

Practice, training and safety of laparoscopic surgery in low and middle-income countries

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Abstract

Surgical management of diseases is recognised as a major unmet need in low and middle-income countries

(LMICs). Laparoscopic surgery has been present since the 1980s and offers the benefit of minimising the morbidity and potential mortality associated with laparotomies. Laparotomies are often carried out in LMICs for diagnosis and management, due to lack of radiological investigative and intervention options. The use of laparoscopy for diagnosis and treatment is globally variable, with high-income countries using laparoscopy routinely compared with LMICs. The specific advantages of minimally invasive surgery such as lower surgical site infections and earlier return to work are of great benefit for patients in LMICs, as time lost not working could result in a family not being able to sustain themselves. Laparoscopic surgery and training is not cheap. Cost is a major barrier to healthcare access for a significant population in LMICs. Therefore, cost is usually seen as a major barrier for laparoscopic surgery to be integrated into routine practice in LMICs. The aim of this review is to focus on the practice, training and safety of laparoscopic surgery in LMICs. In addition it highlights the barriers to progress in adopting laparoscopic surgery in LMICs and how to address them.

Key words: Laparoscopic surgery; Global surgery; Low and middle-income countries; Laparoscopic training; Patient safety; Laparoscopy; Minimally invasive surgery

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Core tip: The rate of laparoscopic surgery in low and middle-income countries (LMICs) is gradually increasing. In this review we highlight the practice of laparoscopic surgery in LMICs from diagnostic procedures to complex resections. Training in laparoscopic surgery is inherently variable in LMICs, however innovative teaching methods with inexpensive materials have been developed. Safety data on laparoscopic surgery in LMICs is minimal and more research needs to be done. It is essential to establish safe practices that must be contextualized to serve the population in various LMICs.

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INTRODUCTION

Surgical management of diseases are now recognized as major unmet needs in low and middle-income countries (LMICs)^[1]. These countries are defined by the World Bank as having a gross national income (GNI) per capita of \$1045 or less for low-income countries and more than \$1045 but less than \$12736 for middle income countries^[2]. High-income countries (HICs) by definition have a GNI per capita of more than or equal to \$12736^[2].

Laparoscopic surgery was first introduced in the 1980s and is the preferred approach to a number of surgical procedures in HICs^[3]. There are growing numbers of global surgery initiatives that have acknowledged surgical need and volume will continue to rise in LMICs^[4-6]. Laparoscopic surgery offers the benefit of minimizing the morbidity and potential mortality associated with laparotomies. Several studies have shown that laparoscopic surgery is feasible in LMICs with reports of laparoscopy reducing laparotomy rates from fourteen to six percent^[7-11]. Particular advantages of minimally invasive procedures are lower surgical site infection rates, ileus, earlier return to work, better pain control and cosmesis^[12,13]. Decreasing the length of stay in hospital is of paramount importance to patients in LMICs, where days lost working translates into lack of food for some families. Hence, laparoscopic surgery seems attuned to serve such communities.

There has been sporadic and marginal adoption of laparoscopic surgery in LMICs for various reasons. Some of the obstacles are intrinsically health care system related, others financially driven such as inadequately trained personnel and lack of equipment. The cost of initial set up and maintenance of laparoscopic surgery equipment has been reported in some studies as the main inhibitory factor for minimally invasive surgery being commonly used in LMICs^[9,10]. Nevertheless, laparoscopic procedures are performed in a number of surgical specialties in LMICs such as general surgery, urology, paediatric surgery and gynaecology. Laparoscopic procedures such as hysterectomies, tubo-ovarian surgery, cholecystectomies, appendicectomies, herniorrhaphies and diagnostic laparoscopies are well established and performed routinely mainly in private centres in LMICs^[7,10,14,15]. The aim of this review is to highlight the practice, training and safety of laparoscopic surgery in LMICs.

PRACTICE OF LAPAROSCOPIC SURGERY

The benefits of laparoscopic surgery in LMICs are parallel to those of HICs. Diagnostic laparoscopy has the value of

decreasing laparotomy rates. Furthermore, laparoscopy in certain LMICs has replaced radiological diagnosis due to the lack of radiologists and radiological facilities. A study from Nigeria by Adisa *et al*^[16] reported neoplastic lesions identified in 64 patients through diagnostic laparoscopy, which aided further management of their cancers in some cases with chemotherapy or palliative procedures. The study highlighted only six computed tomography (CT) scanners and three magnetic resonance imaging (MRI) scanners were serving a population of approximately 15 million in Southwestern Nigeria as at 2012^[16].

