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REVIEW

Role of pathology in sub-Saharan Africa: An example from Sudan

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Abstract: In sub-Saharan Africa there is an extreme shortage of pathology services and, when provided, they are of unacceptable standard. Specimen handling and storage are very poor, and render this important aspect of medicinal practice rudimentary. The situation on the ground reflects the full spectrum of the educational, cultural, political, and economical challenges that must be confronted in building basic scientific capabilities in the life sciences, including medicine, in such countries. It is a difficult and often discouraging situation, however, several constructive initiatives have been promoted to address this problem. In this paper we describe the current state of pathology services in sub-Saharan Africa, documenting our experience in Sudan. We also report some of the results obtained by others and our future goals, and propose how pathology-related problems could be addressed in sub-Saharan Africa, by focusing on specific critical points, which may also be considered for other developing countries outside Africa.
Keywords: pathology, Africa, networks, standard operative procedures, telepathology

Introduction

Pathology plays a major role in the diagnosis and staging of many diseases and subsequently in the treatment and management of patients.[1,2] Furthermore, pathology now has an important role in the definition of molecular prognostic/predictive parameters in cancer that leads to more targeted therapy for cancer patients in developed countries.[3–12] Worldwide, histopathologic diagnosis is one of the backbones of tumor registries.[3,13] Moreover, because of the experience in continuously improving specimen handling and cryopreservation protocols, pathology departments are increasingly involved in the development of biobanks that collect, classify, and store cells and/or tissues for translational research.[14] This is in addition to the great quantity of formalin-fixed and paraffin-embedded tissue samples that are already stored in pathology archives, which represent by far the most abundant source of solid-tissue specimens associated with clinical records.[14] These clinicopathologically annotated tissue blocks provide the solid base for two major research goals, ie, gene expression studies in cancer[15–17] and faster validation of potentially useful biologic markers.[14,18] These activities need sophisticated technologies to produce the fine-tuned diagnosis necessary for targeted medicine, ie, so-called "modern medicine".[18,19] Thus, adequate pathology services and finely-tuned diagnosis are a prerequisite for exact definition of disease patterns, and subsequently better treatment and management of patients, as well as the availability of clinicopathologically annotated tissue banks, which are, in turn, necessary to design health care policies and research priorities. Even though current clinical practice in most sub-Saharan African countries will gain little from

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such advances, fine-tuned diagnosis is required as a first step because it will eventually lead to better medical practice.

Here we discuss the current state of pathology services in sub-Saharan Africa, documenting our experience in Sudan as an example of an African context. We also report some of the results obtained by several constructive initiatives, as well as future goals. We also propose how pathology-related problems could be addressed in sub-Saharan Africa by focusing on specific critical points, which may also be considered in developing countries outside Africa.

Pathology services in sub-Saharan Africa

In sub-Saharan Africa, there is an extreme shortage of pathology services and, when provided, these are below acceptable standards.[2,3,20,21] Specimen handling and storage is very poor, which renders this important part of medicine rudimentary.[2] This is mainly due to the fact that diagnostic pathology services lag behind the development of clinical resources and also lag behind in the availability of upgrading.[2,20,22] This is a major problem, because it undermines the possibility of rationally addressing health care needs for patients.[1–4,13]

Most sub-Saharan African countries have an extreme shortage of medical personnel, including pathologists.[2] As an example, in 2007, Uganda had 18 practicing pathologists for a population of 28 million and Tanzania had 15 pathologists serving a population of 38 million people.[3] Emigration of doctors compounds this problem further. The necessity of obtaining training in foreign countries, awareness of the difficulties in applying new skills back home, and experience of the Western job market leads to a "brain drain" from developing to developed countries. Moreover, international nongovernmental organizations (NGOs) sponsored by/or directly part of the United Nations often tend to divert physicians and pathologists from daily practice to projects offering both higher salaries and a more socially rewarding role.[23]

Sudan: An example of the challenges

Sudan, with an area of one million square miles (2,505,810 km^2) and a population of nearly 40 million, of which about 15% live in Khartoum, the capital city,[24] is an example of the challenges that need to be addressed in establishing pathology services in sub-Saharan Africa.

