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Perspectives

Imaging as a tool for global cancer control

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1. Global burden of cancer

There are more than 12.4 million new cancer cases and 7.6 million cancer deaths each year worldwide. Conservative estimates indicate that global cancer incidence and mortality will approximately double during the next two decades [1]. Low-income and middle-income countries bear a steadily increasing share of this global burden due to rapid population growth, aging, and reduced mortality from infectious diseases [2]. The fraction of cancer deaths occurring in developing countries has increased from 55% in 2002 to 64% in 2008, and is projected to reach 69% or higher by 2030 [3]. Cancer survival rates are lower in the developing world than in the developed world due to a combination of late stage diagnosis and limited access to treatment [4]. Low-income countries often lack the financial resources, health care delivery systems, and public awareness to carry out effective cancer prevention and screening programs. Most patients are therefore diagnosed with advanced-stage disease, frequently leaving palliative care as the only option [5]. It is estimated that only 5% of the resources required for adequate cancer control are available in low- and middle-income countries, and that 80% of cancer patients in those countries are incurable at the time of diagnosis [6].

2. The need for effective cancer diagnosis and treatment

In the developed world, the term "cancer" calls to mind a familiar set of images: a patient in the hospital, examined by teams of specialists; the use of sophisticated imaging technologies such as computed tomography and magnetic resonance imaging; courses of treatment often involving surgery, chemotherapy, and radiotherapy; and, with treatment, the hope of survival. Early detection and diagnosis help promote successful treatment. Patients diagnosed at an early stage can be treated while the disease is still localized, when simpler interventions are possible and patient outcomes are more likely to be favorable.

In the developing world, where most patients present with advanced cancers, the reality of a cancer diagnosis is very different. The health care infrastructure to manage and treat cancers, particularly advanced-stage cancers, does not exist. Shortages of trained personnel, inadequate facilities, and lack of technological resources leave late-stage cancer patients on their own with little chance of survival, and only the hope that inexpensive medications may be available to help manage the pain. Given this absence of health care infrastructure, it is critical to focus efforts in developing countries on the detection of precancer and early stage cancer, which are treatable in these settings. In the developing world, early detection followed by treatment may be the only pathway to survival for many patients.

3. New imaging technologies can promote early detection

To improve early detection and prevention of cancer, a new generation of high-performance, low-cost imaging technologies is being developed to help detect precancers and early stage cancers at the point of care in low-resource settings around the world. These new diagnostic tools minimize the need for conventional biopsy and histopathology, streamline the detection process, and enable low-cost point-of-care diagnosis and treatment where patient follow-up after traditional laboratory testing may be difficult. These new methods build on advances in consumer electronics, affordable computation power, new communication technologies, and low-cost imaging techniques, such as optical and ultrasound imaging.

Breast cancer is the leading cause of cancer mortality in women in the developing world. While mammograms are the preferred method for breast cancer screening in developed nations, ultrasound imaging is often more practical for use in early detection efforts in low-resource settings because the equipment is less expensive and more versatile, and it requires less maintenance [7]. However, conventional ultrasound imaging still requires highly trained personnel. In an initiative led by Imaging the World in Uganda, local health providers are given minimal training that enables them to perform ultrasound scans based only on external anatomic landmarks. The data files are compressed and transmitted via Internet or cell phone to a central facility, where the images are read and interpreted by an expert [8]. The results are then transmitted back to the local health care clinic by text message. The central facility can be located anywhere in the world.

Cervical cancer is the second leading cause of cancer death in women in developing countries. This is in contrast to the developed world, where mortality rates are dramatically lower due to widespread screening with the Papanicolaou (Pap) test and,

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more recently, the availability of vaccines that protect against the human papillomavirus (HPV) types that cause the disease [5]. Palcic and coworkers have described an automated quantitative cytology system for cervical cancer screening in low-resource settings [9]. This method replaces visual analysis of Pap test cytological samples with computerized image analysis techniques. Screening can therefore be performed rapidly at the point of care, even in settings where expert cytologists and laboratory facilities are unavailable. The automated system has been implemented for cervical cancer diagnosis in patient populations in rural China.

Oral cancer is a major health problem in many developing countries. Cancers of the oral cavity and pharynx are among the most common cancer types among men in the developing world [10]. Oral precancer and cancer are typically identified by visual examination and palpation, followed by invasive biopsy of suspected sites and histopathologic evaluation of the removed tissue. Conventional diagnosis is strongly dependent on the expertise of the clinician and the availability of laboratory facilities and personnel. Low-cost multimodal optical imaging techniques can be used to reduce the need for highly trained personnel and infrastructure. A portable, handheld widefield fluorescence imaging device can be used to rapidly scan the oral cavity to identify areas at high risk for oral cancer. This device has been implemented for oral cancer diagnosis in India [11]. High-risk sites can then be imaged with subcellular resolution using a compact, battery-powered fiber-optic imaging probe, providing real-time point-of-care diagnostic capability [12].

4. Using appropriate imaging tools to shift from palliation to prevention

There have been substantial advances in screening, diagnosis, treatment, and management of cancer in the past several decades. Unfortunately, most people in developing countries do not have access to these lifesaving interventions, because they are costly and require extensive health care infrastructure. Modern computerized imaging techniques and communication technologies offer the opportunity to shift the focus in low-resource settings from palliative treatment of advanced cancers to detection of precancers and early cancers while they are still treatable. As new methods are being implemented, there is a need for studies to evaluate the performance of these methods with respect to conventional imaging techniques. However, this new generation of technologies has the potential to improve early detection and diagnosis of cancer in the developing world. In the developed world, too, improving early detection of precancers and cancers could yield tremendous health benefits. With the help of appropriate imaging tools, we can reduce not only cancer mortality, but also cancer incidence, in the developing and developed worlds alike.

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