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Barriers in surgical research: A perspective from the developing world

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NARRATIVE REVIEW

Innovations in surgery between the past and future: A narrative review of targeted literature

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Abstract

Innovation is the introduction of a new method or technology designed to change the way things are done. History is full of remarkable innovations in surgery over the years as surgeons have always been innovating and pioneering latest techniques and equipment that can benefit the mankind. Though persistent, progress has been far from uniform. Despite all the bells and whistles that these innovations bring to the table, the little acknowledged fact is that they are only accessible to a very small proportion of the global population. Five billion people on this planet do not even have access to an operating room when needed. It has been reported that conditions requiring surgery are responsible for one-third of all the deaths in the world. The current narrative review was planned to focus on the importance of innovations in surgery, to highlight the problems that were faced by resource-restricted countries in the past, and the necessity of innovative solutions to improve global surgical care in the future.

Keywords: Innovation, Surgery, Affordable, Cost, History.

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Introduction

Three-dimensional (3D) organs made by special printers, surgical simulators and stem cell delivery devices are some examples of research revolutions. A simple internet search will demonstrate the remarkable potential technology has to transform surgical care. Innovation is and has always been at the heart of surgery's core. Just as scientists and inventors have introduced telephones, air travel, space shuttles and robots, surgical innovations have proven to be equally revolutionary. Surgical care has come a long way and one must only take a glance at the past to be aware of the ground-breaking changes and developments that have taken place.

Throughout history, surgeons have always been innovating and pioneering latest techniques and equipment that can benefit the mankind. However, progress has been far from uniform. Despite all the bells and whistles that these innovations bring to the table, the little acknowledged fact is that they are only accessible to a very small proportion of the global population. Five billion people on the planet do not even have access to an operating room when needed. It has been reported that conditions requiring surgery are responsible for one-third of all the deaths in the world.[1-3] This is more than the numbers caused by the human immunodeficiency virus (HIV), tuberculosis (TB) and malaria combined.

The current narrative review of targeted literature was planned to focus on the importance of innovation in surgery, to highlight the problems that were faced by resource-restricted countries in the past, and the necessity of innovative solutions to improve global surgical care in future, especially in low- and middle-income countries (LMICs). Specialists in the field of Surgery, Epidemiology and Basic Sciences were involved to have a multidisciplinary view of the progress.

Results and Discussion

The demand for cost-effective inventions in surgery

The field of surgery has come a long way in the past few years, but, unfortunately, progress has not been uniform. Numerous advanced and sophisticated inventions are not available to most parts of the world owing to paucity of resources. Only 6% of all the surgical operations in the world are performed in the developing countries. As a result, the mortality rates for surgical conditions are extremely high in these countries.[3,4]

Lack of access to surgical care: Based on the Lancet Commission on Global Surgery report of 180 countries from all over the globe highlighting 98% of the inhabitants, it was found that there is a dire need of surgeons in Africa and rural areas which, on an average, had one surgeon serving over 2 million people.[5] One-third of the world's population cannot get optimum care owing to the lack of operation theatres. On the other hand, people of high-income countries (HICs) are rarely seen lacking access to surgical care.

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Accessibility and availability to surgery are vital issues in LICs, and can be further described by the three delays in pursuing, attaining and obtaining care.

Poor surgical outcomes: Even where surgical care is available, it is of poor quality. A lack of skilled surgeons in these countries results in severe concerns. The difference in mortality around surgery in the developing and the developed countries is 10% and 0.4%, respectively. In regions where there is no access to clean water and blood banks are scarce, the morbidity extent is more prominent.[6-9] Such high rate of postoperative complications leads to more frequent and longer hospital stays, making hospital beds unavailable to other patients. Early discharge is not a solution either as patients in LICs are not able to afford nursing care or physiotherapy at home even if such services are available in society.

Financial barriers to basic surgical care: Unlike the developed countries, which are covered by tax-funded health systems or health insurance schemes, all healthcare related expenses in developing countries are out of one's own pocket.

Additionally, there may be just one young breadwinner for the family and they cannot afford being hospitalised for a long time. Moreover, paid leave is a luxury which they do not often have. The women are the care-givers in such families, dragging their focus from their children and education.

