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The need for craniofacial trauma and oncologic reconstruction in global surgery

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ABSTRACT

The global burden of surgical disease is concentrated in low- and middle-income countries and primarily consists of injuries and malignancies. While global reconstructive surgery has a long and well-established history, efforts thus far have been focused on addressing congenital anomalies. Craniofacial trauma and oncologic reconstruction are comparatively neglected despite their higher prevalence. This review explores the burden, management, and treatment gaps of craniofacial trauma and head and neck cancer reconstruction in low-resource settings. We also highlight successful alternative treatments used in low-resource settings and pearls that can be learned from these areas.

1. Introduction

Global surgery has gained increasing attention in recent years.[1,2] Plastic and reconstructive surgery plays an important role in addressing the surgical burden of disease within low- and middle-income countries (LMICs) given relevance of the field to reconstruction of trauma, burns, and congenital anomalies.[3,4] Within the realm of global reconstructive surgery, injuries and malignancies contribute to the volume of surgical disease processes at 38 % and 19 % of surgical diseases, respectively, while congenital anomalies represent 9 % of surgical disease processes.[5] Despite these statistics, cleft lip and palate repair draws 26 % of global surgery funding from international charitable organizations[6] and represents 72 % of global plastic surgery research.[7] Craniofacial trauma and malignancy, on the other hand, are given disproportionately little attention relative to their prevalence. As global surgery advances, global craniofacial trauma and oncologic reconstruction must be prioritized. Here, we discuss the management of craniofacial conditions with a particular focus on trauma and oncologic reconstruction in low-resource environments. Care must be taken not to equate low-income countries with low-resource, as quality training, cost-effective methodologies of care, and evidence-based algorithms are accessible worldwide. As such, the challenges faced by those in low-resource environments are present in high- and low-income countries alike.

2. Craniofacial trauma reconstruction

2.1. Burden of craniofacial trauma

Over 7.5 million new facial fractures occurred in 2017.[8,9] The most commonly fractured bones of the face are orbital, mandibular, and nasal.[10] Males suffer trauma at twice the rate as females,[9] and falls are the most common cause of facial fractures.[8] Other causes of craniofacial trauma include motor vehicle accidents, burns, physical assault, sports-related injury, occupational accidents, self-harm, and unintentional injury.[11] Trends in the incidence and cause of craniofacial trauma have shifted over time with changes in helmets, airbags, and other safety equipment, as well as with international conflicts. For instance, craniofacial trauma increased ten-fold in the Middle East between 1990 and 2017 due to the rise of armed conflict in the area.[9] As another example, the global trend for motorization in LMICs has led to increased use of two-wheel vehicles, and poor helmet fastening among users of these vehicles contributes to increased rates of injury.[12,13] Overall, the burden of craniofacial burns and trauma remain higher in LMICs due to a combination of poorer living conditions, fewer safety regulations, and lack of education.[14]

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2.2. Management of craniofacial trauma

Prompt and accurate repair of craniofacial injuries can decrease morbidity due to visual disturbances, malocclusion, and psychosocial sequelae related to physical disfigurement.[15] Thus, high-quality surgical repair is essential. In high-resource areas, patients with craniofacial trauma are typically brought quickly to medical attention. Well-equipped ambulance services provide early stabilization of the patient during transport to surgical centers with adequate equipment, capacity, and personnel. After achieving necessary stabilization and resuscitation, patients typically undergo imaging to fully evaluate the extent and severity of their trauma. The first-choice imaging modality for craniofacial trauma patients is CT, which serves not only as a diagnostic tool but also as an important resource for surgical planning.[16] Pre-operative planning can be further augmented by three-dimensional virtual and printed reconstructions of the patient's bony fractures and the creation of custom fixation devices or implants.[17] The gold standard for the treatment of craniofacial fractures is through internal fixation with biocompatible plates and screws.[16] However, treatment with these imaging modalities and devices can cost tens of thousands of dollars per patient, rendering them only useful for the most complex of cases.[18]

