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Surgical long-term outcomes of Hirschsprung Disease in the Democratic Republic of Congo: a case series of 31 patients in a resource-limited setting

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Abstract

Background Hirschsprung disease (HD) contributes significantly to the burden of disease related to conditions amenable to pediatric surgery within the Democratic Republic of Congo (DRC). However, it has received less clinical attention due to limited resources. We aimed at assessing the long-term follow-up outcomes following an innovate resection approach in South Kivu, eastern DRC.

Methods In this case series, the authors elucidate the admissions for HD spanning from 2016 to 2021 at a Pediatric Surgical Center in the DRC. All patients underwent surgical management. Due to the absence of an extemporaneous biopsy, the resection margin was defined by a formula developed by the authors: 5 cm for patients under 5 years, 5 cm plus 1 cm per age from 6–10 years, and 5 cm plus 0.5 cm per age above 10 years. Post-operative mortality and complication rates were equally computed. Descriptive statistics were calculated for continuous variables. Discharge-to-Follow-up data were visualized using time-to-event curves.

Results Thirty-one patients aged 195 (interquartile range: 18–669) days were included in this study. Thirteen (58.93%) were from mining areas. The patients were surgically managed and follow-up for a year. 6.45% died in the 30-day post-operative period and 19.35% were lost to follow-up. The complaints were recorded from the fourth month following the surgery with most of the patients complained about fecal soiling (58.06%). The overall complaint rate was 80% (95%CI:56.20%-90.69%). The overall rate of incontinence was different compared to those with fecal soiling (p = 0.04). Although lacking statistical significance, the length of stay (LoS) post-surgery predicting an 9% increased incidence of complaints during the follow-up period (adjusted Hazard Ratio: 1.09, 95% CI:0.97–1.23).

Conclusion HD cause avertable morbidity in South Kivu. These data suggest that the long-term outcome in HD can be mitigated through appropriate surgical management during the operative and intervention aimed at optimizing the LoS. **Keywords** Digestive Tract Congenital Anomalies, Pediatric Surgery, Long-term follow-up, Pull-through, South Kivu

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Introduction

Hirschsprung's disease (HD) is a congenital intestinal anomaly that typically manifest during early infancy leading to enterocolitis, severe constipation and intestinal obstruction [1, 2]. This condition involves anomaly in the development of the rectum between the sixth and the tenth week of embryonic development. The HD is known to be primarily a functional abnormality due to the lack of ganglia cells in the rectum. It characterizes with heterogeneous functional prognosis and associated in up to 60% of cases with other malformations [3]. As this condition is typically identified postnatally, accurate decisionmaking and parental counseling during the early neonatal period are crucial for optimal outcomes.

The management approach focuses on isolating the unaffected colon or rectum and precisely positioning it within the anal sphincter complex. In the case of HD, surgical intervention is directed towards reinstating intestinal continuity through excision of the aganglionic and transition zones, followed by anastomosis of the ganglionic bowel to the rectum [4]. Although variability exists among institutions regarding the timing for the definitive pull-through procedure, it is typically initiated within the first weeks of life. Three primary procedures are employed: the Duhamel, Soave, and Swenson techniques sharing a common characteristic; the incorporation of histological analysis, typically facilitated through on-table frozen sections. Histological analysis allows for identification of the ganglionic bowel, resection of the aganglionic and transition zone bowel, and preservation of the anal continence mechanism [5]. The Soave and Swenson procedures involve transanal resection starting above the dentate line and extending around the rectum. While the Swenson procedure ensures complete removal of the aganglionic proximal bowel by extending through the rectal wall, there are concerns about potential sacral plexus exposure. Nonetheless, proponents argue that adherence to the bowel wall minimizes nerve injury risk. However, both procedures may affect continence mechanisms due to sphincter retraction during dissection.

Outcome analysis for HD parallels that of other digestive tract birth defects by posing challenges in assessing functional outcomes, requiring extensive long-term follow-up spanning decades. Such assessments are crucial for guiding future advancements in treatment and for optimal outcome [6, 7]. Although concerns regarding incontinence or constipation are relatively common, they can generally be managed to help a child start school while maintaining cleanliness, with minimal difficulty for both the child and their family [4].

