WaidX: a novel Telepathology approach for Developing Countries

Introduction

Africa is a continent of opportunities for growth, undergoing a rapid economic transformation, which, however, will result in an increase of noncommunicable diseases (NCDs). Estimates in 2015 suggested that the annual number of new cases over the next 5 years will grow to above 1 million. Predicted deaths from NCDs over the next 10 years will also increase globally by 17%, the greatest increase being in Africa (27% or 28 million deaths)[1,2,3].

The ability to provide early diagnosis, treatments, and follow-up care has a large impact on care efficacy and patient survival. The importance of pathology in correct diagnostics and further adequate cancer treatments cannot be emphasized enough. There are currently still a high number of African countries in which pathology services are struggling with a limited number of pathologists, inadequate infrastructure and with severely restricted budgets from the government. At the same time, pathology is unarguably the backbone of the success of the cancer care.

The challenges facing pathology diagnostics, education and oncology research in Africa, are multiple and daunting. They include the lack of or inadequate infrastructure and personnel: both pathologists and technical personnel, inadequacy of opportunities for professional education or training, 'brain drain' following many years of political military taking over with mismanagement of the health-care services and a lack of or insufficient funding for basic laboratory materials such as reagents.

While we acknowledge these challenges, many of which are not going to go away in the foreseeable future, custodians of African pathology and clinical oncology must begin to ask new and pragmatic questions, for example: how can we deliver a better and more acceptable quality of services within

the limits of current resources? The ‘game plan’ must address the following, immediately and in a sustained way.

It must:

- explore avenues for updating the knowledge base of practicing pathologists in a sustainable way, addressing the processes for enhancing the quality of training of current pathology trainees and technical staff
- explore the need for continuous quality improvement and quality assurance
- develop new models for healthcare in appropriate new technologies

Telepathology in Developing Countries

Telemedicine has the potential to be used in many services and applications such as VoIP and web conferencing, teleconsulting, medical records software, digital imaging, e-learning and several others. The World Wide Web (WWW) and Information & Communication Technologies (ICT) play a pivotal role in telemedicine diffusion.

Despite the term “Telepathology” was defined more than 30 years ago, telepathology practice largely remains a privilege of high-income countries. Digital Divide, the economic and social inequality of peoples in their access, use or knowledge of ICT, plays a determining role in curbing the spread of telepathology, such as the lack of solutions tailored for the Developing Countries (DC) needs.

The divide between differing regions of the world is hugely remarkable between developing and developed countries in terms of technological gap, social engagement, information poverty, and Internet access diffusion.

However, other “divides” exist: Sub-Saharan African Countries suffer a dramatic shortage of medical pathologists (in the range of 1 to 10 pathologists per 10 million people).

During the last decade, Pathology has benefited from the rapid progress of image scanning technology. Progress in improving this technology has led to the creation of slide scanners that are capable of producing digital images of a complete histological cut, that can be exploited by image

viewers in a manner comparable to the conventional microscope. When the slide is digitally scanned in its entirety in high resolution (Whole-Slide Imaging), the resulting digital image is called "virtual slide".

Although the capture of photos of microscopic views opened the road to "static telepathology" (store-and-forward model), telapathology based on virtual slides offers a much more effective means to view an entirely digitized slide, allowing the remote browsing of the slide by running image management software on a standard web browser[4].

File size of the digital images ranges from a few Megabytes to several Gigabytes, which routinely address storage and image management challenges in daily clinical practice, particularly with regard to virtual slides scanning which produces the largest files.

Digital slides are used in pathology for educational purposes, diagnostics (clinical-pathological meetings, consultations, reviews, panels, and increasingly for tele-diagnostics), research and archiving. Digitisation of slides provides several advantages, but the diffusion of Digital Pathology in DC opens new challenging issues to be faced including costs for virtual slide scanning, accessibility and limitation to the net-neutrality due to local Internet Service Providers (ISPs), management of huge sized files, security for sensitive data.

