Global Neurosurgery – What are the Current Barriers to Neurosurgical Care in Low-Middle Income Countries

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Abstract

Surgical access inequities in low-middle income countries substantially contribute to global morbidity and mortality. The objective of this article was to examine the barriers to implementation of neurosurgical infrastructure in currently underserviced countries. Specifically, barriers in neurosurgical education programs, medical equipment availability, diagnostic imaging quality, and presence of adjunct services such as intensive care and anesthesia are discussed throughout this review. Current improvements and solutions to historic methods of delivering neurosurgical education are elaborated. Finally, the sustainability of neurosurgical programs in low-middle income countries is called into question, and benefits to a data-driven approach to elicit governmental support are described.

Introduction

In January of 2014, the *Lancet Commission on Global Surgery* was formed in an effort to assess the need and establish a plan to improve surgical, obstetric, and anesthetic infrastructure in low-middle income countries* (LMIC). This Commission published a document titled *Global Surgery 2030: evidence and solutions for achieving health, welfare and economic development*. Outlined in this report were five key findings that underscore the importance of a concerted effort to establish and optimize surgical practice in underserviced LMICs.[1] Some of these findings include the fact that five billion people worldwide are entirely lacking access to safe and affordable surgical or anesthetic care. Over 300 million operations take place annually, of which only 6% occur in LMICs, where case outcomes are amongst the worst in the world. In 2010, it was estimated that 33% of global mortality was related to medical conditions requiring surgical intervention.[2] The Commission predicts this lack of safe surgical access in LMICs will translate to an economic productivity loss of 12.3 trillion US dollars between 2015 and 2030 if these issues remain unaddressed.[1]

The World Bank independently released a series of documents describing worldwide *Disease Control Priorities*, which aim to capture global burden of disease through a socioeconomic lens. In the first volume, which focused on essential surgery, a list of 44 surgical procedures are described as having favorable cost-benefit profiles, being feasible to implement, and as being capable of addressing a substantial burden of disease. If these essential procedures were accessible to patients worldwide, an estimated 1.5 million deaths, equivalent to 6-7% of global annual mortality, would be averted in LMICs.[3] Two of these essential procedures fall within the neurosurgical scope of practice. These include burr holes for management of intracranial hematomas and shunt placement for congenital hydrocephalus.[3-5] Other literature includes management of unstable cervical spine injuries and neural tube defects in the list of essential neurosurgical procedures.[6,7] The above reports highlight the role that global neurosurgery is poised to play in the management of neurotrauma and congenital neurological malformations – both of which are socially and economically devastating for patients, families, and countries.

A brief discussion about the impact of global neurotrauma will further underscore the scale of neurosurgical care requirements worldwide. Traumatic brain injuries (TBI) and spinal cord injury (SCI) represent an enormous source of disability and mortality in young adults around the world. In the United States alone, approximately 100,000 patients will undergo intracranial hematoma evacuation and about 50,000 will suffer fatal TBIs.[8,9] The epidemiological data to assess these numbers in LMICs is drastically less reliable due to low levels of TBI reporting.[9] The WHO predicts that by 2020, the third leading global cause of death will be motor vehicle accidents.[2] It has been shown that treatment of patients with severe TBI in centers capable of offering neurosurgical support reduces the odds of death by 2.15 compared to a non-neurosurgical centers, further underscoring the importance of neurosurgical access in LMICs.[10]

Based on estimates made by the WHO in 2004, the median number of neurosurgeons in countries (that responded to their national survey) is 0.56 per 100,000 people. In low income countries, the same survey showed 0.03 neurosurgeons per 100,000 while there were 0.97 in high income countries.[11]

*Low-Middle Income Countries are economically defined by the World Bank as having a Gross National Income (GNI) per capita below $4,035 for the fiscal year of 2015.[2]

According to the Study on Surgical Services for the United States, the target neurosurgeon per population ratio should be 1 per 100,000, which LMICs are not close to attaining.[12] One barrier to fulfilling these neurosurgical care requirements is access and quality of education. When considered in the context of a growing demand for global neurosurgical care, this scarcity of trained neurosurgeons in LMICs reveals the true magnitude of global neurosurgical demandand suggests the benefit of timely access to basic neurosurgical care. This review will serve to outline the broad barriers that currently exist around the implementation of basic neurosurgical care in LMICs. Specifically, the current state of neurosurgical education, medical equipment, diagnostic services, and program sustainability will be discussed.

