scanner was acquired in 1994 at the Korle-Bu Teaching Hospital. Following that event, radiography machines, CT scanners and ultrasound scanners have been acquired by other hospitals and private institutions in the country since the early 1990s. The climax of equipment acquisition however occurred when a new Spiral CT Scanner, an MRI machine, 4 ultrasound machines, 2 out of which had Doppler capability, a new mammography machine as well as a Siemens fluoroscopic machine with image intensifier and remote-control system were installed at the Korle-Bu Teaching Hospital in 2006. There is now an increasing number of 1.5 Tesla MRI machines in private and a few public facilities, and a 3 Tesla MRI machine at the International Maritime Hospital in Tema. The MRI machine at the 37, Military Hospital is however non-functional, and the School of Medical Sciences of the University of Cape Coast is yet to acquire an MRI machine. Coronary angiograms and virtual colonoscopy can be undertaken in private facilities at the Euracare Advanced Diagnostics and Heart Health Centre, and Akai House clinic in Accra, as well as the Spectra Health Centre in Kumasi.

Achievements/Observations

By the end of the year 2008, four (4) residents had qualified as members of the faculty of radiology (of the Ghana College of Physicians and Surgeons) by examination and 3 of them, namely Drs. K. Amedi, Mrs. E. A. Idun and E. K. M. Edzie, had embarked on a fellowship program which they successfully completed in 2009. By the year 2012 there were in total 30 radiologists in the country, about 56 in 2019 and 92 in 2021, to further improve the Radiologist/Population ratio from30/26,000,000, i.e., 1/866,666in 2012 and still further in 2019 to 56/30,417,856 i.e.,1/543,176 as well as in November 2021 to 92/30,800,000 i.e., 1/334,782. The Radiologist/Radiographer ratio also improved from the mid-70s from 2/70, i.e., 1/35 to 92/342, i.e., 1/3.713 in 2021. The Radiographer/Population ratio also improved in the middle seventies from 70/10,395,452, i.e., 1/148,506 to 342/30,800,000 i.e., 1/90,058 in 2021.[3,8,9] The recommended mean number of radiologists in Western Europe, for example, Germany is 12 per 100,000 people, and the USA 10-12 per 100,000. Ghana has 0.289 radiologists per 100,000 (2.89/1,000,000) people and Nigeria has 0.231 per 100,000 (2.31/1,000,000) in 2019. This means that the Ghanaian Radiologist-population ratio of 92/30,800,000 i.e., 1/ 334,782 is favourable compared to the Nigerian Radiologist-population ratio of 1/566000. Africa generally has very low numbers of radiologists for their population.[10]

However, the trend in Ghana shows improvement compared with the past period. By the effort of the training colleges and Ghana Association of Radiologists, the Eastern, Western, Volta, Bono, Bono East, Northern and Central regions which hitherto had no radiologists, obtained pioneer radiologists in the persons of Drs. C. Tasiame, Mrs. M. Twum, K. Kekesie, K. Adu Gyimiri, Isaac Quaye, A. Bawa and E. K. M. Edzie respectively.

Despite the low availability of, and familiarity with the use of teleradiology in Ghana, there is a significant reduction in radiological reporting times by radiologists since the introduction of the application. According to Edzie E. K. M *et al* only 13% of radiologists in Ghana had availability to teleradiology even though 32.6% were familiar with it. About 95.7%, 13% and 10.9% of radiologists used WhatsApp, Facebook and Twitter facilities respectively for the communication of radiological information. Other supporting ICT facilities such as Picture Archiving and Communication System (PACS), Electronic Patients Record (EPR), and Radiology Information Systems (RIS) have all contributed to the improvement created by teleradiology. Digital Imaging and Communications in Medicine (DICOM) software was used by 58.7% of radiologists in Ghana while MicroDicom and AMIDE (a Medical Image Data Examiner) were scarcely used[10].