In the Democratic Republic of the Congo (DRC), digestive tract birth defects occur in 72 out of 100,000 live births, with a prevalence notably higher in mining

zones [8]. While these birth defects, including HD, are multifactorial conditions, exposure to mining toxins appears to triple their occurrence [8]. Exposure to toxic chemical elements such as arsenic and mercury is a major health concern that could significantly affect maternal and child health outcomes. Higher exposure to arsenic and mercury during pregnancy can increased prevalence of adverse birth outcomes including spontaneous abortion, stillbirth, preterm birth, low birth weight and visible congenital anomalies [9, 10]. Indeed, Lubala et al. [11] revealed a significant increase in the prevalence of congenital malformations in the City of Lubumbashi. He hypothesized that the intensification of mining activities and environmental pollution from quarries, mines and mineral processing plants would be associated with the increase in this phenomenon [12].

In the past two decades, artisanal mining has significantly expanded in Eastern DRC, engaging tens of thousands of young people, including children, in hazardous mining roles. Many of these workers, known locally as "creuseurs," are employed under poor regulatory standards with minimal safety oversight [13]. Additionally, metal-processing furnaces have been erected near residential areas, posing significant environmental health risks due to inadequate emissions control.

Emerging research indicates that paternal mining occupations and maternal occupational exposures, along with elevated prenatal manganese (Mn) and zinc (Zn) levels, correlate with an increased risk of birth defects [14]. Parental age, particularly within urban, mining town, and rural settings, is notably relevant, as it has been shown to correlate with increased rates of stillbirth, infant mortality, and congenital malformations [15, 16]. In addition to environmental exposures and parental factors, malnutrition continues to severely impact child health, with the DRC reporting a national chronic malnutrition prevalence of 43% [17]. South Kivu, a province in eastern DRC, has faced endemic malnutrition since the 1960s, with half of all children under five suffering from chronic malnutrition. This chronic malnutrition significantly correlates with elevated hospital mortality rates among pediatric patients, compounding the health burden [17]. These overlapping environmental and nutritional challenges highlight the urgent need for interventions that address industrial safety standards alongside comprehensive nutritional support programs to alleviate burden of disease in neonates and children.

Despite a throughout understanding of their epidemiology, an increase in morbidity and mortality persists due to limitations in diagnostic capabilities, insufficient skilled surgical workforce, and inadequate long-term postoperative follow-up. Moreover, HDs have been subject to limited clinical investigation in the country, hence, we aimed at describing long-term outcomes following surgical management using an innovative resection approach in Bukavu, a limited-resource setting of the DRC.

Methods

Study design, population and context

We conducted a case series of patients diagnosed with HD who underwent surgical treatment at the Provincial General Reference Hospital of Bukavu (HPGRB) between January 1, 2016, and December 31, 2021, in Bukavu. Bukavu is the capital city of the South Kivu province in the eastern DRC, and in the domain of health administration, it is segmented into 34 health zones, each hosting a general referral hospital. These hospitals serve as critical intermediaries for directing cases to the HPGRB, recognized as the apex in the local healthcare hierarchy and possesses the resources to manage complex cases of birth defects. The rich mining industry in South Kivu may significantly compound the prevalence of diseases linked to birth defects through both direct and indirect pathways. Primarily, mining activities, often conducted without adherence to environmental regulations, engender extensive pollution of the air, water, and soil during the processing of gold, tin, coltan, and tungsten. This environmental degradation heightens exposure to heavy metals, acknowledged contributors to birth defects. Secondarily, the socioeconomic fallout of the mining sector, characterized by prolonged armed conflicts, displacement, poverty, and social instability, engenders substandard access to quality healthcare infrastructure and services. Consequently, this culminates in diagnostic and treatment delays and suboptimal outcomes for birth defects, particularly HD. The nexus of mining activities with structural healthcare challenges and inadequacies further compounds the hurdles faced by individuals grappling with birth defects in South Kivu.

