The Need for Cost-Effective Neurosurgical Innovation—A Global Surgery Initiative

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Key words
- Cost effectiveness
- Global
- Innovation
- Neurosurgery

Abbreviations and Acronyms
CPC: Choroid plexus cauterization
ETV: Endoscopic third ventriculostomy

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Citation: World Neurosurg. (2015) 84, 5:1458-1461. http://dx.doi.org/10.1016/j.wneu.2015.06.046

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

The authors discuss the unmet needs for neurosurgical care around the world and some of the innovative work being done to address this need. The growing demonstration of surgical innovation and cost-effective technology represents an opportunity within neurosurgery to achieve the goal of making surgical care more accessible to the global population.

UNMET NEEDS

Surgical diseases comprise a substantial proportion of the global burden of disease—the World Health Organization estimates that injuries cause 5.7 million deaths yearly, and others estimate that nearly 11%–15% of the world's disability is caused by surgically treatable disease (16). Global health pioneers Paul Farmer and Jim Kim keenly noted that "surgery may be thought of as the neglected stepchild of global public health" (5). Of the nearly 250 million operations performed each year, only 3.5% are performed on the poorest one-third of the world's population (16). Despite the desperate need, an estimated 2 billion people lack access to the most basic surgical care (7), and this number is significantly larger for patients who might require more advanced neurosurgical care.

A series of studies performed in the 1990s demonstrated a fundamental shift in the previous ideology that surgery was too costly and ineffective in the developing world. For instance, Javitt (12) demonstrated that cataract surgery was cost effective even under resource-constrained circumstances, and McCord and Chowdhury (18) showed that emergent obstetric surgical services could be cost-effective in Bangladesh. The Lancet Commission on Global Surgery has also pioneered the role of surgery in global health (19), and with a new emphasis by the World Health Organization, surgery is now coming to the forefront of the global health stage.

Despite expanded recognition that surgical care must be made more available to more of the world's population, the full spectrum of surgical conditions and treatments is still not emphasized. The only neurosurgical procedure listed among the 44 essential surgical procedures in the *Disease Control Priorities*, 3rd edition (Volume 1: Essential Surgery) is burr hole evacuation of subdural hematoma, although surgical drainage of intracranial hematoma is mentioned as a procedure that would be more suitable at higher-level facilities (19). Neurosurgical diseases have an enormous impact on society but have remained off the priority list of governmental or private health or support organizations (11). One example of such a disease is infantile hydrocephalus (15, 26). There is an enormous economic burden of untreated hydrocephalus worldwide, and Warf et al. (27) demonstrated that the cost–benefit ratio for treating infantile hydrocephalus in sub-Saharan Africa is more favorable than for the surgical treatment of trauma, elective orthopedic operations, and the repair of cleft lip and palate. Yet, the condition is not always recognized as a major public health priority.

HUMAN RESOURCES

We suspect that the lack of attention is often attributable to limited access to neurosurgical specialists. For example, in sub-Saharan Africa, there is 1 neurosurgeon per approximately 7 million people, and in East Africa, there is estimated to be 1 neurosurgeon per 9 million people. In contrast, in the United States, there is one neurosurgeon per 62,500 people, and in Europe, there is one neurosurgeon per 100,000 people (4, 29). The advent of telemedicine has improved the reach of specialty and subspecialty care, especially for neurosurgery. Ganapathy has developed the Apollo Telemedicine Networking Foundation, which provides neurosurgical teleconsultation throughout rural India as well as sub-Saharan Africa (8, 9). Telemedicine can address the lack of neurosurgical manpower with the "virtual specialist," who can provide guidance through direct visual access to the operating room, trauma bay, disaster site, or classroom. Telemedicine has revolutionized stroke care, particularly in rural areas (3), and is becoming an outlet for education for common to complex pathology (21). For regions with few or no neurosurgeons, the possibility for neurosurgical consultation is tremendously beneficial. Currently, general surgeons, trauma surgeons, obstetricians and gynecologists, and orthopedic surgeons are the surgical caregivers of the developing world. Neurosurgical needs remain unmet across the globe, and neurosurgical procedures remain limited to the sidelines in many locations.

Neurosurgical humanitarian aid in the developing world has been established for some time. Neurosurgeons from all over North America and the world have assisted underserved populations by transferring knowledge, technique, service, and

skill. The Foundation of International Education in Neurological Surgery (www.fiens.org), founded in 1969, serves as a beacon for teaching techniques, procedures, and education in more than 22 countries to improve the delivery of neurosurgical care (6). Current programs include twinning programs, which have established partnerships between neurosurgery departments in the developed and developing world; international fellowship opportunities through U.S. neurosurgery residency programs; and numerous volunteer opportunities throughout the world in which neurosurgeons or neurosurgery residents can volunteer. Volunteers often are working in difficult conditions with limited resources that require improvisation and ingenuity (6).