Sudan adopted a federal system in 1995, whereby public resources are managed by a federal or a central government, comprising 26 states and 100 local councils.[22] In 2002 Sudan spent about 0.2% of its gross domestic product on health. Even though it rose from 1.5 billion Sudanese pounds in 1999 (a 74% increase), it remains extremely low by all standards.[22] Data on the 26 state budgets and actual expenditures are scattered throughout different branches of central government and are extremely difficult to collect. The difficulty lies not only in their bureaucratic dispersion, but also in the fact that states do not use a single template for reporting.[22]

Historically, Sudan pathology laboratory services were initiated by the Wellcome Tropical Research Laboratories in 1903, followed by the Stack Medical Research Laboratories, established by the British General Governor, Sir Lee Stack. This is now the National Health Laboratory of Sudan. It was the only laboratory providing histopathology services for Sudan until 1978, and reports were sent by telegraph to all the Sudanese states. Gradually some regional histopathology laboratories were established, the first of them built by the University of Gezira in 1978. Currently, all histopathology services in Sudan are sustained by only 51 pathologists, 40 (78.4%) of whom are working mostly in Khartoum. Three pathologists (5.9%) service the Northern States, two (3.9%) work in Western Sudan, two (3.9%) in the western part of Central Sudan, two (3.9%) in eastern Sudan and three (5.9%) in Gezira State. Pathology laboratory services are also provided by private laboratories in Khartoum and in few other main towns, eg, Wad Medani in Gezira State. Up until 1980, most pathologists were trained in Western countries, mainly in the UK. This important training opportunity was unfortunately interrupted for political and economic reasons. Currently, there are two postgraduate clinical pathology programs for medical officers in Sudan, one at the University of Khartoum (since 1980) and the other at the University of Gezira (since 1993). Both are four-year MD programs (Table 1). During 2009, there were 40 clinical pathology students enrolled at the University of Khartoum and 12 at the University of Gezira. In both programs, the first two years comprise Part 1, with theoretical general teaching in the four major branches of pathology, ie, chemical pathology, microbiology, parasitology and entomology, hematology and blood transfusion, and histopathology and cytopathology. Students also rotate periodically in major laboratories. In the second two years, ie, Part 2, students choose two subjects which they study in detail, with regular seminar and journal club attendance. The main training in Part 2 is practical work in recognized laboratories under the supervision of experienced clinical pathologists. A research project is required from each student as a partial fulfilment of the MD. About 50% of the students take histopathology as their major subject. This four-year course leads to specialist registration on the

Table 1 Sudanese clinical pathology postgraduate program for doctors

Medical school	Location	Hospital	Duration	Type of training*	
Faculty of Medicine, University of Khartoum‡	Khartoum, Central Sudan	Khartoum Teaching Hospital	Four years	First two years	Theoretical general teaching and rotation in major laboratories
				Second two years	Focus on two subjects with practical work under supervision of experienced pathologists
Faculty of Medicine, University of Gezira#	Wad Medani, Central Sudan	Wad Medani Teaching Hospital	Four years	First two years	Theoretical general teaching and rotation in major laboratories
				Second two years	Focus in two subjects with practical work under supervision of experienced pathologists

*Research project is required from each student as a partial fulfilment for the MD; ‡last enrolment was 40 students; #last enrollment was 12 students.

Sudan Medical Council register. As stated previously, most of the graduates prefer to work in the capital, Khartoum. The Federal Ministry of Health has an agreement with Malaysia where about 40 candidates are trained to MSc level in hematology, histopathology (10 candidates), and microbiology. Candidates undergo a minimum of three months of assessment by two consultants when they return to Sudan before being granted their specialist registration.

In Sudan there are 19 faculties of medical laboratory sciences. The programs are generally of four years' duration and consist of a three-year general course in medical laboratory technology and basic medical sciences, followed by a fourth year for specialization in one of the four major branches of pathology, leading to registration as a technologist on the Sudan Health Profession Council register. Laboratory technicians and technologists mostly practice independently, except in histopathology and cytopathology.

According to the Sudanese Ministry of Higher Education and Scientific Research statistics (http://www.mohe.gov.sd/content/statistics.htm), the Sudanese medical laboratory schools had 4,505 undergraduate students in 2007–2008. In the same year, 837 medical laboratory technologists graduated in medical laboratory technology. There is still no clear career structure for scientists in the field of pathology in Sudan.