Even though there are now well established facilities for the training of radiographers especially in ultrasonography, a number of recalcitrant institutions are still operating in the field with inadequate training, sometimes as short as 2 weeks, with certification of participants. This situation has led to a spurious act of the 'mushrooming' of untenable and fake ultrasound units all over the country to the detriment of the unsuspecting patient. Sixteen percent (16%) of ultrasonographers in Ghana are not licensed despite the existence of regulatory bodies for licensure. Despite the existence of ultrasound practice in eleven (11) out of sixteen (16) regions in the country, there is still an unfair distribution of sonographers because 70% of them are located in the Greater Accra- and Ashanti regions.[11]

There has been a marked improvement in the acquisition of CT facilities in Ghana currently compared with the early 90s, while MRI equipment acquisition has witnessed only a marginal increase of 1, i/e. (14) currently compared with the figures of 2016, i.e. (13), most probably because of the high cost of the MRI equipment. However, there is a progressive increase in MRI utilization in Ghana due to increased sensitivity (better contrast resolution capability than CT scan) and

the fact that it does not use ionizing radiation. The trend of inadequate availability of MRI equipment and application for the population goes for the West African subregion, even though there has been an increase in the number of equipment in the last decade. Ghana's 14 MRI units were fairly equally distributed between the private (57%) and the public sectors (43%). Ghana with 0.48 units/million population had the highest number of MRI units/million population followed by Nigeria with 0.30 units/million population.[12,13] There has been a steady increase in the types of specialized radiological examinations including new techniques of interventional radiology compared with the past period. This has been exemplified by Benjamin Sarkodie *et al* [14,15] and George Asafu Adjayi Frimpong *et al*.[16,17]

Mammography remains the mainstay examining tool in the diagnosis of breast diseases. Breast cancer is the commonest female cancer worldwide and also the commonest cause of cancer related deaths in Ghanaian women. Screening mammography is practiced worldwide and helps in early detection of breast cancer. Although a retrospective study on breast diseases in 2013 revealed that there was a larger number of screening mammography evaluations (115 out of 180) 63.8% than symptomatic diagnostic evaluations,[18] a more recent study on cervical and breast screening of Ghanaian women in 2020 shows a low mammogram screening practice of 3.4% among Ghanaian women.[19] Tomosynthesis (commonly known as three-dimensional mammography) has become more common although not available in all breast imaging centers. New modalities for breast screening such as MRI and USG, despite their specific advantages and drawbacks, are unlikely to overtake mammography screening for the general population in the near future.[20,21] To date there are 92 radiologists, 68 radiology residents and 342 certified radiographers in Ghana with the distribution of Radiologists as shown in **Table 1**.

Challenges

A few of the many challenges facing the delivery of radiological services in Ghana are as follows. 1)The need to establish more subspecialties in radiology to cater for all aspects of specialized diagnostic and therapeutic needs cannot be overemphasized and needs financial support from the ministry of health. 2)There is inadequate funding for the purchase and maintenance of equipment in public hospitals and health posts. 3)There is the need to address the existing unfair distribution of radiologists in the various regions.

Ghana Association of Radiologists (GAR)

The Ghana Association of radiologists was inaugurated in 2009 with the present author as the first president, followed by Dr. Mrs. A. Badu-Peprah, Dr. E. K. Brakohiapa, Dr. Mrs. Ewurama A. Idun and presently re-elected Dr. Mrs. Augustina Badu-Peprah. Since the formation of the association there has been a study progress in the collective services of radiologists in the country through annual conferences and meetings with multiple scientific sessions for continuing professional development (CPD). These have included both in person, and online teaching sessions, the first online lectures being held in 2016 using the teamviewer App. With the advent of the COVID-19 pandemic, Zoom meetings have however become the most predominant teaching modality. One such notable event was the first update course organized on a webinar by the West African College of Surgeons (Faculty of Radiology) during the COVID-19 pandemic and hosted by Ghana.[22]

Table 1. Regional distribution of Ghanaian radiologists

Region	
GREATER ACCRA REGION	54
CENTRAL REGION	5
WESTERN REGION	1
EASTERN REGION	5
ASHANTI REGION	18
VOLTA REGION	2
NORTHEN REGION	3
SAVANNAH REGION	0
NORTHEAST REGION	0
WESTERN NORTH REGION	0
BONO REGION	3
BONO EAST REGION	2
AHAFO REGION	0
UPPER EAST REGION	0
UPPER WEST REGION	0
OTI REGION	0

The annual conferences feature both internal and external presenters on various topics including interventional and paediatric radiology. The GAR is an Associate Institutional Member of the European Society of Radiologists (ESR). To date the GAR can boast of 140 members.[23] **Table2** lists the private diagnostic centers in Ghana, and the public and private diagnostic centers in Ghana that provide CT and MRI services.