TECHNOLOGICAL INNOVATION

Although logistical access to neurosurgical care remains an important issue, especially for those living in rural areas, access to cost-effective technology represents another barrier to global neurosurgery. Many of the expensive instruments and implants used in the developed world are not available, or appropriate, for use in underdeveloped areas of the world. This has led to the development of lower-cost, practical solutions. Innovation has a critical role for the advancement for medicine as vocation; it is an essential driving force for patient care improvement, promoting patient safety, and satisfying cost-effective restraints. These advances are equally important in improving healthcare in developing countries. General surgeons, in particular, have led the charge towards cost-effective innovation in the developing world by creating reusable and lower-cost laparoscopic instruments that have resulted in up to 5.2 times cost reduction versus traditional laparoscopic techniques (22).

This evolution has enabled the import of first-world technology to the developing world, and vice versa. This emphasizes the argument of equality and access made by Dr. Paul Farmer during his early years working in Haiti: Although the developing world may not have access to emerging technologies and equipment in the traditional sense, does this mean they should not have access to it at all? Despite technological advances, however, access to emerging technology in neurosurgery remains an issue for patients across the globe, even in the United States and North America.

There have been several laudable attempts at cost-effective innovation in neurosurgery. With respect to pediatric hydrocephalus, Dr. Benjamin Warf has reported the success of endoscopic third ventriculostomy (ETV) with and without choroid plexus cauterization (CPC) in Ugandan children with hydrocephalus (24). These advances came as a result of necessity in treating patients with hydrocephalus who face significant barriers to shunt placement, including economic limitations, transportation, and lack of routine and appropriate follow-up (25). The use of ETV with or without CPC has expanded surgical options for many patients; however, ETV is not appropriate for all children. Thus, additional alternative treatment methods for treating hydrocephalus have been developed. The "Malawi shunt," developed in 1992, was constructed from siliconized rubber tubing and a right-angled metal connector; its invention came in response to a shortage of conventional shunts. In the original series, 80% of the shunts functioned well after insertion (2). The Chhabra shunt (G. Surgiwear Ltd., India), manufactured in India, can be purchased for $35, whereas the traditional Codman-Hakim Micro Precision Valve shunt system costs $650. The Chhabra shunt was created as an alternative system engineered in a cost-effective manner to treat hydrocephalus in the developing and developed world. In a large prospective study there was no difference between the two shunt systems, meaning it is possible for ventriculoperitoneal shunt placement to be performed in the developing world with similar results to those reported in developed countries (23). Lane et al. (17) compared 80 children who had a Bactiseal Universal Shunt in place and 80 children with Chhabra shunts; they found no significant difference in rates of shunt failure, shunt infection, and death. Interestingly, endoscopic treatment is more cost-effective over time than shunt placement, even when using cost-effective shunts (15, 27). Subsequently, Dr. Warf's experience in Uganda with ETV, and subsequently ETV + CPC, has been brought back to the Western world and adopted as a "novel" treatment for hydrocephalus for those patients with favorable anatomy.

Stereotaxy is used routinely by neurosurgeons for navigating difficult cranial and spinal cases but because the cost and size of the equipment can be limiting, the University of Cape Town developed the Cape Town Stereotactic Pointer as a simple device to mitigate the use of cumbersome frames and machinery that accompany traditional stereotactic methods (1). For spinal fusion surgery, image guidance techniques have improved the accuracy of the placement of spinal instrumentation (14), but the associated cost is nearly $500,000. These costs have been prohibitive for many hospitals in North America, let alone the developing world (28). Jost et al. (13) used an easily accessible and affordable 3rd-generation iPod Touch with the application Angle (Smudge Apps, Christchurch, New Zealand) to successfully identify optimal instrumentation insertion angles for placement of pedicle screws into the lumbar spine. In the management of aneurysmal subarachnoid hemorrhage and detecting vasospasm, Guan et al. (10) have identified the ankle-brachial index, a simple and inexpensive measure of blood pressure differential in the arms and legs, as a predictor for cerebral vasospasm. This finding has been correlated with transcranial Doppler and digital subtraction angiography. Each of these innovations could conceivably be used in the developing world, especially in those places without access to devices such as image guidance, transcranial Doppler, computed tomography angiography, and digital subtraction angiography.

LIMITATIONS OF INNOVATION

Surgical facilities available in developing countries vary based on location, funding, access to electricity, running water, anesthesia capabilities, and many other factors. The resources of the facility often represent a limiting factor in using even the most cost-effective innovations. Patient follow-up after treatment for neurosurgical pathology also represents a significant issue in the developing world. This is often attributable to travel and financial constraints, but also to