It is difficult to obtain data on the number of pathology specimens examined in Sudan due to the fragmented nature of the services. A rough estimation ranges from 30 to 40 thousand specimens per year, handled by the above-mentioned laboratories. Many laboratories use semiautomatic tissue processors and produce formalin-fixed paraffin-embedded blocks and routine sections stained with hematoxilyn and eosin (H & E). A few laboratories add some special stains, like PAS, Alcian Blue, reticulin and Elastic Van Geison, especially for liver, kidney, and gastrointestinal biopsies. Immunohistochemistry services are provided by three laboratories and cytogenetic studies by one laboratory, all located in Khartoum.

Almost all the histopathology laboratories have no written standard operative procedures (SOPs) covering quality control and quality assurance policies, and no strict measures against biologic risk for technologists and pathologists. Frequently the specimens are received unfixed, often being supplied in saline, and sometimes in absolute alcohol or in full-strength formalin, with obvious tissue alterations. The ratio of formalin volume to specimen size is frequently inadequate, with resulting lytic changes in the central parts of the specimens. Disposable jars are not used (to minimize cost), and different containers, ie, any type of available, mostly glass, jars are used, with obvious risks for people handling them. Reagents are imported mainly from low-cost factories that may not observe international quality standards. Precise anagraphic and clinical data are lacking in many cases, making it difficult, if not impossible, to make clinicopathologic correlations and to compile databases and registries. A similarly problematic referral system has been previously described by Dafaallah et al in Wad Medani area, Sudan.[25]

Maintenance of equipment, especially tissue processors, poses problems from time to time, mainly because of unstable power supply, inexperienced maintenance engineers, and difficulty getting correct replacement parts at the right time, either through the original manufacturer or local facilities.

The process from surgical sample to pathologic diagnosis requires several steps to be performed with the aid of different instruments. These instruments are often adequately maintained or may be out of order. This problem, together with the absence of SOPs, is likely to have a deleterious effect on the quality of slides. At times, the combined effect of unavoidable and apparently trivial deviations from standard procedures or good practice makes it very difficult to recognize which step should be modified to improve the overall quality of microscopic preparations which, in turn, impinges on the ability to make an accurate diagnosis. Indeed, the lack of ancillary techniques makes it mandatory to have very good microscopic preparations in order to facilitate diagnoses solely on morphologic grounds. Hence, the limited availability of maintenance services and of spare parts for laboratory instruments is a major problem. The bulk of the above-mentioned problems are caused by constant budget reductions that adversely affect pathology departments.

The Department of Pathology, Faculty of Medicine, University of Gezira has the only "laboratory" in the entire Gezira State, servicing about four million people (10% of the total population of Sudan, spread across 26,075 km^2).[24] This laboratory receives 5000–6500 surgical specimens annually and about 800–1300 cases for cytopathologic assessment, 95% of which are fine-needle aspirations. The average annual load during the years 2005–2009 at Gezira Laboratory was 5749 ± 476 and 1052 ± 128 specimens per year for histopathology and cytopathology, respectively; the overall annual load average was 6802 ± 494 (Table 2). Cytology stains at Gezira laboratory include hematoxylin and eosin, Papanicoloou and MGG. The bulk of the surgical specimens (70%) are from the hospitals in Wad Medani city where the Gezira laboratory is located, and the rest (30%) are received from other areas of Gezira State (10%) and from two neighboring states (20%), with distances reaching 400 km. Generally, there is a very poor logistic system for delivering the specimens to the laboratories. Most specimens are brought in by copatients, and in only two places they are collected by local private laboratories and transported to the Gezira laboratory under the supervision of a laboratory attendant using public transport. Buffered formal saline 10% is rarely used, and sometimes the specimens are received in normal saline and, rarely, in absolute ethanol. Environmental conditions are harsh in sub-Saharan Africa. Dust and/or dust storms that are frequent in Sudan need special mentioning, because many of the laboratory instruments are sensitive to dust, ie, microtomes, processors, and microscopes.[26] Loss of mechanical precision in the case of microtomes may adversely affect the quality of slides.[26,27] Also, dust may play an important role in the frequent breakdowns and shortening of the working life of essential laboratory equipments.[26,27] High ambient temperatures (reaching above 45°C in summer) are a major problem. Room temperature may reach 35°C if the cooling systems break down or during electricity blackout(s). This poses difficulties with wax, stains, and chemicals. Furthermore, request forms, when available, are often inadequately completed.[16]