Diagnostic

In neonatology, the diagnostic paradigm for HD pivots upon the observation of meconium retention exceeding a 48-h threshold. Maternal reports of such occurrences serve as sentinel indicators, arousing suspicion and prompting further clinical inquiry. Additionally, extramural narratives from parents often delineate persistent challenges in defecation or chronic constipation, necessitating adjunctive diagnostic modalities such as abdominal radiography to evaluate colonic dilation (Fig. 1). Histological assessment, typically conducted postoperatively within a fortnight, substantiates the presence of aganglionic segments in HD cases, with meticulous attention directed towards



Fig. 1 Plain abdominal radiography in a newborn with HD. The x-ray reveals distended bowel loops, indicative of colonic dilation, along with air-fluid levels suggesting obstruction of fecal matter and gas

confirming adequate resection margins. In our series, the transitional zone observed intraoperatively served as a complementary diagnostic indicator. This area was macroscopically identifiable by a caliber jump in the rectosigmoid colon. However, it is possible that, relying solely on these clinical and paraclinical findings, we may have overlooked other patients with HD. All the case reported in this series, the histological examination confirmed the diagnostic of HD with the two weeks following surgery.

Given our institutional resources, our framework integrates a comprehensive diagnostic armamentarium, routinely encompassing transfontanelle ultrasonography, alongside cardiac and abdominal ultrasonography, aimed at thorough exclusion of associated birth defects.

Surgical procedures

All patients with HD were managed using the Swenson procedure (Fig. 2). For patients weighing less than 5 kg, a three-step approach was used: initially, a colostomy was created at the right colic angle; the Swenson procedure was performed once the patient reached 5 kg, followed by colostomy closure after six weeks (Fig. 3). For patients weighing more than 5 kg (Fig. 4), a two-step approach was employed: the Swenson procedure and colostomy were performed simultaneously, with colostomy closure scheduled six weeks later.



Fig. 2 Intraoperative view of a Swenson technique. A classic abdomino-perineal pull through procedure: (A) abdominal and (B) perineal steps



Fig. 3 A post-operative view of colostomy

Estimation of the Resection Margin in HD Based on Patient age and weight

To assess the size and extent of the resection in the absence of extemporaneous histopathological examination, we have relied on a few reflections and observations.

1) In the normal anatomical configuration, the terminal segment of the rectum, specifically the anal canal, is devoid of ganglion cells. This inherent absence



Fig. 4 Intraoperative view of distended bowel loops in an adult with HD. The black circle indicates the transition zone where the dilated colon abruptly narrows to the normal segment

ensures that the distal anatomical landmarks remain consistently unaltered.

2) The transitional zone between the normally ganglionated segments containing Meissner's and Auerbach's plexuses and the aganglionic segment is macroscopically delineated by a discernible caliber transition. This transition is characterized by a dilated segment indicative of the cessation of peristaltic activity, followed by a segment of normal or reduced caliber, which reflects the absence of peristalsis. The caliber transition is distinctly observable.

3) Our theoretical model posits that with advancing age, the macroscopically visible caliber transition progressively encroaches upon the transitional zone. This is attributable to the fact that, despite the absence of ganglion cells (and consequently peristalsis), the gravitational force acting upon the fecal contents in the normally ganglionated segment induces gradual dilation of the aganglionic segment over time. This hypothesis is corroborated by observations in Hirschsprung disease, particularly in the short-segment variant, where constipation symptoms are frequently underreported. This is because the fecal material, influenced by its own weight and gravitational force, traverses the aganglionic segment with relative ease. Conversely, rectosigmoid variants, which are more commonly encountered, are characterized by early onset constipation, often observable from the neonatal period. Short-segment variants may either spontaneously resolve after a period of constipation or be alleviated through simple rectal examination.

In our current conditions, the extemporaneous biopsy examination is not available therefore the resection depends on the age of the patient. While based on the transitional zone; under 5 years we do the resection 5 cm (cm) above this line, between 5 and 10 years we add 1 cm per age; beyond 10 years we add 0.5 cm per additional year.

The length of resected section was calculated based on the following formula:

This allows for the performance of the coloanal anastomosis, utilizing the ganglionic zone identified in the first phase following its resection. The third phase consists of an abdominal approach to elevate the anastomotic segment and complete the closure of the abdominal wall.

Data sources

Sociodemographic, clinical, therapeutic, and outcome data for HD patients admitted between 2016 and 2022 were extracted from paper medical records and systematically stored in a Microsoft Excel spreadsheet. Data collection was conducted retrospectively by trained personnel using a standardized tool to ensure consistency and accuracy. Sociodemographic variables encompassed patient age, sex, and place of residence, while clinical data included surgical data, imaging assessment, and functional outcomes evaluated at one-year post-intervention.

Data analysis

R (version 2022.12.0) was utilized for statistical analysis. The recorded data underwent initial analysis employing descriptive statistics. Mean values along with standard deviations and median values with ranges were reported for continuous variables, while frequencies were assessed for categorical variables. Additionally, complication and mortality rates were computed. Discharge-to-Follow-up curves were plotted using a time-to-event function. Finally, predictors of complications during the follow-up were assessed using the Cox-regression, while their occurrence in relation to the diagnosis was evaluated using univariate logistic regression.

Results

A total of thirty-one patients aged 195 (interquartile range: 18–669) days of whom 96.77% of were males and 41.93% originating from mining areas were recruited. For

$$r(t) = \begin{cases} r(t) = 5, if 0 \le t \le 5\\ r(t) = 5 + (t-5), if 5 > t \le 10 \text{ with } r \text{ being the margin length to resect in cm, and } t \text{ the age in years.}\\ r(t) = 10 + \frac{1}{2}(t-10), if t > 10 \end{cases}$$

The length of the affect segment varies. The most distal point is always down in the rectum, at the dentate line [4]. We always keep 2 cm above the anal margin.

The surgical procedure is executed in three distinct phases. The first phase involves a laparotomy to identify and dissect the transitional zone close to the bowel loop up to the pelvic floor, and to estimate the level of the segment to be resected. The second phase encompasses a perineal approach, during which the anal canal is identified and sectioned, preserving 2 cm from the anal margin. majority of patients had the diagnosis was confirmed by X-ray (28, 90.32%). X-ray and ultrasonography were performed in 2 patients (26.79%). 16 patients (51.62%) underwent surgery in two and three steps, respectively. During the post-operative period, only 2 (6.45%) deceases where recorded. After a year of follow, most of the patients complain of fecal soiling (33, 62.26%). The frequency of fecal soiling was 58.06% HD patients (Table 1). The first complaint occurred four months following the surgery (complaint occurrence probability:4.00%, 95%CI:0.90–11.38%),

Table 1 Descriptive presentation Hirschsprung disease in the Eastern Democratic Republic of Congo

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the 12-month probability of complaint occurrence was for 80.00% (95%CI: 56.20%-90.69%). The six-month and tenmonth probability of complaint occurrence were 8.00% (95%CI:0.90–11.38%) and 40.00%(95%CI:8.10%-56.43%), respectively. The probability of complaints occurrence was among patient with incontinence and fecal soiling (p=0.04) (Fig. 5). The incidence of complaints did not significantly differ across age groups (≤ 1 year vs.>1 year), gender, mining, type of malformation, and number of surgical steps (p>0.05). Length of stay in hospital increased in the incidence of complaints by 9% (adjusted Hazard Ratio: 1.09, 95%CI:0.97–1.23). However, this risk was not statistically significant (p>0.14).

Discussion

The goal of surgical management HD is preserving life by reestablishing normal anatomical structure and function, ensuring effective bowel control, preserving sphincter integrity, and ultimately enhancing the patient's quality of life [18, 19]. This study represents the first comprehensive long-term postoperative follow-up of HD patients in a resource-limited setting in the DRC, where local surgeons employed an adapted surgical technique. In HD, given the constraints of not performing preoperative biopsies to delineate the full extent of the aganglionic zone, the resection margin was determined based on the patient's age, with postoperative confirmation achieved through histopathological examination. The observed higher incidence of complaints in HD cases highlights the urgent need for improved long-term postoperative care strategies to address this issue.

Our findings are similar with those of previous studies that have reported predominance HD in males [20–22]. The observed male predominance remains unexplained and warrants further investigation, particularly through genomic studies, to elucidate its underlying causes. In our series, most patients with HD were predominantly diagnosed after the first twelve months of life. This finding



Fig. 5 Time-to-Event Curve of Surgically Managed Patients with HD at HPGRB. This curve displays the probability of occurrence of complaints over a one-year follow-up period: (A) for the overall cohort and (B) stratified by complaint types

aligns with reports from other Sub-Saharan countries [23–26], and contrasts from trends in developed countries, where less than 10% of cases are identified lately [27].

Although majority of studies focus on short-term outcomes in HD, only a limited number have addressed long-term outcomes [28]. Previous studies have underscored a considerable incidence of immediate postoperative complications-particularly constipation, fecal incontinence, and enterocolitis [26, 29, 30]. The rate of fecal soiling reported in this study was similar to those in other settings [31-33]. We observed that first complaints emerged from the fourth month of follow-up. The exact mechanisms that could explain this phenomenon remains unclear; nevertheless, several potential factors warrant thorough investigation. One prevailing hypothesis pertains to the effects of sphincter rehabilitation conducted during hospitalization, combined with adherence to an appropriate dietary regimen. The surgical management protocol at our hospital involves sphincter rehabilitation during hospitalization, along with a strict diet for all patients with HD. It is crucial that future studies assess the relationship between sphincter rehabilitation and adherence to an appropriate diet in relation to the incidence of poor long-term outcomes.

Moreover, favorable long-term outcomes have been linked to enhanced social functioning, including strong social relationships with peers, among children with HD [34, 35]. Children with HD may report poor psychosocial and social functioning after surgery in comparison to their parents. Moreover, previous reviews found that children with HD experience difficulties with anxiety, peer rejection low self-esteem, poor body image, and depression [36–38]. Complaints such as soiling have been reported to lead to psychosocial distress [39]. For patients with HD, achieving fecal continence necessitates an intact anal sensation mechanism (dentate line), adequate sphincter tone, and reliable colonic motility.

We have identified that an extended LOS is associated with a higher incidence of complaints during follow-up. This association may be linked to malnutrition, which is prevalent among patients with HD and leads to nutrient malabsorption [26]. This malabsorption might elucidate why patients with prolonged LOS report more frequent complaints, as impaired nutritional status not only hampers the healing process but also exacerbates postoperative complications. Malnutrition may precipitate immunodeficiency, rendering patients more vulnerable to opportunistic infections and additional pathologies during their hospital stay. Consequently, their duration of hospitalization is extended, largely due to complications arising from their immunocompromised condition. This underscores the critical importance of adequate nutrition in supporting recovery and enhancing long-term outcomes. Furthermore, factors such as delays in care due to late hospital presentation may also impact outcomes. Patients presenting with advanced stages often receive a two-step correction, whereas those who undergo a three-step correction exhibit a 30% reduction in complication rates. Existing literature has shown that early complications such as anastomotic leakage, anal strictures, and perineal excoriations have been observed [26, 40, 41]. The observed late presentation can likely be attributed to challenges in diagnosing the condition during the neonatal period, coupled with the limited access to specialized healthcare facilities, which are often concentrated in urban areas. In contrast, the highest prevalences arise in mining regions, of which most of the are rural areas, where such specialized cares are less accessible [8]. Moreover, most patients in this study resided between 20 and 150 km from our facility. Most of the people living in mining region are experience many financial constrains due to their poor economic status [42, 43]. Therefore, it is imperative to develop and implement strategies to improve access to pediatric surgical care in the region, drawing upon the "Three Delays Model," [44] which focuses on reducing delays in the decision to seek care, access to care, and receipt of care. The most significant delays in the DRC, seeking and accessing care, require a strategic focus on community education, access improvements, and financial and policy support. Educational campaigns are essential to increase community awareness about treatable conditions and the importance of timely medical care, which can help reduce delays in seeking treatment. Partnering with local leaders and media can amplify these efforts and reach underserved areas effectively. To address barriers in accessing care, expanding local health centers and creating reliable transportation or mobile health units can make medical facilities more reachable for remote communities, reducing travel time and costs. Training healthcare providers at all levels and establishing efficient referral pathways will ensure that cases are promptly identified and directed to appropriate facilities. To address financial obstacles, developing community health insurance models or subsidized care programs can make care affordable, preventing families from delaying or forgoing treatment due to cost. Lastly, government support through policy initiatives that prioritize healthcare infrastructure, public-private partnerships, and resource allocation is vital to sustain these improvements. Collectively, these strategies can substantially mitigate the delays in seeking and accessing care in the country, enhancing timely care and better outcomes for people with surgical amenable conditions, particularly children with HD.