The challenges of the adoption and use of new technology or ideas are common to any health care setting. The initial reservations of laparoscopic surgery not being "orthodox" surgery in LMICs are gradually disappearing. Interestingly, hierarchical surgical culture has been quoted as a hindrance for laparoscopic surgery being performed in some hospitals, as senior surgeons "did not feel comfortable with it" due to lack of engagement^[17]. Some patient driven factors due to deficiencies in communication or education also contribute to the hurdles of the acceptance of laparoscopic surgery in LMICs^[18,19].

Equipment donated by charitable organisations has enabled the practice of laparoscopic surgery in numerous LMICs. Minimally invasive procedures are being used in LMICs for both emergency and elective procedures. In many parts of Africa, laparoscopic surgery is much more common in private hospitals due to the availability of funding for equipment and maintenance. Diagnostic laparoscopy in particular has taken center stage in LMICs where radiological facilities are lacking. Udwardia^[9] reported performing approximately 3000 diagnostic laparoscopies over an 18 year period with no mortalities and a complication rate of 0.1%. These procedures had been used for the evaluation of abdominal tuberculosis, peritoneal pathology and abdominal trauma^[9]. Shehata *et al*^[20] reported 36 successful laparoscopic inguinal hernia operations with no recurrences or conversions to open surgery in a paediatric cohort. Day case procedures in LMICs are feasible provided set discharge criteria are in place to ensure patient safety^[18,19]. Laparoscopic appendicectomies have been performed with 87% of patients being discharged on the same day successfully from a cohort of thirty in India^[21].

Studies on certain specialised laparoscopic procedures such as colorectal, endocrine and urological surgery are scarce. Laparoscopic colorectal surgery as a whole is not commonly performed in African countries^[10], this may be a reflection of the low incidence of colorectal disease. An Egyptian study however has reported successful outcomes in 37 patients with colorectal cancer managed laparoscopically^[22]. Laparoscopic urological procedures in sub-Saharan Africa are usually performed by visiting surgeons from HICs during voluntary work or by sponsored invitations.

Spinal and regional rather than general anaesthesia has been safely used in LMICs for laparoscopic surgery^[9,23,24]. Insufflation with carbon dioxide alone is an expensive venture in LMICs. Therefore, the development

and use of “gasless” laparoscopy in LMICs has been revolutionary^[25]. Inventive strategies such as insufflation with room air, extracorporeal knot tying and hand assisted techniques have evolved in LMICs^[26,27]. Adisa *et al*^[10] used tube drapes that can be autoclaved as camera covers. Such innovative measures make laparoscopic surgery more attainable in LMICs.

TRAINING IN LAPAROSCOPIC SURGERY

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 centres in the United States and Europe to gain more laparoscopic experience^[28]. This also stimulates practice on box trainers where available on their return. 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 has the potential for unsafe practices being learnt by surgeons in training.

The challenges for the surgeon of learning to decipher two to three dimensional images, hand eye co-ordination; past pointing and haptic feedback are universal. Learning and practicing outside the operating theatre is crucial for acquiring laparoscopic skills. The resource-limited environment in LMICs also hampers the progress of laparoscopic training, with the lack of expert trainers. Laparoscopy is not taught in postgraduate residency training programmes in several LMICs and hence simulated laboratories are not readily available due to equipment costs. Lack of animal laboratories or wet labs as aids to practice in a safe location also add to the training constraints. Nevertheless, innovative measures have been developed to counteract the simulation problem with low fidelity but effective trainers. Ingenious low technology and cost laparoscopic trainers have evolved from both LMICs and HICs. Low cost trainers vary in price in different countries ranging from \$0 (if using already available materials) to \$85^[29,30]. For example, Mir *et al*^[4] reused an empty dextrose solution cardboard box to make an inexpensive trainer. Home laparoscopic trainers have been made from recyclable materials such as storage and shoe boxes^[29,31]. Simulation based training even with low cost equipment requires investing time and sustainability^[32]. Locally sourced materials are key to the success of making low cost laparoscopic training tools.

Andreatta *et al*^[33] developed a training programme in Ghana with laparoscopic exercises such as cutting or peeling a tangerine into as few pieces as methods to assist in learning dissection and haptic feedback^[33]. American surgeons have used validated training tools such as the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills in Tanzania to assess the use of a low-cost laparoscopic box trainer, which they found to be effective when an expert trainer was

present^[29].

