College of Medicine and Health Sciences

School of Medicine and Pharmacy

Assessing Barriers to Practice and Training in Minimally Invasive Surgery: Towards Surgical and Perioperative Care System Strengthening in Rwanda

Thesis submitted in fulfillment of the requirements for the Doctorate Degree in Medical Sciences

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March 2025

DECLARATION

THE RESEARCHER:

I hereby declare that this thesis "Assessing barriers to practice and training in minimally invasive surgery: Towards surgical and perioperative care system strengthening in Rwanda" is my own work and has not been submitted by anyone to any other University for the award of a degree.

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Date: 30th January 2025
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I hereby declare that this dissertation: "Assessing barriers to practice and training in minimally invasive surgery: Towards surgical and perioperative care system strengthening in Rwanda" was submitted by Dr Martin W. Nyundo with my approval.

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I hereby declare that this dissertation: "Assessing barriers to practice and training in minimally invasive surgery: Towards surgical and perioperative care system strengthening in Rwanda" was submitted by Dr Martin W. Nyundo with my approval.

Signed:
Date: 30th January 2025
Prof Julien K. Gashegu

« Intelligence is the ability to adapt to change » […]

«We are very, very small, but we are profoundly capable of very, very big things... »

Stephen Hawking

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DEDICATION

To Leatitia Nyirazinyoye, my wife, the mother of our children, and the love of my life. Your unwavering support and love have been my guiding light throughout this journey,

To my children, the true source of my joy, happiness, and purpose in life. You are my motivation, and everything I do is for you. May this thesis work inspire you, as you pursue your own path of knowledge and contribution to humanity through research and learning,

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LIST OF ABBREVIATIONS

3D: Three-dimensional

ACS: American College of Surgeons

AR: Augmented Reality

ARES: Académie de Recherche et d'Enseignement Supérieur

BT: Box Trainers

CAGS: Canadian Association of General Surgeons

CAP: Connaissances, Attitudes et Pratiques

CHU: Centre Hospitalier Universitaire

CHUK: Centre Hospitalier Universitaire de Kigali

CMHS: College of Medicine and Health Sciences

CME: Continuing Medical Education

CO2: Carbon Dioxide

COHSASA: Council for Health Service Accreditation of Southern Africa

COSECSA: College of Surgeons of East, Central and Southern Africa

CREDEC: Centre de Recherches et d'Enseignement du Département de Chirurgie

CT: Computed Tomography

CTMC: Continuous-Time Markov Chains

EAES: European Association for Endoscopic Surgery

ERAS: Enhanced Recovery After Surgery

ETCL: Endoscopic Training Center Liège

FLS: Fundamentals of Laparoscopic Surgery

GRACE: Groupement Francophone de Réhabilitation Améliorée après Chirurgie

HE: His Excellency

HICs: High-Income Countries

ICU: Intensive Care Unit

IRB: Institutional Review Board

IRCAD: Institut de Recherche contre les Cancers de l'Appareil Digestif

ISMIVS: International Society of Minimally Invasive and Virtual Surgery

IQR: Interquartile range

J&J: Johnson & Johnson

JSES: Japan Society for Endoscopic Surgery

KAP: Knowledge, Attitudes, and Practices

KFH: King Faisal Hospital

KSERS: Korean Society of Endo-Laparoscopic & Robotic Surgery

LLR: Laparoscopic Liver Resections

LMICs: Low- and Middle-Income Countries

MIS: Minimally Invasive Surgery

NGOs: Non-Governmental Organizations

NIHR: National Institute for Health and Care Research

NPO: Nil per Os

OSATS: Objective Structured Assessment of Technical Skill

PRFI: Pays à Revenu Faible et Intermédiaire

RAAC: Récupération Améliorée Après Chirurgie

RCPSC: Royal College of Physicians and Surgeons of Canada

RMH: Rwanda Military Hospital

SAGES: Society of American Gastrointestinal and Endoscopic Surgeons

SBT: Simulation-Based Training

ULB: Université Libre de Bruxelles

ULg: Université de Liège

UR: University of Rwanda

USA: United States of America

VR: Virtual Reality

WALS: World Association of Laparoscopic Surgeons

WHO: World Health Organization

WLH: World Laparoscopy Hospital

RÉSUMÉ DE THÈSE

Contexte : La chirurgie laparoscopique, largement pratiquée dans les pays développés, reste sous-utilisée dans les pays à revenu faible et intermédiaire (PRFI), en particulier en Afrique subsaharienne, en raison de contraintes de ressources, du manque de personnel qualifié et de limitations financières. L'intégration de la chirurgie laparoscopique aux protocoles de Récupération Améliorée Après Chirurgie (RAAC/ERAS) peut améliorer considérablement les résultats chirurgicaux. Cependant, les obstacles à leur mise en œuvre dans des contextes à ressources limitées, comme le Rwanda, nécessitent une étude approfondie.

Problématique : Malgré leurs bénéfices prouvés, la chirurgie laparoscopique et les protocoles ERAS restent sous-utilisés au Rwanda en raison d'un accès limité aux ressources, d'une formation insuffisante et de lacunes importantes dans les connaissances des professionnels de santé. De plus, l'adaptation et la mise en œuvre réussie d'ERAS dans le contexte local restent inexplorées. Cette étude vise à identifier ces obstacles et à proposer des solutions pratiques pour renforcer la formation, l'allocation des ressources et l'intégration de la chirurgie laparoscopique et d'ERAS dans le système de santé rwandais.

Objectifs de la recherche : Cette recherche explore les défis liés à la mise en œuvre de la chirurgie laparoscopique et d'ERAS au Rwanda, en mettant l'accent sur l'amélioration de la formation et de la pratique en chirurgie mini-invasive. L'étude vise à évaluer les principaux obstacles, à proposer des stratégies pour renforcer les soins chirurgicaux et péri opératoires, et à améliorer les résultats des patients.

Méthodologie : Une approche en plusieurs phases a été menée à travers cinq études :
1. Études 1 & 2 : Enquêtes multicentriques transversales évaluant les obstacles à la chirurgie laparoscopique et à la formation dans les hôpitaux accrédités par le COSECSA.
2. Étude 3 : Étude rétrospective transversale évaluant les résultats cliniques de la cholécystectomie laparoscopique au CHUK.
3. Études 4 & 5 : Études en plusieurs phases portant sur l'adaptation et la mise en œuvre d'ERAS au CHUK. Une évaluation des Connaissances, Attitudes et Pratiques (CAP) a été

menée auprès des prestataires de soins péri opératoires. De plus, un essai clinique prospectif non randomisé a comparé les résultats des patients avant et après la mise en place du protocole ERAS.

Résultats :

Étude 1 : A révélé d'importantes limitations en ressources, avec seulement deux tours laparoscopiques, trois chirurgiens formés et une moyenne de 10 interventions laparoscopiques par an et par hôpital, principalement des cholécystectomies. Les recommandations incluaient des programmes de formation adaptés, l'acquisition d'équipements et des initiatives de sensibilisation du public.

Étude 2 : A mis en évidence des lacunes dans la formation des hôpitaux accrédités par le COSECSA, notamment l'absence de laboratoires de simulation et de programmes structurés. L'intégration de la formation laparoscopique dans les cursus avec un apprentissage basé sur la simulation a été recommandée.

Étude 3 : A évalué 288 cholécystectomies laparoscopiques réalisées au CHUK (2015–2020), révélant une durée moyenne d'hospitalisation de trois jours, un taux de complications de 1,7 % et un taux de mortalité de 0,7 %. La satisfaction des patients dépassait 95 %, mais des défis persistaient, notamment un manque de formation et une sensibilisation insuffisante du public.

Étude 4 : L'évaluation CAP a révélé d'importantes lacunes dans la connaissance des principes ERAS, notamment l'analgésie multimodale et l'alimentation précoce. Bien que 97,7 % des participants soutenaient ERAS, son application restait incohérente. Des sessions de formation ont été organisées et un protocole ERAS adapté localement a été développé.

Étude 5 : Une étude pilote a montré que l'ERAS a réduit la durée d'hospitalisation après cholécystectomie laparoscopique de trois jours à un et a diminué les complications postopératoires, soulignant la nécessité d'une formation continue et d'une adaptation locale.

Conclusion: Cette recherche met en évidence les principaux obstacles à la chirurgie laparoscopique et à la mise en œuvre d'ERAS dans les hôpitaux accrédités par le COSECSA, notamment les contraintes de ressources, les lacunes en formation et les insuffisances dans les connaissances et un engagement institutionnel insuffisant. Malgré ces défis, des

programmes de formation ciblés, l'amélioration des infrastructures et une éducation continue pourraient favoriser leur adoption. Le Rwanda a démontré son engagement dans l'implémentation de la chirurgie laparoscopique avec des résultats satisfaisants malgré des moyens limités. Plus récemment, l'introduction et la mise en œuvre du protocole ERAS ont été couronnées de succès, avec de bons résultats.

Un protocole ERAS adapté localement, combiné à un renforcement de la formation en chirurgie laparoscopique et à un soutien institutionnel accru, pourrait significativement améliorer la prise en charge péri opératoire au Rwanda et servir de modèle pour d'autres PRFI.

THESIS SUMMARY

Background: Laparoscopic surgery, widely practiced in developed countries, remains underutilized in low- and middle-income countries (LMICs), especially in Sub-Saharan Africa, due to resource limitations, lack of trained personnel, and financial constraints. Integrating laparoscopic surgery with Enhanced Recovery After Surgery (ERAS) protocols can significantly improve surgical outcomes. However, barriers to their implementation in resource-limited settings like Rwanda require further investigation.

Problem statement: Despite its proven benefits, laparoscopic surgery and ERAS protocols remain underutilized in Rwanda due to limited resources, inadequate training, and significant knowledge gaps among healthcare providers. Additionally, the adaptation and successful implementation of ERAS in local settings remain unexplored. This study aims to identify these barriers and propose practical solutions to enhance training, resource allocation, and the integration of laparoscopic surgery and ERAS into Rwanda's healthcare system.

Research aims: This research explores challenges in laparoscopic surgery and ERAS implementation in Rwanda, focusing on improving training and practice in minimally invasive surgery (MIS). The study aims to assess key barriers, propose strategies for strengthening surgical and perioperative care, and enhance patient outcomes.

Methods: A multi-phase approach was conducted through five studies:

1. Study 1 & Study 2: Cross-sectional multi-country surveys assessing barriers to laparoscopic surgery and training in COSECSA-accredited hospitals.
2. Study 3: Retrospective cross-sectional study evaluating clinical outcomes of laparoscopic cholecystectomy at CHUK.
3. Study 4 & Study 5: Multi-phase studies adapting and implementing ERAS at CHUK. A Knowledge, Attitudes, and Practices (KAP) assessment was conducted among perioperative healthcare providers. Additionally, a prospective non-randomized clinical trial compared patient outcomes before and during ERAS implementation

Results: Study 1: Found significant resource limitations, including only two laparoscopic towers, three trained surgeons, and an average of 10 laparoscopic procedures annually per hospital, mostly cholecystectomies. The study recommended tailored training programs, equipment acquisition, and public awareness initiatives.
Study 2: Identified training deficiencies in COSECSA-accredited hospitals, including lack of simulation labs and structured programs. It recommended integrating laparoscopic training into curricula with simulation-based learning.
Study 3: Evaluated 288 laparoscopic cholecystectomies at CHUK (2015–2020), showing a three-day hospital stay, a 1.7% complication rate, and a 0.7% mortality rate. Patient satisfaction was over 95%, but challenges included limited training and low public awareness.
Study 4: KAP study revealed knowledge gaps among healthcare providers in ERAS principles like multimodal analgesia and early feeding. Although 97.7% supported ERAS, its application was inconsistent. Training sessions and a locally adapted ERAS protocol were developed.
Study 5: A pilot study showed ERAS reduced hospital stays for laparoscopic cholecystectomy from three days to one and decreased adverse events, reinforcing the need for continuous education and local adaptation.

Conclusion: This research highlights the main challenges hindering the adoption of laparoscopic surgery and the implementation of ERAS in COSECSA-accredited hospitals, including resource constraints, training gaps, limited knowledge, and insufficient institutional involvement. Despite these challenges, targeted training programs, infrastructure improvements, and continuous education could facilitate their adoption.
Rwanda has demonstrated its commitment to implementing laparoscopic surgery with satisfactory results despite limited resources. More recently, the introduction and successful implementation of the ERAS protocol have yielded positive outcomes.

A locally adapted ERAS protocol, combined with strengthened laparoscopic surgery training and greater institutional support, could significantly improve perioperative care in Rwanda and serve as a model for other low-resource countries.

CHAPTER I. INTRODUCTION

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1.1. BACKGROUND

Minimally invasive surgery (MIS), often referred to as laparoscopic surgery, has fundamentally transformed the field of medicine, evolving from its origins as a diagnostic tool nearly a century ago into a cornerstone of modern surgical practice. The procedure's roots can be traced back to the early 20th century when Georg Kelling first demonstrated the principles of abdominal endoscopy in animals, and Hans Christian Jacobaeus performed the first human laparoscopy (1).

The evolution of laparoscopy, particularly from the 1960s to the 1980s, marked a critical period of development. During this time, the technique transitioned from a diagnostic procedure to a fully-fledged surgical approach. Key figures such as Raoul Palmer, Kurt Semm, and other were instrumental in driving this shift, despite initial resistance from the surgical community (2,3). Their pioneering work established laparoscopy as the preferred method for a wide range of conditions, including those in gynecology, where it quickly became the standard for both benign and malignant cases.

Today, laparoscopy is an integral part of surgical practice across numerous specialties, with advancements continuing to emerge. The procedure has paved the way for innovations like robot-assisted surgery, and the future promises even more integration of technologies such as artificial intelligence and augmented reality.

The first laparoscopic appendectomy was performed by Semm on 13 September 1980 at the department of obstetrics and gynecology of the University of Kiel. It was an absolute rarity and an international sensation at the time. As a gynecologist and trained toolmaker, Semm revolutionized the course of traditional surgery (4). However, he aroused the criticism of many of his colleagues in gynecology and surgery. In his words, the medical world at the time reacted with the most violent hostility and opposition he had experienced during his entire career: “Both surgeons and gynecologists were angry with me, they virtually stoned me. All my initial attempts to publish a report on laparoscopic appendectomy were rejected with the comment that such non-sense does not, and will never, belong in general surgery.” Thus, his first report on laparoscopic appendectomy was published no earlier than 1983 (4). Liselotte Mettler recalled in an interview that Kurt Semm was forcibly taken from surgery by government authorities and subjected to

a brain CT scan to prove his mental fitness. This extreme action was a result of the widespread skepticism and resistance he encountered due to his groundbreaking work in laparoscopic surgery (https://www.hindustantimes.com/).

In the following decades, the field of laparoscopic surgery has seen significant advancements, moving from basic procedures to highly sophisticated surgeries performed through minimal access points (5). This revolution has not only reduced the physical trauma associated with surgery but also significantly improved clinical outcomes, including reduced postoperative pain, lower rates of infection, and quicker recovery times (6,7). Despite its widespread success in high-income countries (HICs), the adoption of laparoscopic surgery in low and middle-income countries (LMICs), including in Rwanda remains limited.

MIS represents a transformative shift in surgical practice worldwide, with laparoscopic techniques now widely recognized for their potential to improve patient outcomes while reducing healthcare costs. MIS primary advantages have made it the preferred standard for a growing array of procedures (6,8). However, the implementation of MIS remains limited in LMICs due to various systemic, financial, and infrastructural barriers (9) .

1.2. PROBLEM STATEMENT

Laparoscopic surgery, a groundbreaking advancement in surgical practice, is now considered the gold standard in HICs due to its multiple benefits, such as reduced postoperative pain, decreased risk of wound infections, and quicker recovery (5,10,11). These procedures demand that surgeons develop new skills, including enhanced hand-eye coordination, safe handling of endoscopic instruments.

However, despite these advantages and its extensive adoption in developed countries, the use of MIS in LMICs, including Sub-Saharan Africa and Rwanda, remains limited. Barriers such as insufficient training programs, inadequate resources, poor quality assurance, and challenges in assessing surgical competence hinder the growth of MIS in these regions (5–8). Additionally, the lack of data in Rwanda on the training, practice, and safety of laparoscopic procedures underscores an urgent need for studies that offer practical insights and solutions, echoing similar observations made for other LMICs (10).

1.3. RESEARCH QUESTIONS

1. What are the current practices and clinical outcomes of Minimally Invasive Surgery (MIS) in the College of Surgeons of East, Central and Southern Africa (COSECSA) region?
2. What are the current trends and challenges in the training of MIS within the COSECSA region?
3. What strategies can be implemented to improve the practice, training, and clinical outcomes of MIS in the COSECSA region?

1.4. OBJECTIVES

1.4.1. Aim

The research aims to assess MIS practice, training trends, and outcomes in the COSECSA region, identify challenges, and propose strategies for improvement, including the impact of the Enhanced Recovery After Surgery (ERAS) pathway in Rwanda.

1.4.2. Specific Objectives

The specific objectives of this research are:
1. To assess the current practice of MIS in the COSECSA region and its outcomes, with a particular focus on a Rwandan Teaching Hospital.
2.To evaluate the trends in MIS training within the COSECSA region.
3. To implement a quality improvement program to enhance perioperative care in MIS in Rwanda

1.5. STUDY JUSTIFICATION

MIS has significantly improved surgical care by reducing complications, shortening hospital stays, and enhancing recovery. Despite these advantages, its integration into healthcare systems in the COSECSA region remains underexplored, with limited data on its practice, training, and outcomes. Additionally, while the ERAS pathway has demonstrated benefits in optimizing perioperative care, its implementation within MIS in this region has not been systematically evaluated.

This thesis provides a comprehensive analysis of MIS and ERAS in resource-limited settings, offering valuable insights into their current state and practical implications. By generating empirical evidence on MIS practice and perioperative management, it contributes to the development of structured approaches that can support the expansion of MIS across COSECSA-affiliated hospitals. Furthermore, the evaluation of ERAS in laparoscopic surgery highlights its role in improving surgical efficiency, reducing hospital stays, and enhancing patient outcomes.

Contribution to the Healthcare System

This research strengthens the foundation for MIS development in sub-Saharan Africa by:
Documenting MIS practices and patient outcomes, demonstrating its feasibility and safety in the COSECSA region. Providing data-driven recommendations for improving MIS training, including the role of structured programs and simulation-based learning.
Showcasing the impact of ERAS on perioperative care, offering a model for optimizing surgical pathways in resource-limited settings.
Encouraging institutional engagement in MIS expansion, emphasizing the importance of multidisciplinary collaboration in advancing surgical care.

Through these contributions, this thesis supports evidence-based decision-making for the advancement of MIS in LMICs. Rwanda's successful integration of ERAS and laparoscopic surgery serves as a practical example for other countries in the region, demonstrating the potential for scalable, context-specific surgical innovations.

CHAPTER II. LITERATURE REVIEW

CHAPTER II. LITERATURE REVIEW

2.1. Practice and outcomes in Minimally Invasive surgery

2.1.1. Status of minimally invasive surgery practice in High-Income Countries

In HICs, MIS has evolved into the standard of care for various procedures, including advanced operations (6,8). Routine procedures like laparoscopic cholecystectomy and appendectomy are highly successful, while more complex surgeries such as laparoscopic colectomies, hepatectomies, pancreatectomies, and bariatric procedures have also gained widespread acceptance (12).

1. Laparoscopic colectomies

Laparoscopic surgery has become the preferred approach for many colorectal surgeries in HICs due to its substantial benefits. Studies demonstrate that laparoscopic colectomy is associated with shorter hospital stays, less postoperative pain, and lower infection rates compared to open colectomy. For instance, in the United States of America (USA), about 50-60% of elective colorectal surgeries are now performed laparoscopically. Studies showed that patients who underwent laparoscopic colectomy experienced a 30-40% reduction in postoperative complications and the length of hospital stay was significantly shorter and were discharged approximately 2-3 days earlier than those undergoing open procedures (6,13).

In recent years, laparoscopic colectomy has become the preferred surgical approach for many colorectal surgeries across Europe. Reports indicate that approximately 60-80% of elective colorectal resections are performed laparoscopically in several European countries (14,15).

Furthermore, multicenter studies across Europe have shown that laparoscopic colectomy is linked to lower rates of morbidity and mortality, further encouraging its adoption among surgical teams (16,17).

2. Laparoscopic hepatectomies

Once limited to open surgery, hepatectomies are now commonly handled laparoscopically in specialized centers. European centers report that laparoscopic liver resections (LLR) are safe and yield outcomes comparable to open hepatectomies for selected cases. Studies reveal that for smaller, peripheral liver tumors, laparoscopic hepatectomy is associated with reduced blood loss, shorter operative times, and hospital stays shortened by 2-4 days compared to open procedures. Mortality rates for laparoscopic hepatectomy in HICs are now less than 1% for minor resections, marking a significant improvement over previous rates when these surgeries carried higher risks (12,18) and LLR is a favorable alternative to open surgery due to shorter hospital stays and faster recovery time without compromising oncological outcomes (19–21).

3. *Laparoscopic pancreatectomy*

Laparoscopic pancreatectomies are technically challenging but increasingly performed for benign and malignant pancreatic conditions. Recent data from specialized centers in the USA show that laparoscopic distal pancreatectomy offers advantages such as shorter hospital stays by 3-5 days, reduced need for postoperative opioids, and lower readmission rates compared to open surgery. A meta-analysis of North American and European studies found that laparoscopic approaches lowered perioperative complications by 20-30% without increasing mortality. However, adoption remains lower than other procedures, around 20-30%, due to technical demands and advanced training requirements.

The success of MIS in HICs has been driven by advanced surgical technologies, including high-definition imaging systems, energy devices, and sophisticated instruments that enhance precision. Additionally, specialized training pathways ensure that surgeons master these techniques, which continually evolve to integrate the latest innovations (22,23). The availability of specialized facilities and experienced surgical teams has made MIS the preferred method for complex resections, such as in colorectal, bariatric, and hepatobiliary surgeries, yielding significant improvements in patient satisfaction and overall surgical outcomes.

2.2.2. Minimally invasive surgery practice in Low- and Middle-Income Countries

In LMICs, the gradual adoption of MIS presents unique opportunities for healthcare advancement, given its advantages in reducing postoperative complications and improving recovery times. With healthcare systems often constrained by limited resources, MIS can support higher patient turnover, reduce infection rates, and lower costs by shortening hospital stays (9,24–27).

While basic MIS procedures, such as laparoscopic cholecystectomy, are increasingly being adopted, more complex surgeries remain less common. However, initial successes with basic MIS procedures highlight the potential for MIS to transform surgical care in LMICs. Awareness of MIS benefits is increasing, with many hospitals initiating laparoscopic programs through international partnerships and remote mentoring by experienced surgeons (9,24,28).

In resource-constrained settings, MIS can support a more efficient use of healthcare resources. For example, the shorter hospital stays associated with laparoscopic surgery can alleviate bed capacity challenges in high-demand hospitals. Some LMICs have maximized efficiency by sharing surgical equipment and implementing innovative training models. These advantages make MIS particularly valuable in LMICs, where there is high demand for surgical services, limited bed availability, and a pressing need for cost-effective solutions (8,9).

While MIS is essential to HIC surgical practice, offering substantial benefits across a wide range of procedures, its adoption in LMICs is still in its early stages. The potential for MIS to transform surgical care in these settings is clear, particularly with basic procedures that deliver clear clinical benefits. Continued investment in MIS training and equipment could enable broader use in LMICs, offering access to safer, more efficient surgeries that meet the growing demand for healthcare services. By supporting MIS in LMICs, healthcare systems can improve patient outcomes and quality of care, though sustainable progress requires ongoing support and innovation.

2.3. Status of the training in Minimally Invasive Surgery

Laparoscopic surgery, as a subset of MIS, has become integral to modern surgical practice. However, mastering laparoscopic procedures is challenging, as it requires high technical skill, specialized equipment, and extensive training for safety and proficiency. Globally, training methodologies vary, but many organizations aim to standardize and improve these educational tools (29).

The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) has made significant contributions to this area. SAGES has developed comprehensive training programs in MIS with a focus on safe and effective laparoscopic surgery. Their goal is to integrate advanced laparoscopic techniques into surgical residency programs, ideally within the operating room under faculty supervision (29). Organizations such as SAGES have been instrumental in shaping training frameworks and defining the core competencies for laparoscopic surgery, ensuring these procedures are executed with patient safety as a priority (30).

Additionally, the European Association for Endoscopic Surgery (EAES) and the American College of Surgeons (ACS) have contributed significantly to the development of curriculum guidelines that outline essential skills, simulation standards, and recommended training paths for laparoscopic surgery.

2.3.1. Training tools and methods for laparoscopic surgery

Training in laparoscopic surgery incorporates a variety of tools and methods, each aimed at equipping surgeons with the skills necessary for minimally invasive procedures. These approaches are generally divided into theoretical, simulation-based, and practical methods, all working together to build competence.

Theorical training

Theoretical education forms the foundation of laparoscopic training, covering anatomy, procedural steps, equipment, and safety protocols. Advances in online platforms and digital libraries have expanded access to surgical education globally, allowing trainees to learn through video demonstrations, interactive modules, and expert discussions, thus bridging geographical gaps (31).

Simulation-Based Training

Simulation-Based Training **(**SBT) is crucial for skill development, offering surgeons a controlled, risk-free environment. The following simulators play unique roles in enhancing laparoscopic skills:

1. Box trainers or Pelvic trainers

Box simulators allow trainees to practice using real instruments on synthetic models. Although limited in providing tactile feedback, box trainers are effective in developing hand-eye coordination and motor skills essential for laparoscopic surgery. Studies demonstrate that box trainers contribute significantly to building core skills and familiarizing trainees with laparoscopic instruments (32–34).

2. High-Fidelity Simulators

High-fidelity simulators provide a realistic experience, that involves the use of sophisticated real-life manikins, virtual reality patients, or simulated patient actors in realistic patient environments. This realism is essential for building fine motor skills like depth perception and force control, which are critical in laparoscopic procedures (29).

3. Virtual Reality (VR) Simulators

VR simulators provide an immersive, computer-generated 3D environment, enabling trainees to perform procedures with specialized equipment like VR headsets and hand controllers (35). VR simulation adapts to various scenarios, with increased complexity as the trainee's skill level progresses, effectively supporting spatial and cognitive skill-building (36–40) show that VR-based simulators improve accuracy, reduce errors, and enhance learning efficiency. Compared to video-based methods, VR training also offers improved skill enhancement, realism, and haptic feedback (32).

4. Augmented Reality (AR)

AR overlays educational content onto live or simulated scenarios, enhancing procedural knowledge and technical skill acquisition. Research indicates that AR can improve spatial orientation and decision-making in laparoscopic surgery (41).

Hands-on training

1. Wet labs

Animal models

Both cadaveric and live animal models, offer a realistic simulation of tissue handling and surgical environments. Training on these models provides a high-fidelity experience of the anatomy and physiology of the specific animal model, making them valuable for practicing advanced techniques and managing complex surgical situations. However, ethical concerns, high costs, and logistical limitations restrict their widespread use in training programs (42,43). In Rwanda, the adoption of this model was introduced thanks to the establishment of the Institut de Recherche contre les Cancers de l'Appareil Digestif (IRCAD) Africa in Kigali, where live pigs are utilized in a dedicated wet lab to teach advanced laparoscopic techniques (Figure1).