Neurosurgical Education

It is imperative that a comprehensive needs assessment is done prior to a neurosurgical training partnership in order to understand the context of current surgical capabilities in the LMIC. Depending on the state of neurosurgical infrastructure, resources are allocated to either completion of neurosurgical training or to supplementation of general surgeon skills to perform basic life-saving interventions such as brain abscess drainage, ventriculostomy placement, or intracranial hematoma evacuation. It was reported that centers in Nepal along with many of the African countries continue to prioritize this latter training methodology.[10,13,14]

The traditional top-down neurosurgical training methodology is arguably outdated in the current climate of global connectivity. Both the World Federation of Neurosurgical Societies (WFNS) and Foundation for International Education in Neurological Surgery (FIENS) have historically applied a top-down visit-based model of neurosurgical education outreach.[15-17] During these camps, trained neurosurgeons travel to LMICs and work with local surgeons or medical graduates to develop neurosurgical skills. It has been shown that prolonged visitation to an LMIC center correlate with more effective training and long-term neurosurgical care.[18]

Despite the important role for this approach, the top-down model has been criticized because foreign surgeons are generally unwilling to spend multiple years in an LMIC to establish a comprehensive neurosurgical training program. As a result, these education camps are often sporadic and fail to provide longitudinal learning environments for local surgeons, leading to a lack of self-sustaining programs and brain drain when surgical graduates seek further training in established neurosurgical centers.[19] In a survey of Sub-Saharan African neurosurgical programs (43% of were affiliated with WFNS, 23% were affiliated with FIENS), the self-reported level of training was deemed inadequate in the majority of respondents.[20] Surgical trainees often become fully dependent on the availability of neurosurgeons to physically visit their sites.[14] Furthermore, there have been reports that these camps are associated with a bias towards elective and non-fatal illnesses, which entirely exclude the population of patients suffering from neurotrauma and severe congenital disease.[21]

Agrawal et al. published an article examining barriers to neurosurgical care in Nepal and further cited lack of organizational infrastructure within the hospital as reasons for sub-optimal neurosurgical care. They describe a lack of a centralized patient safety and record keeping to adequately maintain accountability of the service to the patients.[22] In a qualitative study that sought to interview Ethiopian neurosurgeons, this issue of accountability and communication between professional groups arose. Interestingly, it was linked to a core educational issue related to a lack of clinical decision making teaching and inter-professional collaboration methods. In the low resource setting, when the ratio of residents to faculty is far in favour of residents, there is insufficient time for trainees to develop their ethical frameworks for care and critical thinking related to care plans. A more feedback-centered approach was suggested to potentially mitigate this issue.[23,24] It has been shown that a standardized trauma care protocol in LMICs is capable of yielding improved clinical outcomes in the teaching hospital setting.[25]

The above studies underscore the inherent flaws with traditional top-down education approaches. Issues of clinical decision making and ethical frameworks have been under-emphasized in these programs. Recent literature has made the suggestion that supplementation of site-visits in combination with comprehensive online teaching materials may more appropriately address the needs of an LMIC neurosurgical training program.[15,20] Feasibility studies of online educational programs for global neurosurgical development have been previously conducted. These report improved accessibility, longitudinal development, and standardized curricula as major benefits for this model with few user-perceived barriers to online curriculum implementation.[26,27] We believe that the ethicaland clinical decision making deficits, as well as a lack of standardized feedback, would be amenable to remedy through supplementation using longitudinal online resources in combination with traditional outreach training modalities.