Examples of low-cost surgical innovations: Low-income countries (LICs) need innovations that would work best in their environment. That can only be guaranteed when such technology is built specifically for that purpose. The goal is to provide a cost-effective idea which can work with limited resources without compromising on the quality of healthcare and for it to be of reasonable cost. Some of the best examples of low-cost innovations and their benefits have been widely acknowledged (Table).

Bogota bag: Developed in 1984 by Dr Oswaldo in Columbia, the Bogotá bag is one of the many low-cost innovations that emerged from a resource-restricted setting. It is a strong and flexible bag that is attached to the patient's abdominal wound temporarily before the abdomen could formally be closed. This bag costs $5 whereas other techniques with similar purpose cost around $153-$1,600. Studies have reported that it results in a lower incidence of complications compared to similar techniques.[10-12]

Mesh for hernia repair from propylene mosquito net: Dr Reddy and Dr Tongaonkar introduced the use of low-cost polypropylene mosquito net in herniorrhaphy.[13] An important clinical trial in Burkina Faso reported similar outcomes when compared to the more expensive meshes used in the West.[14] There has been no increase in septic complications, and it reduces the cost by two-thirds.[15,16] On occasions, it has even been considered better in terms of strength and anisotropy. Its cost is an estimated one-thousandth of the price of a commercial mesh.

Life box (LB) oximeter: Another groundbreaking innovation designed specifically for LICs is the Life box (LB) oximeter. Perioperative monitoring of patients using an oximeter is a basic requirement for care of surgical

Table: Examples of successful low-cost innovations in surgery.

Innovation	Description	Benefit
Bogotá Bag	A strong and flexible bag that attaches to the patient's abdominal wound temporarily before the abdomen could formally be closed.	This bag costs $5 whereas other techniques with similar purpose cost around $153-$1600. Studies have reported that it results in a lower incidence of complications when compared to much more expensive techniques.
Mosquito Net Mesh for Hernia Repair	Low- cost polypropylene mosquito nets for hernia surgeries	1000 times cheaper than traditional meshes but with similar outcomes when compared to its much more expensive counterparts.
Life-box Oximeter	A low-cost pulse oximeter that can be used in even the most resource restricted regions of the world without compromise on accuracy.	They cost around $250, compared with at least $1000 for a standard device used in HICs. Various studies have validated the positive effects and accuracy of LB oximeters.
The Chhabra Shunt	Low-cost alternative to shunt placement in patients suffering from hydrocephalus.	It is manufactured in India and can easily be purchased for $35 compared to the standard Codman-Hakim Micro Precision Valve shunt system which costs over $650. Many studies have been conducted comparing the two devices and it has been concluded that there is no significant difference in outcomes.
Arbutus surgical drill	A sterilized cover combined with a low-cost cordless drill with a similar torque and speed of a regular surgical drill	The cover can be changed on a regular basis and the complete unit costs 10 times less than a typical surgical drill.
Jaipur Foot	A prosthetic device that allows amputees to easily perform everyday tasks. The design also allows amputees to squat, sit cross-legged and even trek on rugged terrain.	Readily available using locally sourced materials for as low as 3 USD.

LB: Life-box, HICs: High-income countries, USD: United States dollar.

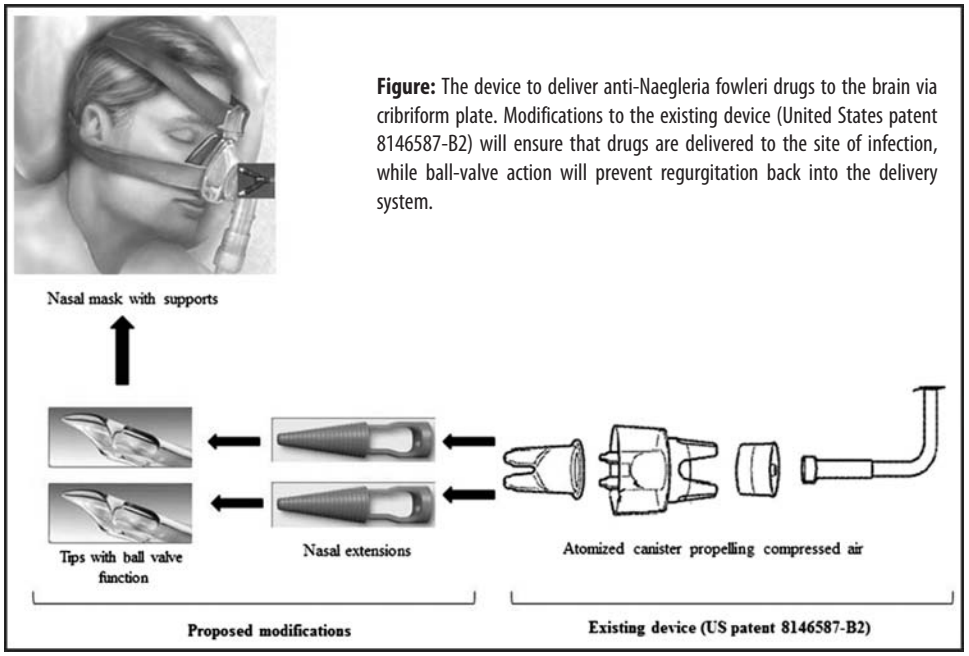

Figure: The device to deliver anti-Naegleria fowleri drugs to the brain via cribriform plate. Modifications to the existing device (United States patent 8146587-B2) will ensure that drugs are delivered to the site of infection, while ball-valve action will prevent regurgitation back into the delivery system.

patients in the developed world.[17] It comes as no surprise that in sub-Saharan Africa, 70% of operating theatres do not have oximeters.[18] Using pulse-oximeters, along with the WHO Surgical Safety Checklist, has the potential to make surgical operations 50% safer.[19]

Various studies have validated the positive effects and accuracy of LB oximeters.[20] These devices have proven to be an inexpensive and excellent alternative that the developing countries can adopt without compromising much on quality. It is being reported that even cheaper versions are on their way to the markets soon.

Chhabra shunt: The Chhabra shunt is a low-cost alternative to shunt placement in patients suffering from hydrocephalus. It is India-made and can be available in $35 compared to the standard Codman-Hakim Micro Precision Valve shunt system priced over $650.

Many studies have been conducted comparing the two devices, and it has been concluded that there is no significant difference in outcomes.[21,22] Furthermore, Kabachelor et al. also compared the Chhabra shunt to the Bactiseal universal shunt and found no difference in rates of shunt complications, and death.[23]

Arbutus surgical drill: A typical surgical drill costs around $30,000. In addition, it needs to be sterilised regularly to prevent postoperative complications. However, Arbutus has recently introduced a cover which can be sterilised repeatedly and, when combined with a low-cost cordless drill of similar speed and torque, costs one-tenth of the price of a regular surgical drill.[24]

Transcribrial route device: Using simple concepts to resolve big problems have invented many devices and instruments that could prove to be of translational significance. One such example is the transcribrial device, which was developed at the Aga Khan University, Karachi, to overcome the blood-brain barrier to deliver drugs to the brain in meningoencephalitis, and stem cells to the brain in neurodegenerative diseases.[25] This device (Figure) is suited to deliver the drugs in Naegleria fowleri-induced encephalitis with nasal components and device details to deliver the drugs.[26] Also, the modified device has been proposed to be used to accelerate stem cell delivery to the brain in Alzheimer's disease.[27]

Jaipur foot: The Jaipur foot has been regarded as one of the best innovations of the 20th century. Developed by orthopaedic surgeon Professor P.K. Sethi, it allows amputees to easily perform movements in almost all directions, including dorsi-flexion, plantar-flexion, inversion and eversion.[28-30] The design also allows amputees to squat, sit cross-legged and even trek on rugged terrain. Due to its immense popularity in LMICs in Africa and Asia, it is made using local materials and is readily available for as low as $3.

The strength of the current narrative review is the involvement of specialists in the field of Surgery, Epidemiology and Basic Sciences who went over a large data set to have a multidisciplinary view of the innovations. However, the current study was not a systematic review of all relevant papers, which is a limitation. There should be future studies reporting the cost-effectiveness of various low-cost innovations.

Conclusion

Technology in the medical field has advanced over the last century. Cost-effective alternatives are mandatory for safe surgical practices in the developing world and are critical for a better change or advancement in the developed world as well.

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