The Mwanza Cancer Project and WaidX

Formerly medical Physicist, I gained a 20-years experience in ICT and Digital Health in the private sector, never neglecting my commitment in scientific research. During the last decade I completed my training with a PhD in General and Molecular Pathology, characterized by the synergy between my skills, and I began to visit health facilities sited in Sub-Saharan Countries.

During my first African journey, visiting the Bugando Medical Centre (BMC) in Mwanza – Tanzania, a question arose urgently in me: how can I help in closing the gap?

BMC hosts the sanitary mission held by Associazione Vittorio Tison ONLUS, an Italian no-profit devoted to develop the Clinical Oncology facility in Mwanza[5]. Amazing achievements were growing

in a scenario characterized by the resource poverty and a strong digital divide issue, with a dramatic impact on the efficacy of the effort put by project managers and volunteers coming from Italy.

This scenario stimulated me in undertaking the design of an intercontinental telematic platform oriented to oncology and its related branches, able to interconnect BMC Oncology Department with the Istituto Scientifico Romagnolo per lo Studio e la Cura dei Tumori (IRST) – Italy, to allow for:

- conference calling and remote tumor boards
- second opinion, e-learning and quality control
- sharing of clinical data on a common electronic clinical records system
- remote control of medical equipment
- carry out GCP clinical trials through data collection, monitoring and evaluation
- activate a telepathology facility for simultaneous counselling sharing microscopy images

After a long development phase and an accurate fine tuning of the platform, we launched the telemedicine project performing a complete demo of the system during the AORTIC East African Regional Meeting hosted at BMC in Mwanza (25-26 June 2015).

From this pioneeristic experience I decided to found the WaidX – World Aid Exchange project, with the aim of prosecute the development of the telemedicine platform through its new applications, giving valid answer at the different requests I was rapidly collecting.

WaidX takes care of remotization of healthcare process, resulting in a critical enhancement of the transmission performance between healthcare facilities sited in developed and DC, using low cost and poor quality connections, overcoming the accessibility problems induced by local ISPs, giving many benefits like an high level of service continuity, privacy for sensitive data, a strong integration of concurrent IT applications on a converged global network, all this oriented to promoting the development of Digital Health applications based on cost-effective resources. WaidX is based on an Italian Computer-Telephony Integration (CTI) technology, appropriately customized for the telemedicine purposes.

APOF NGO

The Mwanza project started in 1999 with the establishment of the histopathology laboratory at BMC, with the Italians sponsoring the training of a pathologist, a medical oncologist and four oncology nurses. Soon after that, Bugando Medical Centre became a specialized hospital in north-west Tanzania. The hospital has 850-bed capacity for a catchment population of 16 million, equivalent to one-third of the population of Tanzania. The histopathology laboratory, which currently has two pathologists, has the capacity to perform 4000 histological analyses and 1000 cytological diagnosis per year.

This prodromic arm of the Mwanza project gave birth to Associazione Patologi Oltre Frontiera ONG – APOF (Pathologists Beyond Borders NGO). The main aim given to the newborn NGO was to promote the growth of Pathological Anatomy in DC, implementing projects for preventive medicine and cancer diagnostics.

The following APOF projects focus on the diffusion of histological and cytological diagnostics, through the training of technical and medical personnel, the direct engagement in the reporting of biopsy and surgical cases, the support to cancer prevention programs, the construction or upgrading of laboratories, in order to achieve the full autonomy of the patronized facilities in a long-term perspective.

During its first decade of activity, APOF took up the challenge of new technologies introducing static telepathology contributions to support the remote diagnostic. This experience has reached its peak thanks to the “Zambia project”, designed with the objective to analyze the potential of telepathology for assisting surgical and cytologic pathology in DC[6]. The results demonstrate a high correlation between telepathology and traditional microscopy and indicate that the project may be repeated similarly in other DC. Nevertheless, different factors restrain the spread of this model: high costs for satellite connections, limitation in transmission speed and quality combined with the asynchronous workflow for remote pathologists. It was clear that static telepathology couldn’t address all the open questions concerning the establishment of a diagnostics routine in such very poor contexts.