Figure 1. IRCAD Africa, simulation wet lab, advanced laparoscopic general surgery course using pigs

Human cadaver models

Human cadavers provide the closest approximation to real surgery, allowing trainees to practice procedures on actual human anatomy. They offer an unmatched level of anatomical accuracy, giving trainees a realistic environment to refine surgical techniques on human tissue. Although cadaveric training is highly effective, it comes with high costs, requires specialized facilities, and is limited by cadaver availability (42). At the University of Liège, this method is employed to introduce surgical residents to laparoscopic techniques during intensive one-day courses (Figure 2).

Figure 2. Endoscopic Training Center Liege (ETCL) fully equipped to simultaneously offer laparoscopic training opportunities on 6 cadavers at the Department of Human Anatomy of the University of Liege

2. Mentorship, apprenticeship and clinical immersion

Clinical immersion allows trainees to work alongside experienced surgeons in the operating room, progressively taking on more responsibility as their skills develop. This hands-on approach fosters growth by providing real-world experience and direct mentorship.

Structured training programs

Structured training programs are the backbone of laparoscopic surgery education, tailored for different levels of experience. These programs systematically develop laparoscopic skills across medical education stages.

Residency programs

Laparoscopic surgery is increasingly incorporated into residency training, with rotations designed to cover both fundamental and advanced techniques.

Fellowship programs

Fellowships in minimally invasive surgery provide specialized post-residency training focused on complex laparoscopic procedures, equipping surgeons with advanced expertise in specific areas.

Workshops and Boot camps

Short-term programs, such as workshops and boot camps, provide targeted, intensive training to quickly enhance surgeon skills in specific techniques (29).

Assessment and Feedback

Effective assessment tools and continuous feedback mechanisms are vital to ensure proficiency in laparoscopic surgery.

Objective structured assessment of technical skill (OSATS)

This standardized evaluation tool assesses a surgeon's skills objectively, ensuring that trainees meet competency thresholds before performing unsupervised procedures (29,44).

Performance metrics and peer review

Data from simulation and real surgeries are used for feedback, allowing for continual skill refinement and fostering a collaborative learning. Ongoing feedback from peers and senior surgeons fosters skill refinement and lifelong learning (45)

Continuous education and practice

Continuous education is essential for maintaining proficiency in minimally invasive surgery techniques.

Continuing Medical Education (CME)

CME programs help surgeons stay updated with advancements in laparoscopic surgery.

Lifelong learning and practice

Surgeons are encouraged to continually practice and refine their skills to ensure sustained excellence. Regular participation in CME, workshops, and seminars keeps surgeons updated with the latest advancements and techniques, fostering lifelong learning and improvement.

Modern technological aids in surgical training

The integration of modern technology into surgical training has revolutionized the way surgeons learn and practice laparoscopic techniques. Emerging technologies have expanded training opportunities, allowing real-time, interactive learning experiences:

Tele-mentoring and Tele-surgery

These technologies allow remote supervision and guidance, broadening access to expert mentorship even in resource-limited settings (46).

Online platforms and digital libraries

These resources support independent learning, offering extensive libraries of surgical videos, case studies, and interactive training modules that broaden educational reach.

In summary, the combination of theoretical knowledge, high-fidelity simulators and VR provides a comprehensive approach to laparoscopic training. VR simulators excel in enhancing spatial and cognitive skills, while high-fidelity models offer the necessary tactile experience for motor skill mastery. Box trainers, hands-on training in wet labs with animal models and human cadavers play vital roles in developing foundational skills essential for laparoscopic procedures. Continuous tracking of progress through stochastic modeling, like Continuous-Time Markov Chains (CTMC), adds an objective framework for monitoring and providing feedback in real time. Together, these methods support a structured and effective learning curve, enabling surgeons to achieve proficiency across cognitive, spatial, and tactile domains essential for MIS procedures.

2.3.2. The learning curve for laparoscopic surgery

Mastering laparoscopic surgery, like all surgical disciplines, requires understanding fundamental surgical principles, including the advantages and limitations of open versus minimally invasive approaches (30). The learning curve for laparoscopic surgery is notably steep and varies among surgeons and procedures. This curve represents the rapid skill acquisition phase until errors are minimized and proficiency reaches a stable level. In a comprehensive review of 272 studies, Ramsay et al. examined the learning curve for laparoscopic surgery, finding that while existing data on learning curves are somewhat

limited, metrics such as the number of procedures performed, along with learning duration and rate, are valuable in assessing skill development (8,44).

To accurately develop learning curves, it is essential to select appropriate independent (predictor) and dependent (response) variables. In 2009 Feldman et al. (47) introduced the concepts of the learning plateau (intercept) and learning rate (slope), suggesting that skill progression often follows an S-curve pattern, represented as a sigmoid function. This curve typically reflects three phases: an initial rapid improvement phase, followed by a slower growth period as skills mature, and finally reaching a plateau as mastery is achieved. Such a model helps in measuring progress and identifying specific points where additional training or resources might enhance skill acquisition. This steady improvement in skill acquisition was also explored by Bosse et al. 2015, (48) who provided both high- and low-frequency feedback. Conversely, Khan et al. 2014 investigated procedural factors, such as experience and level of supervision, in modeling learning curves through logistic regression. Additional studies, such as those by Subramonian and Muir and Suguita et al., analyzed factors like technique and average operating time to further understand learning progressions in surgery.

A significant innovation in understanding and enhancing the learning curve is stochastic modeling, particularly through CTMC. CTMC has been proposed as a robust method for assessing trainee progression in VR training environments. This approach allows for continuous evaluation of a trainee's development by providing real-time feedback derived from CTMC-based data. By comparing outcomes from real-world scenarios with VR simulations, researchers have validated VR simulators as effective tools for laparoscopic training. These findings contribute to the establishment of evidence-based learning models that deliver systematic and continuous feedback throughout the training process, enhancing skill acquisition and learning retention (38,49)

Time factors also play an essential role in learning curve analysis. Brunckhorst et al. 2015 explored the influence of time in VR-based training, while Howells et al. 2009 examined how a delay (e.g., six months between training sessions) affects skill retention, concluding that repeated exposure, even with gaps, improves proficiency. Additionally, Uribe et al. 2004 observed a steeper learning curve in novice trainees, while Leijte et al. 2020 found a delay in performance improvements in MIS compared to robot-assisted procedures.

Another important consideration for developing learning curves involves grouping trainees by expertise. In 2016 Papachristofi et al. demonstrated that prior experience

affects learning curves, while Hardon et al. in 2021 assessed expertise through metrics like force and motion. Research by Grantcharov et al. (39) suggested that adjusting curve parameters alone is insufficient to capture differences in trainer proficiency, underscoring the need for distinct learning curve kernels. A comprehensive review by Chan et al. 2021 summarized learning curve modeling in surgical training, noting that individual differences among trainees pose a challenge in generalization. Furthermore, when analyzing multiple response variables, such as completion time and accuracy, separate learning curves for each variable may be necessary to provide an accurate assessment of trainee progression.

In conclusion, the best approach for developing learning curves in laparoscopic surgery integrates a combination of real-world practice, VR simulation, and continuous evaluation through advanced models like CTMC. Simulation tools, particularly VR, offer a valuable, controlled environment that supports skill acquisition through immediate, real-time feedback. Stochastic modeling with CTMC enhances these benefits by enabling ongoing assessment of trainee progress, providing data-driven insights to guide individualized feedback. Selecting relevant metrics, such as procedure frequency, completion time, and skill accuracy, is crucial for accurately modeling progress, especially when tailored to the trainee expertise level. Time-based and expertise-adapted strategies, coupled with both high- and low-frequency feedback, further support proficiency, making this combined approach one of the most effective for surgical skill development.

2.3.3. Current landscape of minimally invasive surgery training in High-Income Countries

Training in MIS within HICs is characterized by advanced programs integrating simulation, hands-on practice, and structured curricula that allow for skill mastery at various stages of surgical education. Below is an in-depth overview of the approaches taken in the USA, Canada, and Europe, with a focus on the pioneering role of IRCAD in France, alongside insights into other university and hospital-based units in Europe that significantly contribute to laparoscopic training.

United States of America

In the USA, laparoscopic surgery training is integrated into general surgical residency programs and is supplemented by fellowships for advanced training. The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) has been instrumental in developing standardized training protocols, including the Fundamentals of Laparoscopic Surgery (FLS) program (30,50), which was made a prerequisite for board certification by the American Board of Surgery in 2009. Preparing for and passing the FLS exam has been shown to improve general surgery residents' operative performance and autonomy MIS training programs emphasize hands-on experience through various modalities, including simulation centers and wet labs, which are essential for all surgical residents and fellows. This comprehensive setup prepares trainees to handle the varied challenges of real-world surgical procedures, allowing them to develop mastery in laparoscopic techniques.

Canada

In Canada, laparoscopic training is regulated by the Royal College of Physicians and Surgeons of Canada (RCPSC), which, in collaboration with SAGES, has established the FLS as a national standard. Recently, the Canadian Association of General Surgeons (CAGS) has endorsed the FLS program, highlighting its importance in surgical education (available at https://www.flsprogram.org/news/the-canadian-association-of-general-surgeons-has-endorsed-the-fls-program/). Training centers across the country focus on providing high-quality educational environments with dry labs, cadaver labs, and simulation-based assessments to ensure that trainees gain both foundational skills and advanced techniques. This comprehensive setup prepares Canadian surgeons for the varied challenges of real-world surgical procedures, particularly in minimally invasive techniques.

Europe

In Europe, laparoscopic training varies by country but follows overarching guidelines set by the European Association for Endoscopic Surgery (EAES)(website: https://eaes.eu). Training programs typically include standardized residency training, fellowships, and specialized courses supported by simulation facilities, cadaver labs, and hands-on

opportunities. Among European centers, the IRCAD in France has become a model for its comprehensive, technology-driven approach to MIS training, serving as a benchmark for other institutions.

1. IRCAD, Strasbourg, France

IRCAD in Strasbourg is globally recognized for its pioneering role in MIS training. As a leader in surgical education, IRCAD integrates advanced technologies like virtual reality simulators, high-fidelity models, and tele-mentoring systems to deliver comprehensive training.

IRCAD's curriculum ranges from foundational laparoscopic techniques to complex, procedure-specific skills, drawing surgeons from around the world to participate in its structured, hands-on programs. Its facilities include both dry and wet labs, where surgeons can practice on high-quality anatomical models and animal tissues to refine their skills. The cadaver labs provide realistic anatomical experiences, allowing trainees to work in environments like live surgery.

One of IRCAD's unique contributions is its emphasis on remote and digital training, including tele-mentoring, which connects experienced surgeons with trainees globally in real-time. This innovation has extended IRCAD's reach, allowing surgeons from lower-resource settings to access top-tier MIS education and training. IRCAD's influence is further reflected in its establishment of sister centers worldwide, demonstrating its dedication to advancing surgical training on an international scale (avalaible at website: https://www.ircad.fr).

2. Other university-based training units in Europe

Alongside IRCAD, various European universities have developed MIS training units within their teaching hospitals, providing structured educational programs for medical students, residents, and fellows. These units, while not as expansive as IRCAD, contribute to essential practical and theoretical training aligned with EAES standards.

University of Liège, Belgium

The Department of Abdominal Surgery and Transplantation at CHU de Liège has established a longstanding implementation of MIS and ERAS protocols, facilitated by active collaboration between anesthesiology and surgical teams. MIS techniques are

employed for a wide range of procedures, from basic to complex, including esophagectomies, major liver resections, pancreatectomies, and colorectal surgeries. The department is accredited by the GRACE association (Groupement francophone de Réhabilitation Améliorée après Chirurgie - www.grace-asso.fr) for excellence in bariatric and hepatic surgeries.

The University of Liège has developed a comprehensive MIS training program that focuses on both medical students and surgical residents. The Centre Hospitalier Univeristaire (CHU) de Liège, along with the university, hosts a Medical Simulation Center featuring a dedicated MIS training section that includes advanced simulation facilities (Figure 3)

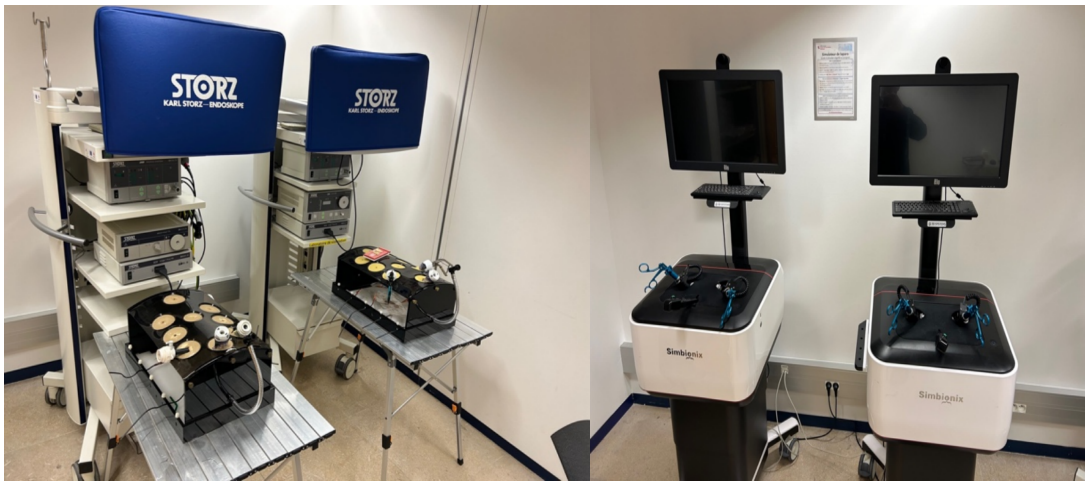

Figure 3. Laparoscopic box trainer connectable to laparoscopic tower (right) and Virtual reality simulator (left) at CHU de Liège, University of Liège

Moreover, the Department of Human Anatomy established the ETCL, equipped to accommodate six cadaveric laparoscopic training stations (Figure 4). The CREDEC (Centre de Recherches et d'Enseignement du Département de Chirurgie) complements these resources, providing research and training facilities for laparoscopy on small and large animal models, including pig models.

Figure 4. Cadaveric laparoscopic lab at the University of Liège, Human anatomy Department

The medical students and the surgical residents are offered the opportunity to be trained on MIS and ERAS throughout their training. The medical students actively participate to laparoscopic procedures and post operative care. Before the start of their residency, the selected young trainees participate to a Bootcamp of 8 active days of both theoretical and practical basic surgical sessions, including on MIS, with dry labs (Figure 5), advanced simulation and cadaveric labs.

During their 6 years of residency, the surgical trainees have free access to the MIS surgical corner of the simulation center, and the opportunity to participate to wet labs sessions regularly organized, with the active help of pharmaceutical companies.

Figure 5. Dry Lab session, basic simulation with Applied (Right) and *advance simulation with Simendo, J&J (Left)*

Asia

In recent years, countries in Asia have made significant strides in enhancing the quality of training in MIS. The integration of advanced technologies, structured curricula, and

simulation-based training has positioned several institutions as leaders in surgical education. Below is a detailed overview of the current training landscape in notable Asian countries.

1. Japan

Japan has been at the forefront of laparoscopic surgery training, with several institutions implementing structured training programs. The Japan Society for Endoscopic Surgery (JSES) has established a certification program for laparoscopic surgeons, emphasizing hands-on training and simulation. For instance, the Nagoya University Hospital offers comprehensive laparoscopic training that includes simulation in dry and wet labs, allowing residents to practice under expert supervision.

2. China

China has made substantial advancements in MIS training, with several leading institutions adopting structured programs. Hospitals like Peking Union Medical College Hospital offer comprehensive curricula that blend simulation labs with clinical exposure, providing trainees with hands-on experience in a controlled environment. However, a unified, standardized MIS training pathway is not yet part of China's national medical education. Consequently, many young surgeons acquire laparoscopic skills primarily through mentorship and clinical practice rather than a structured curriculum.

Two prominent organizations have played essential roles in advancing MIS within China. The Hong Kong Society of Minimally Access Surgery, founded in 1992, has focused on developing and promoting MIS applications throughout Hong Kong and mainland China. Additionally, the International Society of Minimally Invasive and Virtual Surgery (ISMIVS), established in Chongqing in 2013, seeks to accelerate the adoption of MIS techniques, advocating for the integration of innovative technologies and training methods.

3.India

India has established itself as a significant hub for MIS training in Asia, particularly with World Laparoscopy Hospital (WLH) in Gurgaon. Founded in 2001 by Dr. R.K. Mishra, WLH is recognized by both the World Association of Laparoscopic Surgeons (WALS) and the SAGES and is ISO 9001–2008 certified. The hospital offers a wide range of specialized

programs, including fellowships in minimal access and robotic surgery, a diploma in minimal access surgery, and a master's degree through Global Open University, Nagaland. WLH's curriculum includes hands-on courses in assisted reproductive technology, gastrointestinal endoscopy, and arthroscopy, as well as cadaver-based workshops and virtual reality simulations. Over 7,000 surgeons and gynecologists worldwide have completed their training at WLH, highlighting its extensive impact on MIS education in the region (available at: https://www.laparoscopyhospital.com) (51).

4. South Korea

South Korea is a leader in surgical training innovation, particularly in the field of MIS. The Korean Society of Endo-Laparoscopic & Robotic Surgery (KSERS) has developed a comprehensive training system that includes simulation labs, hands-on workshops, and technology-enhanced surgical methods. Yonsei University College of Medicine has been at the forefront of robotic and MIS training, with the Yonsei Da Vinci Training Center offering advanced training in robotic-assisted surgery. Through its partnership with Severance Hospital, Yonsei University has established itself as a prominent center for laparoscopic training, drawing local and international surgeons for advanced MIS education.

In conclusion, laparoscopic surgery training in HICs varies worldwide but commonly includes a mix of theoretical education, simulation-based training, and hands-on experience under supervision. The integration of standardized programs, such as the FLS, and adherence to guidelines set by professional associations like SAGES, EAES, and national surgical boards, play a crucial role in shaping training processes.

2.3.4. Current situation of minimally invasive surgery training in Low- and Middle-Income Countries

The training of MIS in LMICs is progressing, marked by several initiatives aimed at enhancing surgical education and skills development. Despite facing numerous challenges, the landscape reflects a commitment to integrating laparoscopic techniques into surgical practice to improve surgical outcomes and access to care.

Structured training programs and curriculum development

Training programs in LMICs are increasingly adopting structured curricula that emphasize both theoretical knowledge and practical skills in laparoscopic surgery. Organizations such as the SAGES have pioneered frameworks for integrating advanced laparoscopic training into surgical residency programs (30). These frameworks help establish standard practices that ensure residents gain essential laparoscopic skills, ultimately fostering a new generation of surgeons capable of performing these advanced procedures (42).

Innovative training approaches

Practical training tools, particularly low-cost simulators, are vital for skill development in LMICs. For example, the use of manual laparoscopic skills development trainers has been successfully implemented in Tanzania, demonstrating that affordable resources can significantly enhance training opportunities (52). Moreover, the FLS course has been adapted for local settings, with studies indicating its feasibility and positive impact on surgeons' competencies (53).

Research and evaluation of new techniques

Research into innovative surgical techniques is also underway. Gasless laparoscopy has emerged as a promising alternative in resource-constrained environments, with studies suggesting that it could improve access to laparoscopic surgery in LMICs without the need

for expensive gas insufflation equipment (54). Such approaches highlight the adaptability of surgical practices in response to local limitations.

Assessment and certification

The development and implementation of assessment tools are crucial for ensuring the quality and safety of laparoscopic training. Comprehensive programs designed to evaluate surgical skills, such as those established by Peters et al. in 2004 (50), are being introduced to ensure that trainees meet the necessary competencies before performing laparoscopic procedures independently.

Challenges and Barriers

Despite these advancements, significant challenges persist. Access to surgical instruments, training facilities, and qualified instructors remains limited in many regions, particularly in rural areas where surgical care is often inadequate (55). Addressing these barriers is essential for maximizing the effectiveness of MIS training programs and ensuring that all surgeons, regardless of their location, can acquire the necessary skills.

Collaboration and knowledge sharing

International collaboration plays a critical role in enhancing MIS training. Partnerships among institutions can facilitate knowledge exchange and provide mentorship opportunities, further enriching the training experience (56). Such collaborations are vital for building a sustainable training framework that can respond to the evolving needs of surgical practice in LMICs.

While MIS training is not yet fully established across LMICs, there is clear momentum toward developing these skills through local and substantial international support.
The recent opening of IRCAD Africa in Kigali, Rwanda, represents a major step forward, symbolizing both the continent's commitment and the power of global collaboration to integrate MIS into surgical education. This center is designed to provide advanced MIS training, improve surgical safety, and elevate the overall quality of care. IRCAD Africa

underscores the willingness and capacity within Africa to promote MIS techniques and create structured learning opportunities for surgeons in the region.

The current state of MIS training in LMICs reflects a landscape of innovation and dedication. Despite ongoing challenges such as limited funding, shortages of equipment, and a lack of trained personnel various initiatives are fostering the development of structured curricula, practical workshops, and simulation-based learning. International collaborations continue to play a crucial role, bolstering local initiatives and supporting the training of surgeons in MIS techniques.

These combined efforts signal a promising trajectory toward broader adoption of MIS, even in resource-limited settings. As infrastructure, funding, and training resources continue to expand, these developments are expected to enhance surgical outcomes and widen access to high-quality, minimally invasive care for patients across LMICs.

2.4. Evolution of minimally invasive surgery in Rwanda and vision for excellence in healthcare delivery

2.4.1. Early beginnings (1997-2015)

The journey of MIS in Rwanda began in 1997 at the University Teaching Hospital of Kigali (CHUK), following the devastating genocide. Prof. Jean Jacques Houben, a surgeon, retired Professor of Surgery at the Université Libre de Bruxelles (ULB), performed the first laparoscopic cholecystectomy and continued to impart his knowledge to Rwandan surgeons. This initial exposure to MIS techniques allowed some local surgeons and gynecologists to receive basic training, either during their specialization or through short stints in Europe. However, due to limited expertise and resources, laparoscopic procedures were performed sporadically and primarily for promotional purposes.

From 2005 to 2015, CHUK, along with other referral hospitals like King Faisal Hospital (KFH) and Rwanda Military Hospital (RMH), continued to perform basic laparoscopic procedures, thanks to donations of laparoscopic equipment and consumables from external donors. Despite the intermittent nature of these operations, this period laid the foundational skills necessary for the future expansion of MIS in Rwanda.

2.4.2. Structured growth and international collaboration (2015-2020)

In 2015, CHUK began integrating laparoscopy into routine procedures, although on a limited scale due to the high cost of consumables. A significant milestone was the launch of the ARES Project PFS 2018-Rwanda, entitle ***"Fellowship in Minimally invasive Surgery at the University of Rwanda"*** a five-year collaboration between the University of Rwanda (UR) and ULB et University of Liège (ULg), funded by the Belgian Ministry of Cooperation. This project aimed to address the skill gaps in MIS by training young Rwandan surgeons and gynecologists (Figure 6).

Figure 6. Meeting with the Ministers of Health during the preparation of the PFS pre-project December 2016. From left to right: Dr. Raymond Muganga (UR - lead for Result R4 of the AI UR-ARES project), Prof. Roland Marini (ULg - northern partner of the PRD project), Dr. Diane Gashumba (Minister of Health, Rwanda), Prof. Jacob Souopgui (ULB - lead for Result R4 of the AI UR-ARES project & northern partner of the current PFS), Pudence Rubingisa (Deputy Vice-Chancellor for Administration and Finance –UR), and Dr. Patrick Ndimubanzi (Minister of State in the Ministry of Health, Rwanda).

To facilitate this programme, an agreement with MEDTRONIC South Africa facilitated the provision of laparoscopic equipment and the establishment of a simulation laboratory (Figure 7), while the Rwanda ministry of health with the Académie de Recherche et d'Enseigement Superieur (ARES) fund supported the programme by funding the experts' travel and accommodation. Experts from Belgium and other partner countries visited Rwanda monthly, a one-week workshop to teach, perform surgeries, and support local medical professionals (Figure 8).

Figure 7. MEDTRONIC Box Simulator within the lap simulation laboratory at CHU Kigali

Figure 8. Laparoscopic clinical immersion sessions with expert from Belgium at CHUK.

2.4.3. Institutionalizing MIS education (2020-Present)

In 2020, the University of Rwanda developed and launched a comprehensive curriculum for a two-year master's program in MIS, approved by the High Council of Education. This program aimed to produce a cohort of highly skilled surgeons and gynecologists proficient in basic laparoscopic techniques. The first group of 6 candidates has graduated in October 2024 (Figure 9) and the second group of 4 candidates currently in clinical placement at Boramae Medical Center, Seoul, South Korea (Figure 10) is set to graduate next year in 2025, ready to train future generations, including those in the surgical residency program.

Figure 9. First MIS graduates at the UR, October 2024

Figure 10. Rwandan MIS trainee's cohort 2, in clinical placement in Seoul South Korea at Boramae medical center

The successful integration of MIS into routine surgical practice across various hospitals is a testament to the efforts of the Rwandan government, international collaborators, and local medical institutions. The Ministry of Health continues to support this initiative by funding external trainers and external clinical placement to give more exposure to the trainees and encouraging hospitals to invest in necessary equipment and instruments.

The University of Rwanda, through its Global Surgery Research Hub, has partnered with the University of Edinburgh and other members of the Global Surgery Health Technology

Evaluation and Validation Consortium to advance MIS training and skill acquisition. Supported by the National Institute for Health and Care Research (NIHR) Global Surgical Unit, this collaboration aims to establish scalable training centers for laparoscopic simulation and postoperative monitoring across diverse healthcare settings. As part of this initiative, two simulation centers were established and equipped in two level 2 teaching hospitals: Kibogora Hospital in the Southern Province and Kibagabaga Hospital in the City of Kigali. These centers provide hands-on training for MIS, offering structured platforms for validating and demonstrating laparoscopic training programs methods. More than 18 intern doctors and medical officers have received training and undergone skill assessments in these facilities, supporting their development in minimally invasive surgical techniques. This effort is set to enhance surgical skills and patient outcomes, particularly in resource-limited environments, by fostering sustainable improvements in training and care (Figure 11).

Picture 11. Trainees' laparoscopy skills acquisition and assessment exercises by assessor (Prof Nyundo & Prof Ntirenganya)

2.4.4. Vision for excellence: IRCAD Africa and Kigali health city

IRCAD is an acronym for Institut de Recherche contre les Cancers de l'Appareil Digestif, which is French for Institute for Research into Cancer of the Digestive System.
The IRCAD Africa initiative seeks to establish Rwanda as a leading center of Excellence in Minimally Invasive Surgery training and research across the continent (Figure 12).