Neurosurgical Infrastructure in Low-Middle Income Countries

Neurosurgical care requires a complex multi-disciplinary team in conjunction with numerous medical resources to perform safe surgical procedures and appropriate perioperative patient care. Translation to a resource-poor environment is expectedly challenging. Specific infrastructural barriers to care include medical equipment availability and quality, diagnostic imaging access, and presence of trained adjunct services such as anesthesiology and nursing support.

Medical Equipment and Neuro-imaging

The Tribhuvan University Teaching Hospital has had developed neurosurgical capacities since the 1960s and is currently one of the leading hospitals in Nepal. In 2004, a report was released outlining barriers to care moving forward. Many of their concerns surrounded access to imaging and reliable medical equipment.[28] Due to the complex and resource-intensive nature of peri-operative neurosurgical care, access to ventilators and appropriate vital monitoring was noted to largely limit care.

In a study assessing neurosurgical care in Papua New Guinea - an LMIC that has slowly improved its neurosurgical capacity through mentorship by Australian-certified surgeons - Park et al. show that over 1,020 procedures were performed over the past decade, marking a substantial improvement in capacity.[29] The two most frequently consulted cases were TBI in adults and hydrocephalus in children. This study evidenced the potential positive outcomes of a competent neurosurgical service as they were able to manage a spectrum of neurotrauma, CNS infections, and complex congenital neurological disease. However, they cite the largest barrier to improved outcomes as the lack of imaging access, which drastically limited their ability to assess acute TBI. This shift of priority to imaging and medical equipment infrastructure seems to be characteristic of centers that have achieved a level surgical competence in the management of common neurosurgical cases.

A one-year review of cases managed in the Black Lions Hospital of Addis Ababa, Ethiopia (affiliated with the FIENS initiative) was conducted between 2006-2007 to establish a baseline profile of neurosurgical capacity prior to renewal of their residency training program. In their review, it was noted that there is no CT scanner at the hospital and therefore 54% of patients consulted for head trauma underwent exploratory burr holes. In general, the lack of diagnostic imaging was a main finding of this study.[23] Many centers suffer from a lack of sterile gowns and sterilization machines, which prevents multiple neurosurgical cases from taking place each day.[30] The above examples taken from Nepal, Ethiopia, and Papa New Guinea provide a snapshot of the role for medical technology as an important commodity for neurosurgical infrastructure development. Our intention is not to delve into the ethics of medical equipment donation (as that would be an entirely separate review), but to underscore the theme of medical equipment as a limiting factor for neurosurgical care in LMICs.

Ramamurthi – a neurosurgeon with over 50 years of LMIC experience – counters the above points by criticizing international training programs for fostering the dependence of LMIC surgeons on medical technology available in high-income countries.[31] A concerted effort must be made to develop clinical decision making within the environment of intended clinical practice. This criticism provides more merit to a hybrid online education model in which surgeons have access to both travelling neurosurgeons and online resources as the optimal training approach. There is a demonstrated need for creative problem solving within the low-resource setting, which may not be best fostered through a top-down teaching model. One such example is the implementation of the awake-craniotomy for brain tumour resection in Indonesia, Ghana, China, and Nigeria, which allows for the circumvention of general anesthesia in these patients.[32] We suggest that some of the resource limitations faced by LMIC surgeons are amenable to this style of problem solving. Development of these abilities and acknowledgement of the low-resource environments must be preserved in the didactic teaching methods of international surgical programs.