The large number of pending issues indicates the need of a more adequate and modern approach to deal with telepathology requirements, so I decided to support APOF projects with the design of WaidX applications devoted to virtual and dynamic telepathology.

Telepathology in the Horn of Africa

The commitment of WaidX in favour of APOF takes shape on the "Horn of Africa" Project, towards the ambitious goal of creating a network of Pathology laboratories among different countries of the Greater Horn of Africa.

Since 2010 APOF proceeds with a project in the Hospital of Balbala, Republic of Djibouti, aimed to the institution and the development of a Pathology Department. At present this department is fully operative, with complete equipments, four well-trained technicians and two medical pathologists, and it remains the sole lab of the whole country.

In 2015 APOF received a request from the Hargeisa Group Hospital (HGH) of Hargeisa, Somaliland, concerning the institution of a Pathology Department. APOF started a project aimed to create a network of Pathology labs through the "Hub & Spoke" method, where the more equipped laboratory of Djibouti will act as Hub for the neighbouring Pathology lab of Hargeisa with no available pathologists.

In order to reach this goal, several hot points are identified:

- The technicians should be well, fully trained on the preparation not only of the biopsies but even of the surgical specimens
- The slides should have an optimal technical quality
- The pathologists need to be trained also for making diagnosis on virtual slides
- A slide scanning system with a proper tropicalization and a powerful telepathology platform is needed

Since WaidX platform was ready to support all telepathology needs enabling a good level access of remote pathologists to the local virtual slides, we ventured with the development of a Digital

Pathology solution based on manual scanning, adequate for the needs of a remote lab with a limited amount of slides to be managed (few thousands per year) and no local pathologists. This goal has been reached through a system integration task, adopting the Microvisioneer software suite in association with the Olympus CX33 Microscope coupled with a Basler CCD camera, running on a basic HP workstation with an EIZO high resolution monitor. This set allows the whole slide image scanning through a manual process, performed by local lab technicians after a 3-hours training course. Once the virtual slides are saved on the workstation, the local operator can share them into the telepathology collector with a simple drag&drop action, and remote pathologists can immediately access them through the telematic connections handled by WaidX.

We connected to WaidX the 2 Internet access lines previously serving the Hospital network, both provided by Djibouti Telecom: a WiMax bridge with a download bandwidth of 3 Mbps and upload of 2.5 Mbps, and a ADSL line with a download bandwidth of 8 Mbps and upload of 0.7 Mbps. The upload values were very weak and particularly impacted from a high frequency of transmission defects (packet loss, significant variance in data packet transmission latency), drawing a prohibitive framework in which we had to perform the live tasks of virtual telepathology with the other concurrent telematics applications. To benefit from all its features, WaidX became as the border gateway for the entire Hospital network. We defined a set of policies concerning LAN-WAN traffic prioritization, link aggregation, recovery of transmission defects and a redundant connection topology optimized to confer high availability to the telematics services. The outcome of adopting this design was the achievement of more than 5 Mbps of stable upload effective-bandwidth, allowing us to perform a good level telepatology activity assuring the Internet service for the common needs of the Hospital network on the same two connections.

This model addresses the main issues involved in the telepathology process: solidity and affordability of the local equipment, integration of the system in the existing IT infrastructure, accessibility for remote pathologists, efficacy and efficiency of the whole diagnostic process running on poor connections.

The first WaidX-based Digital Pathology facility within the "Horn of Africa" Project was put into operation in early 2018 at Balbala Hospital.

The platform resulted easy-to-use, all sanitary operators involved in the testing find it friendly and effective.

The virtual slides remotely viewed are fully compliant with the diagnostic requirements in terms of definition and magnification. The images browsing on the screen is very fast and precise, professional operators evaluated the effectiveness of this solution equivalent to the use of the microscope.

