REVIEW

Challenges in Pediatric Spine Deformity Management in Areas with Limited Resources

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Abstract

Background data: **Pediatric spine deformity (PSD) represents a true challenge worldwide, a challenge that is significantly heightened in low- and middle-income countries (LMICs) due to health inequity and inequality based on political, ethnic and socioeconomic status. As such, poor people in LMICs suffer from higher rates of illnesses and, thus, morbidity and mortality. Amidst the lack of global consensus on the treatment of PSD and the organizational and financial limitations in LMICs, we herein explore the challenges and provide a holistic management plan for PSD in these countries.**

Purpose: **This review aims to shed light on the limitations in the delivery of care and provides a holistic management plan for PSD in areas with limited resources.**

Study design: **This is a narrative review study.**

Patients and methods: **The authors performed a review of peer-reviewed literature on PSD, trends, management, outcomes and complications, in addition to a review of the challenges and limitations in care delivery in LMICs and experiences in dealing with the problem.**

Results: **The first step should be dedicated to clarifying the indications and identifying the surgical candidates. The choice of surgical technique should be in harmony with the patient's deformity, affordability, resource availability and surgical expertise. The management of PSD is possible in resource-limited countries if the proper preoperative optimization and evaluation, intraoperative care and postoperative management are meticulously undertaken. Blended learning and technology have a role in the teaching and training of medical personnel. Governments should play central roles in collecting information, identifying the gaps, finding solutions to the PSD problem and applying new reforms to the current system that facilitate delivery and improve the quality of care. Surgeons in LMICs should not limit themselves to traditional techniques but be versatile and cost-efficient.**

Conclusion: **A blueprint for an ideal healthcare system does not exist yet. Success in strengthening healthcare systems is a long-term process that comes from improvising proper strategy and creating an environment supporting innovations. Experts in the treatment of PSD are available in LMICs and can provide services to the local population and innovate new ways to compensate for limited resources.**

Keywords: Blended learning, Holistic management, Limited resources, Low-income countries, Pediatric spine deformity

Introduction

Pediatric spine deformity (PSD) is a three-dimensional deformity that presents as a lateral curvature of the spine more than 10° [1]. Its complex and heterogeneous nature requires understanding the spinal growth and the different aetiologies that can contribute to these deformities. Early-onset scoliosis (EOS) is a spine deformity that occurs before 10 years of age [2]. PSDs are usually not present at birth and progress with growth of the spine [3].

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It is essential to recognize that the growth spurt of the pediatric spine mainly and rapidly happens before age 3 and during adolescence. Hence, a key to successfully managing such deformities and associated complications is anticipating the growth potential of vertebral elements and controlling it [3,4].

Pediatric deformities of the spine are associated with a variety of multisystem anomalies based on the nature of the disease. Recently, it has been realized that a pediatric patient with scoliotic deformity has an increased risk of pulmonary insufficiency syndrome regardless of the disease and, thus, increased risk of morbidity and mortality [1]. In cases of congenital scoliosis, VACTERL syndrome: anorectal, cardiac, tracheoesophageal, renal and limb defects are associated with the vertebral problem. The major determinants of life expectancy in pediatric patients with scoliotic deformities include but are not restricted to immobility, cardiopulmonary compromise, neurological deterioration and feeding ailments, among others [1,5].

Health equity and inequality are used interchangeably, though not synonymous, yet they are concepts that convey a moral commitment to social justice [6]. Health equity and inequality are concepts describing the differences in healthcare that are unnecessary, unfair and unjust and refer to disparities in healthcare delivery to individuals and groups [6,7]. As such, there is no mystery why poor people in low and middle income countries (LMICs) suffer from higher rates of illnesses and, thus, morbidity and mortality.

Debates on global health increased since the beginning of the 21st century. Close attention has been paid to the importance of healthcare systems, especially in LMICs, due to the substantial funding provided for drugs and medical supplies, yet the underfunding of healthcare infrastructures in these countries [8]. Multiple limitations in LMICs, mainly at organizational and financial levels, have put the healthcare system at a huge disadvantage, resulting in inequality and poor quality of services.