Figure 12. IRCAD Africa, Kigali, Rwanda

Leveraging Rwanda's strong governance in healthcare, strategic location, and exemplary standards in safety and cleanliness, this center aspires to become Africa's largest MIS training hub. Launched in October 2023 by His Excellency (HE) Paul Kagame, President of the Republic of Rwanda, IRCAD Africa reflects the high-level commitment of Rwanda's leadership and government to invest in advanced surgical technology and deliver high-quality healthcare (Figure 13). Rwanda stands as a model for medical innovation in Africa, highlighting the potential for MIS to elevate surgical care across the region.

IRCAD Africa is a key component of the broader Kigali health city project, which seeks to develop a significant medical research hub that will positively impact millions of lives across the continent. In line with this vision, Rwanda is constructing new health infrastructures and acquiring modern medical equipment to comply with international

standards, while developing new surgical specialties to facilitate the learning of advanced skills. This initiative aligns with Rwanda's ambition to close the technological and knowledge gap in MIS and improve surgical standards throughout Africa.

Figure 13. IRCAD Africa Simulation lab, Launching of IRCAD Africa, Rwandan MIS trainees demonstrating a simulation exercise in presence of HE Paul Kagame and Prof Jacques Marescaux

2.4.5. Achievements and future directions

Rwanda has achieved several milestones in its quest to enhance healthcare standards. The rigorous quality assurance and accreditation process at CHUK, which has attained the Council for Health Service Accreditation of Southern Africa (COHSASA) accreditation, and the repeated accreditation of KFH are notable achievements that reaffirm the country's commitment to high standards of care and patient safety.
Standardized protocols and routine audits further enhance the safety and consistency of laparoscopic procedures, promoting the adoption of MIS techniques and perioperative practices. The training of doctoral candidates and the development of research capabilities ensure that Rwanda remains at the forefront of advancements in MIS.

In conclusion, through strategic investments in training, infrastructure, and international collaborations, Rwanda has made significant strides in adopting and integrating minimally invasive surgery (MIS). The country's vision to become a center of excellence in healthcare delivery is supported by its commitment to quality, innovation, and continuous improvement. Efforts such as the construction of new healthcare facilities and the acquisition of modern medical equipment not only improve surgical outcomes but also expand access to high-quality healthcare for patients across the region. These

initiatives position Rwanda as a leader in modern surgical techniques and healthcare delivery in Africa.

2.5. Quality improvement in Minimally Invasive surgery with Enhanced Recovery After Surgery

ERAS was initiated by a group of surgeons from Northern Europe focused on improving perioperative care for patients undergoing colonic resections. In the 1990s, Henrik Kehlet pioneered fast-track surgery, demonstrating that most patients could be discharged just two days after open sigmoid resection a significant reduction from the typical ten-day stay common at the time (57). The ERAS Society has since developed standardized, evidence-based guidelines now implemented in over 25 countries, promoting structured perioperative care to enhance recovery and minimize surgical complications (58).

2.5.1. ERAS framework and principles of care

ERAS protocols encompass a series of evidence-based treatments across the perioperative period, formulated to reduce surgical stress, maintain postoperative physiological function, and improve mobilization (59). This approach has led to reduced morbidity, enhanced recovery, and shorter hospital stays in various clinical settings (60,61). These protocols have been shown to cut medical complications by nearly 50%, lower infection rates, and potentially improve survival after oncologic surgery, underscoring ERAS as a transformative shift in perioperative management (62–64).
ERAS begins in the preoperative phase, where patient optimization is essential. Education, perioperative instructions, and setting achievable expectations empower patients to actively engage in their own recovery (65–68). This patient-centered approach aligns well with ERAS goal of creating an active partnership in the surgical process.

2.5.2. Integration of Minimally Invasive Surgery in ERAS Protocols

The incorporation of MIS, particularly laparoscopic surgery, within the ERAS framework represents a notable advancement in perioperative care. Laparoscopic surgery aligns well

with ERAS principles, as laparoscopic approaches reduce tissue trauma, leading to lower postoperative pain and quicker mobilization. The adoption of laparoscopic techniques within ERAS protocols has allowed healthcare providers to further optimize the surgical experience and outcomes, making MIS and ERAS a synergistic approach that benefits patients and healthcare systems alike (69,70).

Laparoscopic techniques, in conjunction with ERAS protocols, further minimize the impact of surgery on patients. For instance, anesthesiologists can use loco-regional techniques to reduce pain and limit fluid overload, while early feeding and ambulation are facilitated by multimodal analgesia, often avoiding opioids and their associated side effects. As a result, patients experience fewer postoperative complications, and their recovery is often accelerated compared to open surgery (71,72). These enhancements are well-supported in ERAS pathways and contribute to smoother, faster recoveries (62,71).

2.5.3. Patient benefits of ERAS: Recovery, complications, and costs

The clinical and economic benefits of ERAS are substantial, with studies consistently demonstrating that ERAS reduces both hospital stays and healthcare costs. For example, Gustafsson et al. found that ERAS protocols in elective colorectal surgery reduced hospital stays by over 30%, with a corresponding decrease in complication rates (73), ultimately improving survival outcomes in oncologic surgeries (62–64,71,72,74). The protocols emphasize patient education and engagement as essential components, with clear expectations set preoperatively to ensure patients understand their active role in recovery (66,71,72,75).

From an economic perspective, ERAS pathways have shown substantial cost-saving potential by reducing hospital stays and postoperative complications. This model has been considered transformative in surgical care, as it supports cost savings and efficient resource use and improves patient throughout (70,76,77).

In conclusion, ERAS and MIS together present a powerful model for improving patient outcomes and optimizing healthcare resources. The global adoption of ERAS, supported by advancements in laparoscopic techniques, is transforming perioperative care and recovery worldwide. With ongoing research and broader implementation of ERAS

protocols and MIS approaches, the future of surgical care promises even greater improvements in patient satisfaction, recovery times, and overall healthcare efficiency.

2.5.4. Barriers to adoption of laparoscopic surgery and ERA for quality perioperative care in Low- and Middle-Income Countries

The adoption of laparoscopic surgery and ERAS protocols in LMICs faces numerous barriers that impede the delivery of safe and effective perioperative care. These challenges stem from several key issues, including fragmented care pathways, resource limitations, high direct and indirect patient costs, and low patient expectations regarding care quality.

1. **Challenges in training and capacity building**

There is a significant shortage of healthcare professionals trained in laparoscopic techniques due to the limitation of training opportunities (8). Training programs for surgeons and support staff are not sufficiently widespread, limiting the ability to perform and expand MIS practices. A survey highlighted that only a small fraction of surgeons in LMICs have received formal training in laparoscopic surgery, leading to a reliance on traditional open surgery techniques (24,78). There is a need for comprehensive educational programs that include both theoretical and practical training in MIS. Existing training initiatives are often short-term and do not provide the depth of knowledge and skill required for proficient practice. A study by Beard et al. (52) underscores the necessity of ongoing, hands-on training to ensure skill retention and competence in laparoscopic techniques. The absence of simulation labs and training facilities exacerbates these challenges, making it difficult for surgeons to acquire and refine their skills (9,25–28,79).

2. **Resource constraints and infrastructure limitations**

A major barrier in LMICs is the lack of consistent infrastructure and resources required to support laparoscopic surgery. Equipment shortages, inconsistent access to essential surgical tools, and insufficient maintenance facilities are widespread, limiting the reliable

delivery of laparoscopic procedures. Essential consumables for laparoscopic surgeries, including the carbon dioxide (CO_2) for pneumoperitoneum, are often in short supply due to limited and unreliable supply chains. The high costs associated with purchasing and maintaining laparoscopic equipment further exacerbate these issues, making their availability and sustainability difficult (9,24). The need for CO_2 is particularly critical, as it is a prerequisite for safe laparoscopic operations; however, its inaccessibility poses a significant challenge in LMICs. Some authors have proposed developing "gasless" laparoscopy as an alternative to address this shortcoming in regions facing CO_2 shortages (8,80). Less than 20% of hospitals in LMICs have the necessary infrastructure to support advanced MIS, significantly limiting their capacity to provide laparoscopic care (81). The World Health Organization (WHO) reports that economic constraints in LMICs often divert resources to immediate healthcare needs, leaving advanced surgical practices underfunded (82–84). Furthermore, inadequate monitoring of postoperative outcomes and the underreporting of complications restrict quality improvement measures and hinder the development of standardized protocols (8,24).

3. Cost barriers and accessibility challenges

Both the direct (surgical fees, hospitalization) and indirect costs (travel, lost income) associated with laparoscopic surgery present considerable financial burdens for patients in LMICs. This financial pressure is heightened by the need for expensive, sophisticated equipment that many healthcare facilities cannot afford, impacting the sustainability of MIS programs (9). These cost barriers are further intensified by geographic and socioeconomic disparities; low-income and rural populations face significant challenges in accessing MIS due to the concentration of resources in urban centers and the absence of infrastructure in peripheral areas (8,85,86). The economic burden of purchasing and maintaining specialized laparoscopic equipment and consumables limits their widespread use and availability, which, in turn, restricts equitable access to safe, quality surgical care (9).

4. Variability in training and standardization

The safety and quality of laparoscopic surgery in LMICs are also undermined by inconsistent training and a lack of standardized protocols. This variability poses a significant risk, as the absence of formalized training frameworks results in differing levels of competency among healthcare providers, increasing the likelihood of adverse events. Structured training programs and collaborative effort such as IRCAD Africa's recent establishment in Kigali, Rwanda are promising developments, signaling a commitment to integrating MIS into surgical education and addressing the training gap in LMICs through international partnerships.

5. Potential of ERAS in resource-limited settings

Despite these barriers, ERAS protocols hold promise for enhancing perioperative care in LMICs. ERAS has been shown to reduce hospital stays, lower complications, and improve overall outcomes by adhering to a structured, patient-centered pathway (70,77). While initial implementation costs may be high, these are often offset by long-term savings achieved through reduced hospitalization and complication rates. Additionally, ERAS protocols emphasize patient-centered care such as continuous support and clear communication throughout recovery that has been shown to improve postoperative outcomes (87–89).

6. Cultural barriers and traditional preferences

Lastly, the preference for open surgery and extended hospital stays remains ingrained within some medical and paramedical practices, as well as among patients in LMICs. These traditional preferences can slow the acceptance and integration of laparoscopic surgery and ERAS protocols, requiring sustained advocacy and education to encourage a shift toward minimally invasive techniques and improved perioperative protocols.

The integration of laparoscopic surgery and ERAS protocols in LMICs faces considerable barriers but also presents significant potential to improve perioperative care. By addressing issues such as training variability, resource limitations, and socioeconomic

disparities, and through initiatives like IRCAD Africa, LMICs can move closer to establishing comprehensive MIS training and ERAS adoption. Despite current challenges, the commitment to expanding minimally invasive techniques in these regions underscores a drive toward better surgical outcomes, patient safety, and healthcare accessibility for diverse populations.

CHAPTER III. RESEARCH METHODOLOGY

CHAPTER III. RESEARCH METHODOLOGY

3.1. Introduction

The cross-sectional component assessed the status of laparoscopic surgery training and practice, while the retrospective cohort component evaluated clinical outcomes and patient experiences. Additionally, a Knowledge, Attitudes, and Practices (KAP) study was conducted to evaluate perioperative care providers' knowledge and practice regarding current trends in perioperative care and the ERAS pathway. The non-randomized prospective study investigated the implementation and outcomes of an ERAS protocol following laparoscopic surgery.

This thesis employs a combination of study designs tailored to address three major objectives related to MIS in low-resource settings within the COSECSA region. Five published studies were conducted in COSECSA-accredited hospitals, including the CHUK to assess current MIS practices and outcomes, evaluate training trends, and implement a quality improvement program aimed at enhancing perioperative care through a locally adapted ERAS protocol. This chapter outlines the study designs, data collection methods, statistical analyses, and ethical considerations for the research.

3.2. Study designs and Methods

3.2.1. Objective 1: Assess the Current Practice and Outcomes of MIS in the COSECSA Region

Study 1A: Cross-sectional capacity and resource survey

Design and Period:
A cross-sectional survey conducted from January 2021 to October 2021.

Population and Setting:
Health professionals (surgeons) from COSECSA-accredited training hospitals across 16 countries participated via an online survey platform.

Data Collection:

A structured questionnaire, including numerical scoring, close-ended, and open-ended questions was used to capture data on hospital capacity (trained staff, equipment, instruments, and surgical activity) and perceived challenges in laparoscopic surgery practice. Implied consent was obtained upon registration.

Data analysis:

Data were recorded in Microsoft Excel and analyzed using SPSS version 25. Categorical variables were summarized as frequencies and percentages, while continuous data were described using the median and interquartile range (IQR).

Ethical approval:

Approved by the COSECSA Institutional Review Board (IRB) Registration Number: 00011122).

Study 1B: Retrospective-prospective outcome evaluation

Design and period:

A cross-sectional observational study combining retrospective data review (January 2015–December 2020) with prospective telephone follow-ups

Population and setting:

Patients undergoing laparoscopic cholecystectomy at CHUK.

Data collection:

Retrospective data were extracted from operating room registers and hospital records for 288 cases out of 446 laparoscopic procedures. Information included demographics, surgical details (e.g., intraoperative complications, drain placement, conversion to open surgery, duration), and postoperative outcomes classified using the Clavien-Dindo system. A random sample of patients was contacted by phone, provided verbal consent, and completed a structured questionnaire regarding their experience, including pain levels, scar aesthetics, time to return to normal activities, surgical cost, and overall satisfaction.

Data analysis:

Data were processed in Microsoft Excel and analyzed with SPSS version 25 using descriptive statistics and chi-square tests (with significance set at $p < 0.05$).

Ethical approval:

Approved by the Institutional Review Board of the University of Rwanda and the Ethics Committee of CHUK (Reference Ns. 412/CMHS IRB/2021 and EC/CHUK/075/2021).

3.2.2. Objective 2: Evaluate MIS training trends in the COSECSA region

Design and period:

A cross-sectional study conducted concurrently with Study 1A (January 2021–October 2021).

Population and setting:

Surgeons and training faculty from COSECSA-accredited hospitals.

Data collection:

An online structured questionnaire was administered focusing on training capacity, including available equipment, qualified staff, curriculum content, and teaching methods. Open-ended questions allowed participants to discuss resource limitations and opportunities for enhancing laparoscopic surgery training. Implied consent was obtained via the survey platform.

Data analysis:

Responses were compiled in Microsoft Excel and analyzed using SPSS version 25. Data were summarized using frequencies, percentages, and measures of central tendency (median and IQR) for continuous variables.

Ethical approval:

Approved by the COSECSA IRB Registration Number: 00011122).

3.2.3. Objective 3: Implement a Quality Improvement Program to Enhance Perioperative Care in MIS

This objective was addressed through a two-phase quality improvement project:

Phase 1: Cross-Sectional KAP Study

Design and process:
A half-day webinar was organized in collaboration with the Departments of Surgery and Anesthesia at CHUK to introduce ERAS principles. Following the webinar, a KAP survey was administered to perioperative care providers to assess their understanding of ERAS, attitudes towards its adoption, and current practices.

Purpose:
The KAP study aimed to identify knowledge gaps and inform the development of a modified ERAS protocol suitable for local implementation.

Phase 2: Non-Randomized Controlled Trial evaluating the modified ERAS protocol

Design and period:
A prospective non-randomized controlled trial initiated in January 2022.

Population and setting:
Fifty patients undergoing elective laparoscopic cholecystectomy managed under the modified ERAS protocol (ERAS group) were prospectively compared with a control group of 50 patients treated prior to the implementation of the ERAS pathway. Participants were over 16 years of age and provided informed consent.

Intervention:
A locally adapted ERAS protocol developed based on existing evidence, expert consensus, and local constraints was implemented. Information regarding the protocol was provided preoperatively by the surgical team.

Data collection:

Collected variables included demographics, ASA score, operative time, intraoperative events, postoperative complications (classified using the Clavien-Dindo system up to postoperative day 90), hospital length of stay (LOS), and direct surgical costs (surgical, anesthesia, nursing, consumables, drugs, and hospitalization). Patient satisfaction and pain levels were assessed using Likert and numeric rating scales, respectively. Protocol adherence was monitored using a checklist completed by the perioperative team.

Data analysis:

Continuous variables (e.g., operative time, LOS) were compared using the Mann–Whitney U test, while categorical variables were analyzed using chi-square or Fisher's exact tests. Cost comparisons were performed by summing the direct costs, and statistical analyses were conducted using Prism 9.5.1 for Mac. A pre-study sample size calculation determined that 48 patients per group were required to detect a significant reduction in LOS with 90% power and a significance level of 0.05.

Ethical approval and registration:

Approved by the University of Rwanda IRB and the CHUK Ethics Committee (EC) (Reference No. 412/CMHS IRB/2021 and EC/CHUK/1/074/2021) and registered on ClinicalTrials.gov (NCT05516056).

CHAPTER IV. RESULTS

CHAPTER IV. RESULTS

4.1. Assessment of resource capacity and barriers to effective practice of laparoscopic surgery in training hospitals affiliated with the College of Surgeons of East, Central and Southern Africa (COSECSA)

4.1.1. Summary

Laparoscopic surgery has revolutionized surgical practice in developed countries due to its advantages over open surgery. However, its adoption and accessibility in developing countries, particularly those with limited resources, have been sporadic and minimal. The inherent challenges of implementing such a complex surgical program in low-resource settings have produced varying effects. Moreover, the widespread introduction of laparoscopic techniques in developed countries has highlighted the need for adequate training, as these procedures require significant expertise. This study aimed to assess the resource capacity and identify barriers to the effective practice of laparoscopic surgery in training hospitals affiliated with the COSECSA, with the goal of providing recommendations for improvement.

This cross-sectional multinational study, conducted from January to October 2021, surveyed 94 surgeons from COSECSA-accredited training hospitals in 16 countries using an online questionnaire. The study assessed available resources and surgical volume, identified barriers to routine laparoscopy, and explored challenges and solutions for the practice and safety of laparoscopic surgery in LMICs. Questions focused on hospital capacity, including trained staff, equipment, instruments, and surgical activities. The study sought to identify shortfalls, solutions, and recommendations to comprehensively analyze current laparoscopic surgery practices.

The findings from this multi-country and multicenter survey underscored the insufficient resource capacity within COSECSA-accredited hospitals, limiting the scope of laparoscopic procedures to basic interventions. On average, the participating hospitals were staffed with three laparoscopic surgeons and were equipped with two laparoscopic towers and instrument sets. Each hospital performed approximately 10 laparoscopic

procedures per month. Among these procedures, cholecystectomy was identified as the most performed, followed by diagnostic laparoscopy, appendectomy, adhesiolysis, and hernia repair.

Primary barriers to the routine implementation of laparoscopic surgery in COSESCA accredited hospitals include a lack of consumables, insufficient number equipment, availability of skilled surgeons, financial constraints for patients, and the complexity of cases that necessitate experienced practitioners. Furthermore, challenges extended to inadequate anesthesia staff and equipment, limited access to CO_2, inconsistent power supply, and medical equipment maintenance.

In response to these challenges, participants proposed several comprehensive recommendations. Firstly, capacity building initiatives were suggested, focusing on the training of skilled personnel. Secondly, policymakers and hospital administrators were urged to collaborate with manufacturers and pharmaceutical companies to secure low-cost laparoscopic equipment, instruments, and consumables. This collaboration is intended to enhance affordable access and ensure proper maintenance of surgical resources. Lastly, there was a call for increased public and patient awareness of laparoscopic procedures to stimulate demand and garner support from policymakers, thereby facilitating advancements in the field. This strategy aimed to overcome existing barriers and promote the successful integration of laparoscopic surgery into routine practice in the region.

4.1.2. First published study

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Assessment of resource capacity and barriers to effective practice of laparoscopic surgery in training hospitals affiliated with the College of Surgeons of East, Central and Southern Africa (COSECSA)

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Abstract

Background The adoption and accessibility of laparoscopy have been serious issues in countries with limited resources, and for varied reasons. This study assessed resource capacity and barriers to the effective practice of laparoscopic surgery in training hospitals affiliated with the College of Surgeons of East, Central and Southern Africa (COSECSA).

Methods A multi-country survey was conducted from January 2021 to October 2021 using a questionnaire distributed to surgeons in COSECSA hospitals located in 16 different countries. Available resources and surgical volume were assessed, and the barriers to routinely performing laparoscopy were determined.

Results Ninety-four surgeons working in 44 different hospitals from 16 countries participated in the survey. The majority of respondents were general surgeons ($n=75$, 79.7%). Other specialties included urology ($n=12$, 12.8%) and pediatric surgery ($n=7$, 7.4%). Senior surgeons accounted for 60.6% of participants, more than 40% had a managerial position and approximately 20% were surgical trainees. Most respondents practiced in public hospitals ($n=66$, 70.2%). A median of three surgeons per hospital performed laparoscopic surgery with, on average, two laparoscopic towers and two sets of laparoscopic instruments available. A median of 10 procedures was carried out per month. The cost of laparoscopic procedures and laparoscopic consumables were reported as being covered by some health insurance payments in 76.9% and 48.4% of cases, respectively. Cholecystectomy was the most commonly reported laparoscopic procedure performed. The five top barriers to performing laparoscopic surgery were: a lack of consumables, a limited quantity of equipment, a lack of skilled surgeons, the high cost of laparoscopic procedures and complicated cases. In addition, having access to skilled anesthesiologists and anesthesia equipment, carbon dioxide, a consistent electric power supply and equipment maintenance were cited as significant challenges.

Conclusion The practice of laparoscopy is currently limited in COSECSA countries due to a scarcity of skilled staff and the lack of a funding plan to make laparoscopic services accessible. Therefore, policymakers and stakeholders should take strategic measures to respond to this need.

Keywords Laparoscopic surgery · Global surgery · Sub-Saharan countries · Resources capacity · Barriers to laparoscopy

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Global Surgery, as defined by the Lancet Commission, is universal access to safe, affordable surgical and anesthesia care, when needed. Global Surgery saves lives, prevents disabilities and promotes economic growth. However, this is not the reality in Sub-Saharan Africa where 93% of the population have no access to safe, affordable surgical and anesthesia care, when needed [1, 2].

Laparoscopic surgery has revolutionized the practice of surgery in developed countries [3–5]. In essence, it represents a new era of technology-dependent surgical interventions, and to some extent its future progress depends on the development of interventional technologies and devices [3].

Recent studies have demonstrated the adoption of laparoscopy in Low- and Middle-Income Countries (LMICs) to be safe, feasible, and clinically beneficial [6–8]. However, on a worldwide basis, it faces many constraints and several outstanding issues need to be addressed, including the training of qualified staff, the assessment of competence, limited resources and resource allocation, limited equipment and maintenance capacity, lack of safe procedural guidelines and quality assurance [3].

The effort to integrate laparoscopy into the delivery programs of surgical services in low-resource settings has produced varying effects, resulting from the challenges inherent in a complex surgical program [9, 10]. Additionally, the widespread introduction of laparoscopic techniques in developed countries has emphasized the need for adequate training as operations that were straightforward open procedures may require considerable laparoscopic expertise, and this has raised questions about trainee surgeons acquiring adequate training [4].

The College of Surgeons of East, Central and Southern Africa (COSECSA) is a professional organization, founded in 1999, that fosters surgical education and training. The college currently includes 139 accredited hospitals in 14 Sub-Saharan countries: Botswana, Burundi, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Rwanda, South Sudan, Sudan, Tanzania, Uganda, Zambia and Zimbabwe. A hospital is accredited by COSECSA after expressing interest in becoming a training site for surgeon candidates (selected by COSECSA). The organization assesses its capacity in terms of trainers, equipment and infrastructure; and subsequently certifies the hospital to become a COSECSA training site. The mission of COSECSA is to increase the accessibility of surgical services, especially to the rural populations of Africa, by standardizing and widening access to surgical training, skills and knowledge with a mandate to advance the science and practice of surgery in the region [11].

This study aimed to assess the resource capacity and barriers to the effective practice of laparoscopic surgery in the COSECSA accredited hospitals, to determine the gaps and challenges, and to provide recommendations for the improvement of the system for future laparoscopic surgery programs.

Material and methods

Research method and setting

This was a cross-sectional study based on the experience of health professionals. The authors conducted a multinational survey from January 2021 to October 2021 using a structured questionnaire containing numerical scoring and close-ended questions. Open-ended questions were asked to reveal the challenges and solutions for the practice and safety of laparoscopic surgery in LMICs. The questionnaire was distributed to surgeons in different accredited training hospitals in 16 countries using an online survey form. Implied consent was obtained from all the study participants when they registered on the web-based survey. The COSECSA Institutional Review Board (IRB) (IRB Registration Number: 00011122) approved this study.

Data collection

Questions focused on the capacity of the hospitals in terms of trained staff, equipment, instruments and surgical activities in laparoscopic surgery. The shortfalls, solutions and recommendations were identified in order to analyze the present practice of laparoscopic surgery in the respective hospitals to the widest possible extent.

Data analysis

Data were recorded using Microsoft Excel spreadsheets and exported to International Business Machines (IBM) Statistical Product and Service Solutions (SPSS) software platform version 25 for analysis. Descriptive data were used to generate frequencies and percentages for categorical variables. The median and interquartile range (IQR) were used to describe the central tendency and dispersion of continuous data, respectively.

Results

Demographic characteristics

The target population was all Fellows in general surgery, urology and pediatric surgery working in the countries affiliated to COSECSA. The survey questionnaire was distributed to 291 surgeons via the COSECSA fellows email group and 100 (45.7%) responded; however, 6 were excluded due to an excessive lack of information and therefore 94 participants were considered. Interestingly, these participants represented all the countries affiliated to COSECSA (85.7%) with the exception of 2 (Sudan and South Sudan).

A total of 94 surgeons working in 44 hospitals located in 16 countries participated in the survey (Fig. 1). Table 1 shows that the majority of respondents were general surgeons ($n=75$, 79.7%) and other specialties included urology ($n=12$, 12.8%) and pediatric surgery ($n=7$, 7.4%). Senior surgeons accounted for 60.6% of participants, more than 40% had a managerial position and approximately 20% were surgical trainees. In terms of the status of the hospital, the majority of respondents practiced in public hospitals ($n=66$,

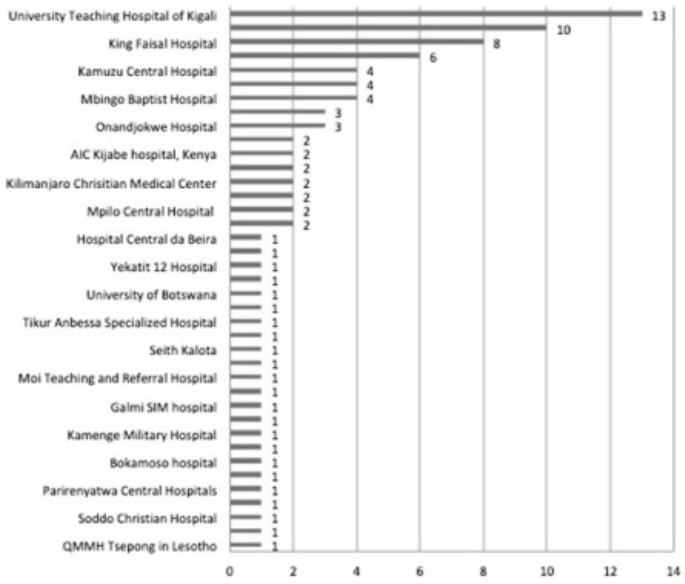

Fig. 1 Number of responders of Hospitals affiliated to COSECSA

70.2%) including 46.8% in university teaching hospitals and 39.4% in referral hospitals.