Recommendations

Postgraduate radiology residency training in Ghana needs to be strengthened to deliver the core mandate of producing members and fellows of the college with requisite professional skills, who would deliver quality radiological services to the citizenry, engage in research as well as achieve the aim of producing 3 radiologists for the regions and 2 for the districts in the near future. This can be achieved by 1) Increasing the number of slots for resident trainees in the program by the Ministry of Health. 2)Re-establish post graduate external attachments for trainers to deepen their knowledge and skills for training residents. 3)Institute bidirectional performance appraisal to enable trainees to evaluate their trainers in order to counteract the 'little or no accountability concept' on the part of trainers. 4)In addition to professional qualification and competences there is the need to instruct trainers in modern medical

education and pedagogic techniques. 5)The concept of overemphasis on service provision of the resident to the detriment of educational enterprise needs to be changed.[24] Funding for the purchase and maintenance of modern diagnostic equipment in public hospitals and other public health facilities would be desirable for implementation by the Ministry of Health. To stem the unacceptable and unwarranted status quo and health menace posed by unlicensed sonographers, regulators and other stakeholders must cooperate by subjecting all practicing diagnostic medical sonographers to register with the professional body, the Ghana Society of Radiographers (GSR). The GSR umbrella association must also support the licensed sonography practitioners and the regulatory body.

Table 2. Regional distribution of imaging facilities in Ghana

PRIVATE DIAGNOSTIC CENTRES	
GREATER ACCRA REGION	**ASHANTI REGION**
International Maritime Hospital	Quitt Healthcare Ltd
C and J Hospital	Hopexchange Medical Center
Supreme Specialist Scan	Aninwah Medical Center
Best Scan	Gimc
Quest Medical Imaging	Spectra Health
Scanport Medical Diagnostics	**CENTRAL REGION**
Euracare	Raaj Specialist Scan
Sonotech Medical and Diag Center	Rand Medical and Health Systems
Plus Diagnostics	**BRONG AHAFO REGION**
Sunshine Health Care	Techiman Holy Family Hospital
Paradise	**EASTERN REGION**
Synlab	St Dominic Hospital
Bog Hospital	**WESTERN REGION**
Grace Diagnostic	Oasis Medical Consult
The Trust Hospital	Raaj Specialist Scan
Diagnostic Centre	Diascan
Akai House Clinic	
Genesis Diagnostics	
Precious Gem Diagnostics	
Medray Diagnostic	
Nyaho Medical Center	
Clinax Health Care	
Accra Medical Center	

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DIAGNOSTIC CENTRES WITH CT	
GREATER ACCRA REGION	**ASHANTI REGION**
International Maritime Hospital	Gimc
C And J Hospital	Spectra Health
Supreme Specialist Scan	Aninwah Medical Center
Quest Medical Imaging	Knust Hospital
Euracare	Hopexchange Medical Center
Sonotech	KATH
Pluslab Diagnostics	**WESTERN REGION**
Sunshine Health Care	Oasis Medical Consult
Paradise	Ghana Ports and Harbour Authority Hospital
Synlab	Diascan
Bog Hospital	Efia Nkwanta Reg Hospital
Grace Diagnostic	**EASTERN REGION**
The Trust Hospital	St Dominic Hospital
Diagnostic Centre	Koforidua Regional Hospital
Akai House Clinic	**BRONG AHAFO REGION**
KBTH	Techiman Holy Family Hospital
Medray Diagnostic	**CENTRAL REGION**
Plus Diagnostics	Cape Coast Teaching Hospital
Nyaho Medical Center	**NORTHERN REGION**
Clinax Health Care	Tamale Teaching Hospital
Accra Medical Center	**BONO REGION**
37 Mil Hospital	Sunyani Regional Hospital
Gt Accra Reg Hosp	**VOLTA REGION**
Univ Of Ghana Medical Center	Grace Diagnostic
DIAGNOSTIC CENTRES WITH MRI	
GREATER ACCRA REGION	**ASHANTI REGION**
International Maritime Hospital	KATH
C and J Hospital	Spectra Health
Quest Medical Imaging	
Euracare	
Paradise	
Sunshine Health Care	
Diagnostic Centre	
KBTH	
Focos Orthopedic Hospital	
Sinel Hospital	
Accra Medical Center Center	
Sonotech	

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