Table 2 Total number of specimens received per year at the Department of Pathology, Faculty of Medicine, Gezira University, 2005–2009

Year	Histopathology, n (%)	Cytopathology, n (%)	Total, n (%)
2005	5065 (83.3)	1012 (16.7)	6077 (100)
2006	6003 (83)	1230 (17)	7233 (100)
2007	5446 (83.2)	1100 (16.8)	6546 (100)
2008	6194 (85.6)	1041 (14.4)	7235 (100)
2009	6039 (87.3)	879 (12.7)	6918 (100)
Average ± SD	5749 ± 476	1052 ± 128	6802 ± 494

Abbreviation: SD, standard deviation.

Diagnosis depends mainly on routine H and E and the use of a few special stains such as PAS, Alcian Blue, reticulin, Perl's stain, silver-methenamine, and Congo Red, used mainly for liver and kidney biopsies. Frozen section and electron microscopy services are presently not available. The range of diagnoses is quite wide, from tropical pathologic problems to different types of malignancy. Cancer accounts for about 7% to 8% of all specimens received (Tables 3, 4, and 5). Tables 4 and 5 detail the most common malignancies diagnosed in our laboratory.

Cancer patients are usually referred at the National Cancer Institute University of Gezira (NCI-UG), located on the same campus as the Gezira pathology laboratory. With involvement of oncologists, surgeons, gynecologists, pediatricians, and pathologists, different clinical approaches have been implemented to assure proper management of

Table 3 Total number of patients diagnosed with cancer from 2005 to 2009

Year	Male, n (%)	Female, n (%)	Total, n (%)
2005	270 (44.2)	341 (55.8)	611 (100)
2006	347 (45.1)	423 (54.9)	770 (100)
2007	351 (44.7)	435 (55.3)	786 (100)
2008	416 (46.1)	487 (53.9)	903 (100)
2009	513 (43.8)	659 (56.2)	1172 (100)
Average ± SD	379 ± 91	469 ± 118	848 ± 209

Abbreviation: SD, standard deviation.

Table 4 The 10 most common cancers in men, 2005–2008

Rank	2005		2006		2007		2008	
	Cancer type	**n (%)**	**Cancer type**	**n (%)**	**Cancer type**	**n (%)**	**Cancer type**	**n (%)**
1	Prostate	27 (10)	Prostate	53 (15.3)	Prostate	64 (18.2)	Prostate	96 (23.1)
2	NHL	23 (8.5)	NHL	35 (10.1)	NHL	21 (6)	Liver	32 (7.7)
3	Colorectal	19 (7)	Bladder	21 (6.1)	Nasopharynx	17 (4.8)	Nasopharynx	26 (6.3)
4	Nasopharynx	18 (6.7)	Unknown primary	19 (5.5)	CML	17 (4.8)	NHL	26 (6.3)
5	ALL	12 (4.4)	Skin	16 (4.6)	Colorectal	15 (4.3)	Colorectal	20 (4.8)
6	Hodgkin's disease	12 (4.4)	Liver	15 (4.3)	CLL	14 (4)	Esophagus	19 (4.4)
7	Liver	12 (4.4)	ALL	15 (4.3)	Larynx	12 (3.4)	Stomach	14 (3.4)
8	Esophagus	10 (3.7)	Nasopharynx	12 (3.5)	Liver	11 (3.1)	Bladder	13 (3.1)
9	Hypopharynx	9 (3.3)	Esophagus	11 (3.2)	Bladder	11 (3.1)	Lung	13 (3.1)
10	Unknown primary	9 (3.3)	Hodgkin's disease	10 (2.9)	Oral	10 (2.8)	CLL	12 (2.9)
Sub list total		151 (55.9)		207 (59.7)		192 (54.7)		271 (65.1)
Total male cancer		270 (100)		347 (100%)		351 (100)		416 (100)

Abbreviations: ALL, acute lymphoblastic leukemia; NHL, non-Hodgkin's lymphoma; CML, chronic myelogenous leukemia; CLL, chronic lymphocytic leukemia.