Hospital resources capacity and surgical volume

According to the respondents, the COSECSA hospitals had a median per hospital of 3 (1–15) surgeons practicing laparoscopic surgery, 2 (1–10) laparoscopic towers, and 2 (1–10) sets of laparoscopic instruments. An average of 10 (1–65) laparoscopic procedures per month was reported (Fig. 2). Regarding the laparoscopic procedures performed within the COSECSA hospitals, the majority of participants (n=95.6%) reported that cholecystectomy is the commonest procedure performed. Considering the other procedures frequently performed, diagnostic laparoscopy (90.1%), appendectomy (80.2%), adhesiolysis (70.3%) and hernia repair (51%) completed the top 5 (Fig. 3). The participants declared that (n=70, 76.9%) of laparoscopic procedures are covered by health insurance, while it only covers (n=44, 48.4%) of laparoscopic consumables (Table 2).

Challenges and barriers to routinely performing laparoscopic surgery

Figure 4 shows the perceived barriers reported by the participants that prevent the routine performance of laparoscopic surgery. The five top barriers cited included: a lack of consumables (n=75, 79.8%), a limited availability of equipment (n=70, 74.4%), a lack of skilled surgeons (n=64, 68%), patients unable to afford laparoscopic surgery (n=40, 42.5%) and complicated cases (n=34, 36.2%). However, participants agreed, or strongly agreed, that a skilled anesthesia team (n=29, 30.9%,), anesthesia equipment (n=19, 20.2%), CO_2 availability (n=15, 16%), a consistent electrical power supply (n=14, 14.9%) and equipment maintenance (n=34, 45.7%) were among the most significant challenges when performing laparoscopic surgery (Table 3).

In terms of recommendations that could ameliorate laparoscopic practice, the participants proposed improvements in three specific areas: infrastructure and equipment (85%), the training of the surgical team (80.2%), and costs with health insurance cover of laparoscopic consumables (24.2%) (Fig. 5).

Discussion

The introduction of laparoscopic surgery in developed countries has revolutionized surgical practice with its superior advantages over open surgery in many surgical disciplines, however, its adoption in developing countries has been sporadic and minimal [4]. Although commonly

Table 1 Hospital and Professional profile of the participants

	n	%
Specialty		
General surgery & subspecialties	75	79.7
Pediatric surgery	7	7.4
Urology	12	12.8
Clinical position		
Senior consultant and above	28	29.8
Consultant	28	29.8
Junior consultant	19	20.2
Surgical trainee	19	20.2
Administrative position		
Hospital director	3	3.2
Clinical director	4	4.3
Program coordinator	18	19.1
Head of department	23	24.5
None	52	55.3
Hospital type		
District teaching	4	4.3
Non-teaching	4	4.3
Provincial teaching	5	5.3
Referral teaching	37	39.4
University teaching	44	46.8
Hospital ownership		
Public	66	70.2
Private	21	22.3
NGO	7	7.4

cited challenges include the apparent lack of resources and trained personnel [4, 5, 9, 10], recent studies have shown that these reported challenges might not be the only significant barriers and further investigations are recommended.

This study aimed at estimating the resource capacity and identifying obstacles to the effective practice of laparoscopic surgery in the COSECSA region. The findings from this multi-country and multicentre survey showed that the resource capacity is insufficient, that the practice of laparoscopy is limited to basic procedures, and that the laparoscopic procedures and consumables are not covered in full by health insurance in different COSECSA-accredited hospitals. Five key barriers emerged from the data: (1) a lack of consumables, (2) a limited amount of equipment, (3) the unavailability of skilled surgeons, (4) unaffordable laparoscopic surgical services and (5) an absence of practice in complicated and advanced cases. Additionally, this study also identified important challenges that have not been adequately addressed in previous research writing on the barriers to the implementation of laparoscopic surgery in LMICs. These include: a lack of skilled anesthesia teams and anesthesia equipment, the reliable availability of CO_2, control of the electrical power supply and equipment maintenance. While the practice of laparoscopic surgery is generally quite limited in the COSECSA region, in some countries, especially in Kenya, minimal access surgery is acceptable to patients, and significantly favorable outcomes have been established in all cases undertaken [12].

The unavailability of skilled surgeons and a limited amount of equipment have been cited as barriers in this study, and these findings have also been reported by many previous authors citing the fact that the lack of appropriate personnel and the high cost involved in acquiring modern equipment are some of the challenges faced by laparoscopic surgery in developing countries [13, 14]. Other studies have reported that the lack of resources and education are only two of the potentially numerous challenges

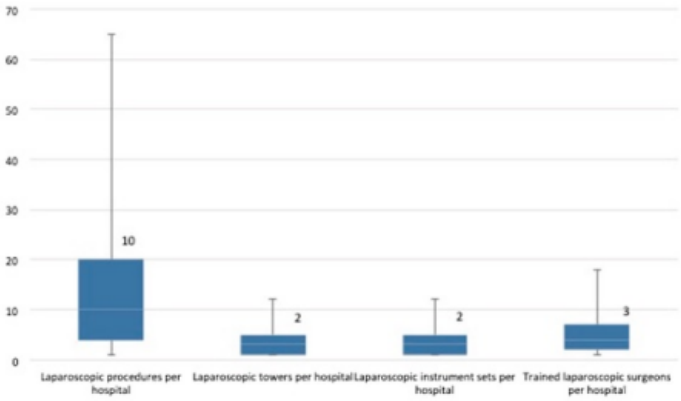

Fig. 2 Resources and performance at the Hospitals of respondents

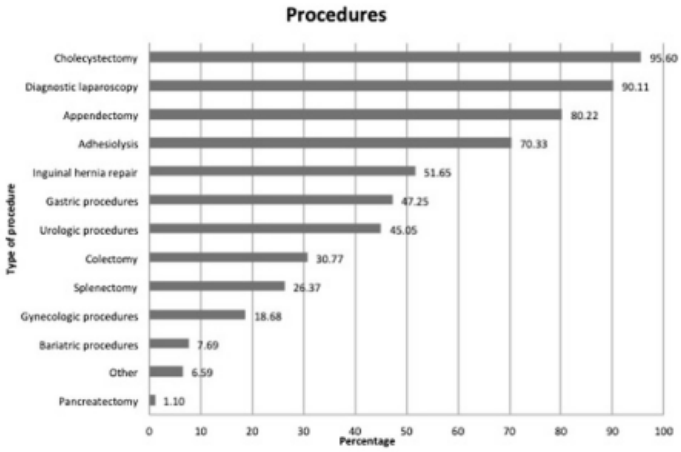

Fig. 3 Percentage of procedures performed using laparoscopy

Table 2 Health insurance cover of laparoscopic procedures and consumables

	n	%
Laparoscopic procedures covered by health insurance in the hospital		
No	21	23.1%
Yes	70	76.9%
Laparoscopic consumables covered by health insurance in the hospital		
No	47	51.6%
Yes	44	48.4%

in the complex problem of the adoption of laparoscopic surgery in LMICs [15, 16].

In the literature some surgeons have reported that laparoscopic surgery is not done routinely in complicated cases, as they prefer to perform open surgery due to their lack of expertise in advanced laparoscopic surgery. According to other reports, laparoscopic surgery is a time-consuming approach and surgeons are less willing to practice more technically complicated cases [16], and only a limited number of surgeons perform complex and advanced laparoscopic surgery [17]. It has been reported that the expertise and skills

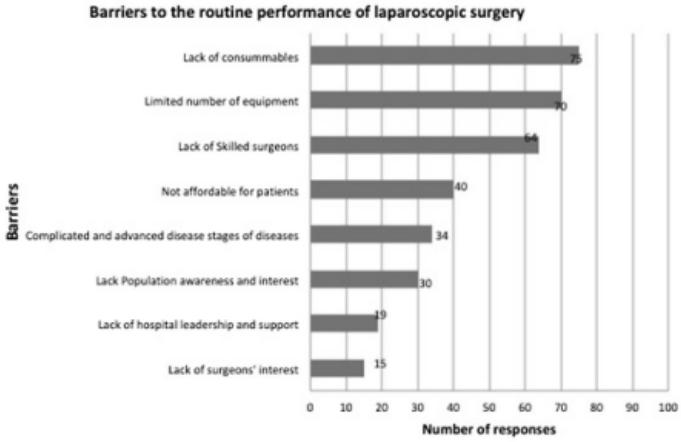

Fig. 4 Barriers to the routine performance of laparoscopic surgery

Table 3 Perception of respondents to laparoscopic surgery challenges in their hospital

	n	%
Is shortage of anesthesia-trained staff a concern for the performance of laparoscopic procedures in your hospital?		
Strongly disagree	16	17.0
Disagree	25	26.6
Neutral	24	25.5
Agree	20	21.3
Strongly agree	9	9.6
Is lack of anesthesia equipment a concern for the performance of laparoscopic procedures in your hospital?		
Strongly disagree	20	21.3
Disagree	36	38.3
Neutral	19	20.2
Strongly agree	2	2.1
Agree	17	18.1
Is CO2 availability a problem in your hospital?		
Strongly disagree	22	23.4
Disagree	37	39.4
Neutral	20	21.2
Agree	12	12.8%
Strongly Agree	3	3.2%
Is the electric power supply a problem in the running of surgical activities in your hospital ?		
Strongly disagree	38	40.4
Disagree	42	44.7
Neutral	4	4.3
Agree	10	10.6
Is the maintenance of medical equipment a problem in the running of surgical activities in your hospital		
Strongly disagree	11	11.7
Disagree	19	20.2
Neutral	21	22.3
Agree	33	35.1
Strongly Agree	10	10.6

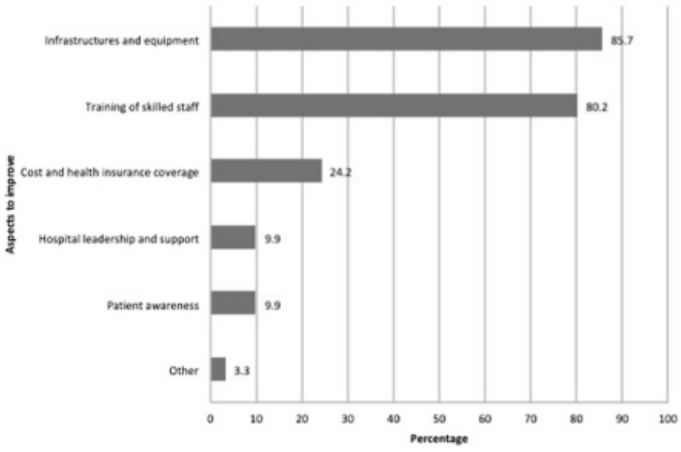

Fig. 5 Aspects to improve laparoscopic surgery in Hospitals

associated with a change in practice were found to play a greater role in the adoption of laparoscopy than has been reported in the current literature [16].

The high cost of laparoscopic services and the lack of availability of laparoscopic consumables are among the top five barriers cited by the participants in this study, and these findings are similar to many studies that have been carried out in LMICs [18, 19], with some authors questioning whether the benefits are justifiable when even basic supplies are scarce [16]. In many sub-Saharan countries the pricing for the patient and/or for their health insurance separates the cost of surgery, drugs and the consumables or equipment that has been used. For example, in Rwanda the public health system covers a surgical intervention such as "colonic resection" but does not systematically cover laparoscopic staplers if they are used, because they are expensive. Some private health insurance may cover consumables, but only a limited number of patients have private health insurance. However, the economic situation of these countries is not homogeneous and several powerful incentives exist to encourage LMIC hospitals to adopt laparoscopic surgery [10, 16]. Farrow et al. also found that poor access to training, laparoscopic equipment, equipment maintenance and consumables were among the obstacles barring access to laparoscopy in developing countries [17].

Laparoscopic consumables are prohibitively expensive and unaffordable for many patients in developing countries. The results of this study have shown that laparoscopic services and consumables are not fully covered in full by health insurance, and a significant number of COSECSA countries do not have community health insurance to cover these costly procedures and consumables. Even in countries where health insurance covers the services provided, this is done through private health insurance that is equally inaccessible to patients from lower socio-economic classes. This situation requires adaptation strategies for financing including the implementation of policies for community health insurance cover and also strategic partnerships with pharmaceutical firms for cost reduction, thus allowing easier access to services.

The results of this study also show that there are still other challenges that prevent surgeons from embracing laparoscopic surgery in their routine surgery; this includes insufficient anesthesia staff and anesthesia equipment, and the maintenance of medical equipment. It is crucial that the complete surgical team including surgeons, anesthesiologists and nurses, should be trained in the principles and practical aspects of laparoscopic surgery. The practice of laparoscopic surgery requires specialized knowledge and skills for surgeons and nurses, both to work directly with this technological approach and to interact effectively on an interprofessional level with other members of the surgical team [20]. Additionally, the maintenance of laparoscopic equipment, which requires both additional time and knowledge, discourages surgeons from committing to this technology [16]. Knowledge of the instruments used is essential when performing laparoscopic surgery, therefore the training and practice of laparoscopic surgery in LMICs could be improved and made more widely available through postgraduate medical education [10].

Pneumoperitoneum using CO_2 is known to be common and very essential as a prerequisite to operating safely in laparoscopic surgery. The lack of accessibility to CO_2 has not yet been sufficiently discussed in the literature as being a common obstacle to laparoscopy; it is a costly undertaking in LMICs, and some authors have proposed the development and use of "gasless" laparoscopy in LMICs as an alternative for countries with a shortage [10, 21].

Although sub-Saharan countries face many surgical challenges, laparoscopic surgery is particularly beneficial and can be feasible and safe. However, innovation and coping strategies are required to sustain the practice of laparoscopy in these countries [22] while local adaptation techniques have facilitated cost reduction [23]. There has been an improvement in the acceptance of laparoscopic procedures among patients [23] and surgeons have shown a real need and interest in increasing the implementation of laparoscopic practice in the COSECSA region [17].

Limitations

Two COSECSA countries were not represented in our study, notably Sudan and South Sudan; conversely, Rwanda was over-represented as 15% of the questionnaires were answered by Rwandese surgeons, undoubtedly due to the geographic location of the principal investigator. However, the authors limited this bias by presenting the results as median, as the responses were not symmetrically distributed.

The accuracy of responses cannot be verified as the survey was carried out online. It involved a limited number of hospitals, namely 44, but given that COSECSA has 139 accredited hospitals this is a significant proportion.

Conclusion and recommendations

The practice of laparoscopic surgery in the COSECSA region is currently limited. Common barriers to laparoscopic surgery include unaffordable services and consumables, unavailability of skilled surgeons, a lack of access to appropriate equipment, the inaccessibility of CO2, and the need for the maintenance of laparoscopic equipment. Taking these issues into account, the best initial targets for intervention to improve access to laparoscopy in COSECSA countries would be the following:

1. Capacity building in terms of the surgical workforce (including surgeons, anesthesiologists, nurses, and biomedical engineers) by creating specific laparoscopic training programs and the progressive integration of laparoscopic training in existing postgraduate surgical studies, but also in routine surgical practice.
2. Policymakers and hospital administrators should set up innovation and adaptation strategies to support the practice of laparoscopy, by creating a collaborative framework with manufacturers and pharmaceutical companies to facilitate the acquisition of low-cost laparoscopic equipment, instruments, and consumables; to permit affordable access to services but also a clear plan for the maintenance of medical equipment.
3. An increase in public and patient awareness of the procedure could also be a driver for the policymakers, showing that there is a demand for the service.

These strategies would improve patient acceptance of laparoscopic procedures and encourage surgeons to adopt laparoscopic practice.

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Declarations

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4.2. Exploring laparoscopic surgery training opportunities in the College of Surgeons of East, Central, and Southern Africa region

4.2.1. Summary

Training in laparoscopic surgery initially involved unstructured, short courses, leading to high complication rates and the development of training and credentialing guidelines. Despite these efforts, nearly a decade later, effective training remains unresolved in many countries. Laparoscopic surgery offers clinical benefits over laparotomy but requires significant investment, making it inaccessible in many LMICs including COSECSA countries. Integrating laparoscopy into these settings is challenging due to the complex skills required and unique training demands for educators.

This survey aimed to evaluate laparoscopic surgery training at COSECSA teaching sites, identify barriers and opportunities, and provide recommendations to enhance education quality and safety. By addressing gaps in training and practice, the survey sought to improve future training programs and patient care services in the COSECSA region, while seeking to review current training opinions and teaching models.

This cross-sectional multinational survey, conducted from January to October 2021, involved surgeons and surgical trainees, in COSECSA-accredited training hospitals. Utilizing a structured questionnaire with numerical scoring, close-ended, and open-ended questions, the study assessed the training capacity and identified opportunities and limitations for fully implementing laparoscopic surgery training programs. The questionnaire covered various aspects including staff qualifications, equipment availability, curriculum content, and teaching methods.

The survey unveiled significant deficiencies in laparoscopic surgery training infrastructure across COSECSA-accredited hospitals, despite a willingness to adopt the technology. Five key barriers were identified: limited equipment, absence of simulation labs, shortage of qualified trainers, lack of structured programs, and insufficient teaching time. Institutional support emerged as a major challenge

Respondents, primarily from teaching or referral hospitals across COSECSA countries, held senior positions, lending credibility to the findings. Most laparoscopic surgeons

received local training, with few trained in Europe or North America. Teaching of laparoscopic modules lacks structure, mainly relying on workshops, lectures, and box simulations. Graduating surgeons lack proficiency in basic procedures, highlighting the need for structured training from the outset. There is a pressing demand for well-structured laparoscopic surgery training integrated into COSECSA and university curricula, requiring concerted efforts to address barriers such as limited equipment, shortage of trainers, and lack of institutional support.

Improving laparoscopic surgery training in the COSECSA region is vital for surgeons to acquire essential skills and ensure patient safety, ultimately improving patient outcomes. Recommendations will enhance future programs, leading to better care. Integrate laparoscopic surgery training into surgical programs, utilizing a hands-on simulation-based model followed by a period of preceptorship.

4.2.2. Second published study

ORIGINAL REPORTS

Exploring Laparoscopic Surgery Training Opportunities in the College of Surgeons of East, Central, and Southern Africa region

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OBJECTIVE: The resource-limited environment in Sub-Saharan countries, with a lack of expert trainers, impedes the progress of laparoscopic training. This study aimed to identify the opportunities and limitations of laparoscopic surgery training in the College of Surgeons of East, Central, and Southern Africa (COSECSA) countries.

DESIGN AND SETTING: A multicountry online survey was conducted from January 2021 to October 2021 in COSECSA-accredited training hospitals within 16 countries. Available resources and challenges faced in order to set up well-structured laparoscopic training programs were explored.

RESULTS: Ninety-four surgeons answered the questionnaire. The average resources reported per hospital were 3 trained laparoscopic surgeons, 2 laparoscopic towers, and 2 sets of laparoscopic instruments. The training of the majority of these surgeons has been in local institutions (53%), a further 37% within African countries and only 10% outside Africa. Approximately 45% of them declared that laparoscopic modules were planned within the University Curricula, while only 18% of surgeons recognized that laparoscopic modules are only planned within the COSECSA program. About 57% of participants reported that at the end of residency training, graduating surgeons were not able to perform basic laparoscopic procedures. The quoted barriers included: limited laparoscopic equipment, absence of simulation lab, lack of qualified trainers, lack of training programs and time for teaching by skilled doctors, and lack of institutional support.

CONCLUSIONS: The well-structured set up of laparoscopic training programs in the COSECSA region is hindered due to the lack of qualified personnel and insufficient resources for the acquisition of equipment and simulation laboratories. Ongoing efforts to set up laparoscopic programs through the development of adaptive curricula, innovative strategies for reduction of equipment cost and adequate training of surgeons are crucial for patient safety and the development of laparoscopy. (J Surg Ed 80:1454–1461. © 2023 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

ABBREVIATIONS: LMIC, Low and middle-income countries COSECSA, College of Surgeons of East, Central and Southern Africa MCS, Membership of the College of Surgeons FCS, Fellowship of the College of Surgeons HIC, High-income country FLS Fundamentals of Laparoscopic Surgery

KEY WORDS: laparoscopic surgery, minimally invasive surgery, training, opportunities, limitations, Sub-Saharan Africa

COMPETENCIES: Medical Knowledge, Practice-Based Learning and Improvement

INTRODUCTION

It has been demonstrated that access to surgical care in Sub-Saharan Africa is limited by many factors such as

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transport, infrastructure, geography, culture, and finances.[1] The insufficient number of qualified healthcare professionals also remains a major issue, particularly in modern approaches such as laparoscopy.[1,2] The main advantages of the laparoscopic approach have been documented in many clinical trials.[3] In low and middle-income countries (LMICs) it has been reported that laparoscopy may be associated with a significant reduction in postoperative wound infection rate, shorter hospital stay and faster recovery, when compared to open surgery.[4-8]

Laparoscopy has brought new educational challenges to ensure that surgeons are adequately trained to provide its benefits in a safe environment. The College of Surgeons of East, Central, and Southern Africa (COSECSA) is a professional organization, founded in 1999, that fosters surgical education and training. The college currently includes 139 accredited hospitals in 14 Sub-Saharan countries: Botswana, Burundi, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Rwanda, South Sudan, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe. The mission of COSECSA is to increase the accessibility of surgical services, especially to the rural populations of Africa, by standardizing and widening access to surgical training, skills and knowledge with a mandate to advance the science and practice of surgery in the region.[9] There are 2 training systems for surgeons in the COSECSA region. The first is based within the universities and trains postgraduate students in a variety of surgical specialties through a Master of Medicine program. The second system, established by COSECSA, oversees accredited training programs in several hospitals and includes 2 years of basic surgical skills from the Membership of the College of Surgeons (MCS) and a following 3 years from the Fellowship of the College of Surgeons (FCS). The laparoscopic surgery modules are integrated into the teaching curricula of some universities and the modules are elective in the COSECSA program.

Mastering laparoscopy and its training is an exciting challenge for the next generation of surgeons in Sub-Saharan Africa.[10,11] Currently and in the majority of situations, the main model for developing a laparoscopy program in LMICs is that of partnering with a surgical program in a high-income country (HIC) that facilitates staff training, equipment purchase, and development of clinical guidelines.[4,5,7,12-15] This model still leads to expectable challenges. Programs offering intermittent clinical support in LMICs may result in inadequate training and program discontinuation after course has been completed if a sustainability plan has not been designed.[4,5,7,12,16]

The aim of this study was to identify the opportunities for and limitations of training in laparoscopic surgery in the COSECSA countries, to provide recommendations to strengthen laparoscopic surgical education and to improve the quality and safety of laparoscopic practice in this Sub-Saharan region.

MATERIAL AND METHODS

Research Method and Setting

This was a cross-sectional study based on the expertise of healthcare professionals. The authors conducted a multinational survey from January 2021 to October 2021 using a structured questionnaire containing numerical scoring and close-ended questions. Open-ended questions were asked to reveal the resource capacity and limitations for the teaching of laparoscopic surgery in their universities and hospitals. The questionnaire was distributed to surgeons in different COSECSA-accredited training hospitals using an online survey form. Implied consent was obtained from all the study participants when they registered on the web-based survey. The COSECSA Institutional Review Board (IRB) approved this study (IRB Registration Number: 00011122).

Data Collection

Questions focused on the training capacity of the hospitals including qualified staff, equipment, instruments, surgical activities, in addition to curriculum and teaching methods, in laparoscopic surgery. The opportunities and limitations were identified in order to fully implement the laparoscopic training program in the respective Universities and hospitals.

Data Analysis

Data were recorded using Microsoft Excel spreadsheets and exported to International Business Machines (IBM) Statistical Product and Service Solutions (SPSS) software platform version 25 for analysis. Descriptive data were used to generate frequencies and percentages for categorical variables. The median and interquartile range (IQR) were used to describe the central tendency and dispersion of continuous data, respectively.

RESULTS

Demographic Characteristics

Ninety-four surgeons from 16 countries replied to the questionnaire. The East and Central African countries accounted for 75.4% while Southern African countries represented 24.6%. Table 1 shows that the majority of responders were practicing in public hospitals (n = 66, 70.2%) including 46.8% in university teaching hospitals and 39.4% in referral hospitals. The majority were

TABLE 1. Hospital and Professional Profile of the Participants

	n	%
Hospital ownership		
Public	66	70.2
Private	21	22.3
NGO	7	7.4
Hospital type		
District/provincial Hospital	13	13.9
Referral Hospital	37	39.4
University Teaching Hospital	44	46.8
Administrative position		
Hospital manager	3	3.2
Clinical director	4	4.3
Program coordinator	18	19.1
Head of department	23	24.5
None of the above	52	55.3
Specialty		
General surgery and subspecialties	75	79.7
Pediatric surgery	7	7.4
Urology	12	12.8
Clinical position		
Chief consultant	13	13.8
Senior consultant	15	16
Consultant	28	29.8
Junior consultant	19	20.2
Surgical trainee	19	20.2

NGO, Nongovernmental organization.

general surgeons (79.7%), and other specialties included urology (n = 12, 12.8%) and pediatric surgery (n = 7, 7.4%). The participants who occupied a managerial position accounted for 40%, and approximately 20% of responders were surgical trainees.

Surgical Volume and Hospital Capacity for the Laparoscopic Surgery Training in the COSECSA Region

On average the hospitals each had 3 surgeons practicing laparoscopic surgery, 2 laparoscopic towers, and 2 sets of laparoscopic instruments. A median of 10 laparoscopic procedures per month was reported (Table 2). Generally, surgeons who performed laparoscopic procedures declared that they had been trained locally (53%), while 37% had been trained in African countries and only 10% had been trained outside Africa (Fig. 1).

Teaching Capacity and Teaching Methods

Almost 43.6% (41/94) of participants indicated that modules were actually planned within universities, while only 35.1% (33/94) of participants declared that these modules are actually taught. In the case of the COSECSA program, 28.7% (27/94) of participants recognized that the modules were really planned in the curriculum, while 18% (17/94) of participants declared that the modules were planned and taught, and only 8.5% (8/94) of

TABLE 2. Hospital Capacity and Surgical Volume Per COSECSA Affiliated Hospital

	Minimum	Q1	Median	Q3
Performed laparoscopic procedures	1	4	10	20
Laparoscopic towers	1	1	2	3
Laparoscopic instrument sets	1	1	2	3
Trained laparoscopic surgeons	1	2	3	4

participants declared that the modules were taught during clinical rotations of the trainees even if they had not been planned in the COSECSA program. Considering the teaching methods of laparoscopic surgery, Table 3 shows that 4 key teaching methods were used, including workshops (68.1%), lectures (53.2%), simulations (53.2%) and videos (34%). The dry laboratory was the most commonly used type of simulation (57.6%) (Table 3) while the wet lab was used by 1.1% and the cadaver was never employed in laparoscopic training in the region (Table 3).