Children with HD limited to the rectosigmoid frequently experience persistent constipation following pull-through surgery. Conversely, patients with longsegment HD may face challenges with loose stools due to the reduced colon length available for water absorption, complicating stool management [45]. The incidence of enterocolitis in HD varies significantly from 6-60% before definitive pull-through surgery and 25-37% after surgery, reflecting the challenges in diagnosing this condition accurately [46, 47]. Contrary to studies that report constipation and enterocolitis as common complications in both short- and long-term follow-ups, our series did not observe these adverse outcomes. This discrepancy may highlight the effectiveness of our technique in managing HD, particularly in settings with limited resources where advanced diagnostic tools such as extemporaneous biopsy and histopathology are not available. Our findings suggest that adjusting the resection length based on the patient's age can be a viable strategy, potentially offering a cost-effective alternative that improves patient outcomes in resource-limited environments. Given that in our series, patients did not report cases of constipation, we can infer that our method for measuring the resected portion is likely accurate and not inflated. However, further research should prioritize examining the relationship between the length of the resected segment and patient outcomes to validate our hypothesis. This would provide a clearer understanding of how variations in resection length might influence postoperative results, ultimately refining surgical strategies and improving patient care.

In resource-limited settings, the diagnostic and therapeutic approach is often guided by the two steps. First, once the temporary diverting stoma is functional, it confirms that the stoma is located above the transition zone. Secondly. During the pull-through procedure, an additional five to ten centimeters above the stoma is resected to ensure that the transition zone is not involved before performing a watertight anastomosis. The presence of ganglion cells in the stoma was confirmed through final pathology permanent sections [26].

This study has several limitations related to the resource-constrained environment in the DRC, which impacted various aspects of care for children with HD. Diagnostic limitations were a major challenge, with restricted access to advanced diagnostic tools such as contrast enemas, rectal biopsies, and manometry. Consequently, diagnoses often relied on clinical and operative findings rather than comprehensive imaging or histopathology, which may have led to potential underdiagnosis or misclassification. Surgical management was also constrained by limited operating facilities and essential surgical equipment, necessitating adaptations of standard procedures that may have influenced treatment options and impacted functional outcomes. Postoperative monitoring and long-term follow-up, essential for assessing outcomes and identifying complications, were hindered by geographic and financial barriers, limiting many patients' ability to return for follow-up visits. As a result, outcomes beyond the immediate postoperative period were inconsistently documented, affecting the understanding of long-term functional results. Additionally, data collection relied heavily on paper records, challenging the consistency and completeness of information due to the absence of standardized electronic records. Given these resource-related challenges, findings from this study are specific to the DRC and may not be fully generalizable to settings with more robust healthcare infrastructure. Nevertheless, these findings can provide preliminary insights into the effectiveness of this innovative approach within resource-limited settings, offering a foundation for further study and adaptation in similar environments. This study highlights the pressing need for investment in healthcare resources to enhance diagnostic accuracy, surgical outcomes, and long-term follow-up for children with HD in resource-limited settings.