cancer patients. The ongoing lack of immunohistochemistry hinders effective treatment of female breast cancer according to, eg, estrogen-progesterone receptor, proliferative index (Ki67), and HER2-neu expression status,[28] and also limits the differential diagnosis of, eg, small blue round cell tumors of infancy as well as poorly differentiated neoplasms.[29,30]

Nevertheless, there are some positive points to consider. First, there is now a federal general directorate for laboratory medicine, which promotes organizational plans and facilities for clinical and anatomic pathology laboratories. Because much has to be done to improve the management and technical capability of the laboratory services in Sudan, the effects of the efforts of the above-mentioned directorate should be visible in a few years' time. Second, Sudan is fairly well advanced in telecommunications and Internet services, which may facilitate telepathology services,[31,32] which have yet to be implemented in Sudan. Efforts to solve these problems are ongoing, including external collaborations with Italy and the UK. Currently, bilateral visits with Italian collaborators are regularly taking place. The introduction of an immunohistochemistry service is

Table 5 The 10 most common cancers in women, 2005–2008

Rank	2005		2006		2007		2008	
	Cancer type	**n (%)**	**Cancer type**	**n (%)**	**Cancer type**	**n (%)**	**Cancer type**	**n (%)**
1	Breast	105 (30.8)	Breast	163 (38.5)	Breast	147 (32.5)	Breast	195 (40)
2	Cervix	27 (7.9)	Cervix	50 (11.8)	Cervix	38 (8.4)	Ovary	41 (8.4)
3	Ovary	26 (7.6)	Ovary	29 (6.9)	Ovary	31 (6.8)	Cervix	35 (7.2)
4	Esophagus	24 (7)	Esophagus	18 (4.3)	Esophagus	25 (5.5)	Esophagus	28 (5.7)
5	Colorectal	14 (4.1)	Uterus	13 (3.1)	NHL	22 (4.9)	Uterus	26 (5.3)
6	NHL	10 (2.9)	NHL	12 (2.8)	Uterus	13 (2.9)	Colorectal	17 (3.5)
7	CML	10 (2.9)	Unknown primary	11 (2.6)	Colorectal	12 (2.6)	Bladder	15 (3.1)
8	Hypopharynx	9 (2.6)	AML	9 (2.1)	Hypopharynx	12 (2.6)	AML	14 (2.9)
9	Nasopharynx	9 (2.6)	CML	8 (1.9)	Nasopharynx	11 (2.4)	CML	13 (2.7)
10	Liver	9 (2.6)	Nasopharynx	7 (1.7)	Liver	10 (2.2)	Unknown primary	11 (2.3)
Sub list total		243 (71.3)		320 (75.7)		321 (70.9)		395 (81.1)
Total female cancers		341 (100)		423 (100)		435 (100)		487 (100)

Abbreviations: ALL, acute lymphoblastic leukemia; NHL, non-Hodgkin's lymphoma; CML, chronic myelogenous leukemia.

moving along at a good pace. As a first step, testing for estrogen-progesterone receptor and HER2-neu expression status in breast cancer and a basic panel for lymphoma are now available. A frozen section facility is to be established with the help of an experienced Italian pediatric histopathologist who is currently working at the laboratory for three months, with direct involvement in the process of upgrading a pediatric pathology service. Biobanking, SOPs, validation of diagnosis, and telepathology projects are being seriously considered.

Molecular techniques are well established in Gezira state at the NCI-UG and, with the help of colleagues from Italy, training in detection assays in formalin-fixed paraffin-embedded tissues, mycobacteria, and viral agents was established.

In Gezira, pathologists and clinicians exchange information by mobile phone, during discharge clinics, clinicopathologic conferences, multidisciplinary teams and clinics, and by sending junior staff to get more information. Multidisciplinary services are now well established for breast, gynecologic, prostate, and head and neck cancers.

Upgrading pathology services in Africa

The situation at the coal face reflects the full spectrum of the educational, cultural, political, and economical challenges that must be addressed to build basic scientific capabilities in the life sciences in developing countries.[2,33]

However, there are countries that in the past have faced similar situations and overcome them, eg, the National High-Tech R & D Program launched in China[4] and the development of the Indian pharmaceutical industry that presently manufactures an impressive list of recombinant vaccines.[35] Another example was the creation of a network of primary medical research centers in South Africa.[36] However, the number of countries that have not made significant strides ahead in the biomedical field is large, and includes most sub-Saharan African countries.