Adjunct Services

Beyond imaging, the resource limitations of anesthesia services, operating rooms, and trained ICU staff - among others - also limit neurosurgical care. This is demonstrated by Fuller et al. who document the outcome of an eight-year top-down collaboration between Duke University Medical Center Neurosurgery Department and Mulago Hospital in Kampala, Uganda that was aimed at improving neurosurgical care.[14] They employed a "technology, twinning and training" approach, whereby medical equipment was sent to Uganda (including equipment ranging from ICP monitors to microscopes and anesthesia machines) with concurrent training efforts targeted at biomedical engineers to ensure maintenance of this equipment.[30] The "twinning and training" phases transition from surgical camps to an established residency program. Despite the improved neurosurgical care and more trained residents, equipment remained a limiting factor, echoing the challenges expressed in the previous section. Anesthesia, ICU, and nursing services were further cited by the Mulago Hospital local chief of surgery to be the single most important element of infrastructure to providing surgical care. Contrary to the United States, ICU patients in LMICs are typically much younger and afflicted with curable surgical conditions. The systemic shortage of trained ICU staff remains a challenge for neurosurgical care.[33] This emphasis on anesthesia was echoed by the *Lancet Commission* in their meetings on essential surgery.[1]

Following appropriate operative and peri-operative care, rehabilitation services are essential in the field of neurosurgery. Without these services, there is a tremendous socioeconomic strain placed upon primary care providers and caretakers of patients afflicted with neurosurgical conditions. Inadequate rehabilitation access has been shown to delay discharge, result in health deterioration, increase dependence for assistance, and decrease quality of life.[34,35] The extent of rehabilitation challenges is largely unknown due to the overall scarcity of reliable data from LMIC rehabilitation services.[36] Some evidence has shown the promise of cognitive rehabilitation via tele-rehabilitation in post-traumatic brain injury patients.[37] This further emphasizes the role that internet connectivity plays in circumventing access issues faced by many patients in LMICs.

Sustainability of Neurosurgical Programs

It is at this point of our discussion that we must critically evaluate the role of foreign surgeons and health care providers in LMICs. Despite the demonstrated ability to improve a countries' neurosurgical capacity as described above, there is a notable lack of sustainability stemming from a deep dependency on the international relationship. From the moment that a country receives subsidized medical equipment and surgical expertise from another country, a cycle of dependence is propagated. This theme is well described in the literature.[13,14,38] Furthermore, international collaborations tend to focus on medical care output rather than the larger health ecosystem of the LMIC they are aiming to develop. As an example, Fuller et al. explain that there was still minimal government inter-

est in neurosurgical care following 8 years of international collaboration and care improvement.[14] Viswanathan describes the crippling costs facing patients when complex care is delivered in an environment of insufficient health insurance and haphazard governmental commitment to life-saving medical support.[23] Beyond discharge, these staggering healthcare costs and lack of social supports are capable of economically crippling a family for numerous years following their care.

In LMICs, the average gross domestic product allocated to healthcare is about 60% less than that of their high income country counterparts – much of which is dedicated to primary care, infectious disease, and maternal health.[39] In a review of initiatives focused on pediatric surgery in Sub-Saharan Africa, Ekenze et al. conclude that sustainability is frequently not a focus of international surgical collaborations.[40] The challenges with sustainability of neurosurgical infrastructure are attributable to a general lack of funding, lack of governmental motivation to focus on neurosurgical illness, and a propensity for international fellows to remain in the country of their fellowship following completion of their training.[41] Many of the sustainability issues discussed above may be mitigated through a more collaborative approach with the LMIC government in order to understand sociocultural perceptions and political climates that affect disease management, funding, and government commitment.

Ibrahim et al. conducted an international qualitative study surveying 31 surgeons currently involved with international partnerships and outreach programs in LMICs. The objective was to develop a framework for monitoring and evaluating these initiatives.[42] In their evaluation criteria, they cite a strong indicator of a program's self-sufficiency to be the degree of funding the program receives from the government in the LMIC. The theme of prospective data acquisition was also discussed. The authors suggest that reliable collection of data would more effectively allow the LMIC health care providers to lobby their local governments for improved resources and funding. Many of the studies cited throughout this article demonstrate the effectiveness of neurosurgical programs in LMICs. However, underreporting related to socioeconomic impacts of neurosurgical illness, traumatic brain injury, and spinal cord injury in unequipped care centers remains a pervasive issue.