The recording of commonly performed procedures such as appendicectomies and cholecystectomies for teaching and training is significantly underutilized in both LMICs and HICs. This can allow nurses, medical students, surgical and anaesthetic trainees to understand the processes involved in these laparoscopic operations. Access to the Internet can also aid learning as a number of laparoscopic operations are freely available online. Curricular can facilitate learning of laparoscopic skills in LMICs using low cost trainers and these need to be developed.

Both surgeons and nurses need to be trained in the principles and practical aspects of laparoscopic surgery. Knowledge of the instruments is essential when performing laparoscopic surgery. The training and practice of laparoscopic surgery in LMICs, could be improved and made more widely available through postgraduate medical education. In Nigeria for example, a group of general surgeons have recently formed the Laparoscopic Surgery Society of Nigeria to assess the scope of practice, basic competency, proficiency, and outcomes of laparoscopic surgery, so as to develop training.

SAFETY OF LAPAROSCOPIC SURGERY

Variability in safety and quality exists with laparoscopic surgery in LMICs^[34]. Although a number of studies have reported safely performing laparoscopic surgery, studies on the early complication rates may however be under reported in the literature. Mortality associated with anaesthesia is a major concern in LMICs, with reports ranging from 1 in 100 to 500^[35,36]. The direct relationship of anaesthetic risks during laparoscopic surgery in LMICs is scarce in the literature. This may be because in a number of LMICs, spinal rather than general anaesthetic is used for laparoscopic surgery. Furthermore, the numbers of laparoscopic cases in most units have not reached a level whereby complications directly related to laparoscopy are reported such as respiratory compromise secondary to a pneumothorax or pulmonary edema.

In a comparative study, Manning *et al*^[37] reported major complications such as bile leaks and duodenal perforations in patients following laparoscopic cholecystectomy in a large patient series from Afghanistan. More advanced laparoscopic procedures are being undertaken in certain LMICs. Senthilnathan *et al*^[38] reported long-term results of a 130 patients following a laparoscopic pancreaticoduodenectomy for pancreatic cancer. This included a 5-year actuarial survival of 29%, a mortality rate of 2% and a positive margin rate of 9%^[38]. Adequate training is crucial for patient safety. The inability to easily recognise the complications associated with laparoscopic surgery is a potential safety concern. In LMICs, there are significant implications with morbidity and mortality risks that can be associated with laparoscopic surgery such as bile duct injury in laparoscopic cholecystectomies, as facilities such as

endoscopic retrograde cholangiopancreatography are lacking^[39].

The use of reusable laparoscopic instruments has helped in reducing the financial load in LMICs compared with disposable instruments. Studies have reported instruments being used for over 10 years, as well as reusing disposable instruments^[9,40]. However, safety data about such usage is unknown. Nonetheless, no short-term safety concerns or suboptimal function have been described post sterilization. The upkeep and repairs of laparoscopic equipment is a significant challenge in LMICs. Part of the problems with donated instruments and equipment is the unavailability of trained personnel to undertake servicing. To counteract this, the manufacture and maintenance of low-cost equipment should be part of the future projects for industries to cater for LMICs.

DISCUSSION

Laparoscopic surgery has been a paradigm shift in surgical practice. Global surgical diseases have been estimated at eleven percent, although this may be an underestimate^[41-44]. Only four percent of surgical procedures are carried out in low-income countries^[45]. Lower life expectancy and infant mortality, which could partly be related to surgical need in terms of trauma and obstetric care respectively, remain a major issue in LMICs^[46,47]. Therefore, there is a rising trend to develop surgical treatment in LMICs^[48-50] with laparoscopic surgery playing a central role.

Surgical cultures and behaviours have been narrated as having an impact on the introduction and progress of new technology. Therefore a mindshift towards laparoscopic surgery and other new surgical techniques needs to be encouraged in LMICs to challenge the status quo. The time taken for some laparoscopic procedures, because of the set up, is much longer than open surgery. Therefore in LMICs where demand for high output surgical procedures is great, the throughput ability of laparoscopic surgery may be questioned. The specialist "general surgeon" is fast disappearing in HICs due to sub-specialisation. In LMICs however, the general surgeon is still very necessary given the array of conditions he or she is required to treat. Controversially, the generalist laparoscopic surgeon may be too demanding to have among a personnel limited and population heavy setting that exists in many LMICs.