The above-mentioned success stories may provide a general guide and/or specific case studies of how to overcome such impediments in the life sciences in sub-Saharan Africa. It is noteworthy that the so-called "inactive participation" in programs originating abroad does not work. At the moment there is no consensus on how to help developing countries, whether large centrally coordinated efforts are needed, or whether solutions should be found by innovative people "on the ground", known as "searchers".[3,37] This debate is complex, but these issues have to be more familiar to pathologists who would like to get professionally involved in health care in developing countries or simply want to understand the problems.[3,38]

The main problems that need to be addressed in the sub-Saharan region are the shortage of dedicated resources, the extremely low number of pathologists and pathology departments, the geographic distances involved, the poor SOPs used in sample handling, the extreme temperatures (even within the laboratories), and the need for developing logistic systems for sending specimens from peripheral hospitals to centralized pathology laboratories.

Obviously, these problems cannot be addressed only by NGOs or by single pathologists with good will. Government investments are needed to create the backbone on which projects for the development of pathology departments can be built. Consolidation of the existing resources could be the first step. The consolidation of all activities in centralized laboratories allows better education as well as continuous training of pathologists, biologists, and technologists. Resources can be concentrated, hence, optimizing costs. The concentration of specimens in core laboratories must respect specimen handling procedures and ensure that the personnel are trained to adhere strictly to all applicable SOPs. Central laboratories need to sponsor and track the overall procedures, ie, fixatives, disposable jars, and working temperatures. Fixation times must be strict, so peripheral collection centers should send specimens jars by courier, a service functioning reasonably at an acceptable cost in most developing countries. Specimens and smeared slides could be shipped at room temperature in insulated packages to protect them from high temperatures. In this regard the National Cancer Institute Best Practice for Biospecimens Resources[39] provides an excellent guide to SOPs for specimen collection and shipping. Specific training to formalize quality management systems is necessary. Quality assurance and quality control programs could be provided by expert external pathologists, but procedures should always be shared with local personnel.[28] In fact, perceived involvement of all members in team decisions is positively and significantly associated with team cohesiveness, productiveness, satisfaction with the team, satisfaction with team communication, and desire to stay with the team. The College of American Pathologists' international survey program may serve as a guide to set up laboratory quality control and quality assurance.[40–43]

Telepathology and networks creating new opportunities

The Internet is an important tool for ongoing medical education, and is critical for histopathology.[31,32] Telepathology can be classified into technical solutions and fields of application. Using static telepathology, a passive system based on offline imaging without interactivity between operators, it is easy to share macro- and microscopic photographs, but dynamic telepathology allows producing of "virtual slides" with navigation tools. These slides can be moved, arranging magnification powers as desired, transforming the computer into a microscope. The main fields of application are frozen section service, expert consultation, education and training, and quality control.[32,44,45] Virtual microscopy with "whole slide" images is a technology that breaks the limitations of conventional static telepathology.[46] However, there are still technical problems, particularly the limited bandwidth of the usual networks, with consequent delayed transmission rate and screen presentation time. These problems can be solved with high-resolution/high-speed digital scanners and broadband optic fiber networks, but costs are still unrealistically high for many developing countries.

During the last five years, the use of static, low-cost telepathology has become popular in many countries, particularly in Latin America, where learning, teaching, and exchange of views in special web forums is permitted.[32] Many medical schools participate in these forums and in the ensuing autoevaluation tests for teaching purposes. Recently the use of Windows Live Messenger and Skype for image transmission has been proposed for interconsultation at low cost.[31] Both programs allow voice transmission concomitant with images. Internet transmission speed varies from 400 Kb to 2.0 Mb. With the use of high-speed broadband, this system could become important in pathology teaching in poorly resourced countries.