Conclusion and Important Takeaways

Through this review, several barriers to neurosurgical care in LMICs were discussed. The literature summarized above suggests that education, imaging access, medical equipment quality, adjunct service development, and sustainability must be integral components of LMIC neurosurgical initiatives. These findings underscore the necessity for a comprehensive neurosurgical needs assessment prior to offering support. This review demonstrates the phases of neurosurgical development in an LMIC. Beginning with training of general surgeons to perform life-saving procedures such as ventriculostomy placement and intracranial hematoma evacuation allows a country to provide care for common acute neurosurgical problems in relatively low resource settings (this still requires a minimum level of medical equipment). Progression to specific neurosurgical training programs requires a concerted effort by local leaders with international support to ensure a high quality of record-keeping, standardized training, and quality of care evaluations. As suggested, this process may benefit from a hybrid approach combining online education resources and international collaboration from established neurosurgeons.

Current initiatives have adopted this notion of hybrid education platforms to supplement traditional methods of physical outreach. Described by Blankstein et al.,[27] there are numerous modalities of online educational materials in current use. These range from listservs that circulate case reports and clinical teaching through open access email threads to modular courses that deliver seminar-style information. The American Association of Neurological Surgeons (AANS) offer these webinar sessions directly through their website on a multitude of topics.[43] Despite this great resource, there is a lack of feedback capability as participants are led through cases in an online module or video format that does not allow for collaborative learning. Further access issues exist as these videos are restricted to AANS members. At present, the most recently developed modality for online education is achieved through structured online courses.[15,27] These courses adhere to a traditional curriculum with determined deadlines for assignments, quizzes, and other assessments. There are students and faculty that enroll in the course, participate in discussion, pose questions, and provide feedback through a defined virtual classroom. This model has been applied through the WFNS with excellent qualitative feedback from participating students. This continues to be an area of current educational focus for institutions affiliated with global neurosurgical development.[16]

A paralleled emphasis on infrastructure development including anesthesia, nursing, and ICU services will further augment the quality of neurosurgical care offered. Throughout the entire process, larger societal initiatives may help prevent injury. Studies have shown that trauma related to motor-vehicle accidents in LMICs is a leading cause of disability and death.[44] With specific regard to pediatric and young adult neurotrauma, motor-vehicle accident prevention initiatives as well as helmet campaigns are an important element of public awareness - commuting to and from school is often the most dangerous part of a child's daily activities.[45,46] Finally, as the service becomes more competent in its ability to handle neurosurgical disease, refinements to imaging modalities and cutting-edge surgical equipment become important to the management of more complex neurologic pathology.

The ultimate goal of neurosurgical infrastructure development is to create a self-sustaining program that is able to service the population whilst producing qualified neurosurgical graduates. For an LMIC government to prioritize neurosurgical care in the context of the myriad other health and economic issues in their country is challenging. It remains difficult to transition the current model of foreign collaboration for LMIC neurosurgical training to a local government-support

neurosurgical program. However, evidence summarized in this review suggests the prospective collection of data related to outcomes, epidemiology of disease, and neurosurgical specialist training may be useful in eliciting governmental support of international neurosurgical collaborations. We posit that adherence to strong data collection is paramount to subsequent partnership and relationship building with local governments to improve sustainability and care in the long term.

The specific barriers to an LMICs neurosurgical development must be closely considered within socioeconomic and cultural climates of a particular country. A strong understanding of barriers to implementation of specialized surgical care is essential to the targeted and high yield deployment of resources in LMICs. The *Lancet Commission* of Global Surgery explains that a paradigm shift is required for achievement of the 2030 milestone goals.[1] It is imperative that we transition from a traditionally disease-oriented global health approach to a more holistic integrated care model that is able to support accessible surgical care. In order to make this transition, a concerted effort must be made to address the barriers discussed previously. Sustainability must be central to the steps we take towards the 2030 goals. Government ownership of international surgical programs will galvanize our progress moving forwards. Global neurosurgical development must continue to be a priority of health infrastructure development in the future so that we may adequately face one of the fastest growing and underserviced patient populations on the planet.

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