Laparoscopic Teaching Program Model and Trainee Learning Process

About 57% of participants answered that, in their view, at the end of residency training, the graduating surgeons were not able to perform basic laparoscopic procedures. In addition, 55.3% of participants said that in formal training, the trainee should be exposed to basic laparoscopic skills throughout their education, starting from year 1. About 95% of the participants declared that there was an urgent need to implement well-structured laparoscopic surgery training programs in their own country. However, they confirmed that the best way of achieving this would be by integrating laparoscopic training into

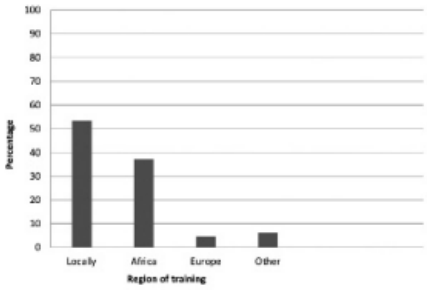

FIGURE 1. Training region for surgeons in laparoscopic surgery.

TABLE 3. Teaching Capacity and Teaching Methods of Laparoscopic Surgery in the University and COSECSA Hospitals

	n	%
Teaching methods of laparoscopic surgery		
Workshops	64	68.1
Lectures	50	53.2
Simulations	50	53.2
Videos	32	34
Cadaver	0	0
None	12	12.8
Simulation Lab type		
Dry lab	53	57.6
Virtual simulation	10	10.9
Wet lab	1	1.1
None	28	30.4

existing COSECSA and university curricula, without it being a stand-alone program (Table 4).

Barriers to Proper Training in Laparoscopic Surgery

Figure 2 shows the perceived barriers that prevent the proper training of laparoscopic surgery in COSECSA region. The 5 most highly cited obstacles were limited laparoscopic equipment (n = 79, 84%), lack of simulation lab (n = 51, 54.3%), lack of qualified trainers (n = 48, 51%), lack of training program (n = 44, 46.8%) and time for teaching by skilled doctors (n = 39, 41.5%), respectively. In addition, the receiving support from institutions, either the hospitals or universities, has been found to be a significant challenge. Consequently, participants suggested that in setting up proper training in laparoscopic surgery in the COSECSA region, special attention should be paid to the availability of equipment and consumables, increasing the number of trainers, developing formal laparoscopy training programs and simulation laboratories, and establishing serious leadership involvement (Table 5).

TABLE 4. Laparoscopic Teaching Program Model and Trainee Learning Process

	n	%
Do you think that at the end of residency training in your hospital, the graduated surgeon is able to perform basic laparoscopic procedures?		
No	53	57
Yes	40	43
When do you think that residents in surgery should be exposed to basic laparoscopic surgical skills?		
Throughout their training starting from year 1	52	55.3
Second year	13	13.8
Third year	13	13.8
First year	10	10.6
Fourth year	5	5.3
Final year	1	1.1
Do you think that it is important to have formal laparoscopic surgery training in your country?		
No	5	5.3
Yes	89	94.7
What is the best way of developing and promoting laparoscopic surgery in your country?		
Integrated program into the existing programs without a standalone program	81	86.2
COSECSA fellowship in laparoscopic surgery	37	39.4
University training degree in laparoscopic surgery	24	25.5

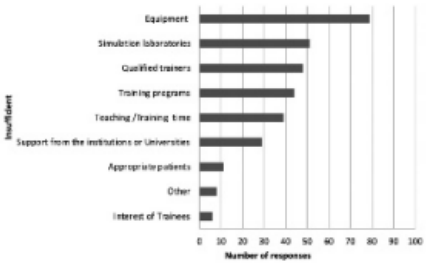

FIGURE 2. Barriers to proper training in laparoscopic surgery in COSECSA countries.

DISCUSSION

The advent of laparoscopic surgery has caused a model shift in surgical practice. Conditions requiring surgical care account for an estimated 20% of the global burden of disease, but unfortunately the delivery of surgical services within sub-Saharan Africa is challenging.[17-19] However, there is a rising trend to develop surgical treatment in LMICs[20-22] with laparoscopic surgery playing an

TABLE 5. Aspects Needed to Improve Training in Laparoscopic Surgery

Aspects needed to improve training in laparoscopic surgery	n	%
Equipment and consumables	59	71.1
Number of trainers	40	48.2
Formal training program	28	33.7
Simulation laboratory	23	27.7
Hospital leadership and support	6	7.2
Other	7	8.4

important role. As surgical culture and behavior have been reported as having an impact on the introduction and progress of new technology, a mind shift regarding laparoscopic surgery and other new surgical techniques needs to be encouraged in Sub-Saharan countries in order to improve the current situation. The aim of this study was to identify the opportunities for and limitations of laparoscopic surgical education in the COSECSA region. This multicountry survey demonstrates that COSECSA-accredited hospitals have basic and insufficient resource teaching capacity for the implementation of the laparoscopic surgery training programs, despite being willing to embrace this new technology. Figure 2 shows the 5 perceived barriers that prevent the proper training of laparoscopic surgery in the COSECSA region: 1) limited laparoscopic equipment, 2) lack of simulation labs, 3) lack of qualified trainers, 4) lack of training programs and 5) limited time for teaching by skilled doctors. In addition, this study identified the fact that gaining the support of the institutions, either hospitals or universities, as an important challenge. Therefore, the laparoscopic volume reported in this study was very low, 10 laparoscopic procedures per month per hospital, which becomes another barrier to laparoscopic training.

All but 2 COSECSA countries were represented in this survey and the majority of responders were working in teaching or referral hospitals and with managerial positions. This made the study population of great interest as most surgeons are trained in university teaching and referral hospitals. The fact that the responders to the survey were in senior positions increased the accuracy and relevance of the information collected, as they are the ones who deal with the day-to-day situations, are familiar with the system, but are also able to come up with the appropriate strategies to resolve any issues. However, in Africa, the practice of laparoscopic surgery is not sufficient in teaching hospitals. For example, Afuwape et al. reported that only a few therapeutic laparoscopic surgery procedures are performed in Nigerian teaching hospitals on an annual basis.[23]

A short supply of sufficiently skilled laparoscopic surgeons and limited of equipment have been cited as barriers in this study. Laparoscopy programs are complex and require initial and sustained investments, including high levels of human capital, equipment, technical facilities and finances.[4-6,24,25] Farrow et al. also found that poor access to training, laparoscopic equipment, equipment maintenance, and consumables were among the obstacles barring access to laparoscopy in developing countries.[26] Others studies have reported that the lack of resources and education are only 2 of the potentially numerous challenges in the complex problem of the adoption of laparoscopic surgery in LMICs.[27,28] The findings from this present study found that the majority of surgeons who performed laparoscopic procedures have been trained locally and in African countries, with only a small minority undergoing training in Europe and North America. In certain LMICs visiting surgeons, and some nationals who have relocated from HICs, work on the expansion and further development of laparoscopic surgery. Moreover, as part of their continuing professional development, some surgeons from LMICs travel to centers in the United States and Europe to gain further laparoscopic experience.[29]

The data from this survey revealed that the teaching of modules of laparoscopic surgery in the universities and COSECSA countries is not well structured, hardly a few of the surveyed surgeons recognized that the modules are planned and taught during clinical rotations and the teaching methods used include workshops, lectures, simulations and videos while the use of a wet lab is scarce. It has been reported that laparoscopy is not taught in postgraduate programs in several LMICs because simulation laboratories are not readily available. This is due to the high cost of the equipment and the lack of animal or cadaver laboratories.[30] Laparoscopy is not suited to the old surgical mantra of "see one, do one, teach one." Under this traditional model some local surgeons in LMICs have acquired and developed laparoscopic abilities in an unstructured way. This approach potentially teaches unsafe practices to surgeons in training.[30] The training programs should be structured to include lectures and workshops rather than just short-term courses. Global connectivity through technology can also facilitate teaching and training methods with the development of Google glasses, Facetime, and Skype, for example, which permit communication, consultation, and feedback.[30]

From our findings it is appears that the majority of graduating surgeons are not able to perform basic laparoscopic procedures. Additionally, participants thought that to have good acquisition skills the trainees should be exposed to basic laparoscopic skills throughout their education from the beginning of their surgical training. Therefore, it is important to set up a structured model where the trainee will take part to simulation exercises outside away from the operating room. The participants showed an urgent need to implement well-structured laparoscopic surgery training and to integrate it into existing COSECSA and university curricula. In response to this perceived need for more advanced training within residency, the afore-mentioned FLS was created. Its cognitive content, manual skills training, and assessment were formalized, standardized, and then disseminated via a national curriculum.[31]

Limited laparoscopic equipment, lack of laparoscopic simulation labs, lack of qualified and motivated

laparoscopic trainers, fewer laparoscopic procedures, clack of training laparoscopic program, and lack of leadership involvement were found to be the barriers for the proper set up of laparoscopic surgery training in COSECSA region. The resource-limited setting in LMICs hinders the progress of laparoscopic training, with the scarcity of expert mentors.[30] Innovative measures have been developed to counteract the simulation problem with low fidelity but effective trainers. Resourceful laparoscopic trainers using simple technology at a low cost have emerged from both LMICs and HICs. Home laparoscopic trainers have been made from recyclable materials such as storage and shoe boxes.[30,32] Simulation-based training, even with inexpensive equipment, requires an investment in time and sustainability.[33] Using materials sourced locally is key to the success of making affordable laparoscopic training tools.[30] The recording of common and basic procedures such as appendectomies and cholecystectomies for teaching and training purposes is considerably underutilized in both LMICs and HICs.[30] This can allow all the team in the operating room, including trainees, to understand the processes involved in these laparoscopic operations.[30] Internet access can also facilitate learning as a number of movies of laparoscopic procedures are freely available online. Curricular can facilitate the learning of laparoscopic skills in LMICs using low cost trainers and these need to be developed.[30] Zadey et al. have developed a low-cost laparoscope called KeyScope and a lift retractor called KeyLoop, collectively referred to as KeySuite. It has been designed for the challenges and needs of LMICs,[34] while lift laparoscopy has been documented for performing cholecystectomies and appendectomies in LMICs.[35] KeyScope has been bench-tested against the standard laparoscope and was found to have noninferior image quality and illumination with a comparable field of view, depth, resolving power, lens distortion, and color reproduction accuracy.[36] The global economic picture for better healthcare should include the manufacture of robust, durable, and affordable surgical instruments that can be used by LMICs.[30]

Limitations

The accuracy of the answers could not be verified as the survey was conducted online. Two COSECSA countries were not represented in our study, notably Sudan and South Sudan; conversely, some East African community countries were over-represented, undoubtedly due to the geographic location of the principal investigator. However, the authors limited this bias by presenting the results as median, as the responses were not symmetrically distributed.

CONCLUSION

Laparoscopic surgery requires extensive experience. When performed safely it offers better results in comparison to open surgery. At a present time, 20 years after the introduction of these procedures, there is still a need for training opportunities at all levels.[37,38] However, in the COSECSA region it remains difficult to set up laparoscopic training programs due to the lack of qualified personnel and insufficient financial resources for the acquisition of equipment and the simulation laboratories. Ongoing efforts to overcome these limitations through the efforts of the surgeons, the development of structured programs and innovative measures, and the adequate training of surgical trainees, are crucial for patient safety. Improving laparoscopic training could lead to an increase in the number of laparoscopic cases and reduce the learning curve of trainees, which is a primary goal of imparting skills. The training and practice of laparoscopic surgery in Sub Saharan Africa could be improved and made more broadly available through postgraduate medical education.

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4.3. Patient-Reported Outcome, Perception and Satisfaction after Laparoscopic Cholecystectomy in Kigali, Rwanda

4.3.1. Summary

Laparoscopic surgery is the standard approach for many abdominal procedures in high-income countries but remains largely inaccessible in LMICs, including much of Sub-Saharan Africa. In these regions, laparoscopic surgery faces numerous challenges, and where it is practiced, patient outcomes and satisfaction are often underreported. Understanding these factors is essential for improving the quality of care. This study aimed to evaluate these aspects by analyzing a retrospective series of 288 patients who underwent laparoscopic cholecystectomy at CHUK.

Recent studies indicate that laparoscopy is a feasible, safe, and clinically beneficial approach in LMICs, though complication rates may be underreported. In Rwanda, laparoscopic surgery was introduced into routine elective procedures at CHUK in 2015, with laparoscopic cholecystectomy being among the most frequently performed operations. However, data on patient safety, satisfaction, and the overall quality of these procedures remain limited. This study sought to assess the clinical outcomes of laparoscopic cholecystectomy at CHUK and evaluate patient satisfaction and experience to enhance the quality of care for individuals undergoing laparoscopic surgery in Rwanda.

This cross-sectional observational study used both retrospective and prospective data collection methods. Retrospective data were obtained from medical records and operating room registers for 288 laparoscopic cholecystectomies performed at CHUK between January 2015 and December 2020. Collected data included patient demographics, surgical details, intraoperative and postoperative complications, and hospital length of stay. Additionally, a random sample of patients was contacted via telephone for follow-up. After obtaining verbal consent, these patients completed a structured questionnaire assessing their awareness of laparoscopic surgery, pain levels, scar aesthetics, recovery time, surgery costs, and overall satisfaction. The questionnaire incorporated a Likert scale and open-ended questions, allowing patients to describe negative experiences and provide recommendations for service improvement.

The study found that laparoscopic cholecystectomy at CHUK resulted in favorable outcomes, with low rates of postoperative complications (1.7%) and mortality (0.7%) and a short hospital stay (median: 3 days). Serious complications, such as biliary peritonitis and bowel injuries, were rare. Conversion to open surgery was infrequent (1.4%) and primarily due to bleeding or technical difficulties.

Patients, although initially unfamiliar with laparoscopic techniques, were generally satisfied with the surgical approach and reported a positive experience. Over 95% of patients expressed satisfaction with the overall service, appreciating factors such as hospital stay, recovery time, pain management, and scar aesthetics. Many also indicated their willingness to advocate for the adoption of laparoscopic surgery, despite its associated costs.

However, patients made several critical recommendations for improving service delivery. These included:

- **Capacity building** through increased training of laparoscopic surgeons to ensure skill development and expertise.
- **Improving equipment and consumables** availability to support the effective execution of laparoscopic procedures.
- **Strengthening professional-patient relationships** to enhance communication and trust.
- **Increasing public awareness** about minimally invasive surgery (MIS) to inform and educate the population on its benefits and availability.

These recommendations highlight the areas for improvement in laparoscopic service delivery and the potential for enhancing patient outcomes in Rwanda. While the study's retrospective design may limit its generalizability beyond Rwanda, it provides valuable insights into patient experiences and surgical outcomes within a resource-limited setting. Addressing the identified recommendations could pave the way for significant advancements in laparoscopic surgery and patient care in Rwanda and similar LMIC contexts.

4.3.2. Third published study

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Research Paper

Patient-reported outcome, perception and satisfaction after laparoscopic cholecystectomy in Kigali, Rwanda

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ABSTRACT

Background: Laparoscopic surgery is the gold standard for many abdominal surgeries. Laparoscopic programs in low- and middle-income countries (LMICs) and in sub-Saharan Africa face many constraints, although its use is safe, feasible, and clinically beneficial. The authors assessed patient-reported outcomes and the experience of patients operated on at the University Teaching Hospital of Kigali (CHUK).

Methods: This is a retrospective cross-sectional study combining medical data from medical files and information collected from telephone calls to 288 patients who underwent laparoscopic cholecystectomy at CHUK from January 2015 to December 2020.

Results: Among 446 laparoscopic surgeries performed at CHUK over 6 years, cholecystectomies accounted for 64.6 % of cases (288/446). Postoperative complications and mortality after laparoscopic cholecystectomy were low, respectively 1.7 % and 0.7 %, while the median length of stay was 3 days. About 74 % of surveyed patients had never heard of laparoscopic surgery prior to their procedure. Knowledge of laparoscopic surgery was associated with patient education level ($p < 0.001$). Half of patients had not been involved in the choice of the surgical technique. Overall satisfaction was over 95 % and >90 % of patients consider laparoscopic surgery as the best surgical approach in Rwanda, and for this reason they declared to be ready to promote this new technology despite its higher cost. However, patients reported some weaknesses and made recommendations for improving public awareness of laparoscopy and its benefits, patient-provider relationships, training of surgical workforce, laparoscopic equipment, and infrastructure.

Conclusion: Laparoscopic cholecystectomy can be performed with a low rate of postoperative complications in a resource-limited setting like Rwanda. Patient satisfaction was high, but efforts should be made to improve public awareness of laparoscopic surgery, improve surgical capacity, laparoscopic equipment, and infrastructure.

Introduction

Laparoscopic surgery has become the gold standard for many abdominal surgical procedures in the Western world [1–3]. Laparoscopic programs in Low- and Middle-Income Countries (LMICs) face many constraints, including a shortage of qualified staff, limited resources, equipment, and maintenance capacity, increased operating time and lack of safe procedural guidelines [4–8]. Recent studies have shown that laparoscopy is feasible in LMICs and could be safe and clinically beneficial [8–10]. However, it has been proven that complication rates might be underreported in the literature. In addition, the number of laparoscopic cases in most LMIC units has not reached a level where complications directly related to the laparoscopy are reported [11–13]. Major complications such as bile leaks and duodenal

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perforations following laparoscopic cholecystectomy have been reported in a large series of patients in Afghanistan [5].

Among patient-reported outcomes, patient satisfaction (PS) and quality of recovery are key measures of patient-centered care. PS can relate to the outcome of care treatment and/or to the perception of the process of care, and it has emerged as an important indicator of health care quality [14,15]. This applies to surgical care in general, but also to laparoscopic surgery whose benefits in terms of perioperative morbidity, postoperative pain, hospital stay, cosmesis and overall cost have been proven, with consequently a rapid postoperative recovery [16,17].

Approximately 80,000 surgical procedures are annually performed in Rwanda [15]. Rwanda, a country of 11.9 million people in Sub-Saharan Africa, has 4 main referral hospitals performing surgical operations including laparoscopic procedures. The University Teaching Hospital of Kigali (CHUK) is the main public, tertiary referral hospital of Rwanda. CHUK has 565 beds and 11 operating rooms, shared among all surgical units that annually perform approximately 4000 major surgical procedures. In 2014 a national assessment of laparoscopic practice in Rwanda showed that 209 laparoscopic procedures had been performed in Rwanda, and only 7 cholecystectomies in CHUK [18]. To fill this gap, CHUK started performing laparoscopic procedures in 2015 and laparoscopic cholecystectomy was among the most performed procedures.

In many LMICs, patient safety, patient satisfaction and the quality of laparoscopic surgery are not sufficiently documented. This study aimed to evaluate the clinical outcomes of laparoscopic cholecystectomy and to assess the satisfaction and experience of patients operated on at CHUK with laparoscopic techniques in order to further improve the process of care for patients undergoing laparoscopic surgery in Rwanda.

Material and methods

Method and setting

This was a cross-sectional observational study combining a retrospective review of data from medical records and data from phone call follow-ups of the patients who had undergone laparoscopic cholecystectomy in the Surgery Department of CHUK from January 2015 to December 2020. This study was approved by both the Institutional Review Board (IRB) of the University of Rwanda, and the Ethics Committee of CHUK with reference numbers No 412/CMHS IRB/2021 and EC/CHUK/075/2021, respectively.

Data collection

Data were retrospectively retrieved from operating room registers and medical record system. A total of 288 cases of laparoscopic cholecystectomy among 446 laparoscopic procedures were recorded during the study period. Data collected included age, gender, transfer note, date of surgery, medical diagnosis, procedure performed, intra-operative complications, drain placement, conversion to open surgery, duration of surgery, postoperative complications according to the Clavien-Dindo classification [19] and hospital length of stay (LOS).

Patient opinions

A random sample of patients underwent cholecystectomy were contacted prospectively by telephone and provided verbal consent to participate in this study; additionally, they completed a structured questionnaire that included end-to-end questions, a Likert scale rating and open-ended responses. The questionnaire covered awareness of laparoscopic surgery, patient experience during the surgical process including pain, scar aesthetics, time to return to normal activities, cost of surgery and overall satisfaction about the technique. Patients were asked to express their bad experience and provided recommendations to improve service delivery.

Data analysis

Data were recorded using Microsoft excel spreadsheets and exported to international business machines (IBM) Statistical Product and Service Solutions (SPSS) version 25 for analysis. Descriptive data were used to generate frequencies and percentages for categorical variables. The median and interquartile range (IQR) was used to describe the central tendency and dispersion of continuous data, respectively. The significance of the association between dependent and independent variables was measured using Chi-square for expected frequencies of >5. A p-value <0.05 was considered significant.

Results

Socio-demographic characteristics

A total of 288 laparoscopic cholecystectomies over 446 laparoscopic procedures were performed during the study period, with a gradual annual increase (Fig. 1). The majority (87.2 %) of patients were women and >58 % of patients were older than 40, with a median age for women of 44.5 years and 34.2 years for men. More than 50 % came from their homes without any medical transfer and 44.4 % of patients were transferred from district hospitals (Table 1).

Clinical features of laparoscopic cholecystectomy and post-operative complications

Laparoscopic cholecystectomy was performed successfully with only 4 cases (1.4 %) of conversion to open surgery. Five patients (1.7 %) developed post-operative complications with a grade > 1 using Clavien-Dindo classification. Two patients suffered from biliary peritonitis secondary to bile duct injury, one suffered from iatrogenic bowel injury, one from surgical site infection and an additional one from deep vein thrombosis. Among the patients with postoperative complications 2 were re-operated on for further management. Two patients were admitted to the intensive care unit for cardiorespiratory support, and in total 2 patients died (0.7 %) due to hemorrhage and biliary sepsis from bile duct injury (Table 2). Fig. 3 shows the evolution of laparoscopic skill acquisition by junior consultants and the gradual annual increase in the volume of laparoscopic procedures, where currently almost half of laparoscopic cholecystectomies are performed by junior consultants after 6 years of surgical exposure.

Patient information and knowledge

In total 164 random patients were contacted by telephone and interviewed regarding their social status and education as well as their preoperative knowledge and experience of the laparoscopic procedure they had undergone. Concerning the level of education, 62 % of contacted patients had at least completed secondary school and the patient's knowledge of laparoscopic surgery was strongly associated with the level of education ($p < 0.001$) (Table 3). In total, 122 (74 %) patients confirmed that they had never heard of laparoscopic surgery before undergoing their operation, and of those who knew before, only 30 (24.6 %) obtained the information from the attending surgeon (Fig. 2). More than 64 % of the interviewed patients were informed about this technique and its advantages, for the first time, just before surgery and half of the patients were not involved in the choice of the laparoscopic technique (Table 4). However, following surgery, >90 % of the contacted patients stated that laparoscopic surgery is the best surgical approach for surgical care in Rwanda, and that they were willing to promote this technique despite its higher cost (Table 4).

Patient-reported experience and satisfaction

Patient satisfaction as measured using indicators including the

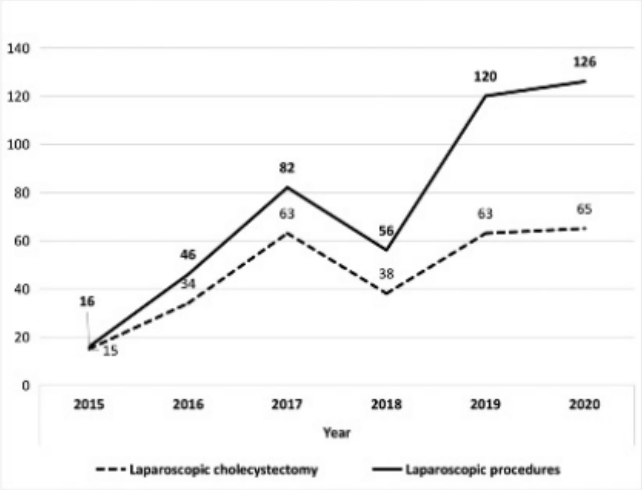

Fig. 1. Trend of laparoscopic cholecystectomies at CHUK since 2015.

Table 1
Socio-demographic characteristics of operated patients.

	n (288)	%
Age at operation		
<20 years	3	1.1
20–39 years	91	31.6
40–69 years	169	58.7
≥70 years	25	8.7
Sex (median age)		
Male (34.2 years)	37	12.8
Female (44.5 years)	251	87.2
Transferring hospital		
Home	150	52.1
Private clinic	2	0.7
District hospital	128	44.4
Referral hospital	8	2.7

Table 2
Characteristics of the laparoscopic cholecystectomy and postoperative complications.

Laparoscopic cholecystectomy	n (288)	%
Conversion to open surgery		
No	284	98.6
Yes	4	1.4
Reason for conversion	4	1.4
Bleeding	1	0.25
CBD injury	1	0.25
Bowel perforation	1	0.25
Instrument problem	1	0.25
No complications	283	98.3
Post-operative complications Clavien-Dindo classification	**5**	**1.7**
Grade I	2	40
Grade II	0	0.0
Grade III	1	20
Grade IV	0	0.0
Grade V	2	40
Types of post-op complications (n = 5)		
Biliary peritonitis	2	0.4
Bowel perforation	1	0.2
Surgical site infection	1	0.2
Thrombophlebitis	1	0.2
Indications for reoperation (n = 2)		
Biliary peritonitis	2	100
Reason for ICU admission (n = 2)		
Cardiorespiratory support	2	100
Mortality	**2**	**0.7**
Cause of hospital death (n = 2)		
Hemorrhage	1	50
Biliary sepsis	1	50
Hospital stay	Median: 3 days (Min 1, Max 13)	

Abbreviations: ICU: intensive care unit, CBD: Common bile duct.

assessment of LOS, time to return to normal activities, pain, scar size and aesthetics, and general care, is reported in Table 5. More than 95 % of interviewed patients said that they were satisfied with laparoscopic surgery.

Around 10 % of patients reported having a poor experience of the service provision and/or a substandard interaction with health care providers during admission (Table 6). All surveyed patients came up with recommendations for future laparoscopic surgery care and suggested that more improvements should be made in 5 aspects of care, including public awareness of the laparoscopic service, resource and training capacity, the patient-provider interaction, the cost of service and service delivery in general (Table 6).

Discussion

Laparoscopic surgery remains unavailable to the majority of the population living in LMICs. Additionally, the majority of countries in sub-Saharan Africa have not yet fully adopted this surgical practice due to several challenges that need to be addressed [1]. In certain countries where laparoscopic surgery is practiced, patient outcomes are underreported. Patient experience and satisfaction with this new surgical approach have not yet been evaluated or reported, even though they are indicators used to improve the quality of care. This reality motivated us to conduct this study to evaluate the postoperative results of a retrospective series of 288 patients who had undergone laparoscopic cholecystectomy at CHUK. In this series, which we consider to be among the

Table 3
Information about laparoscopic surgery and level of education.

	Yes	No	p value*
	n (%)	n (%)	
Level of education (N = 164)			
None	2 (7.4)	25 (92.6)	<0.001
Primary	6 (16.7)	30 (83.3)	
Secondary	13 (17.3)	62 (82.7)	
University	16 (44.4)	20 (55.6)	

* Chi-square test.

most significant reported in laparoscopic surgery in the East and Central Africa region, more than half of operated patients were randomly called and their perceptions and satisfaction following their experience about this new surgical approach were assessed.