A similar system has been developed in Zimbabwe, a country particularly afflicted by shortage of medical teaching personnel.[47] Interesting and promising experiences occurred in Bulawayo where, using local hospital libraries, the Internet, and recruiting local clinicians, it was possible to set up the first histopathology course in the region.[47] Obviously, lessons and locations could be considered unorthodox compared with more formal teaching in developed countries, but the information obtained by the students reflects the clinical relevance of the diseases prevalent in Zimbabwe.[47]

Role of pathology in cancer prevention in Africa

In developing countries, the need for creating solid networks of pathologists continues to grow in parallel with the increasing incidence of cancer. According to the African-Oxford Consortium and World Health Organization, 15 million new cases of cancer worldwide are projected by 2020, and 70% of these will be in developing countries.[48] A special problem will be cancer in Africa.[49] African governments and development agencies have focused their attention on common health issues, such as communicable diseases, and maternal and child mortality.[48,50] However, in Africa, these older health problems coexist with new ones that are closely connected and rapidly progressing, in particular autoimmune deficiency syndrome and cancer. Accurate data are difficult to obtain because cancer registries cover only 11% of the African population,[51] and the quality of information about cancer types is poor because of the above-mentioned severe shortcomings in histopathologic diagnosis.[52,53] Mortality statistics for cancer are also inadequate; since 1995, only three African countries (Mauritius, Egypt, and South Africa) have contributed to the cancer mortality database. However, even in South Africa, death registrations for cancer are estimated to be incomplete.[53]

About 650,000 new cases of cancer are estimated to have occurred in Africa in 2002 (530,000 of which were in sub-Saharan African countries).[54] It is interesting to observe that cancer incidence and mortality seems to have risen before the spread of the current human immunodeficiency virus/AIDS epidemics.[55]

Cancer of the cervix, the most common cancer in African women (30–40 per 10^5 women),[56] is of special interest here because of the important contribution of pathologists to its prevention. In this regard, pathology departments should be closely involved with local communities. Human papilloma virus (HPV) testing, solely or in combination with cytology, can detect cervical cancers and their precursor lesions. The low specificity of HPV-DNA testing and the lack of skilled cytotechnologists in sub-Saharan Africa suggest that other techniques should be considered. This includes HPV typing for high-risk HPV genotypes, mRNA coding for E6 and E7 viral proteins, and markers of HPV-related proliferative lesions, such as p16. However, these are expensive techniques that are best centralized in specialized laboratories. In countries with limited resources, the use of a single HPV test followed by immediate "screen and treat" algorithms based on visual inspection in HPV-positive cases could be the best choice to minimize the number of visits and make the best use of resources.[57] As mentioned earlier, in Gezira, pathologists and clinicians interact by mobile phones, by sending junior staff to get more information, during discharge clinics, clinicopathologic conferences, and multidisciplinary teams and clinics.

Here, it is worth mentioning that the NCI-UG at the University of Gezira has recently launched a pilot cervical cancer screening program (P-CCSP-2009), targeting an area considered to be "high-risk" by gynecologists at the Wad Medani teaching hospital. The NCI-UG is providing the funds necessary to establish the program. P-CCSP-2009 evolved from the efforts of gynecologists, two pathologists, three oncologists, and two molecular biologists. Regular meetings are ongoing. Efforts to arrange mobile clinics are underway, including transportation of specialist(s) onsite and facilitating interactions.

Conclusion

Pathology services in sub-Saharan Africa are severely underdeveloped, in spite of their pivotal role in identifying and addressing health needs. To address this problem, the rudimentary laboratories existing in sub-Saharan African countries should be upgraded to meet diagnostic needs. These laboratories should have more scientific value with modern programs of training and teaching, which may take advantage of telepathology and the Internet. Adequate technologies tuned to local possibilities and clear identification of and adherence to SOPs, are urgently needed. Good will is necessary, but by itself is not sufficient alone. Only local governments and academic, scientific, and political authorities with proper programs and investments can change the reality on the ground.

Pathologists in more developed countries can play an important role in supporting programs for technological innovation, acting in cooperation with local medical and governmental institutions. In this regard, ethnic and lifestyle differences should be kept in mind.[58] Specific guidelines should be developed for each country, trying to build local expertise rather than promoting inappropriate and unsuitable high-technology solutions based on evidence from the Western world.[3] Time, expertise, and respect for local culture and lifestyle are requested from Western pathologists to support their colleagues working in developing countries.

Disclosures

The authors report no conflicts of interest in this work.

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