Inequalities in health with regards to access and affordability are wider in LMICs, where the more affluent are more likely to have their operations performed laparoscopically. The payment plans of health care services vary in LMICs. They may be self-financed, government subsidized or insurance based and this has the potential effect of influencing the choices in procedures carried out specifically with regards to cost such as in laparoscopic surgery. A number of units in LMICs have acquired their laparoscopic instruments through donations or following surgical missions from HICs. A way of accessing materials is for surgeons,

healthcare service providers and governments to engage in the development process for laparoscopic surgery to be more accessible in LMICs.

Cost is a major barrier to healthcare access for a significant number of individuals in LMICs. The financial afflictions that face some LMICs may have been the result of war, conflict, corruption and other humanitarian crises. Thus, understanding the baseline operative capabilities in these countries is paramount before embarking on an improvement operation^[51]. It is also key for surgical mission trips to endeavour to build, adapt and tailor practices that are sustainable for LMICs, rather than perform procedures with considerations only for the standards of HICs. The focus of these mission trips should be goal directed with long-term planning for continuous teaching, training and supervision of new initiatives.

The price of equipment is a major obstacle to laparoscopy being routine in LMICs. This was one of the initial factors hindering rapid uptake of laparoscopic surgery in a number of hospitals in HICs. Although some studies have reported diagnostic laparoscopy to be more cost effective in some African countries, others have reported laparoscopy costs to be similar to that of laparotomy^[7-9]. Remarkably laparoscopic equipment per case has been reported to be as low as \$20, with the cost of the procedures themselves ranging from approximately \$55 to \$300 in some LMICs^[9,10,15]. Lowering the cost of the equipment, maintenance and surgery itself will increase the endorsement of laparoscopic surgery in LMICs. This could be achieved through collaborative work with governments and medical equipment suppliers.

Bal *et al*^[18] have shown that day case laparoscopic procedures such as laparoscopic cholecystectomies are feasible in LMICs. Chauhan *et al*^[19] on the other hand argue that day surgery is not cost effective in LMICs compared with HICs because of infrastructural constraints. The practice of day case surgery to negate the cost of hospital stay would be variable in LMICs. As patients sometimes have come from long distances and for safety reasons a period of in-patient observation may be necessary. However with the advent of global mobile phone technology, telephone and video based reviews and follow-ups may be the way forward to offset this problem.

The Fundamentals of Laparoscopic Skills, which involves web-based and technical skills training in the United States, is a good example of a method for standardizing skills. A low cost version of such a program would be appropriate in a resource-limited environment to provide education, training and accreditation. The training programmes 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, Face Time and Skype for example, to allow communication, consultation and feedback.

International organizations provide a lot of surgical

care in LMICs; therefore, cooperative efforts are crucial to the success of safe laparoscopic operations in LMICs. The benefit of experience from visiting or locally trained surgeons will provide insight into potential short and long-term problems with solutions, as well as the economic contingency measures. Centralization of laparoscopic surgery maybe better for infrastructure planning in the initial stages of service provision in LMICs. This may curtail the differences in the quality of health care delivery and integrate various concepts such as patient selection, safety, re-cycling of equipment and resource allocation. It could also help in training surgeons and nursing staff from different peripheral hospitals to a certain standard.

This review has a number of limitations that we acknowledge such as the difficulty in generalizing the differences between LMICs in terms of health care budgets and the surgical needs of the population. Therefore, some of the solutions we suggest may not be suitable for all LMICs. Most of the studies reported in the literature were retrospective, non-comparative with short-term follow-up periods. More research needs to be encouraged into data collection, formation of registries and reporting of outcomes of laparoscopic surgery in LMICs.

CONCLUSION

The management of surgical conditions in LMICs are now of great interest to health care funders and researchers in HICs. We believe laparoscopic surgery in LMICs offers the same advantages as in HICs - reduced surgical site infections, length of stay; and should be promoted as such. Social and economic change alongside with manufacturers and health ministries are the main drivers for cost effective healthcare in LMICs to enable deprived individuals access to surgical care. The global economic picture for better healthcare should include the manufacture of robust, durable and affordable surgical instruments that can be used by LMICs.

The realms of safety in surgery in certain LMICs still lies in the ability to obtain basic amenities such as clean water and electricity as well as having adequately trained medical, nursing and allied health professional staff. The culture of guidelines, regulation and monitoring also needs to be adopted in LMICs in line with accountability for complications. The trend of laparoscopic surgery is here to stay for a few years before robotic surgery or other means take over. It is therefore vital to establish safe practices that must be contextualized to serve the population in various LMICs.

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