We presented these achievements at World Cancer Congress 2018, held in Malaysia, where we chaired a 90-minute session dedicated to Teleoncology and Telepathology[7,8]. The session was aimed at illustrating the potential of the ECHO e-learning project[9] and of remote oncology diagnostics in association with virtual telepathology, relatively to DC requirements. After the presentations by the speakers from the involved organizations, we moved to the discussion of a patient case via remote tumor board collecting different teams of medical oncologists and pathologists, spread over 4 continents (Malaysia, New York, Djibouti, Italy and San Marino). The session audience was very impressed by the powerful interaction gained by our telemedicine model, fueling an intense discussion during the final question time.

During 2018 the first database of virtual slides, related to clinical cases managed by the Balbala Pathology Department, has been digitized. In 2019 a quality control study on the whole Digital Pathology and Telepathology process will be carried out.

The next phase of the project concerns the commissioning of the Digital Pathology node at HGH, where APOF is currently patronizing the realization of the local Pathology Department. It will allow the achievement of a full diagnostic routine based on the counseling of remote specialists from Djibouti, working on the Hargeisa patients' slides through virtual telepathology, with the remote tutoring and counseling of APOF volunteers.

This is the first time that a model involving exclusively African departments of pathology through telepathology is tested. The "Hub & Spoke" method is demonstrating its efficacy in allowing the optimization of the local resources and will be extended in other areas of the Horn of Africa.

Conclusions

Information and Communication Technologies are triggering stellar improvements in healthcare: the collaboration between remote medical staff through telepathology represents a virtuous development model to support DC in providing an appropriate level of diagnostics to the whole population.

This model is driven by a truly cooperative intent: switching the focus from the simple providing of equipment for labs in DC and diagnoses coming from outside, to a vision strongly centered around a pervasive action of capacity building, knowledge transfer and interaction between the available local health specialists, to enhance the diffusion of modern healthcare to the disadvantaged populations and averting new forms of scientific colonialism such as the so-called “helicopter science”[10].

Moreover, it shows how the development cooperation can be an ecosystem for the growth of highly innovative solution like WaidX, increasing the diffusion of health practices and boosting the use of modern technologies in DC.

Abstract

According to the World Health Organization (WHO), deaths from non-communicable diseases (NCDs) will increase globally, with the largest increase being on the African continent. Projections have indicated that deaths from NCDs will exceed all combined communicable, maternal, perinatal and nutritional diseases as the most common causes of death by 2030 in Africa. Hence, the importance of a functional and improved pathology system in the diagnosis of cancer cannot be debated.

How can we deliver a better and more acceptable quality of healthcare within the limits of current resources? WaidX platform application to Virtual Telepathology tries to give valid answers to this urgent requirement.

Images and captions

1 – Remote tumor board and telepathology demo at 2015 AORTIC East African Regional Meeting: attendees of the congress in Mwanza, Tanzania (pictures on top) and the IRST staff in Meldola, Italy

2 – APOF technician during calibration of the manual whole slide scanning system - Balbala Hospital, Djibouti

3 – Training of the lab chief technician on the digital pathology platform - Balbala Hospital, Djibouti

4 – Diagnostic session between local pathologists and APOF remote specialists through WaidX telepathology platform - Balbala Hospital, Djibouti

5 – Prof. L.M. Looi, Dr. M. Botteghi, Dr. V. Stracca and Prof. F. Ismail after the monographic session at World Cancer Congress 2018 in Kuala Lumpur

Keywords

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Author details and contact

Matteo Botteghi, PhD

matteo@botteghi.com

I declare no conflict of interest.

Affiliations:

1) Department of Clinical and Molecular Sciences (DISCLIMO)

Experimental Work Pathology Research Group

Università Politecnica delle Marche, Ancona, Italy

2) WorldConnex R&D Telemedicine group - San Marino

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