This review aims to shed light on the limitations in the delivery of care and provides a holistic management plan for PSD in areas with limited resources.

Patients and methods

Search strategy

A review of peer-reviewed literature on PSD, trends, management, outcomes and complications, in addition to a review of the challenges and limitations in care delivery in LMICs and experiences in dealing with the problem, was conducted in October 2022. The database reviews were Medline and PubMed. Keywords used across searches were variants of the following: PSD, limited resources, low-income countries, middle-income countries, holistic management and blended learning.

Eligibility criteria

Peer-reviewed journal articles that involve descriptions of PSD, trends, management, outcomes and complications, in addition to challenges and limitations in care delivery in LMICs and experiences in dealing with the problem, were included. Excluded from this review were articles not related to PSD, a few articles that were part of a systematic review and/or meta-analysis, but related to management in high-income countries that were beyond the scope of our study aim. Fig. 1 shows a flowchart of paper selection in this study.

Procedure

The authors of this study independently reviewed both selected databases for all titles and abstracts and resolved any difference regarding full-text inclusion via consensus. The authors then abstracted data across all included studies independently concerning PSD, trends, management, outcomes and complications, as well as challenges and limitations in care delivery in LMICs and experiences in dealing with the problem. The findings were then compared, and any discrepancies were resolved among the authors through active discussions.

Ethics

Institutional review board approval was not required for this review.

Results

Limitations in care delivery

Approximately two billion people lack access to surgical care [9]; this inequity in surgical delivery in LMICs resulted in a vast number of people being denied access to treatable surgical cases, whereby 74 % of surgeries worldwide are performed in the wealthiest third of the world and only 3.5 % being performed on the poorest third [10]. Regarding spinal disease management, the previous numbers might be underestimated; two-thirds of the population lives in LMICs, whereas 80 % of orthopedic surgeons reside in 26 developed countries [11]. The management of PSD is associated with psychosocial,

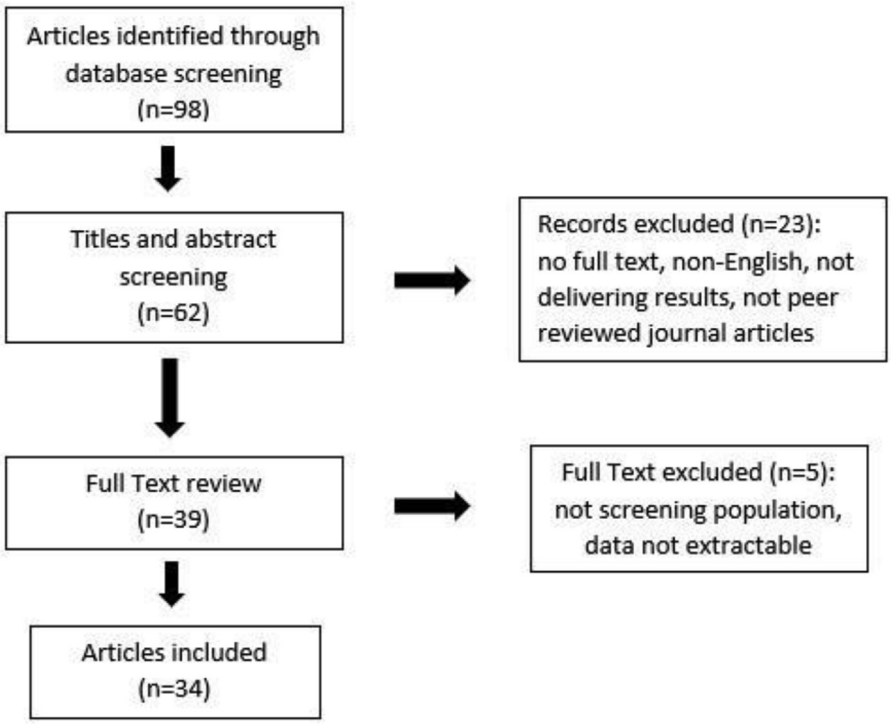

Fig. 1. Flowchart of article selection in this study.

financial and economic burdens for patients and their families in both developed and developing countries. Treatment and evaluation are particularly associated with cost-effectiveness, surgical expertise and resource availability.