The results from this Rwanda experience have shown that laparoscopic cholecystectomy, the most performed laparoscopic procedure (64.6 %) can be performed with a minimal rate of postoperative complications (1.7 %) with low mortality rate (0.7 %) and an average LOS in hospital of 3 days. In our study only 4 (1.4 %) cases required conversion to open surgery due to bleeding, CBD injury, bowel perforation and non-surgical technical issues and 2 (0.7 %) cases needed reoperation for postoperative complications. In addition, considering the interviewed patient, the majority of them (>95 %) reported satisfaction with the procedure despite insufficient resources in equipment and qualified personnel, and despite the fact that 74 % of them declared that they had never heard of laparoscopic surgery before undergoing their operation.

Many series have shown that laparoscopic cholecystectomy has gained wider acceptance, accounting for roughly 90 % of all cholecystectomies in the United States despite an overall serious complication rate of 5 % that remains higher than that seen in open cholecystectomy, despite increasing experience with the procedure [20–23]. A reduced hospital stay averaging three days similar to our result has been reported [24]. In this series the most serious complications were biliary peritonitis due to common bile duct and bowel injuries. Serious complications that occur with laparoscopic cholecystectomy, including bile duct injury, bile leaks, bleeding, and bowel injury have been reported previously [9,25–27], and this is due in part from patient selection, surgical experience, and the technical constraints that are inherent to the minimally invasive approach [23]. The mortality was low in our series compared to other LMICs where the perioperative mortality is reported to be 5–10 %; encouragingly, our result is similar to the mortality rate of 0.4–0.8 % reported in Western countries [13].

During the survey, 164 patients among the 288 were randomly interviewed, the patients were asked about their knowledge and experience concerning the laparoscopic surgery they had undergone. About 74 % of the interviewed patients reported that they had never heard of laparoscopic surgery before their surgery, and this knowledge of the surgical technique was associated with the level of education of the patient ($p < 0.001$). It was found that than half of the patients interviewed were not involved in the choice of laparoscopic technique. There is no indication in the reported data about patient awareness and knowledge of the laparoscopic technique, as well as the choice of involvement or not in laparoscopic techniques before surgery in LMICs.

Laparoscopic surgery is generally considered less invasive than open abdominal surgery, both from the viewpoint of aesthetics and postoperative recovery. The indicators used in order to assess the level of

Table 4
Information provision about performed surgical technique.

Information provision n = 164	Yes		No		Neutral	
	n	%	n	%	n	%
Information about my surgery, benefits and consequences	105	64.0	55	33.5	4	2.4
Involved in the choice of the laparoscopic surgery technique	80	48.8	81	49.4	3	1.8
Laparoscopic surgery is the best option for surgical care in Rwanda	149	90.9	3	1.8	12	7.3
Cost of this treatment is high considering my income	62	37.8	90	54.9	12	7.3
If I had to be operated again, I would choose the same technique	157	95.7	3	1.8	4	2.4
Willing to promote this new technique	156	95.1	3	1.8	5	3.1

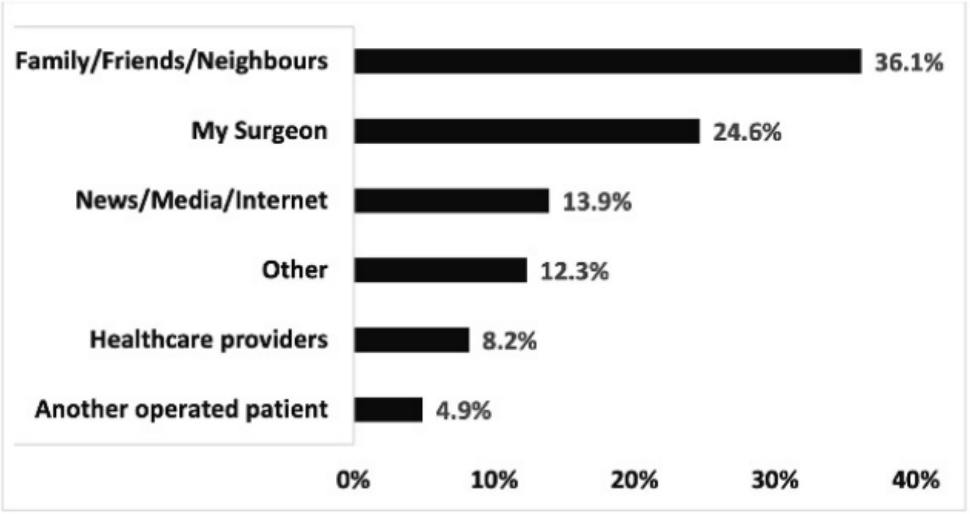

Fig. 2. Source of information about laparoscopic surgery.

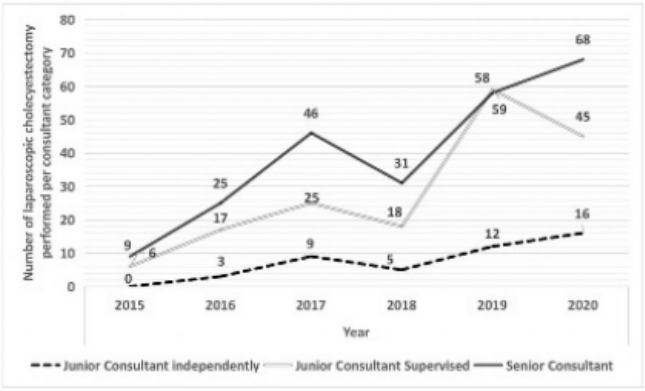

Fig. 3. Laparoscopic cholecystectomy performance and learning curve of junior consultants at CHUK.

Table 5
Patients' satisfaction.

Patients' satisfaction N = 164	Satisfied		Unsatisfied		Neutral	
	n	%	n	%	n	%
Length of hospital stay	159	96.9	1	0.6 %	4	2.4
Time of recovery to normal activities	157	95.7	4	2.4 %	3	1.8
Post-operative pain	155	94.5	6	3.6 %	3	1.8
Scar size and aesthetics	157	95.7	2	1.2 %	5	3.0
Service/care delivery at the hospital	160	97.6	0	0.0 %	4	2.4

Table 6
Patient-reported bad experience during hospital stay and recommendations.

	n (164)	%
Patient-reported bad experience		
Bad patient - caregiver relationship	3	1.8
Delay in service provision	13	7.9
Everything went well	148	90.2
Recommendation from patients		
Public awareness of the laparoscopic technique	6	3.6
Capacity – resources, equipment and laparoscopic instruments	4	2.4
Capacity – training of laparoscopic surgeons	16	9.7
Improve professional - patient relationships	3	1.8
Improve service provision	29	17.7
Maintain good service	58	35.4
Decrease service cost	4	2.4
No comment	44	26.8

satisfaction included length of hospital stay, time of recovery to normal activities, pain improvement, scar size and aesthetics, and general care. It was found that the general satisfaction of the patients in this study was >95 %. More than 90 % of interviewed patients declared that laparoscopic surgery was the best approach for surgical care in Rwanda and that they were willing to promote this technique. These results are similar to a previous study that reported that early laparoscopic cholecystectomy resulted in a significant reduction in LOS and an acceptable rate of operative complications and conversion rates and the overall patient's satisfaction between 75 and 93 % [28]. Several studies have shown that lack of resources, skills training and the hierarchical nature of the local surgical culture are barriers that have affected the practice of laparoscopic surgery in different developing countries [29,30]. A study reported in 2018 identified the lack of trainers as the most unaffordable barrier to laparoscopic practice in Rwanda [18]. The patients in this series reported some weaknesses in the laparoscopic service delivery including the training of laparoscopic surgeons, laparoscopic resources, infrastructure, the patient-caregiver relationship and public awareness of the laparoscopic technique. However, overall experience and opinions of patients regarding laparoscopic surgery techniques is insufficiently documented, this needs a prospective evaluation throughout Rwanda where the results could be used to improve the quality of surgical care as well as the quality of life for patients after laparoscopic surgery.

The present study is a retrospective cross-sectional observational study, and therefore may weaken the generalizability of the results. The authors included all laparoscopic cholecystectomies performed at CHUK surgical department during the study period; thus, the risk of selection bias is low. Due to the retrospective design of the study some patient data were missing. However, this study has its strengths as it includes a considerable series of laparoscopic cholecystectomy in East and Central Africa that explored patient outcomes, experience and satisfaction in Rwanda, a country with limited resources but where approximately 90 % of the population is covered by the community-based health insurance.

Conclusion

Laparoscopic cholecystectomy can be performed with a low rate of post-operative complications in resource-limited country, and in addition to that patients have reported being satisfied with this new technology. However, an effort should be made to improve public awareness of laparoscopic surgery, improve the interactions between patient and healthcare provider, increase capacity in the training of the surgical workforce, upgrade laparoscopic equipment and develop the infrastructure. Therefore, a shift towards laparoscopic surgery and other new surgical techniques must be encouraged in our settings in order to meet the surgical needs.

CRediT authorship contribution statement

Martin Nyundo is the principal investigator in this study and has been involved in all steps of the research from the conceptualization, methodology, validation, investigation, writing original draft, writing review and editing; King Kayondo contributed to designing, methodology, validation, writing review and editing; Miguel Gasakure was involved in data collecting, data analysis, writing review and Editing;

Jean Christian Urimubabo was involved in data collection, writing review and editing; Antoine Nifasha was involved in data collection, writing review and editing; Augustin Limgba contributed to data collecting, writing review and editing; Jean Jacques Houben was involved in conceptualization, methodology, writing review, editing, validation, and Supervision; Julien Gashegu contributed to writing review and editing, validation, and supervision; Olivier Detry was involved in conceptualization, methodology, writing review, editing, validation, and Supervision.

Ethics approval

This study was approved by both the Institutional Review Board (IRB) of the University of Rwanda, and the Ethics Committee of CHUK with reference numbers No 412/CMHS IRB/2021 and EC/CHUK/075/2021, respectively.

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Declaration of competing interest

Dr. Martin Nyundo, Dr. King Kayondo, Dr. Miguel Gasakure, Dr. Jean Christian Urimubabo, Prof. Jean Jacques Houben, Dr. Augustin Limgba, Dr. Antoine Nifasha, Prof. Julien Gashegu and Prof. Olivier Detry declare that they have no conflicts of interest or financial ties to disclose.

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4.4. Introducing Enhanced Recovery After Surgery program in Rwanda: A Step-By-Step Approach from KAP Study to protocol development and preliminary implementation

4.4.1. Summary

The ERAS program, developed in Northern Europe, represents a significant advancement in perioperative care, demonstrating the ability to improve patient outcomes and expedite recovery times. Initially introduced by Henrik Kehlet in the 1990s, ERAS protocols have proven effective in reducing hospital stays for major surgeries from ten days to as few as two. This approach focuses on minimizing surgical stress through various strategies, such as preoperative optimization, MIS techniques, and early patient mobilization.

In Rwanda, the context of healthcare has seen substantial progress; however, perioperative care still faces challenges. Factors such as inadequate infrastructure, inconsistent care standards, and limited intensive care unit (ICU) capacity hinder the optimal implementation of surgical practices. Despite these obstacles, the Rwandan healthcare system, supported by national health insurance, the community-based health Insurance (CBHI) covering over 90% of the population, is well-positioned for the integration of ERAS strategies. This study specifically aimed to adapt and implement the ERAS program in Rwanda, using a structured methodology that began with a KAP assessment to inform protocol development.

The study utilized a multi-phase methodology to implement the ERAS protocol at CHUK, starting with a webinar conducted in August 2021. This event was designed to introduce ERAS principles to perioperative care providers and facilitate discussions about evidence-based practices in LMICs. The webinar identified the significant gaps in ERAS knowledge among healthcare professionals, setting the stage for further assessments through a KAP study.

Subsequently, a cross-sectional KAP study was conducted to evaluate the understanding and attitudes of perioperative providers toward ERAS. This descriptive study uncovered notable knowledge gaps. For instance, while 63.6% of respondents were aware of

international NPO (nil per os) guidelines, specific knowledge about critical ERAS elements such as multimodal analgesia with restricted opioid use and the practice of early discharge varied significantly. Only 45.7% of respondents supported early postoperative feeding, indicating the need for targeted educational interventions.

In response to these KAP findings, training sessions were organized to equip staff with essential ERAS principles. The training emphasized components such as multimodal analgesia, fasting and early feeding, as well as early mobilization and discharge. Additionally, ERAS groups were established within hospital wards, with departmental champions designated to oversee implementation, address challenges, and provide continuous education. A modified ERAS protocol for laparoscopic cholecystectomy was developed, incorporating insights from the KAP study and training sessions. This protocol was tailored to fit the Rwandan healthcare context and involved collaboration with a multidisciplinary team to ensure its practicality. To assess the effectiveness of the modified ERAS protocol, a pilot study was conducted that focused on key outcomes such as recovery times and patient satisfaction. The results of this pilot study are anticipated to provide valuable insights for the broader adoption of ERAS protocols in Rwanda, ultimately aiming to enhance surgical outcomes across various procedures.

The demographic analysis of respondents revealed that the majority were aged between 30 and 40 years and predominantly female, with educational qualifications varying widely. A significant portion of the participants were nurses, with many having over 10 years of work experience. The study found that although there was substantial awareness of the potential benefits of ERAS, 97.7% of respondents believed it could improve perioperative care actual application of ERAS principles in practice was lacking. Furthermore, while 85% of respondents acknowledged that laparoscopic surgery enhances ERAS protocols, the variability in knowledge and utilization underscores the need for continuous education and reinforcement of ERAS practices. The establishment of multidisciplinary teams was highly favored, with 94.8% of respondents supporting this approach, and 79.2% agreed that ERAS could reduce hospital expenses, further alleviating the financial burden on patients.

The findings from this study indicate that the introduction of the ERAS protocol at CHUK could significantly enhance perioperative care for laparoscopic surgeries in Rwanda.

Despite existing knowledge gaps and inconsistencies in the application of ERAS principles, the structured approach taken in this study has shown promise in improving patient outcomes. Ongoing education, contextual adaptation, and support from local healthcare champions are crucial for the sustained expansion of ERAS practices in Rwanda and similar resource-limited settings. Continued monitoring and research will be essential for refining ERAS protocols, ensuring their long-term success, and establishing a global model for surgical care improvement in these context

4.4.2. Forth submitted study

Abstract

Introducing enhanced recovery after surgery program in Rwanda: A step-by-step approach from KAP study to protocol development and preliminary implementation

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Background: ERAS programs improve postoperative outcomes through standardized, evidence-based perioperative care. While widely implemented in high-income settings, their adoption in resource-limited environments like Rwanda remains challenging due to infrastructural, educational, and cultural barriers. This study aimed to introduce an ERAS program at CHUK and develop a locally adapted approach for sustainable implementation.

Methods: A multi-phase strategy was employed to introduce ERAS at CHUK. An initial KAP survey was conducted following an educational webinar on ERAS principles to assess perioperative care providers' awareness and perceptions. Identified knowledge gaps guided targeted training sessions, culminating in the development of a context-specific ERAS protocol. A pilot intervention was subsequently implemented to evaluate feasibility and acceptance among healthcare providers.

Results: The KAP survey revealed that 45.7% of respondents were unfamiliar with ERAS principles, yet many unknowingly incorporated ERAS elements in routine practice. Despite limited awareness of international NPO guidelines and postoperative feeding recommendations, 97.7% recognized ERAS as beneficial for perioperative care, and 79.2% perceived its potential to reduce healthcare costs. Resistance to eliminating opioids entirely was noted in 81.5% of respondents. Targeted training sessions addressed these gaps, leading to the development of a modified ERAS protocol. Key facilitators of ERAS implementation included the formation of multidisciplinary collaborative groups and the designation of ERAS champions to oversee protocol adoption.

Conclusion: This study represents a foundational step in integrating ERAS principles into perioperative care in Rwanda. By addressing knowledge gaps, adapting protocols to local constraints, and fostering multidisciplinary collaboration, we demonstrated that ERAS implementation is feasible even in resource-limited settings. A structured educational approach can facilitate adoption and improve perioperative care quality. However, sustained implementation requires ongoing evaluation, investment in infrastructure, and continuous provider training. Future research should focus on long-term patient outcomes, cost-effectiveness, and strategies for nationwide ERAS adoption in low- and middle-income countries.

4.5. Implementation and outcomes of an Enhanced Recovery After Surgery Pathway for laparoscopic cholecystectomy in East and Central Africa: A Prospective Non-Randomized Controlled Trial in Rwanda's tertiary Teaching Hospital

4.5.1. Summary

The study examines the implementation and outcomes of an ERAS protocol for laparoscopic cholecystectomy in a resource-limited setting in Rwanda, specifically at CHUK. ERAS is an evidence-based, multimodal approach that minimizes surgical stress and enhances recovery by optimizing preoperative and postoperative care. Originally developed in Europe, ERAS has been widely adopted to improve patient outcomes, reduce hospital stays, and lower healthcare costs. However, its implementation in LMICs remains underexplored. This study assesses the feasibility, safety, and effectiveness of ERAS in Rwanda, hypothesizing that the protocol would benefit Rwandan patients and healthcare providers and could be adapted successfully to the local context.

A prospective, non- randomized controlled trial was conducted with two groups: an ERAS group of 50 patients who underwent laparoscopic cholecystectomy during ERAS implementation, and a control group of 50 patients who underwent laparoscopic cholecystectomy before ERAS adoption. Purposive sampling of patients operated on before ERAS implementation and prospective sampling of patients operated on under the ERAS pathway. The ERAS protocol, introduced at CHUK in January 2022, included preoperative education, intraoperative management, and postoperative strategies such as early feeding, multimodal analgesia, and early mobilization. Patient eligibility was limited to elective laparoscopic cholecystectomy cases without acute cholecystitis or ASA class IV conditions.

The study demonstrated high feasibility and acceptance of the ERAS protocol. Adherence to ERAS elements was achieved by over 90% of participants, aided by targeted educational sessions for both healthcare providers and patients. A key finding was the significant reduction in hospital length of stay, from an average of three days in the non-ERAS group to one day in the ERAS group. This reduction in hospital stay was achieved

without an increase in postoperative complications, with similar rates of adverse events and postoperative pain between groups, consistent with existing literature.

The ERAS protocol also led to cost savings despite the added expenses associated with additional medications and multimodal care. The study found that the ERAS approach was ultimately less expensive than traditional method due to shorter hospital stays, making it a more affordable solution even in a resource-limited setting.
Additionally, patient satisfaction was high, supporting the notion that ERAS can improve recovery experiences. While most patients were comfortable with early discharge, about 30% expressed a need for additional education and reassurance, underscoring the importance of clear communication in ERAS programs.

Overall, this study suggests that the ERAS protocol for laparoscopic cholecystectomy is both safe and effective in Rwanda, with the potential to serve as a model for implementing ERAS in similar LMIC contexts and for expanding ERAS to other types of abdominal surgeries. The findings emphasize the importance of training and patient education for successful ERAS adoption, showing that even in a resource-constrained environment, ERAS can improve surgical outcomes, optimize resource use, and reduce expenses.

4.5.2. Fifth published study

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ORIGINAL SCIENTIFIC REPORT

World Journal of Surgery

Implementation and outcomes of an enhanced recovery after surgery pathway for laparoscopic cholecystectomy in East and Central Africa: A prospective non-randomized controlled trial in Rwanda's Tertiary Teaching Hospital

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Abstract

Background: Enhanced recovery after surgery (ERAS) programs have demonstrated efficacy in optimizing perioperative care and improving patient outcomes in various surgeries. However, their implementation and outcomes in resource-limited settings remain underexplored. This study aimed to assess the implementation of an ERAS protocol for laparoscopic cholecystectomy in such a setting.

Methods: This prospective non-randomized controlled trial involved 100 patients undergoing laparoscopic cholecystectomy at the University Teaching Hospital of Kigali, Rwanda. The first 50 patients on the ERAS pathway were prospectively evaluated and retrospectively compared to the last 50 patients operated on before ERAS implementation. Data on demographics, preoperative information, intraoperative compliance, postoperative events, and patient feedback were collected and analyzed.

Results: ERAS implementation resulted in a significant reduction in hospital length of stay (LOS) ($p < 0.001$) without increase in complications. Compliance with ERAS principles, including preoperative education and perioperative management, was more than 90%. ERAS also reduced costs due to quicker recovery and shorter hospital LOS.

Conclusion: The implementation of ERAS for laparoscopic cholecystectomy in a limited-resource setting is feasible and safe, suggesting the possibility of its potential adoption in other abdominal procedures. A high level of adherence to the ERAS pathway can be achieved with effective patient education and the dedication of healthcare providers.

KEYWORDS

enhanced recovery after surgery, laparoscopic cholecystectomy, perioperative care, postoperative outcomes

1 | INTRODUCTION

The enhanced recovery after surgery (ERAS) program represents a multimodal perioperative management approach aimed at a reduction of the surgical stress response and accelerate recovery of operated patients.[1,2] Central to ERAS protocols is the concept of targeting neurohormonal processes involved in the body's response to surgical stress, utilizing a standardized bundle of interventions to mitigate this stress and optimize patient's outcomes.[3–7]

In laparoscopic cholecystectomy, a common procedure in both developed and developing countries, ERAS pathways have demonstrated significant benefits including reduced postoperative morbidity, shortened length of hospital stay (length of stay (LOS)), and decreased overall healthcare costs.[8–10] However, the implementation of ERAS in laparoscopic cholecystectomy, particularly in resource-limited settings, presents unique challenges and opportunities. ERAS pathways for laparoscopic cholecystectomy emphasize patient's education, preoperative optimization, and setting realistic expectations. By actively involving patients in their own recovery process, ERAS protocols aim to enhance patient's autonomy and improve surgical outcomes.[8–10] ERAS protocols have been successfully implemented in various abdominal procedures and particularly in cholecystectomy.[11–17] Despite the proven benefits, including reduced LOS, faster recovery, and lower complication rates, the implementation of ERAS can be challenging due to perceived increased costs, the need for multidisciplinary coordination, and the adaptation of protocols to fit local resources and patient populations.

In Rwanda, following the successful establishment of a laparoscopy surgery program at the Centre Hospitalier Universitaire de Kigali (CHUK),[18] the authors hypothesized that integrating an ERAS pathway into this program could provide significant benefits to Rwandan patients undergoing laparoscopic cholecystectomy.

Given that laparoscopic cholecystectomy is the most frequently performed laparoscopic procedure at CHUK,[18] it was chosen as the initial focus for a modified and adapted ERAS protocol. The primary aim of this study was to prospectively evaluate the implementation and outcomes of a modified ERAS pathway for laparoscopic cholecystectomy in a resource-limited setting, with a specific focus on reducing the LOS to one day. Additionally, this study seeks to identify potential challenges and barriers specific to the Rwandan healthcare environment.

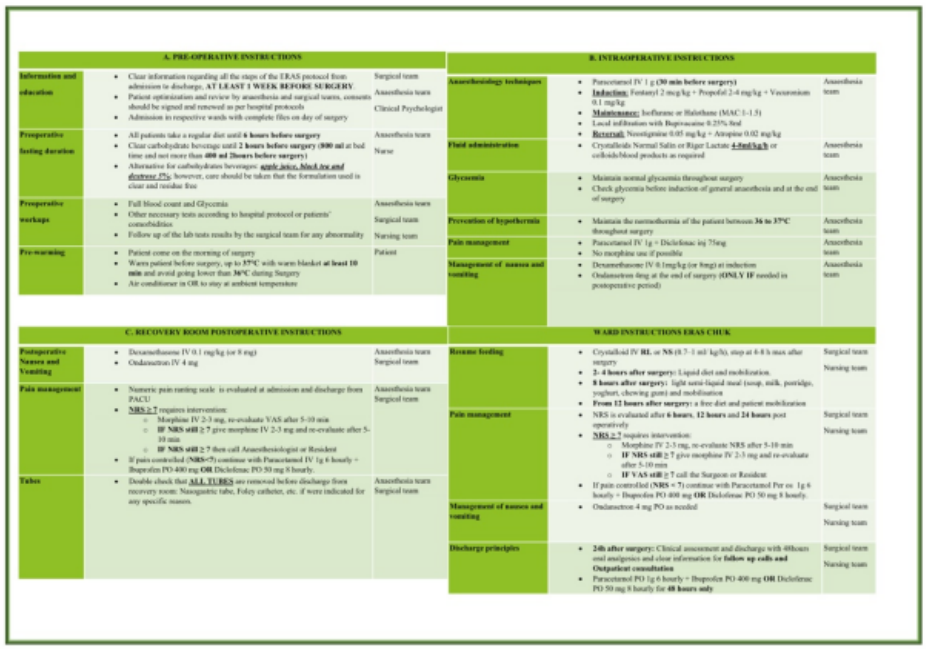
2 | MATERIAL AND METHODS

2.1 | Methods and setting

This non-randomized controlled trial prospectively studied the first 50 laparoscopic cholecystectomy patients managed according to a modified ERAS pathway (the ERAS group) implemented in the department of general surgery at CHUK, Rwanda, in January 2022 (Figure 1). Recognizing that specific ERAS guidelines for laparoscopic cholecystectomy do not exist, we developed a modified ERAS pathway tailored to our context, based on ERAS guidelines for elective abdominal surgery. The selection of elements for this pathway was informed by existing evidence, expert consensus, and the specific needs and constraints of our setting. These patients were retrospectively compared to the last 50 patients undergoing laparoscopic cholecystectomy before the implementation of the ERAS pathway (the control group) and who were prospectively included in the CHUK minimal invasive surgery (MIS) database according to the study reported by Nyundo et al.[18] This study was approved by both the Institutional Review Board (IRB) of the University of Rwanda and the Ethics Committee of CHUK with reference numbers No 412/CMHS IRB/2021 and EC/CHUK/1/074/2021, respectively, and was registered in ClinicalTrials.gov (NCT05516056). Informed consent was obtained from all patients participating to both groups. Information on the ERAS pathway was given by the surgeon or his assistant at a preoperative outpatient visit and confirmed by the theater nurse prior to surgery.

Inclusion criteria were all patients over 16-year of age undergoing elective laparoscopic cholecystectomy who consented for study participation. Exclusion criteria were urgent surgery or acute cholecystitis and American Society of Anesthesiology (ASA) class IV patients. Collected data encompassed demographics, ASA score, operative time, LOS, intraoperative events, postoperative adverse events, and postoperative complications. Postoperative complications were classified according to the Clavien–Dindo classification system up to postoperative day 90.[19] For the cost analysis, data on six primary cost drivers were gathered: surgical acts, anesthesia acts, nursing acts, consumables, drugs/medications, and hospitalization. The direct costs associated with each driver were obtained from the national health services tariff of the hospital. The total direct cost per patient was calculated by summing the costs across these six drivers, and the mean direct surgical cost of laparoscopic cholecystectomy was then determined. This straightforward summation method provided an overview of the direct financial implications of implementing the ERAS pathway, although it did not extend into more complex cost analyses.