This study lacks proper statistical power to correlate the investigated variables with HD as the sample size is small. Another limitation of this study was the lack of robust investigation protocol to thoroughly detect associated congenital anomalies and, lack of long-term follow-up; but it retains its value as described in a resource-limited setting with acceptable results.

Despite its limitations, this study provides valuable insights with significant implications for both clinical practice and public health. Our findings underscore critical areas that need to be addressed to mitigate longterm complications. We emphasize the importance of incorporating sphincter rehabilitation through kinesitherapy to improve long-term outcomes, advocating for its integration into care strategies for families. Moreover, the innovative technique for HD has proven effective even in environments lacking advanced diagnostic tools, such as preoperative biopsy and immunohistochemistry. Considering the substantial financial burden of these advanced procedures, our results suggest that this technique offers a viable, cost-effective alternative. It enhances patient outcomes while addressing financial constraints in resource-limited settings. Ultimately, our approach enables the precise minimization of the resection area, thereby significantly reducing the risk of postoperative digestive complications that might otherwise result from an overly extensive resection lacking clinical justification.

Conclusion

This study underscores the substantial morbidity attributable to HD within the DRC. It advocates for the implementation of appropriate operative and post-operative management strategies to enhance better long-term outcomes. The surgical technique employed in this study can be adapted for use in other resource-limited settings to achieve improved outcomes with reduced resource expenditure "doing more, with less".

It is evident that addressing the challenges posed by HD in the context of limited resources in regions like South Kivu demands a multifaceted approach. Beyond surgical intervention, there is a critical need for comprehensive healthcare infrastructure development to ensure timely access to specialized care, adequate post-operative monitoring, and patient follow-up. Furthermore, capacity-building initiatives targeting healthcare providers in these regions can enhance their skills in managing complex pediatric surgical cases effectively.

Additionally, community engagement and awareness programs are essential to promote early detection, timely referral, and adherence to post-operative care protocols. By fostering collaboration between healthcare providers, policymakers, and community stakeholders, sustainable solutions can be developed to alleviate the burden of HD and improve the overall quality of care for pediatric patients in resource-limited settings.

Future research should prioritize corroborating our findings in similar resource-limited settings, such as the DRC. Large-scale, robust studies are necessary assess the effectiveness of innovative surgical approaches to determine their impact on survival rates, functional outcomes, and overall quality of life. Moreover, future research endeavors should focus on evaluating the long-term efficacy of interventions aimed at optimizing post-operative outcomes, such as early mobilization protocols, nutritional support strategies, and psychosocial interventions for patients and families. By continuously refining and adapting our approaches based on empirical evidence and local contextual factors, we can strive towards achieving better health outcomes and reducing the morbidity associated with HD in similar resource-constrained settings globally.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

F.C.G., A.D.N., K.N., D.M.A, T.K., M.M., and D.M. conceived and designed the study; K.N., D.M.A, T.K., M.M., and D.M. supervised the study; A.D.N., and F.C.G. wrote the first draft; F.C.G, A.B.W, B.S.M, F.M.M., C.M.S., P.B.M., and L.M.M. acquired the data; A.D.N. analyzed the data and prepared the figures; A.D.N and F.C.G interpreted the data; All the authors reviewed the manuscript;

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Data availability

The datasets used and/or analyzed for the current study are publicly available as supplementary information file (Supplement 1).

Declarations

Ethics approval and consent to participate

Ethical clearance was secured from the Institutional Review Board (IRB) at the Catholic University of Bukavu (U.C.B) (Ref. N* UCB/CIES/NC/020/2021). The requirement for the informed consent was waived by the IRB at the UCB due the retrospective design of the study. The gathered data was treated with confidentiality, and access was limited to the research team. Additionally, any details allowing for the identification of participant were removed, and the authors were barred from accessing such information.

Consent for publication

Not applicable. The requirement for the consent for publication was waived by the IRB at the UCB due the retrospective design of the study.

Competing interests

The authors declare no competing interests.

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