PSD represents a true challenge worldwide, a challenge that is significantly heightened in LMICs with limited resources. The most common problems include limited financial resources, limited human resources, weak infrastructure and deficient entrepreneurship. The total cost of PSD in developing countries is yet to be determined because of a lack of information/database about direct and indirect expenditures [4]. Financial support is a major problem in LMICs where most of the platforms that deliver care are out-of-pocket, private health insurance or charitable platforms [36]; 50 % of healthcare financing in low-income countries is out-of-pocket as opposed to 30 % in middle-income countries and 14 % in high-income countries [12].

Of paramount importance is the lack of experienced medical teams: surgeons, anesthesiologists, radiologists, pediatricians, pulmonologists, neuromonitoring technicians, nutrition specialists, nursing staff and physiotherapists, among others. That, in addition to the low level of education among children and parents in LMICs, makes the shared decision process even harder. The infrastructure of the healthcare delivery systems is as important as the available skilled human resources. In most LMICs, the infrastructure is deficient, and most hospitals are not well-equipped to facilitate PSD surgeries or to take care of those patients postoperatively; hospitals at most times lack the following: neuromonitoring machine, good-quality C-arm, surgical constructs, blood products, ICU availability and Cell Saver systems [4]. Even specialized centres that are well-equipped are centralized, contributing to the late presentation of patients and worse deformities due to poor transportation, high costs of transportation and having to sacrifice time and wages. A recent study on operative morbidity in LMICs compared with high-income countries concluded that lack of access to orthopedic care and late presentation to the clinic are major contributors to the postponement of treatment and worse outcomes [13].

Governments in LMICs have poor care systems and strategies to treat PSD. These countries lack a public health screening programme designated for the detection of spine deformities at an early stage. There is also a deficiency in national registries and databases, which is a venue of innovation. Additionally, PSD is not a new pathology, yet LMICs are still left with yesterday's solutions. The root of this problem is due to a mismatch between innovative, profit-driven industries in developed nations, and limited resources and financial capabilities in LMICs [4].

Holistic management plan

There is no global consensus on the treatment of PSD. The outcomes rely on disease characteristics, geographical location and management protocols. A management protocol does not depend solely on surgical intervention. However, it includes the preoperative phase even before a diagnosis is established and the postoperative phase until the definitive surgery is done.

At the early stages of PSD, observation and frequent clinic visits are key to proper follow-up of the spinal deformity through serial physical examinations and radiographic imaging to have a baseline Cobbs angle and RVAD for future comparison. As the deformity progresses, intervention becomes inevitable; in fact, this is the stage at which proper management and care plan are of paramount importance, especially in LMICs, because it can, at most times, halt disease progression and correct deformity or at least delay the need for surgical intervention and narrow down the subset of the patients that are surgical candidates. The latter is achieved through bracing and serial casting, which are the most common efficacious nonsurgical interventions for pediatric spine deformities. Proper bracing and casting require specific skills to properly fit the patient in which the corrective forces are constant on the spinal curve and the lung space is not narrowed by avoiding pushing the ribs towards the spine [14]. More importantly, casting is a serial process that requires frequent follow-ups at 4–6-month intervals for cast check and change and curve progress reassessment over a minimum of 1 year, and when deformity resolves, a brace usually follows.

Despite all the efforts invested to avoid surgery on PSD patients, some curves are resistant to the aforementioned interventions and continue to progress and worsen, necessitating surgery. However, the 'one-size-fits-all' technique is not yet established, and surgery should be personalized to each patient to maximize benefit and achieve the best outcomes secondary to the operation. As such, the choice of surgical technique should be in harmony with the patient's deformity, affordability, resource availability and surgical expertise taking into consideration the risks of future complications and the need for postoperative surveillance.

Principles of preoperative, intraoperative and postoperative management

It is extremely important that a pediatric patient in the preoperative period is optimized through a series of assessments to ensure the patient is an appropriate surgical candidate. Cardiopulmonary assessment is vital to identify a pre-existing pulmonary disease, the need for physiotherapy and bronchodilators and airway assessment by an anesthesiologist [15]. Nutritional status is another crucial factor that needs to be optimized, which is critical to minimize wound-healing complications that could interfere with growth and facilitate recovery [4].

Intraoperatively, a well-equipped operating room is ideal, and a setup comprising the minimum requirements of a complete surgical team with trained manpower and sufficient resources cannot be uncounted, including but not limited to anesthetic drugs, antibiotics, intraoperative neuromonitoring, blood component, and Cell Saver system. To proceed with surgery, certain anesthetic drugs and antibiotic prophylaxis need to be available, and there seems not to be a deficiency in the latter drugs in most LMICs. However, there is a deficiency regarding the availability of blood components and cell savers needed for blood loss management in scoliosis surgeries. Additionally, there is a huge gap in terms of intraoperative spinal neuromonitoring: it is considered a standard of care in developed countries, yet it continues to be unavailable in most healthcare facilities in resource-limited countries [4].

Postoperative care starts at the moment the patient is turned supine after surgery till complete rehabilitation is achieved, and functional status is restored. It is divided into three periods: immediate, early and late. In the immediate postoperative period, from day 0 until discharge, the major emphasis is on maintaining hemodynamic stability [16], pain and nausea and vomiting management [17], transition to oral feeding and early mobilization as part of the 'Accelerated Discharge' protocol, which was found to be associated with a reduction in economic burden and is especially needed in LMICs, however, this protocol should take into consideration available resources outside the hospital and accessibility for follow-up after discharge [18,19]. The early postoperative period extends from discharge till 10–12 weeks after surgery and is when the patient returns to school and regular daily life activities while providing maximal spine protection. It is also the period where monthly follow-ups are needed. After 12 weeks and up until 1 year is the late postoperative period when an EOS patient is expected to return to full independence, regaining strength and flexibility, and is the period where distraction/lengthening is initially done [20].

The management of PSD in LMICs is possible in resource-limited countries if the proper preoperative

optimization and evaluation, intraoperative care and postoperative management are meticulously undertaken.

Technological advancements

Just as technological advancements place LMICs at a disadvantage when it comes to prosthetics and medical equipment, they can be advantageous when it comes to incorporating technology in teaching, training and guiding physicians and medical personnel in LMICs.

In the era of the Internet and in the context of the recent COVID-19 pandemic, online learning (OL) as a form of e-learning has flourished as the main form of learning. It allows users easy access to various educational resources and latest updates at marginal costs, making OL a suitable tool in LMICs [21,22]. The drawback associated with this type of learning includes inadequate hands-on training and weak technical skills compared with cognitive skills, which necessitates those learners to still be part of the learning environment, including residency and fellowship programmes. Blended learning (BL) refers to a combination of online and face-to-face learning. It ensures attaining both cognitive and technical skills [23]. A recent study on BL in PSD to explore its impact on surgeon training demonstrated that BL can be very effective in deformity surgery, whether intraoperatively or when it comes to preoperative planning and decision-making [24,25]. This finding, if not to be used for application on patients yet, can be a milestone to start incorporating training on models, recorded or live surgeries and the use of virtual or augmented reality to provide skills training for surgeons in LMICs. The latter technologies of simulation-based teaching have been previously used and allow training in a secure environment. However, they come at the expense of a huge financial burden and not providing optimal tactile sensation during practice [26].

Telemedicine and telesurgery are part of the clinical practice in developed countries [27]. They facilitate consultations and follow-ups with specialists at lower costs and are proven to correlate with good outcomes and cost-effectiveness in orthopedic surgery [28,29]. Such endeavor can and should be explored in LMICs as it allows more accessible consultation of spine experts and allows expanded reach to specialists even in other countries, in addition to saving the poor some money; however, it requires the proper equipment to be available at both ends, the patient and the hospital/surgeon. Therefore, a greater role of artificial intelligence is expected, especially in the surgical training of upcoming spine surgeons, and should be used in global training programmes.

Further considerations

The right to health obliges governments/states to create healthcare systems of high standards and that includes not only citizens but also refugees and internally displaced people [6]. Additionally, it is important to recognize that PSD is not isolated but could be associated with other potential abnormalities that require further investigation, such as renal ultrasound and echocardiograms [1,30].

Governments should play central roles in collecting information, identifying the gaps and finding solutions to the PSD problem. To improve health quality, there should be a coherent set of actions at all levels, including education, finance, transport, employment and health [6].

To release the constraints on the healthcare system in LMICs, a framework was developed by WHO in 2001 to improve the function of these systems and their healthcare delivery. Due to the lack of financial support for those in need in LMICs and the large amount of financing that comes from out-of-pocket payments, there needs to be gradual progress towards increased financial protection of the poorest people through subsidization from general taxation [8]. Another key issue is to deploy financial incentives to encourage the use of health services and providers to deliver good-quality services; nonetheless, there are no studies in LMICs on this endeavor to achieve better outcomes [31]. The engagement of the private sector, including private providers, itinerant drug sellers and nongovernmental organizations, to be part of healthcare service delivery in LMICs and alleviate the problems of service inaccessibility, staff shortage and maldistribution and inadequate drugs and supplies [32].

A rarely mentioned platform that was found to deliver care to PSD is a charitable platform. These global charitable platforms shifted from organizing missions and paying for expensive implants to focusing on using the resources available and necessary in LMICs to deliver care in an evidence-based and patient-centered manner [33]. The key to the success of such a platform is long-term sustainability and independence with time.

Previous experiences

Several LMICs have incorporated new health plans to improve delivery of care to PSD patients and promising outcomes were recorded thereafter.

PSD services in Mozambique were absent due to a lack of needed constructs and experts in the field; even cases that were done were not adequately followed up. To organize the service and build the necessary local manpower to handle and follow up with the patients, organized missions were initiated that included skilled spine specialists, neuromonitoring technicians and competent nurses. During the first mission in 2018, five scoliosis patients were operated on using the active apex correction (APC) technique [34] and followed up through Internet and smartphone technologies. During the second mission in 2019, it was noticeable that the local workers were more confident in the four scoliosis cases and that the surgeons were more involved in screw placement. Such experience shows the importance of successful collaboration and service establishment between LMICs and global NGOs and experienced doctors under the patronage of the Ministry of Health, which has the resources at hand and at a reduced cost. Additionally, the sustainability of such missions facilitates the learning of local doctors and results in improved outcomes when a suitable surgical technique is followed, in this case, the APC technique that requires lesser follow-up/distraction (Fig. 2). Also shown is the role of telemedicine use and charitable platforms in the current era, specifically in orthopedics (Fig. 3).

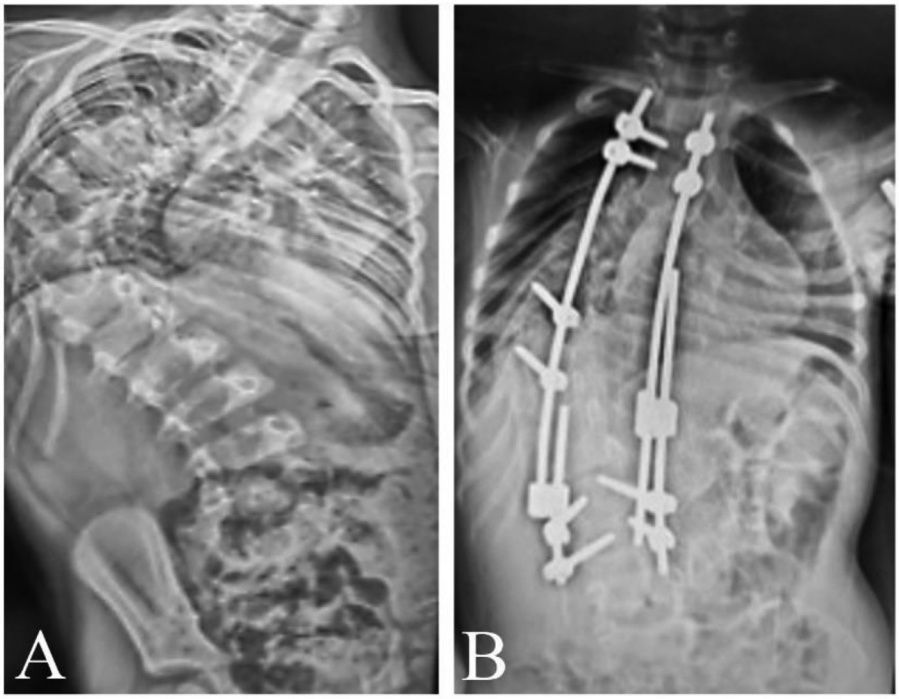

Fig. 2. Active apex correction technique as an example of a reliable, affordable technique for early-onset scoliosis management in low and middle income countries.

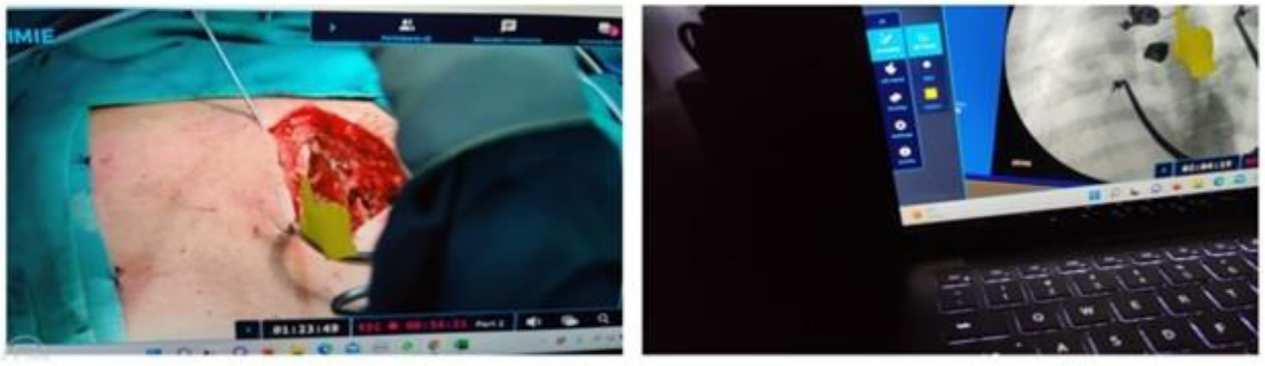

Fig. 3. Proctorship promoting surgical skills in scoliosis as an example of incorporating technology to help treat early-onset scoliosis in low and middle income countries.

Chile has middle socioeconomic development and relatively good health indicators but suffers from limited resources and a high financial burden of treatment and implant costs. In 2005, after law reform that specified timing, quality (specific hospitals and specialists) and required resources for the treatment of spine deformity, among other diseases, funds were assigned, neural monitoring was included and intervention was recommended to be performed within nine months of indication. As such, limiting treatment of PSD to several highly specialized centres allows adequate treatment of complex cases and improves surgical experience and outcomes.

Conclusion

Few clear-cut conclusions regarding the best strategies for improving healthcare delivery to PSD patients in LMICs can be drawn. A blueprint for an ideal healthcare system that automatically improves performance and outcomes does not exist yet. An approach that might work well in one country may not work well in another. Therefore, success in strengthening healthcare systems is a long-term process that comes because of improvising proper strategy as well as creating an environment that supports innovations. Nowadays, a small but growing number of experts in the treatment of PSD exists in LMICs who can provide services to the local population and innovate new ways to compensate for limited resources, considering the basic laws of management and safety.

Ethics Information

The article does not contain information about medical device(s)/drug(s).

Author declaration of funding statement

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Conflict of Interest

The authors report no conflicts of interest.

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