Postoperative patient impressions and satisfaction were assessed using the Likert scale. The numeric rating scale was used to assess the postoperative pain.[20] Primary outcomes included hospital LOS and postoperative complications. Secondary outcomes comprised surgical care direct costs, adherence to all elements of the modified ERAS pathway, and patient satisfaction. Compliance with the modified ERAS pathway was specifically measured for all elements of our protocol. Data



A. PRE-OPERATIVE INSTRUCTIONS

Information and education	• Clear information regarding all the steps of the ERAS protocol from admission to discharge, **AT LEAST 1 WEEK BEFORE SURGERY**. • Patient optimization and review by anaesthesia and surgical teams, consents should be signed and renewed as per hospital protocols • Admission in respective wards with complete files on day of surgery	Surgical team Anaesthesia team Clinical Psychologist
Preoperative fasting duration	• All patients take a regular diet until **6 hours before surgery** • Clear carbohydrate beverage until **2 hours before surgery (800 ml** at bed time and not more than **400 ml 2hours before surgery)** • Alternative for carbohydrates beverages: **apple juice, black tea and dextrose 5%**; however, care should be taken that the formulation used is clear and residue free	Anaesthesia team Nurse
Preoperative workups	• Full blood count and Glycemia • Other necessary tests according to hospital protocol or patients' comorbidities • Follow up of the lab tests results by the surgical team for any abnormality	Anaesthesia team Surgical team Nursing team
Pre-warming	• Patient come on the morning of surgery • Warm patient before surgery, up to **37°C** with warm blanket **at least 10 min** and avoid going lower than **36°C** during Surgery • Air conditioner in OR to stay at ambient temperature	Patient

B. INTRAOPERATIVE INSTRUCTIONS

Anaesthesiology techniques	• Paracetamol IV 1 g **(30 min before surgery)** • **Induction:** Fentanyl 2 mcg/kg + Propofol 2-4 mg/kg + Vecuronium 0.1 mg/kg • **Maintenance:** Isoflurane or Halothane (MAC 1-1.5) • Local infiltration with Bupivacaine 0.25% Inof • **Reversal:** Neostigmine 0.05 mg/kg + Atropine 0.02 mg/kg	Anaesthesia team
Fluid administration	• Crystalloids Normal Salin or Riger Lactate **4-8ml/kg/h** or colloids/blood products as required	Anaesthesia team
Glycaemia	• Maintain normal glycaemia throughout surgery • Check glycemia before induction of general anaesthesia and at the end of surgery	Anaesthesia team
Prevention of hypothermia	• Maintain the normothermia of the patient between **36 to 37°C** throughout surgery	Anaesthesia team
Pain management	• Paracetamol IV 1g + Diclofenac inj 75mg • No morphine unless if possible	Anaesthesia team
Management of nausea and vomiting	• Dexamethasone IV 0.1mg/kg (or 8mg) at induction • Ondansetron 4mg at the end of surgery **(ONLY IF** needed in postoperative period)	Anaesthesia team

C. RECOVERY ROOM POSTOPERATIVE INSTRUCTIONS

Postoperative Nausea and Vomiting	• Dexamethasone IV 0.1 mg/kg (or 8 mg) • Ondansetron IV 4 mg	Anaesthesia team Surgical team
Pain management	• Numeric pain ranting scale is evaluated at admission and discharge from PACU • **NRS ≥ 7** requires intervention: o Morphine IV 2-3 mg, re-evaluate VAS after 5-10 min o **IF NRS still ≥ 7** give morphine IV 2-3 mg and re-evaluate after 5-10 min o **IF NRS still ≥ 7** then call Anaesthesiologist or Resident • If pain controlled (**NRS<5**) continue with Paracetamol IV 1g 6 hourly + Ibuprofen PO 400 mg **OR** Diclofenac PO 50 mg 8 hourly.	Anaesthesia team Surgical team
Tubes	• Double check that **ALL TUBES** are removed before discharge from recovery room: Nasogastric tube, Foley catheter, etc. if were indicated for any specific reasons.	Anaesthesia team Surgical team

WARD INSTRUCTIONS ERAS CHUK

Resume feeding	• Crystalloid IV **RL** or **NS** (8.7- 1 ml/ kg/h), stop at 4-8 h max after surgery • **2- 4 hours after surgery:** Liquid diet and mobilization. • **8 hours after surgery:** light semi-liquid meal (soup, milk, porridge, yoghurt, chewing gum) and mobilisation • **From 12 hours after surgery:** a free diet and patient mobilization	Surgical team Nursing team
Pain management	• NRS is evaluated after **6 hours**, **12 hours** and **24 hours** post operatively • **NRS ≥ 7** requires intervention: o Morphine IV 2-3 mg, re-evaluate NRS after 5-10 min o **IF NRS still ≥ 7** give morphine IV 2-3 mg and re-evaluate after 5-10 min o **IF VAS still ≥ 7** call the Surgeon or Resident. • If pain controlled (**NRS < 7**) continue with Paracetamol Per os 1g 6 hourly + Ibuprofen PO 400 mg **OR** Diclofenac PO 50 mg 8 hourly.	Surgical team Nursing team
Management of nausea and vomiting	• Ondansetron 4 mg PO as needed	Surgical team Nursing team
Discharge principles	• **24h after surgery:** Clinical assessment and discharge with 48hours oral analgesics and clear information for **follow up calls and Outpatient consultation** • Paracetamol PO 1g 6 hourly + Ibuprofen PO 400 mg **OR** Diclofenac PO 50 mg 8 hourly for **48 hours only**	Surgical team Nursing team

FIGURE 1 Modified enhanced recovery after the surgery pathway for cholecystectomy at the Centre Hospitalier Universitaire de Kigali (CHUK), Kigali, Rwanda.

on adherence were collated using a checklist completed by the perioperative team, with oversight from a surgical resident to ensure the checklist was fully completed and to minimize missing data.

After discharge, patients were followed up via phone and/or outpatient consultations on days 3, 7, 15, 30, and 90. No patients were lost to follow-up by day 90.

2.2 | Statistical analysis

Continuous variables, such as operative time and LOS, are presented as median [interquartile range] and were compared between groups using the Mann–Whitney *U* test. Categorical variables, including demographics and ASA scores, were analyzed using chi-squared tests or Fisher's exact tests, as appropriate, and are presented as percentages. The classification of postoperative complications followed the Clavien–Dindo classification, which was used to assess and compare outcomes between the ERAS and control groups. For the cost study, only the direct prices of the cost drivers were utilized and these were summed to calculate the total direct cost per patient. The mean direct surgical cost was then compared between the ERAS and control groups.

Based on a pre-ERAS LOS of 3 days, a sample size calculation determined that 48 patients per group would be needed to detect a significant reduction in LOS to one day, with a significance level of 0.05% and 90% power (standard deviation: 3 days). Statistical analyses were conducted using Prism 9.5.1 for Mac.

3 | RESULTS

3.1 | Patient characteristics

Table 1 shows that there were no detected significant differences between control and ERAS groups including in age, ASA class, and comorbidities.

3.2 | Primary outcomes

The median LOS was 1 day in the ERAS group, ranging from 1 to 4 days, with 96% of the patients successfully discharged on the first day after surgery. In the control group, median LOS was 3 days ($p < 0.0001$) (Table 2). There was no difference in operative time, intraoperative events, conversion to open surgery, or post

TABLE 1 Characteristics of study participants.

Characteristics	Control group (n = 50)	ERAS group (n = 50)	p value
Sex ratio (Females/Males)	43/7	40/10	0.59
Age (years)	51.5 (39–62)	46 (39.7–62.5)	0.56
Comorbidities			0.50
Hypertension	10 (20%)	7 (14%)	
HIV	2 (4%)	4 (8%)	
Diabetes	4 (8%)	3 (6%)	
Hepatitis B virus	0 (0%)	1(2%)	
Hepatitis C virus	0 (0%)	1 (2%)	
Previous abdominal surgery	7 (14%)	14 (28%)	0.13
ASA class			0.54
ASA 1	27 (54%)	31 (62%)	
ASA 2	23 (46%)	19 (38%)	

Note: Data are presented as absolute numbers (percentages) or as median (IQR).
Abbreviations: ASA, American Society of Anesthesiology; ERAS, enhanced recovery after surgery; HIV, human immunodeficiency virus; IQR, interquartile range.

operative complications (Table 2). Patients included in the ERAS pathway reported less nausea, anxiety, tiredness, and pain. Two patients (4%) from the ERAS group were readmitted in hospitalization for pain (n = 1 and 2%) and for pneumonia (n = 1 and 2%).

3.3 | Secondary outcomes

The overall direct surgical costs of a laparoscopic cholecystectomy were significantly lower in the ERAS group compared to the control group ($p < 0.0001$) (Table 2). In the ERAS group, all patients received information about the ERAS pathway including on pain management, perioperative fasting, and discharge plan with education on home medication (Table 3). One patient did not receive the information about the management of postoperative nausea and vomiting. The perioperative fasting plan was respected in 90% of the cases, and among the 5 patients who did not follow the fasting plan, 4 of them were afraid, whereas one reported personal reason (Table 3).

Throughout the surgical procedures, all patients were stable with hemodynamic, temperature, and blood sugar parameters within normal. Multimodal analgesia was respected for all patients but one, and 13 (26%) patients were reported to receive additional opioids because the anesthesiologist considered it necessary (Table 4). Almost all patients (98%) received dexamethasone, whereas 11 patients (22%) received additional ondansetron to prevent nausea and vomiting. Forty-three patients (86%) received infiltration of the surgical wounds with local anesthetics (Table 4).

Early movement and feeding were respected by most of patients under the ERAS protocol. The assessment prior to discharge revealed that all patients started to move, whereas 94% started to eat usual meals on postoperative day one and only one patient remained on antiemetic treatment. No patients reported severe pain on postoperative day one, even if 40% were still complaining of pain. All patients, except one received post-discharge follow-up information and education with a compliance of 98% (Table 5).

Table 6 shows that the consequences of the surgery regressed with time. On postoperative day 7, one pneumonia and one surgical site infection were diagnosed. Some symptoms rarely persisted until day 30 including pain (4%), fatigue (2%), and nausea (2%) (Table 6).

Most of patients (96%) agreed or strongly agreed that the ERAS protocol was clearly explained to them by medical staff during admission, during the surgical process, and after the operation, and about 70% of them disagreed or strongly disagreed with the statement that discharge the next day after laparoscopic cholecystectomy is dangerous, whereas 30% of patients considered that it is dangerous even if they did not encounter any complications. Importantly, 98% of patients were satisfied with the process of the ERAS pathway and their experience of surgery (Table 7).

4 | DISCUSSION

This study aimed to evaluate the implementation and outcomes of the ERAS protocol for laparoscopic cholecystectomy in a resource-limited Sub-Saharan country. This study demonstrated that the implementation of an ERAS protocol is both feasible and safe in an academic hospital in Rwanda, with high acceptance and adherence by both patients and medical staff. Cholecystectomy was

TABLE 2 Comparison of outcomes between groups.

Outcome	Control group (n = 50)	ERAS group (n = 50)	p value
LOS (days)	3 (2–3.2)	1 (1–1)	<0.0001
Operative time (min)	80 (60–120)	70 (60–104.8)	0.82
Intraoperative events	4 (8%)	11 (22%)	0.052
Gallbladder perforation	1 (2%)	8 (16%)	
Common bile duct injury	1 (2%)	1 (2%)	
Bleeding	1 (2%)	1 (2%)	
Bradycardia	0 (0%)	1 (2%)	
Bowel perforation	1 (2%)	0 (0%)	
Conversion	0 (0%)	0 (0%)	
Postoperative events	92	38	
Nausea	23 (46%)	7 (14%)	<0.001
Anxiety	16 (32%)	0 (0%)	<0.0001
Tiredness	21 (42%)	12 (24%)	0.08
Pain	32 (64%)	19 (38%)	0.12
Postoperative complications	3	2	>0.99
Grade 1	2 (4%)	1 (2%)	
Grade 2	0 (0%)	1 (2%)	
Grade 3	1 (2%)	0 (0%)	
Overall costs (RWF)	276,825 (224,448–361,366)	137,461 (114,195–173,682)	<0.0001
Readmissions	0 (0%)	2 (4%)	0.49

Note: Data are presented as absolute numbers (percentages) or as median (IQR).
Abbreviations: ERAS, enhanced recovery after surgery; IQR, interquartile range; LOS, length of stay; RWF, Rwandan Francs.

TABLE 3 Preoperative education and counseling.

	Shared information of the ERAS group (N = 50)	Verification before surgery of the ERAS group (n = 50)
Information on the pain management	50 (100%)	50 (100%)
Information on the preoperative fasting	50 (100%)	50 (100%)
Information on the prevention of nausea and vomiting	49 (98%)	49 (98%)
Information on discharge plan, education, and home medications	50 (100%)	49 (98%)

Note: Data are presented as absolute numbers (percentages).
Abbreviation: ERAS, enhanced recovery after surgery.

chosen as it is the most performed MIS procedure in Rwanda[18] and in Africa.[21] This work builds upon the pioneering efforts of Dr. Ravi Oodit, who has been instrumental in adapting and promoting perioperative care and ERAS guidelines for low- and middle-income countries as highlighted in his contributions to the field.[22,23]

This ERAS protocol made it possible to significantly reduce the length of hospitalization and the cost of laparoscopic cholecystectomy, without an increase in postoperative complications, and with great patient satisfaction. These results align with literature demonstrating ERAS benefits in reducing hospital LOS and complications.[5,6,14,16,24,25] Although adverse intraoperative events showed no different between groups, postoperative nausea and anxiety were lower in the ERAS group with a similar rate of complications, consistent with the safety profile of ERAS in minimizing adverse outcomes.[26]

This study is original because ERAS pathways are very rarely implemented in Sub-Saharan African countries. The tradition of open surgery and long

TABLE 4 Intraoperative compliance to the enhanced recovery after surgery protocol.

	$n = 50$
Glycemia prior to induction (mg/dl)	103.5 (89–115)
Temperature (°C)	36.3 (36–35.5)
Normovolemia	48 (96%)
Multimodal analgesics	49 (98%)
Additional opioids (morphine)	13 (26%)
Dexamethasone	49 (98%)
Additional ondansetron	11 (22%)
Wound infiltration with local anesthetics	43 (86%)

Note: Data are presented as absolute numbers (percentages) or as median (IQR).
Abbreviations: ERAS, enhanced recovery after surgery; IQR, interquartile range.

TABLE 5 Discharge assessment and clinical events within the enhanced recovery after the surgery group.

Events during day 1 postoperative period	$n = 50$
Normal vital signs (Temp, BP, RR, and HB)	49 (98%)
Early mobilization	50 (100%)
Started usual meals	47 (94%)
Need for antiemetic treatment	1 (2%)
Reported pain	20 (40%)
Mild pain	13 (26%)
Moderate pain	7 (14%)
Severe pain	0 (0%)
Post-discharge information and education	49 (98%)

Note: Data are presented as absolute numbers (percentages).
Abbreviations: BP, blood pressure; ERAS, enhanced recovery after surgery; HB, heartbeats; RR, respiratory rate; Temp, temperature.

hospitalization remains anchored both in the medical and paramedical profession and among patients. After setting up a laparoscopic surgery program, the authors aimed to reduce LOS for cholecystectomy by switching to an ERAS program. This type of program changes the routine of healthcare professionals and patients, with the need for educational sessions explaining the reason of these changes and the advantages of ERAS-type care. Patient information is essential and the key to the success of this approach. In this study, we observed remarkable adherence to the ERAS protocol among both patients and among the healthcare professionals, a feat not initially anticipated and previously unreported in Sub-Saharan countries. This information plays a crucial role in promoting ERAS adherence, optimizing perioperative care, and improving surgical outcomes[6,26], and other studies supported that patient education is related to a reduction in hospital stays and complications.[27–29] Interventions, such as preoperative carbohydrate loading and pre-warming, have shown to reduce hospital LOS and improve postoperative outcomes[30,31], and recent studies highlighted that higher adherence to the ERAS protocol may be correlated with a reduction in mortality[8] and also improved 5-year survival after colon surgery.[32] Furthermore, the observed rates of adverse events (20%) and postoperative pain (30%) of this study align with previous literature, with multimodal analgesia administration and early initiation of feeding and mobilization contributing to improved patient outcomes.[33–35] Intraoperative management closely adhered to ERAS principles, maintaining normal hemodynamic and temperature, whereas multimodal analgesia effectively controlled pain in almost all patients.[36,37] Widespread administration of anti-nausea medication aimed at reducing postoperative nausea and vomiting was observed, consistent with evidence-based practices reporting that intraoperative use of glucocorticoids is effective for postoperative nausea and vomiting prophylaxis and can also provide early postoperative analgesic effects.[38–41]

The study findings highlight several key aspects of the discharge process and post-discharge follow-up in the ERAS protocol. Patient perceptions regarding early discharge varied, with the majority agreeing that it is not dangerous, but 30% expressing the need for further education and reassurance. Several studies underscore the importance of patient education and engagement throughout the perioperative period, including post-discharge follow-up, to optimize recovery and reduce readmission rates.[42,43] Evidence suggests that early discharge after surgery is not associated with an increase in readmissions or post-discharge complications, supporting the safety and feasibility of early discharge within ERAS programs. Others highlight the role of patient-centered care in enhancing postoperative outcomes, which encompasses ongoing communication and support after discharge.[9,44,45] Advocating for the use of telemedicine and remote monitoring technologies aligns with the overarching goal of optimizing post-discharge care and reducing readmissions within ERAS programs.[46] Addressing patient concerns through clear communication, education about postoperative recovery expectations, and providing support during the transition to home can help alleviate fears and improve patient acceptance of early discharge within ERAS programs.

In laparoscopy, the cost of surgery greatly depends on the availability of laparoscopic equipment and reusable or disposable instruments. These costs were not different between the control group and the ERAS group. The additional cost associated with modern medications and perioperative multimodal care results in an additional cost in the ERAS group, offset by the reduction in costs associated with a shorter

TABLE 6 Post-discharge symptoms and events among the enhanced recovery after surgery group.

	n = 50				
Events	**Day 3**	**Day 7**	**Day 15**	**Day 30**	**Day 90**
Pain	23 (46%)	10 (20%)	6 (12%)	2 (4%)	0 (0%)
Tiredness/Fatigue	12 (24%)	6 (12%)	4 (8%)	1 (2%)	0 (0%)
Nausea	0 (0%)	0 (0%)	1 (2%)	1 (2%)	0 (0%)
Vomiting	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Post-discharge complications	0 (0%)	2 (4%)	1 (2%)	0 (0%)	0 (0%)

TABLE 7 Patients' feedback on enhanced recovery after surgery pathway.

	n = 50
Protocol clearly explained by medical staff	
Strongly agree	36 (72%)
Agree	12 (24%)
Neutral	2 (4%)
Disagree	0 (0%)
Strongly disagree	0 (0%)
Discharge one day after laparoscopic cholecystectomy is dangerous	
Strongly agree	8 (16%)
Agree	6 (12%)
Neutral	1 (2%)
Disagree	10 (20%)
Strongly disagree	25 (50%)
General satisfaction	
Satisfied	49 (98%)
Neutral	1 (2%)

Note: Data are presented as absolute numbers (percentages).
Abbreviation: ERAS, enhanced recovery after surgery.

hospitalization and the savings on the cost of medications required in prolonged hospitalization. Compared to the Western world, the cost per day of hospitalization is lower in a low-income country as Rwanda, but even in Rwanda, the LOS reduction linked to the ERAS program can be a cost saving. Existing literature supports ERAS cost-effectiveness in various surgical procedures, despite initial higher costs. Implementing ERAS may lead to higher upfront costs but is offset by decreased length of hospital stay and reduced complication rates, resulting in long-term cost savings. These findings underscore ERAS effectiveness in reducing hospital stays, complications rates resulting in long-term cost savings compared to traditional care pathways.[5,16,47,48] Additionally, it is noted that the treatment cost typically peaks in the first days after admission, emphasizing the importance of interventions such as ERAS in optimizing resource utilization and reducing overall healthcare costs.[4]

The main limitation of this study is the absence of randomization, but randomization of a new medical pathway is difficult and nowadays impossible, as ERAS rapidly became the standard of care for laparoscopic cholecystectomy at CHUK. Another limitation is the fact that laparoscopic cholecystectomy is a procedure for which it seems easier to propose early mobilization and feeding, compared to colon surgery. However, even in cholecystectomy, the ERAS pathway meant a total change of clinical practice that is particularly difficult in a low-income Sub-Saharan country as Rwanda. As a first step in modern perioperative management, the ERAS pathway in laparoscopic cholecystectomy paved the way to other indications as in colon surgery. This is particularly important as cholecystectomy is the most frequently performed laparoscopic abdominal procedure in Africa.

In conclusion, this study highlighted ERAS benefits for laparoscopic cholecystectomy in resource-limited settings. Thanks to a high protocol adherence, ERAS allowed shorter hospital stays, reduced costs, and enhanced perioperative care and outcomes. Laparoscopic cholecystectomy may serve as a model for ERAS adoption in resource-limited settings, improving surgical care delivery and resource utilization.

AUTHOR CONTRIBUTIONS

Martin Nyundo: Conceptualization; Data curation; Formal analysis; Funding acquisition; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing. **King Kayondo**: Conceptualization; Methodology; Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing. **Miguel Gasakure**: Data curation; Formal analysis; Investigation; Supervision; Validation; Visualization; Writing - original draft. **Jean Damascene Twagirumukiza**: Data curation; Formal analysis; Software; Validation; Visualization; Writing - original draft. **Julien Gashegu**: Conceptualization; Data curation; Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing. **Olivier Detry**: Conceptualization; Data curation; Formal analysis; Methodology; Software;

Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data supporting this study's findings are not publicly available due to restrictions based on patient privacy and confidentiality. However the data may be available by the corresponding author upon reasonable request and with the permission of the hospital's review board. Access to the data will require an approved request in accordance with institutional and ethical guidelines.

ETHICS STATEMENT

The IRB of the University of Rwanda (412/CMHS IRB/2021) and the Ethics Committee of the University Teaching Hospital of Kigali (EC/CHUK/1/074/2021) approved this study that was registered in ClinicalTrials.gov (NCT05516056).

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

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CHAPTER V. GENERAL DISCUSSION

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Laparoscopic surgery has transformed surgical practices in developed countries, offering significant advantages over traditional open surgery. However, the integration of laparoscopic surgery in LMICs including Sub-Saharan nations like Rwanda, has been hindered by multifaceted challenges and opportunities. The discussions of the five studies included in this thesis offer a comprehensive overview of the state of laparoscopic surgery in the sub-Saharan region, covering practice, training, patient outcomes, and enhanced peri-operative care system. This general discussion synthesizes the key findings and insights from these studies implemented with insights from additional literature.

While laparoscopic surgery has greatly advanced surgical practice in developed countries by offering clear advantages over open surgery, its adoption in developing nations has been inconsistent and constrained by various barriers (10). Commonly reported challenges include a shortage of resources, such as specialized equipment, and a lack of adequately trained personnel (8–11).
However, recent studies suggest that these factors alone may not fully account for the limited adoption of laparoscopic surgery in LMICs and that additional, context-specific barriers might play a significant role (23,90). Thus, a deeper investigation into these limitations was warranted to better understand the multifaceted challenges.

This thesis sought to thoroughly explore the barriers affecting the practice of laparoscopic surgery in COSECSA countries, including Rwanda. It aimed to address well-documented challenges, such as shortages of equipment and training, while also identifying previously unexplored obstacles to the widespread use of laparoscopic surgery in these settings.
The first study focused on assessing resource capacity and identifying these barriers. Key findings from this assessment reveal that resource capacity is severely constrained. Hospitals reported an average of only three trained surgeons, two laparoscopic towers, and two sets of laparoscopic instruments. Consequently, laparoscopic procedures are primarily limited to basic surgeries, such as cholecystectomy, diagnostic laparoscopy, appendectomy, adhesiolysis, and hernia repair, with an average of just 10 procedures conducted monthly. This limited capacity significantly hampers the ability of these

hospitals to both provide adequate laparoscopic services and train personnel in this advanced technology, which requires modern equipment and specialized expertise.
Moreover, it was found that the costs of laparoscopic procedures and associated consumables are not fully covered by health insurance across the surveyed hospitals, which restricts access to these services. The study identified five primary barriers to the practice of laparoscopic surgery in these settings: lack of consumables, limited availability of equipment, shortage of skilled surgeons, the high cost of laparoscopic services, and inadequate experience in performing complex cases.
These findings highlight the need for targeted interventions to address both the infrastructural and educational gaps in laparoscopic surgery in resource-limited settings.

The scarcity of skilled laparoscopic surgeons is a critical barrier identified in this research, aligning with existing literature on the challenges faced by LMICs in adopting advanced surgical techniques (7,91–93). Limited access to training programs, high-fidelity simulators, and mentorship opportunities are recurring issues in these regions, preventing surgeons from achieving the proficiency necessary for effective laparoscopic practice (24,86). Furthermore, a “brain drain” effect exacerbates this issue, as trained surgeons often migrate to high-income countries or private practices with better remuneration and resources, leaving a gap in skilled professionals within the public sector (94).
In some LMIC settings, surgeons tend to prefer open surgery for complex cases due to a lack of confidence in advanced laparoscopic procedures. This reluctance reflects the steep learning curve associated with laparoscopic surgery and the perceived risks involved in complex cases (95). As reported in multiple studies, a surgeon’s comfort with advanced techniques heavily influences their willingness to adopt laparoscopic methods (91). In this context, the lack of routine training on managing intraoperative complications and challenges in performing complex procedures results in hesitation among surgeons, further limiting the use of laparoscopic techniques.

The unavailability and poor maintenance of laparoscopic equipment emerged as a significant barrier in this study, which mirrors challenges observed in other LMIC contexts. Many hospitals in LMICs, constrained by limited budgets, rely on outdated or second-hand equipment that often lacks the durability and reliability necessary for

consistent surgical performance. These issues are further compounded by inconsistent supply chains for essential parts and a shortage of skilled technicians, leading to frequent equipment downtime that disrupts both surgical services and training schedule (7,92,96). Moreover, the absence of sustainable maintenance plans exacerbates equipment-related challenges. Without adequate resources for regular maintenance, the equipment's lifespan and effectiveness are reduced, making it harder for hospitals to sustain laparoscopic programs (91). This shortage of reliable, functional equipment limits the frequency and complexity of laparoscopic procedures that surgeons can perform, effectively hindering the broader adoption of these techniques in LMICs.

The research highlights the high cost and limited availability of laparoscopic consumables as significant barriers in LMICs. These consumables, often costly and not fully covered by health insurance, place a financial burden on patients (91,93). Public health systems may cover the surgical procedure but often exclude expensive consumables, which exacerbates access issues. Economic disparities in LMICs further restrict access, especially in settings with limited private insurance coverage (86).