In low-resource environments, patients often experience delays in care after sustaining craniofacial trauma, which increases the risk of complications and poorer outcomes.[19] Due to the lack of professional prehospital care services in these environments, patients are often transported to the hospital by taxi drivers and relatives with limited medical training and capacity to provide early stabilization of the patient.[20] Hospitals in these settings may lack continuous access to CT scans, leading to reliance on more traditional diagnostic methods such as plain films, the physical exam, and basic lab investigations.[16] Physical exam is critically important in these situations and can guide management in the absence of imaging. Findings of persistent diplopia, enophthalmos, malocclusion, and trismus may indicate the need for operative intervention even in the absence of imaging findings. In these settings, fractures can be treated with closed reduction and immobilization techniques such as maxillomandibular fixation and intraosseous wiring.[16] Although these techniques are indicated in cases of simple or minimally displaced fractures, outcomes are inferior to open reduction and internal fixation in severely displaced or complex fracture patterns.[21]

2.3. Treatment gaps in low-resource settings

Lack of widespread CT imaging and custom biocompatible plating materials result in suboptimal treatment of craniofacial injuries in low-resource settings. In addition to these facility and equipment shortages, low-resource settings often also lack surgeons who are trained in the treatment of craniofacial trauma. There is a global shortage of plastic surgeons and other surgeons who specialize in craniofacial trauma, especially in LMICs.[22,23] Rural areas in particular lack access to sub-specialty workforces able to treat complex craniofacial trauma cases.[24,25] Thus, treatment gaps for craniofacial trauma in low-resource settings can be summarized in the following categories:

1. Prehospital care
2. Advanced imaging modalities
3. Surgical devices
4. Global surgical workforce capacity

Barriers to narrowing these gaps include cost of equipment and devices, poorly regulated social and health infrastructure, and the need for specialized education of medical personnel.

2.4. Addressing gaps in low-resource settings

1. Prehospital Care

The complex prehospital care systems found in many high-income countries are too costly to be practically implemented in a broad-based fashion. The establishment of simple prehospital care systems can save lives if done cost-effectively. Bystanders have been shown to be heavily involved in the prehospital care and transport of trauma patients in low-resource settings.[26] Thus, bystander training such as an adaptation of the American Heart Association's CPR and basic life support course to educate general members of the public may be helpful in providing early life-saving stabilization to injured patients.[27] Establishment of formal Emergency Medical Services systems in low-resource settings is often limited by cost, necessitating financial support from developed countries for successful implementation.[28] Additional prioritization of timely availability and accessibility to ambulance services can improve patient outcomes. In the setting of limited resources, triaging patients appropriately is critical.[2531] Hence, efforts should be focused on training hospital staff on triaging protocols that take into account on-arrival parameters known to be the most effective in the case of low-resource settings in predicting patient outcomes.[29]

2. Advanced Imaging Modalities

Access to and maintenance of advanced imaging technologies is challenging to overcome in many low-resource environments given the high upfront cost of such investments. Acquiring such technology requires financial investment, increased manufacturing capacity, and adequately trained technicians and radiologists. These are best accomplished through changes in national policy and increased investment in health infrastructure. In the interim, the development and establishment of algorithms or validated prediction scores that rely on physical exam findings and other clinical signs can guide optimal triage of available advanced imaging resources in cases of craniofacial trauma, as has been shown for chest trauma and pediatric traumatic brain injury.[30,31]

Lack of advanced imaging modalities in low-resource settings necessitates greater reliance on low-cost alternatives such as the physical exam. In regions where advanced imaging technology is less available, the physical exam skills of clinicians are often more astute and, where appropriate and evidence-based, allows for accurate diagnosis while reducing unnecessary overuse of costly medical technology.[32] There has also been success in choosing less expensive imaging modalities, such as using ultrasound in place of CT for the diagnosis of orbital floor fractures as an effective alternative.[33] Using facial plates and screws made of stainless steel or other cheap alternative materials can be beneficial to both patients and hospitals in high-income countries as an affordable option for patients without health insurance and for smaller hospitals that lack resources to purchase expensive equipment. These strategies should be investigated for adoption in high-income countries, especially in rural or otherwise lower resource areas, as ways to improve access to care while reducing healthcare costs.

3. Surgical Devices

Acquisition of affordable facial plates for fracture fixation can be accomplished through reduction in cost of off-the-shelf plates and locally manufactured plates using less costly materials. Plates used in high income countries are typically made from titanium and can be custom designed for individual patients. Using a standardized generic set of facial plates and screws may be an acceptable alternative in low-resource settings. Another possibility is the use of alternate materials, such as stainless steel, which has been shown to be an effective, affordable alternative in low-resource settings that provides improved outcomes compared to the current closed reduction or wire fixation techniques.[16]

4. Global Surgical Workforce Capacity

Efforts to train more surgical personnel to treat craniofacial trauma has already begun but must be expanded. Task-shifting, which involves redelegation of tasks from highly specialized individuals to appropriately trained but less specialized individuals, may help increase workforce capacity; for example, shifting less complex craniofacial trauma cases to emergency room physicians or general surgeons can increase the availability of plastic surgeons for treating complex facial fractures.[22,23] Further, a competency based craniomaxillofacial trauma curriculum has been shown to effectively educate healthcare staff in LMICs.[34] Although this was a short-term educational event, establishment of long-term, locally integrated training models in partnership with high income institutions can significantly expand future surgical workforce capacity to treat craniofacial trauma.[35] These training models can be used to strengthen residency programs in plastic surgery, otorhinolaryngology, ophthalmology, and emergency medicine, resulting in the creation of a new generation of physicians who are well-equipped to address craniofacial trauma.

3. Head and neck oncologic reconstruction

3.1. Global surgical need for oncologic reconstruction

Head and neck cancer (HNC) affects 890,000 people globally each year, representing 5.3 % of all malignancies.[36] Squamous cell carcinoma is the most common type of HNC and is especially prevalent in LMICs where risk factors such as smoking, alcohol consumption, and HPV infection are common.[37,38] HNC mortality is rising and disproportionately affects LMICs which are least equipped to handle this burden.[39] These cancers are ideally treated with a multidisciplinary approach beginning with CT imaging and tissue pathology to determine type and extent of disease, followed by surgery, radiation therapy, chemotherapy, speech and language services, and nutritional support.[37]

Resection of HNCs typically affect structures such as the oral cavity and pharynx that are essential to adequate nutritional intake and recognizable speech, and may also result in disfiguring defects to the nose, jaw, or other parts of the face that impair social functioning. More than half of HNC resections require reconstruction to improve speech, swallow, and social function.[40] Thus, reconstruction after HNC is often necessary to preserve reasonable quality of life in these patients.

3.2. Head and neck reconstruction techniques

The approach to HNC reconstruction is primarily determined by the size and location of the defect after resection, and secondarily by the resources available (i.e. microscope, microsurgical instruments, imaging technologies, surgical training). Reconstruction options include healing by secondary intention or primary closure for small defects, skin grafts for small to moderately sized defects, and local or free flaps for large defects.

In the oral cavity, the primary goal of reconstruction is to give adequate bulk of the tongue and surrounding structures to maintain intelligible speech and safe swallowing. It is important to reduce contracture and scarring which might limit tongue mobility. To accomplish this, defects less than 3 cm may be closed primarily or left to heal by secondary intention.[41] Larger defects without significant volume loss may be skin grafted. If bulk is needed, free flaps are considered state-of-the-art care. The radial forearm flap is considered the workhorse flap, though many other options including the anterolateral thigh and parascapular flaps can be used.[42]

Hard tissue defects of the maxilla and mandible are preferentially repaired with osteocutaneous free flaps, with the vascularized fibular free flap being the gold standard.[40] For orbital reconstruction and in select other patients, plate fixation may be preferred using custom plates created based off three dimensional CT imaging.[40]

On the face and scalp, when unable to close a defect by primary closure or skin grafting, soft tissue defects are typically closed with local flaps or adjacent tissue transfer. Care should be taken to design flaps much larger than anticipated with the size of the flap at least 1.5 times the defect size to allow for proper closure upon rotation of the tissue into the defect. Very large defects including cranial defects may be closed with free flaps such as the latissimus dorsi and anterolateral thigh flaps, though several other flaps have been used.[43] Radiation can also complicate the reconstructive algorithm due to the increased likelihood of complications; in these cases, counselling patients on the need for multiple operations, wound care, and the potential need for free tissue transfer as a backup option is important.

3.3. Gaps in low-resource settings

Free flap reconstruction requires experienced surgeons trained in microvascular techniques as well as hospital capacity for postoperative monitoring to ensure flap survival. Custom surgical plates require advanced imaging techniques, surgical capacity, and financial means. These resources may not be available in low-resource settings, necessitating the use of alternative techniques. For bulk-filling oral cavity reconstruction, various local and regional flaps may be used in place of free flaps, including the buccinator or tongue myomucosal, facial artery musculomucosal, platysma, pectoralis major, supraclavicular island, submental island, and trapezius can fill larger defects.[40,41] These alternatives have been shown to provide comparable aesthetic and functional outcomes to free flaps while requiring fewer resources.[44] Alternatives to fibula flaps in bony reconstruction include less optimal bony flaps from the iliac crest or scapula or the use of soft tissue flaps alone which may be adequate in select patients.[41]

In addition to the lack of healthcare facilities and surgeons, patient factors may also contribute to delayed or forgone reconstruction after head and neck cancer. Though there is little research on barriers to reconstruction after HNC in low-resource settings, reconstruction after other cancers is hindered by the high cost of reconstruction and lack of healthcare cost coverage, cultural attitudes, and fear or misunderstanding of what reconstruction entails.[45] Similar barriers may be at play in HNC reconstruction.

Treatment gaps for HNC reconstruction in LMICs can be summarized in the following areas:

1. Facilities and equipment
2. Global surgical workforce capacity
3. Patient education
4. Healthcare funding

3.4. Addressing gaps in low-resource settings

1. Facilities and equipment

Many low-resource settings currently lack the facilities and trained personnel to provide state-of-the-art head and neck reconstruction. Surgical mission trips have been used to fill this gap and provide procedures that are normally not available in low-resource areas.[46,47] Although these trips may provide short-term benefits,[48] the ideal long-term goal should be the creation of sustainable local reconstructive surgery capacity. This can be accomplished through expansion of surgical training programs in low-resource settings as was described for craniofacial trauma reconstruction. Implementing manufacturing systems within low-resource environments can improve quality of care in a sustainable manner.

Acquiring advanced equipment such as CT scanners, microsurgical instruments and microscopes, and intensive care facilities for postoperative flap monitoring in free flap reconstruction require local governmental initiatives that prioritize the establishment of healthcare infrastructure. In LMICs, international financial aid and global partnerships may be effective ways to build these capacities. However, this must be balanced with other national expenditure needs in low-resource settings. In resource-constrained environments, imaging must be carefully chosen and should only be employed if there is a considerable likelihood of change in management.[41] If CT and MRI are not available, panoramic dental x-rays, occlusal films, and intraoral dental films can be used to assess mandibular involvement, though not with the same degree of precision.[49] Concerning microsurgical capacity, given the comparable outcomes of local flaps and microvascular free flaps, along with the highly specialized and resource-intensive nature of free flaps,[44] widespread conversion to free flap reconstruction may not be desirable for low-resource settings. Acquisition and establishment of these high-acuity healthcare resources likely represent a lower priority in global cancer control compared to prevention and early detection efforts.

The use of local and regional flaps in place of free flaps for head and neck reconstruction is an effective strategy to provide comparable care to more patients while decreasing facility, equipment, and personnel demands.[44] This may be especially helpful to adopt in rural or lower-resourced areas of high-income countries, as well as in high-resource areas during healthcare capacity shortages such as the COVID-19 pandemic. In this way, microvascular free flaps and their intensive resource requirements may be reserved for the complex reconstruction cases which most benefit, and the resources which would otherwise have been spent on costly free flaps can be redirected to appropriately treat a greater number of less complex cases with local flaps.

In cases where free flaps are indicated, they have been performed successfully in low-resource settings. In a setting without access to frequent flap monitoring or available operating rooms for takebacks, meticulous surgical technique and reservation of intravenous heparin only for difficult anastomoses or thrombosis on the operating table were methods used to reduce complications.[50] Inexpensive and portable binocular microscopes and microsurgery instruments have been shown to be sufficient for performing free flaps in a war setting without access to advanced imaging such as angiography or Doppler services.[51] When even these microscopes are unavailable, free flaps have successfully been performed under loupes alone.[50] Expansion of these low-resource techniques to other areas around the world can help expand the availability of free flaps in resource-constrained settings.

2. Global Surgical Workforce Capacity

Training of the local surgical workforce is essential to building long-term surgical capacity for high-quality reconstruction. Although training to local surgeons is an active part of many surgical mission trips, the proportion of head and neck reconstructive cases in which a local surgeon is permitted to serve as the primary operator or first assist was found to be only 54 % in one study.[52] Placing higher priority on the training of local surgeons can be accomplished through investment in longitudinal international educational partnerships and local training programs.

3. Patient Education

Lack of patient education about head and neck cancer leads to delayed care as patients may not know when to seek medical attention. Patient education programs for cancer such as educational booklets have been shown to be effective in low-resource settings when variable literacy levels and cultural attitudes are accounted for.[53] While most of these cancer education programs focus appropriately on prevention, similar campaigns can be established to normalize and publicize reconstruction options after cancer to increase patient knowledge and comfort with the concept. Additionally, public education about risk factors such as smoking and alcohol may reduce the incidence of HNC.

4. Healthcare Funding

Cancer care is costly both to patients and societies, with financial toxicity affecting as many as 48 % of families seeking cancer care.[54] Meaningful efforts to control cancer in low-resource settings have tended to be national initiatives rather than local programs. Various international partnerships have helped guide the establishment of cancer control infrastructure, primarily focusing on cancer prevention and early detection of common cancers such as cervical and breast cancer.[55,56] Affordable cancer care and protection from financial catastrophe is also gaining attention in cancer control efforts and should continue to be a priority, especially in areas where most patients are financially insecure.[57] International collaboration and investment in establishing comprehensive cancer detection and treatment programs in low-resource settings should be prioritized.

4. Conclusion

Craniofacial trauma and oncologic reconstruction are high-incidence diseases that are not adequately prioritized in global surgical efforts. In craniofacial trauma, barriers to care include poor prehospital care, lack of preferred imaging equipment, unaffordable internal fixation devices, and inadequate surgical workforce capacity. In head and neck oncologic reconstruction, barriers include poor healthcare infrastructure and equipment availability, lack of trained providers, and poor patient education. Improvements and increased international investment in these areas can significantly improve craniofacial trauma and oncologic reconstruction care in low-resource settings. In addition, several low-cost alternative treatment strategies are used in low-resource settings that are often comparable in outcome to the gold-standard techniques popular in high-resource settings. Expansion of these strategies to high-income countries may be an effective way to expand access, address disparities, and reduce costs in high-resource areas.

Declaration of competing interest

The authors have no conflict of interest to declare.

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