Some countries, such as Rwanda, have addressed this by incorporating laparoscopic procedures and consumables into national insurance systems, improving surgical access. Similarly, private insurance schemes in other regions have increased access to laparoscopic surgery (27,92,97). Addressing these barriers requires policy shifts, such as expanding community health insurance and partnering with pharmaceutical companies to lower costs. Innovations in LMICs, such as cost-reduction strategies and a growing acceptance of laparoscopic surgery, are promising (24,27). Additionally, surgeons in the COSECSA region have shown a strong interest in expanding laparoscopic practices, highlighting the potential for sustainable integration (93).

A comprehensive approach should involve enhancing training, investing in modern equipment with sustainable maintenance, and creating policies focused on affordability. Collaborative initiatives with high-income countries, including training exchanges and technology adaptations, are essential to support broader adoption of laparoscopic surgery in LMICs (94). These efforts align with the global trend towards improving surgical care through innovative financing and policy frameworks, ultimately strengthening LMIC healthcare systems for sustainable laparoscopic services.

The study also highlights the accessibility of CO_2 for pneumoperitoneum as a crucial but often overlooked challenge in LMICs. The cost and availability of CO_2 can be prohibitive, leading some researchers to propose alternatives like “gasless” laparoscopy (80,89). However, gasless techniques may pose challenges for inexperienced practitioners, as they require specific technical skills and adjustments to achieve adequate visualization without the insufflation provided by CO_2. Despite these hurdles, gasless approaches could offer a viable solution in resource-limited settings, where CO_2 supply is inconsistent, thus expanding laparoscopic options. accessibility, particularly in resource-limited settings, potentially expanding laparoscopic options, where CO_2 supply is inconsistent.
As a potential solution, exploring the use of CO_2 from alternative sources, such as breweries or other carbonated beverage producers, could help mitigate these limitations. CO_2 from these industries is widely available in many countries and could provide a more affordable and reliable supply, addressing accessibility challenges in surgical settings in LMICs.

The second study of this thesis delves into the training of laparoscopic surgery within the COSECSA region, examining critical barriers and opportunities to enhance surgical education in LMICs. It builds on the findings of the first study, which highlighted broader challenges to the adoption of laparoscopic surgery across these Sub-Saharan Africa countries, such as infrastructure, policy, and financial barriers. This second study, however, narrows its focus to the specific challenges related to training, offering insights into how these issues directly hinder the development of skilled surgeons capable of performing laparoscopic procedures.

The research identified key obstacles to effective laparoscopic training, including:

1. Limited laparoscopic equipment: access to the necessary tools for laparoscopic surgery remains scarce in many LMICs (98–100).
2. Lack of simulation labs: the absence of training facilities like simulation labs means that surgeons do not have opportunities to practice laparoscopic techniques in a safe, controlled environment (82,101,102).
3. Shortage of qualified trainers: a lack of experienced mentors and educators further hampers the development of laparoscopic skills in the region (82,101,102).

4. Insufficiently structured training programs: many LMICs still lack formal, comprehensive training programs for laparoscopic surgery, contributing to a shortage of skilled surgeons (7).

These barriers not only limit the availability of skilled laparoscopic surgeons but also create a vicious cycle: without training infrastructure and resources, new surgeons are unable to gain the expertise needed, which in turn undermines the overall capacity for laparoscopic surgery in these settings. This gap in surgical education aligns with the systemic barriers discussed in the first study, reinforcing the interdependence between the availability of equipment, skilled personnel, and effective training programs.

The common goal emerging from both studies is the urgent need for comprehensive capacity building to overcome these barriers. To this end, several strategies can be employed:

1. Develop specific training programs: establish dedicated laparoscopic surgery programs within postgraduate surgical education to ensure that new surgeons are properly trained in these advanced techniques (8,103). These programs should be structured and formalized to provide trainees with the necessary skills.
2. Integrate laparoscopic surgery into medical school curricula: by incorporating MIS courses into medical school curricula, students can be introduced to laparoscopic techniques early in their education, better preparing them for their future careers (93).
3. Create simulation laboratories: establishing low cost simulation labs allows trainees to practice laparoscopic surgery techniques in a risk-free environment, bridging the gap between theoretical knowledge and practical skills (93).
4. Enhance the surgical workforce: training should not be limited to surgeons alone. Anesthesiologists, nurses, and biomedical engineers should also be involved in the training to create well-rounded surgical teams capable of supporting laparoscopic procedures (91,104).

In addition to these training-specific strategies, both studies emphasize the need for policy and financial interventions to address the broader systemic barriers to laparoscopic surgery:

1. Collaborations with manufacturers: partnerships with medical equipment manufacturers can help secure low-cost laparoscopic equipment and consumables, making surgery more affordable and accessible (9,24).
2. Sustainable equipment maintenance: ensuring the regular maintenance of laparoscopic equipment is crucial to extend its lifespan and functionality, preventing costly downtimes (24).
3. Institutional support: increased support from hospitals and governments is essential to establish and sustain laparoscopic surgery programs. This includes financial investment and institutional commitment to the long-term success of laparoscopic initiatives (9,25).
4. Public awareness campaigns: raising awareness among the public and patients about the benefits of laparoscopic surgery can increase demand, encouraging policymakers to allocate resources and prioritize laparoscopic services in national health systems (28).

In conclusion, the second study underscores the interconnected nature of the challenges faced in both the adoption and training of laparoscopic surgery in LMICs. The lack of training infrastructures directly impacts the availability of skilled surgeons, which in turn affects the broader adoption of these techniques. By addressing these challenges through targeted training programs, institutional support, and strategic partnerships, the capacity for laparoscopic surgery in LMICs can be significantly improved, ultimately enhancing the quality of surgical care in the region.

The third study highlights the feasibility, safety, and patient satisfaction associated with laparoscopic surgery in Rwanda, contributing critical insights into the broader landscape of laparoscopic surgery in LMICs. Despite resource limitations, findings from this study, specifically in laparoscopic cholecystectomy at CHUK, align with global evidence supporting the efficacy and safety of minimally invasive procedures in low-resource settings. This study, which recorded a low rate (1.7%) of postoperative complications, a 0.7% mortality rate, and an average hospital stay of three days, parallels data from high-income countries where laparoscopic surgery is widely accepted and associated with faster recovery and less postoperative pain compared to open surgery.

Patient satisfaction in this cohort was remarkably high, with over 95% of patients expressing satisfaction with their experience. However, the data reveal critical areas for improvement. Approximately 74% of patients were unfamiliar with laparoscopic surgery before their operation, and education level was a significant predictor of patient knowledge, highlighting the importance of preoperative education and patient involvement in decision-making. This aligns with findings in other LMICs where limited public awareness and inadequate preoperative communication affect patient perception and engagement in laparoscopic care (91,92,105).

While this study affirms the feasibility of laparoscopic surgery in resource-constrained settings, it also evidences the pressing need to address training and infrastructure gaps to optimize outcomes. The rate of serious complications, such as biliary injuries and bleeding, though low in this study, mirrors complications reported globally, which are often linked to the steep learning curve and technical demands of laparoscopic procedures (106–109). Addressing these challenges through structured training programs, greater access to essential laparoscopic equipment, and international support in skills transfer is crucial for sustainable laparoscopic surgery growth.

The collective findings from this thesis, alongside previous studies, support a holistic approach to advancing laparoscopic surgery in LMICs. Solutions should prioritize the education and empowerment of healthcare professionals, patient engagement, and the establishment of robust training frameworks. By addressing these barriers, LMICs can work toward scalable and resilient healthcare systems capable of integrating MIS approaches as a standard of care. Rwanda's progress thus far demonstrates that laparoscopic surgery, despite challenges, is both achievable and impactful in improving surgical care quality and patient satisfaction. Promoting these practices and seeking solutions to critical challenges will further enable the adoption of laparoscopic surgery across Sub-Saharan Africa and beyond, ultimately contributing to safer, more effective surgical care in underserved regions.

The adoption of laparoscopic surgery and ERAS protocols in resource-limited settings presents a significant opportunity to improve surgical outcomes despite the challenges posed by limited resources as demonstrated by the previous studies from this thesis. The

consecutive two studies conducted at the University Teaching Hospital of Kigali (CHUK) in Rwanda highlight the feasibility and positive outcomes of integrating laparoscopic surgery within an ERAS framework in such settings.

The fourth study of the thesis work offers a comprehensive approach to the introduction of the ERAS program in Rwanda, focusing on adapting global healthcare practices like ERAS to local resource-limited settings. ERAS protocols, designed to reduce hospital stays and promote recovery through evidence-based practices, have demonstrated significant potential worldwide but encounter unique challenges in LMICs like Rwanda. The study's phased methodology, which began with a KAP survey, was pivotal in identifying gaps in knowledge and attitudes that could hinder ERAS adoption.

The KAP study uncovered substantial gaps, particularly in the understanding of key ERAS principles such as multimodal analgesia, early feeding, and selective opioid use. Many practitioners remained attached to traditional practices influenced by cultural and logistical factors, including limited resources and inconsistent access to supplies (68,110). Through targeted training and the creation of multidisciplinary ERAS teams, these barriers were addressed, fostering collaboration between surgeons, anesthesiologists, nurses, and allied health professionals. This team-based approach, vital for the success of ERAS globally, has been emphasized in other studies from LMICs (111,112). In Rwanda, local champions played a crucial role in driving adherence to protocol changes, underscoring the importance of tailored education and ongoing support (68,112).

Key findings:

1. *Knowledge gaps and attitudinal barriers:* significant gaps were identified in understanding ERAS components like early postoperative feeding and multimodal analgesia, a challenge common in LMICs (68,110).
2. *Multidisciplinary teams and local champions:* a high level of support (94.8%) was found for multidisciplinary teams, which helped overcome cultural and logistical barriers, reinforcing the importance of local champions in ensuring adherence to ERAS protocols (111,112).
3. *Cost benefits and reduced hospital stays:* the study highlighted the financial benefits of ERAS, with 79.2% of respondents agreeing that ERAS could reduce hospital costs, a critical consideration in resource-limited environments.

4. *Challenges with traditional practices:* resistance to abandoning traditional practices remained a barrier, echoing broader issues faced in ERAS implementation globally (113,114). Continued education, policy reinforcement, and collaboration will be necessary for sustained ERAS adoption.

In response to these findings, the target of the fourth study was successfully achieved: a modified ERAS protocol was developed with the collaborative spirit of the multidisciplinary team at CHUK. The protocol was specifically tailored to the resource-limited setting and was proposed to be piloted in laparoscopic cholecystectomy procedures. This pilot project forms the basis of the fifth study, which aims to evaluate the implementation and outcomes of the modified ERAS pathway in the context of laparoscopic cholecystectomy.

Building on these findings, the fifth study further explored the implementation of ERAS protocols in laparoscopic cholecystectomy at CHUK, emphasizing the feasibility and safety of this approach in a sub-Saharan African setting. The study showed a significant reduction in hospitalization time from 3 to 1 day, with no increase in postoperative complications, confirming the global benefits of ERAS protocols (68,70,115,116). Furthermore, patient education emerged as a critical component in ensuring high protocol adherence, which was key to overcoming traditional practices that often favored open surgery and prolonged hospital stays (117,118).
A follow-up phone call was conducted for patients, with only one readmission reported, emphasizing the role of remote monitoring technologies in optimizing post-discharge care. This is particularly beneficial in LMICs, where follow-up care can be limited (119). The success of this implementation reinforced the idea that advanced surgical practices, such as laparoscopic surgery combined with ERAS protocols, are not only feasible but also beneficial in resource-constrained settings, provided there is sufficient training and support for healthcare providers (99,120). Notably, this study represents the first prospective investigation of ERAS in sub-Saharan Africa, demonstrating its potential for improving surgical outcomes even in settings with limited resources.

Both studies demonstrate the importance of adapting global healthcare practices to the local context to improve surgical outcomes. Despite challenges such as limited resources,

traditional practices, and resistance to change, these studies provide compelling evidence that implementing ERAS protocols within laparoscopic surgery can significantly enhance perioperative care in LMICs. Success relies on tailored education programs, the creation of multidisciplinary teams, and patient engagement to ensure adherence to protocols.
The implementation of ERAS protocols not only improved recovery times and reduced hospital stays but also offered substantial cost savings. In resource-limited settings, where healthcare systems face financial constraints, these studies highlight the profound impact ERAS can have on improving surgical outcomes, reducing healthcare costs, and enhancing patient satisfaction, even in Sub-Saharan Africa.

These consecutive studies underscore the potential for scalable improvements in surgical care in LMICs and set a precedent for other resource-constrained regions to consider the integration of laparoscopic surgery and ERAS protocols as part of their healthcare improvement strategies.

CHAPTER VI. CONCLUSIONS AND RECOMMENDATIONS

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6.1. Conclusion

This thesis provides a comprehensive assessment of the practice and training of MIS in sub-Saharan Africa, with a particular focus on Rwanda. It identifies critical barriers to adoption, evaluates clinical and patient-centered outcomes, and highlights the potential impact of ERAS protocols in resource-limited settings.

Findings indicate that MIS practice and training within COSECSA-affiliated hospitals remain significantly limited. Most hospitals operate with only two laparoscopic towers and two instrument sets, with an average of three trained laparoscopic surgeons per facility. This scarcity of resources restricts the volume of laparoscopic procedures to approximately ten per month, primarily laparoscopic cholecystectomies. Key barriers to widespread adoption include the absence of structured MIS training programs, a lack of simulation laboratories, and limited institutional support. Despite these challenges, there is a strong willingness among surgical professionals to advance MIS practice and training in their respective countries.

The study also demonstrates the feasibility and safety of MIS in a resource-constrained environment, as evidenced by high patient satisfaction, low postoperative complication rates, and minimal mortality among patients undergoing laparoscopic procedures at CHUK. Furthermore, the introduction of the ERAS pathway in Rwanda has led to significant improvements, including a reduction in hospital stay duration (from three to one day) and lower surgical costs for laparoscopic cholecystectomy. These findings support the scalability of ERAS protocols across similar contexts within COSECSA countries, provided they are adapted to local healthcare infrastructures.

In conclusion, while significant barriers to MIS implementation persist, the demonstrated benefits particularly with the integration of ERAS underscore the need for enhanced training programs, investment in infrastructure, and policy-level commitment to advancing MIS in sub-Saharan Africa.

6.2. Recommendations

Based on the findings from this research, the following recommendations aim to enhance the adoption and sustainability of Minimally Invasive Surgery (MIS) and Enhanced Recovery After Surgery (ERAS) in Rwanda and the COSECSA region. These focus on strengthening training, optimizing resources, improving policy support, engaging communities, and fostering research to expand MIS and ERAS beyond cholecystectomy to other procedures and hospitals.

Key Recommendations

1. Strengthening training and capacity building

- Institutionalize MIS training in all surgical residency programs and expand fellowship opportunities.
- Develop decentralized simulation labs for broader access to hands-on training.
- Foster partnerships with international institutions for knowledge transfer and skill enhancement.

2. Expanding ERAS protocols

- Implement ERAS protocols for multiple surgical procedures beyond cholecystectomy.
- Establish ERAS champion teams in major hospitals to drive adoption and compliance.
- Utilize telemedicine for remote patient monitoring and postoperative care.

3. Infrastructure and resource optimization

- Standardize procurement of laparoscopic equipment to reduce costs.
- Establish regional maintenance hubs for MIS instruments to ensure longevity.
- Upgrade hospital facilities to support advanced MIS procedures.

4. Strengthening policy and financial support

- Integrate MIS and ERAS into national surgical strategies.
- Develop sustainable financing models through government and private partnerships.
- Advocate for insurance coverage and policy frameworks supporting MIS expansion.

5. Community engagement and patient Education

- Conduct national awareness campaigns on the benefits of MIS.
- Engage community health workers in patient education and follow-up.
- Promote patient-centered care to improve surgical decision-making.

6. Research and data collection

- Establish a national MIS and ERAS database for outcome monitoring.
- Conduct multi-center studies to evaluate the cost-effectiveness and impact of these approaches.
- Foster regional collaboration through COSECSA-affiliated research networks.

7. Positioning Rwanda as a regional surgical Hub

- Organize international surgical conferences to showcase Rwanda's expertise in MIS.
- Develop a structured system to attract international patients seeking advanced MIS procedures.
- Establish a Rwandan Society of Minimally Invasive Surgery to drive training, research, and advocacy.

By implementing these strategic recommendations, Rwanda and the COSECSA region can strengthen surgical capacity, enhance patient outcomes, and position MIS and ERAS as sustainable pillars of modern surgical care.

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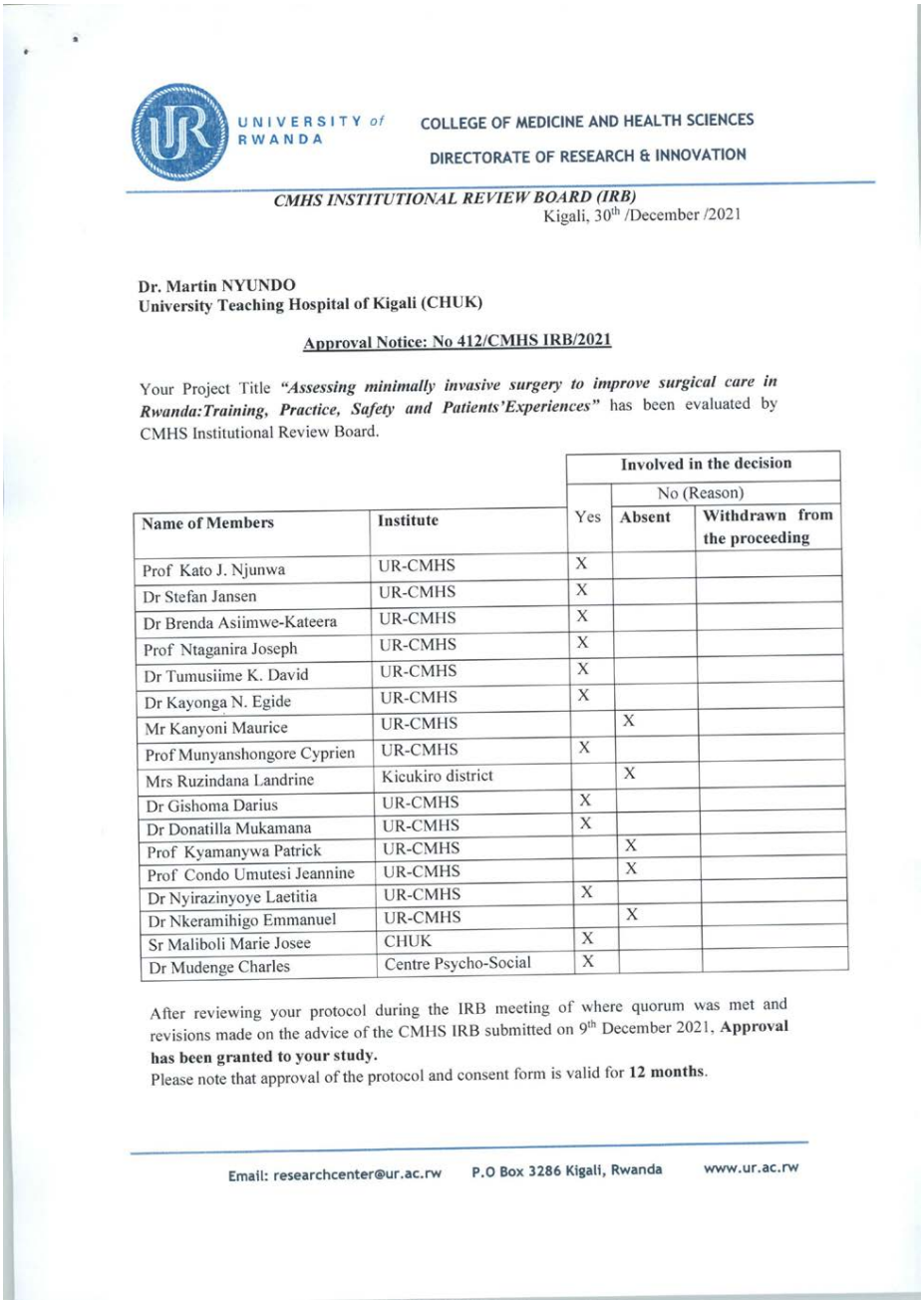
APPENDICES

APPENDICES

Appendix 1. CMHS/UR IRB approval for the thesis



UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 30th /December /2021

Dr. Martin NYUNDO
University Teaching Hospital of Kigali (CHUK)

Approval Notice: No 412/CMHS IRB/2021

Your Project Title ***"Assessing minimally invasive surgery to improve surgical care in Rwanda:Training, Practice, Safety and Patients'Experiences"*** has been evaluated by CMHS Institutional Review Board.

Name of Members	Institute	Involved in the decision		
		Yes	No (Reason)	
			Absent	Withdrawn from the proceeding
Prof Kato J. Njunwa	UR-CMHS	X		
Dr Stefan Jansen	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS		X	
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 9th December 2021, **Approval has been granted to your study.**
Please note that approval of the protocol and consent form is valid for **12 months**.

Email: researchcenter@ur.ac.rw P.O Box 3286 Kigali, Rwanda www.ur.ac.rw

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 30th December 2021

Expiration date: The 30th December 2022

Dr Stefan Jansen
Ag. Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:
- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

Appendix 2. COSECSA IRB Approval for study regarding the status of minimally Invasive surgery in COSECSA region

COLLEGE OF SURGEONS OF EAST, CENTRAL AND SOUTHERN AFRICA
(ASSOCIATION OF SURGEONS OF EAST AFRICA)

East, Central and Southern Africa Health Community (ECSA-HC)
Plot No 157 Olorien-Njiro Road
P.O.Box 1009 Arusha – Tanzania
Phone: +255 27 2549362/5/6
Web: www.cosecsa.org
Email: coo@cosecsa.org
IRB Registration Number: 00011122

Martin Nyundo, MD, MMed, FCS (ECSA), PhD Candidate and Principal Investigator: Senior Consultant General Surgeon
Affiliation: University of Rwanda, University Teaching Hospital of Kigali (CHUK)

Email: nyundomartin@gmail.com | Phone: +250 788418727 | +324 65785777

14th January 2021.

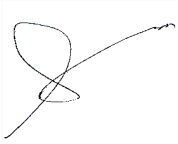
Dear Dr. Nyundo,

RE: "Current status of the training and the practice of laparoscopic surgery in the COSECSA Countries: Barriers and Solutions in the accredited training hospitals sites."

Reference is made to the above subject. I am pleased to inform you that the COSCSA IRB has approved your study protocol. You are required to give period updates on the progress of your research and report any adverse events. You are also required to submit the completed report of your publication to COSECSA.

I wish you success in your study.

Yours Faithfully,



Prof. Laston Chikoya.

Chairman COSECSA IRB.

Appendix 3. CHUK Ethics approval for study regarding patient reported outcome and experiences with laparoscopic cholecystectomy

CENTRE HOSPITALIER UNIVERSITAIRE
UNIVERSITY TEACHING HOSPITAL

Quality Health Care
Training & Research

Ethics Committee / Comité d'éthique

28th Jun,2021 *Ref.:EC/CHUK/075/2021*

Review Approval Notice

Dear Martin NYUNDO,

Your research project: ***"Experiences of patients who underwent laparoscopic surgery in Rwanda: Six years of journey at the University Teaching Hospital of Kigali (2015-2020 "***

During the meeting of the Ethics Committee of University Teaching Hospital of Kigali (CHUK) that was held on 28th Jun,2021 to evaluate your request for ethical approval of the above mentioned research project, we are pleased to inform you that the Ethics Committee/CHUK has approved your research project.

You are required to present the results of your study to CHUK Ethics Committee before publication by using this link:www.chuk.rw/research/fullreport/?appid=404&&chuk.

PS: Please note that the present approval is valid for 12 months.

Yours sincerely,

Dr Emmanuel Rusingiza Kamanzi
The Chairperson, Ethics Committee,
University Teaching Hospital of Kigali

ETHICS COMMITTEE
CHUK

Scan code to verify.

" University teaching hospital of Kigali Ethics committee operates according to standard operating procedures (Sops) which are updated on an annual basis and in compliance with GCP and Ethics guidelines and regulations "

Appendix 4. CHUK Ethics approval for study regarding ERAS in laparoscopic cholecystectomy

CENTRE HOSPITALIER UNIVERSITAIRE
UNIVERSITY TEACHING HOSPITAL

Quality Health Care
Training & Research

Ethics Committee / Comité d'éthique

28th Jun,2021 *Ref.:EC/CHUK/074/2021*

Review Approval Notice

Dear Martin NYUNDO,

Your research project: ***"Enhanced recovery after surgery program in a low and middle-income country: Feasibility, safety, patient's acceptance, reduction of the length of hospital stay, bed turnover and cost benefits for laparoscopic cholecystectomy at CHUK "***

During the meeting of the Ethics Committee of University Teaching Hospital of Kigali (CHUK) that was held on 28th Jun,2021 to evaluate your request for ethical approval of the above mentioned research project, we are pleased to inform you that the Ethics Committee/CHUK has approved your research project.

You are required to present the results of your study to CHUK Ethics Committee before publication by using this link:www.chuk.rw/research/fullreport/?appid=403&&chuk.

PS: Please note that the present approval is valid for 12 months.

Yours sincerely,

Dr Emmanuel Rusingiza Kamanzi
The Chairperson, Ethics Committee,
University Teaching Hospital of Kigali

ETHICS COMMITTEE
CHUK

Scan code to verify.

" University teaching hospital of Kigali Ethics committee operates according to standard operating procedures (Sops) which are updated on an annual basis and in compliance with GCP and Ethics guidelines and regulations "

Appendix 5. Clinical trials registration approval for study regarding ERAS in laparoscopic cholecystectomy

ClinicalTrials.gov PRS
Protocol Registration and Results System

ClinicalTrials.gov PRS DRAFT Receipt (Working Version)
Last Update: 08/31/2022 07:59

ClinicalTrials.gov ID: NCT05516056

Study Identification

Unique Protocol ID:	EC/CHUK/074/2021
Brief Title:	ERAS After Cholecystectomy in Kigali, Rwanda
Official Title:	Enhanced Recovery After Surgery Program in a Low and Middle-income Country: Feasibility, Safety, Patient's Acceptance, Reduction of the Length of Hospital Stay, Bed Turnover and Cost Benefits for Laparoscopic Cholecystectomy at CHUK
Secondary IDs:	

Study Status

Record Verification:	August 2022
Overall Status:	Recruiting
Study Start:	January 1, 2022 [Actual]
Primary Completion:	December 31, 2022 [Anticipated]
Study Completion:	March 31, 2023 [Anticipated]

Sponsor/Collaborators

Sponsor:	Olivier Detry MD PhD
Responsible Party:	Sponsor-Investigator Investigator: Olivier Detry MD PhD [dolivier] Official Title: Chargé de Cours (Associate Professor) Affiliation: University of Liege
Collaborators:	University of Rwanda

Oversight

U.S. FDA-regulated Drug:	No
U.S. FDA-regulated Device:	No
U.S. FDA IND/IDE:	No
Human Subjects Review:	Board Status: Approved Approval Number: EC/CHUK/074/2021 Board Name: Ethics Committee Board Affiliation: University Teaching Hospital, Kigali, Rwanda Phone: 00 (250) 252575462 Email: chuk.hospital@chuk.rw Address: