Essential Surgery Chapter 9: Hernia and Hydrocele

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ABSTRACT

Groin hernia and hydrocele are two of the most common surgical conditions globally. Although the surgical care for these conditions is cost-effective, many people do not have access to hernia repair and hydrocelectomy. These essential operations must be prioritized and integrated into primary healthcare delivery systems in low- and middle-income countries.

INTRODUCTION

Groin hernia and hydrocele are two of the most common surgical conditions globally. In this chapter, we summarize the literature on the pathogenesis, clinical presentation, and treatment for groin hernia and hydrocele, focusing on unique clinical characteristics and management strategies for these conditions in low- and middle-income countries (LMICs).

We present our estimation of the global and regional burden of disease from groin hernia, the first of its kind in the literature. In addition, we highlight the existing data on the cost-effectiveness of surgical treatment for groin hernia and hydrocele. We document the successful global efforts of Operation Hernia and the Global Programme to Eliminate Lymphatic Filariasis (GPELF) in combating hernia and lymphatic filariasis (a common cause of hydrocele in LMICs), respectively.

Groin hernia repair and hydrocelectomy are cost-effective curative therapies that can improve quality of life. In addition, herniorrhaphy can prevent life-threatening complications associated with groin hernia.

Unfortunately, many people do not have access to safe and effective surgical care for these common conditions.

The treatment of groin hernia and hydrocele should be a high priority on any global surgery agenda. Basic surgical care for these conditions is a crucial part of primary health care services that should be available at district-level hospitals. Training programs to improve the skills of surgical care providers in LMICs, along with infrastructure investment to build hospital capacity, are urgently needed to increase access to these essential surgical procedures.

GROIN HERNIA

DEFINITIONS OF GROIN HERNIA

A hernia is a protrusion of a body part through a defect in the anatomic structure that normally contains it. A groin hernia is a specific type of hernia involving the bulging of abdominal contents through the inguinal or femoral canal. The inguinal canal is a "corridor" in the abdominal wall, which houses the spermatic cord as it passes on its way to the testicle in men. Inguinal hernias may be caused either by a failure in the normal closure of the abdominal lining in the inguinal canal during fetal development, or by an acquired weakening of the abdominal wall. In either case, the hernia sac, which may contain fat, ovary, bowel, or bladder, protrudes through the abdominal wall into the inguinal canal.

A scrotal hernia is a type of inguinal hernia in which the hernia sac, often containing bowel, follows the path of the spermatic cord into the scrotum. Femoral hernias occur rarely and involve the protrusion of abdominal contents through the femoral canal, a space adjacent to the femoral vein in the upper thigh. This type of hernia occurs most commonly in women (Nilsson and others 2007).

Groin hernias may be further classified as reducible, incarcerated, or strangulated.

- A reducible hernia is one in which the hernia contents can be gently pushed back into the abdominal cavity.
- An incarcerated hernia is irreducible, meaning that the hernia sac is "stuck" outside the abdomen.
- A strangulated hernia refers to an incarcerated hernia in which the trapped bowel twists on itself, obstructing blood flow and ultimately causing bowel infarction and perforation. These conditions are life-threatening emergencies requiring immediate surgery.

Scrotal and femoral hernias are more likely to become incarcerated and cause complications.

RISK FACTORS AND NATURAL HISTORY OF GROIN HERNIA

In a study of hernias in American adults (5,316 men and 8,136 women) participating in the First National Health and Nutrition Examination Survey (NHANES) between 1971−75 and followed through 1993, male gender and increasing age were identified as important groin hernia risk factors. Black race and obesity were associated with a lower incidence of inguinal hernia in the cohort (Ruhl and Everhart 2007).

Increased intra-abdominal pressure has long been implicated in the pathogenesis of inguinal hernia; however, data on physical activity as a risk factor for groin hernia are inconclusive. The National Health and Nutrition Examination Survey (NHANES) found no evidence of association between physical activity and hernia risk, but two case-control studies from Spain suggest that strenuous activity may play a role in hernia development (Carbonell and others 1993; Flich and others 1992; Ruhl and Everhart 2007). It is likely that different types of physical activity are associated with different levels of risk, and further study is needed on this topic. Other risk factors for groin hernia include a family history of hernia and the presence of a hiatal hernia (Ruhl and Everhart 2007). Prematurity is an important risk factor in children (Lau and others 2007).

The natural history of inguinal hernia is poorly understood. Population-based studies are nearly impossible today since inguinal hernia repair is at least somewhat available in most settings. The little contemporary data that exist are limited by selection bias (Gallegos and others 1991). The key question in determining the natural history of hernia centers on the identification of the annual risk of hernia accident (that is, bowel obstruction, incarceration, or strangulation) without hernia repair. To address this question, Neuhauser examined data in two settings where herniorrhaphy was generally not practiced: Paul Berger's Paris truss clinic (circa 1880) and Cali, Colombia (circa 1970). He found that the probabilities of hernia accident per year were 0.0037 and 0.00291 in the Berger and Colombia data, respectively (Neuhauser 1977).

Using Neuhauser's figures and U. S. life-table analysis, Turaga and colleagues calculated a hernia accident lifetime incidence of 19.4 percent in 18-year-old men with inguinal hernia in the United States (Turaga, Fitzgibbons, and Puri 2008). They found only a 4.4 percent lifetime incidence of hernia accident in 72-year-old men with hernia (Turaga, Fitzgibbons, and Puri 2008). These calculations suggest that hernia accident is a relatively common lifetime event in younger patients with unrepaired inguinal hernia.

Clinical Features of Groin Hernia in LMICs

Patients with inguinal hernia generally present with a bulge in the groin, which may have associated symptoms. Limited access to surgical care in LMICs leads to a clinical picture of groin hernia that is distinct from that of high-income countries (HICs). In fact, most cases of inguinal hernia in LMICs go untreated, resulting in large painful hernias that often limit physical activity (Herazage 2004; Sanders and others 2008; Shillcut and others 2010). In a prospective study from Ghana, 67 percent of patients presenting for repair had scrotal hernias, placing them at increased risk of hernia complications. When the Ghanaian cohort was compared to a similar group of patients from the United Kingdom, the Ghanaians were found to be younger and have larger hernias (Sanders and others 2008).

Groin hernias are often longstanding in LMICs. In Tanzania, nearly half of hernia patients in one study presented for repair more than five years after disease onset (Mabula and Chalya 2012). Groin hernias also have negative effects on patient well-being and productivity in LMICs. For example, in another Ghanaian hernia cohort, 16 percent of hernia patients were unable to work, and 64 percent reported limited daily activity (Sanders and others 2008).

Most symptomatic groin hernias in HICs are treated with elective surgery before complications such as obstruction or strangulation occur. In a prospective study of 6,895 patients in the Swedish Hernia Register, only 5 percent of groin herniorrhaphies in men were classified as emergencies (Koch and others 2005).

In contrast, patients with groin hernia in LMICs often present for medical care with complications. Over two-thirds of inguinal hernias repairs at a tertiary referral center in Kumasi, Ghana, were emergency operations (Ohene-Yeboah and others 2009). In a recent study from Bugando Medical Center in Tanzania, more than half of presenting groin hernias were incarcerated, while 18.6 percent and 11.1 percent of patients, respectively, had obstructed and strangulated hernias (Mabula and Chalya 2012). The unique clinical features of groin hernias in LMICs, including large size, longer disease duration, physical limitations, and complicated hospital presentation, result in high morbidity and mortality rates.

Epidemiology and Burden of Disease

Prevalence and Incidence of Inguinal Hernia in HICs

Inguinal hernia is one of the most common surgical conditions globally. An estimated 20 million groin hernias are repaired annually worldwide (Bay-Nielsen and others 2001). Despite high disease prevalence, there have been relatively few studies of inguinal hernia epidemiology, even in HICs. Data from World War II cohorts demonstrate an inguinal hernia prevalence of between 6.5 percent and 8.0 percent in American soldiers (Everhart 1994). A study from the United Kingdom found a 27 percent lifetime risk for inguinal hernia repair in men and 3 percent in women (Primatesta and Goldacre 1996). A rigorous community-based survey demonstrated an inguinal hernia prevalence of 18.2 percent among men in an ethnically diverse Jerusalem neighborhood (Abramson and others 1978).

Studies of groin hernia incidence are particularly limited. Data from the NHANES study has been used to make the most reliable assessment of inguinal hernia incidence in the United States. In their analysis of the NHANES cohort, Ruhl and Everhart found an annual incidence of inguinal hernia of 315 per 100,000 population in U. S. adults (Ruhl and Everhart 2007).

Not surprisingly, the incidence of inguinal hernia repair is lower than disease incidence. A recent retrospective review of all inguinal hernia repairs in Minnesota over a 20-year period found an incidence of hernia repair of 217 per 100,000 person-years (Zendejas and others 2013). This means that approximately 670,000 inguinal hernia repairs are performed annually in the United States.

The annual inguinal hernia repair rate in the United Kingdom (130 per 100,000 population) is lower than the rate of repair in the United States (Primatesta and Goldacre 1996). Differing practice patterns among surgeons and referring primary care physicians may explain regional differences in the incidence of inguinal herniorrhaphy in HICs (Hair and others 2001).

Epidemiology of Inguinal Hernia in LMICs

Information on the epidemiology of inguinal hernia in low-resource settings is limited to a few published studies from the 1960s and 1970s on inguinal hernia prevalence in Sub-Saharan Africa (Belcher, Nyame,

and Wurapa 1978; Yardov and Stoyanov 1969). Inguinal hernia prevalence in men in these studies ranges from 7.7 percent in rural Ghana to 25 percent on the island of Pemba in East Africa. Given poor access to surgical care in LMICs, it makes sense that inguinal hernia prevalence would be higher in LMICs than in HICs. However, only limited evidence supports this thesis; contemporary data on the incidence of inguinal hernia in LMICs is notably lacking.

To fill this gap in knowledge, Beard and colleagues created a method to estimate inguinal hernia incidence and prevalence in LMICs, carrying out their analysis both in the Ghanaian and Tanzanian contexts (Beard and others 2013; Beard and others, unpublished manuscript). In their Tanzanian analysis, they adjusted incidence data from the NHANES study for the population age and gender structure of the country, and they calculated an annual incidence of new hernias in Tanzanian adults of 244 per 100,000 population. This number is lower than the inguinal hernia incidence of 315 per 100,000 person-years calculated in the NHANES study (Ruhl and Everhart 2007). The authors attributed the lower incidence of inguinal hernia in Tanzania to the relative youth of the population compared to that of the United States.

Despite demonstrating a lower incidence of inguinal hernia, Beard and colleagues estimated a relatively high prevalence of inguinal hernia in Tanzanian men at 12.1 percent. [Q: Confirm meaning**]** (Beard and colleagues, unpublished manuscript). Because heavy labor and racial factors have not been clearly substantiated as significant inguinal hernia risk factors in the literature, the authors attribute the higher prevalence of hernia in Sub-Saharan Africa to a lack of access to surgery in the region (Lau and others 2007; Ruhl and Everhart 2007).

The Global Burden of Inguinal Hernia

Estimates of the global burden of inguinal hernia are rough at best. Yang and colleagues estimated that 58.7 million Disability-Adjusted Life Years (DALYs) would be averted by repair of all adult hernias in Sub-Saharan Africa (Yang and others 2011). This figure is more than double the estimates of the total surgical disease burden for Africa calculated by Debas and colleagues (Debas and others 2006). The discrepancy could be caused by either a previous underestimation of the burden of surgical disease or, more likely, by different methods employed to calculate surgical DALYs. A standard metric to measure the surgical burden of disease is urgently needed to accurately identify global surgical priorities and guide resource allocation and advocacy efforts.

In the 2010 Global Burden of Disease Study (GBD 2010), Murray and colleagues found that 11 DALYs per 100,000 population per year were attributable to groin hernia worldwide. This figure is less than their estimates for non-life-threatening conditions like premenstrual syndrome (18 DALYs per 100,000 population) and scabies (23 per 100,000 population) (Murray and others 2012). We believe that the disease burden of groin hernia has been underestimated in the GBD 2010 study. Following, we present our estimates of inguinal hernia epidemiology and global disease burden.

In order to test our hypothesis, we recalculated the DALYs attributable to groin hernia using the method described by Beard and colleagues (Beard and colleagues, unpublished data). We adjusted the NHANES incidence figures to the population age structures of the six World Health Organization (WHO) regions (U.S. Census). We then calculated incidence and prevalence accordingly. Deaths were estimated by using

Neuhauser's figure of 0.0037 probability of hernia accident per year, along with our own estimates of death from hernia complications in the various WHO regions (Neuhauser 1977).

For our DALY calculation, we assumed that hernia patients in the African region present for surgical treatment at an average age of 45 years, while patients in other regions present at an older age (60 years in North and South America, the Eastern Mediterranean, Southeast Asia, and the Western Pacific; 70 years in Europe) (Mabula and Chalya 2012; Nilsson and others 2007). We used the GBD 2010 inguinal hernia disability weight of 0.012 to calculate years of life lost due to disability (YLL).

The results of our epidemiologic analysis are presented in table __.1. We estimated that inguinal hernia prevalence ranges from 4.06 percent in Europe to 6.05 percent in the Western Pacific. Prevalence differences across regions are likely to be caused by variations in population age structure, access to surgical care, and risk of death from hernia accident. We estimated a global inguinal hernia prevalence of 5.85 percent, meaning that about 223 million people globally have hernias. The global mortality from inguinal hernia is significant; according to our calculations, nearly 44,000 people die from hernia each year.

Table __.1 Estimated Global and Regional Inguinal Hernia Epidemiologic Figures

Region	**Prevalence (%)**	**Yearly incidence (per 100,000)**	**Number of people with inguinal hernia (millions)**	**Estimated deaths per year**
World	5.85	293	223	43,689
Africa	5.35	250	22.7	8,396
Americas	4.36	307	28.2	4,173
Eastern Mediterranean	4.70	251	15.4	2,857
Europe	4.06	336	27.1	3,010
Southeast Asia	4.88	278	54.9	10,159
Western Pacific	6.05	310	81.6	15,094

Sources: Beard and others 2012; U. S. Census Bureau International 2013; and authors' estimates.

In table _.2, we present our estimation of global and regional inguinal hernia disease burden. Our figures suggest that inguinal hernia accounts for a small but measureable proportion of the surgical DALYs, as estimated by Debas and colleagues in 2006. Most importantly, we demonstrate that the disease burden of

hernia is likely to be higher than the GBD 2010 calculations suggest. According to our method, inguinal hernia accounts for an average of 85 DALYs per 100,000 population per year, almost eight times the disease burden calculated by the GBD 2010 study (Murray and others 2012). This places hernia on par with other surgical diseases, like benign prostatic hypertrophy and ovarian cancer, in terms of disease burden. Notably, the burden of inguinal hernia is highest in the most impoverished regions of the world, where access to surgical care and surgical outcomes are likely to be the poorest.

Table __.2 Estimated Burden of Inguinal Hernia by Region

Region	Total DALYs (100,000s)	Estimated surgical DALYs (100,000s)	Estimated inguinal hernia DALYs (100,000s)	Estimated inguinal hernia DALYs as a percentage of surgical DALYs	Estimated inguinal hernia DALYs per 100,000 population per year
World	1,5230	1,640	38.4	2.3	85
Africa	3,770	250	5.8	2.3	136
Americas	1,430	180	4.3	2.4	67
Eastern Mediterranean	1,420	150	2.5	1.7	76
Europe	1,510	220	3.7	1.7	55
Southeast Asia	4,430	480	8.9	1.9	79
Western Pacific	2,650	370	13.2	3.6	98

Sources: Beard and others 2012; Debas and others 2006; U. S. Census Bureau International Database 2013; WHO 2004 DALY tables; and authors' estimates.

Note: DALY = Disability-Adjusted Life Year.

Met and Unmet Need for Inguinal Hernia Repair in LMICs

Mock and colleagues have identified improved access to safe inguinal hernia repair as a high global health priority (Mock and others 2010). Studies indicate that inguinal herniorrhaphy is the most frequently performed general surgical procedure at many district-level hospitals throughout Sub-Saharan Africa (Galakunde and others 2010; Nordberg 1984).

There is general consensus that the unmet need for inguinal herniorrhaphy in LMICs is significant. Estimates of need range from 163 to 357 hernia repairs per 100,000 population per year, depending on whether incident only or incident and prevalent cases are to be addressed (Beard and others, unpublished manuscript; Nordberg 1984). Grimes and colleagues recently reported that the average district hospital in

Sub-Saharan Africa performs only 30 hernia repairs per 100,000 population per year, illustrating the vast unmet need for herniorrhaphy in Sub-Saharan Africa (Grimes and others 2012).

Beard and colleagues recently investigated surgical activity at all seven district-level and mission hospitals in the Pwani Region of Tanzania. Despite its proximity to Dar es Salaam, Pwani is one of the poorest regions in Tanzania. According to estimates by the Tanzanian government, Pwani ranks 14 out of 21 regions in measures of per capita income (Coast Economic Profile 2007).

In table __.3, we present preliminary data from this study, specifically focusing on rates of both elective and emergent repairs in each of the Pwani districts. In our analysis, we found that district-level hospitals in Pwani performed a population-weighted average of 34.5 elective and emergent herniorrhaphies per 100,000 population, a number similar to the hernia repair rate calculated by Grimes. These findings further document the surgical capacity crisis in district-level hospitals in Sub-Saharan Africa (Grimes and others 2012).

There also appears to be a significant disparity in the number of inguinal hernia repairs by district in the Pwani Region. In Kibaha, only 10.5 inguinal hernia repairs were performed per 100,000 population in 2012, compared to nearly 67 repairs per 100,000 population in Kisarawe. It is possible that additional operations are performed in other small health facilities, which may account for variations in hernia repair rates. It is also possible that patients from one district may seek care in a neighboring district. Further research is needed to more accurately characterize surgical capacity and the need for essential surgical services in low-resource settings.

Table __.3 Rates of Elective and Emergent Inguinal Hernia Repair in Pwani Region, Tanzania, 2012

District	Elective hernia repair/100,000	Emergent hernia repair/100,000	Performed by a nonphysician	Performed by a surgeon
Bagamoyo	18.5	12.1	76 (100.0 %)	0 (0.0%)
Kibaha	7.8	2.7	8 (29.6%)	11 (40.7%)
Kisarawe	46.2	20.7	38 (55.9%)	0 (0.0%)
Mafia	23.3	0	4 (40.0%)	6 (60.0%)
Mkuranga	23.8	6.7	58 (98.3%)	0 (0.0%)
Rufiji	47.9	9.6	73 (57.9%)	6 (4.8%)
Weighted Average	25.8	8.7		

Source: Authors' own data

MANAGEMENT OF INGUINAL HERNIA

NONSURGICAL MANAGEMENT

Nonsurgical management is appropriate for small minimally symptomatic or asymptomatic inguinal hernias in HICs. In a randomized controlled trial comparing a "watchful waiting" approach with routine herniorrhaphy for minimally symptomatic inguinal hernias, the risk of hernia accident was low (1.8 accidents/1,000 patient years over the 2- to 4.5-year followup period); outcomes were similar between groups (Fitzgibbons and others 2006). In LMICs, this "watchful waiting" approach to inguinal hernia may not be safe (and is generally not practiced) because patients have limited access to routine followup and emergency surgery.

SURGICAL MANAGEMENT

Various techniques are available for surgical reconstruction of the floor of the inguinal canal. The most common procedures are the Bassini, McVay, and Shouldice repairs, all of which involve different methods of suturing together components of the abdominal wall through an inguinal incision. The problem with these repairs is that groin tissues are sutured together under tension. The tension results in a relatively high risk of postoperative hernia recurrence in the range of 10 percent to 30 percent (Rand Corporation 1983).

In 1986, Lichtenstein introduced a tension-free repair technique, using prosthetic mesh to reinforce weakness in the floor of the inguinal canal. A randomized trial demonstrated a recurrence rate of only 1 percent to 2 percent with the Lichtenstein technique (Fitzgibbons and others 2006). Although some studies suggest that the mesh technique may increase the risk of chronic postoperative groin pain, the results of the Lichtenstein repair represent a significant improvement over traditional tissue repair (Hakeem and Shanmugam 2011).

First described in 2001, the Desarda repair using an undetached strip of external oblique aponeurosis to reconstruct the floor of the inguinal canal is an example of a tension-free tissue repair. This technique has been recently shown to have similar rates of recurrence and post-operative pain when compared to the Lichtenstein technique (Szopinski and others 2012).

Laparoscopic approaches to inguinal herniorrhaphy were introduced in the 1990s. While there is a slightly higher risk of postoperative complications after laparoscopic repair, laparoscopy is associated with decreased recovery time and less postoperative pain than open mesh techniques (McCormack and others 2003; Neumayer and others 2004). Cost-effectiveness studies comparing laparoscopic with open inguinal hernia repair techniques have been inconclusive (Heikkinen 1997; Schneider and others 2003).

While the tension-free repair has become the gold standard in HICs, most inguinal hernias are still repaired with the Bassini method in LMICs because of the high cost of prosthetic mesh and the lack of training in mesh repair (Ohene-Yeboah and Abantanga 2011). However, a recent report from Nigeria found that the mesh repair was well tolerated with few complications at one-year followup (Arowolo and

others 2011). In India, mesh repairs are more common than in other LMICs, and laparoscopic inguinal hernia repair is becoming more widely practiced (Swadia 2011). Nevertheless, the cost of the prosthetic mesh remains prohibitive for most LMIC patients. Although not yet reported in the literature, we have heard anecdotal success stories of the use of the Desarda tissue tension-free technique in Ghana in certain clinical situations. The applicability of this technique to repair hernias in LMICs merits further investigation.

Anesthesia Considerations

Open inguinal hernia repair may be performed using local, spinal, or general anesthesia, depending on both patient status and surgeon preference. All three anesthetic techniques are safe in healthy young patients when administered by skilled practitioners. However, spinal and general anesthesia are associated with a higher rates of myocardial infarction and urinary retention, respectively, in patients over 65 years of age (Bay-Nielsen and Kehlet 2008).

Mosquito Net Mesh Herniorrhaphy

Mosquito netting has been introduced as a prosthesis for inguinal hernia repair to address the high cost of industry mesh. In the 1990s, sterilized mosquito net mesh was first used to repair inguinal hernias in India. In 2003, Tongaonkar and colleagues reported a series of 359 hernias that were repaired with a copolymer mosquito-net mesh (polyethylene and polypropylene) in multiple hospitals throughout India (Tongaonkar and others 2003). On five-year follow up, the minor wound infection rate was less than 5 percent; there were no mesh infections and one hernia recurrence.

These promising findings in India have prompted further investigation into the use of non-insecticide treated mosquito net mesh for inguinal hernia repair in other low-resource settings, specifically, Sub-Saharan Africa. The feasibility and safety of this technique have been demonstrated for nylon and polyester mosquito net mesh in Burkina Faso, Ghana, and India (Freudenberg and others 2006; Clarke and others 2009; Gundre and others 2012). In addition, experimental research in goats indicates that nylon mesh leads to a similar amount of tissue fibrosis when compared to standard polypropylene industry mesh (Wilhelm and others 2007). Effective sterilization techniques have been described for both copolymer and polyester mosquito net meshes (Stephenson and Kingsnorth 2011).

Because the sample sizes of these studies were small and followup was limited, further investigation into the efficacy and safety of mosquito net mesh for inguinal hernia repair is needed prior to widespread implementation. The U. K. nonprofit organization Operation Hernia (see box __.1) is planning an audit of outcomes of copolymer mosquito net mesh purchased from India for use during humanitarian surgical repair camps (Stephenson and Kingsnorth 2011).

If the safety of mosquito net mesh is demonstrated, steps should be taken to make it more widely available for hernia repair in LMICs. Potential challenges to widespread implementation include inadequate training in the mesh technique, barriers to acceptance of mosquito netting as a surgical tool by care providers, and the complexities of acquisition and distribution of the mosquito net mesh. A comprehensive program that addresses these issues is needed to ensure equitable access to mesh inguinal herniorrhaphy in LMICs.

COMPLICATIONS ASSOCIATED WITH GROIN HERNIA REPAIR

REPAIR COMPLICATIONS IN HICS

Complications after elective herniorrhaphy in HICs include wound hematoma (6.1 percent), scrotal hematoma (4.5 percent), urinary tract infection (2.1 percent), wound infection (1.8 percent), and testicular swelling (1.6 percent) (Fitzgibbons and others 2006). Another important and increasingly recognized complication is chronic postoperative groin pain. Postoperative pain syndromes may occur in up to 53 percent of patients and are often difficult to prevent and treat (Poobalan and others 2003).

Mortality following groin herniorrhaphy is difficult to measure. Primatesta and Goldacre observed the rate of postoperative deaths following elective and emergent inguinal hernia repairs over a 10-year period in the United Kingdom (1996). They found a significantly increased risk of death after emergency compared to elective herniorrhaphy (1.6 percent vs. 0.1 percent, respectively) (Primatesta and Goldacre 1996). Inguinal hernia was listed as the cause of death in only 17 percent of the cases, suggesting underestimation of the risk of death from this condition in the United Kingdom (Primatesta and Goldacre 1996).

A study of the mortality rate after groin hernia surgery in Sweden found similar results. The mortality rate after elective hernia repair was similar to that of the background population, but it increased seven-fold after emergency operations and 20-fold if bowel resection was required (Nilsson and others 2007).

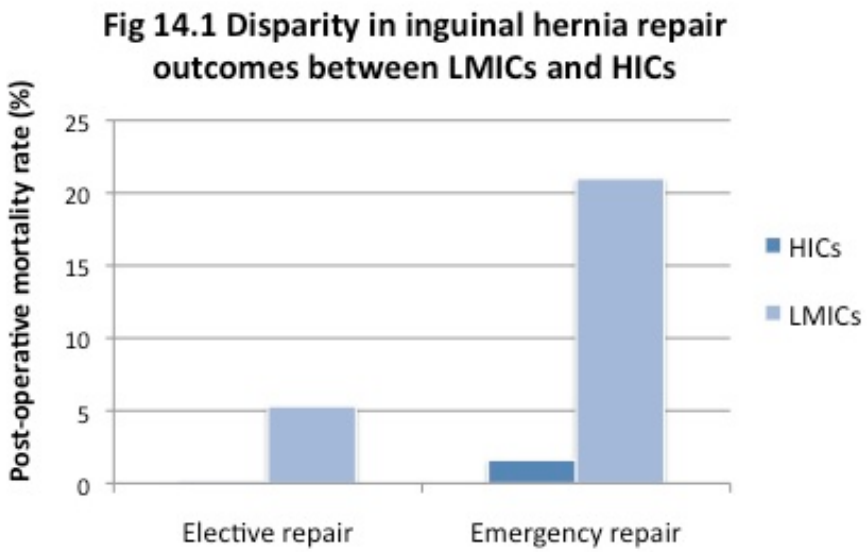
REPAIR COMPLICATIONS IN LMICS

Although the literature on the subject is sparse, complications after groin hernia repair in LMICs appear to be higher. In Senegal, Fall and colleagues reported a complication rate of more than 20 percent after elective groin herniorrhaphy. Some of the most serious postoperative complications found in this study, such as bladder injury and immediate hernia recurrence, are likely to be related to surgical technique (Fall and others 2005). In Jos, Nigeria, rates of wound infections after elective inguinal hernia repair approach 8 percent, significantly higher than the less-than-2-percent rate reported in the United States (Ramyil and others 2000). Reliable data on the rate of hernia recurrence are not available in LMICs.

In a review of the literature on inguinal hernia epidemiology and management in Sub-Saharan Africa, Ohene-Yeboah found in-hospital inguinal hernia-related mortality rates ranging from 0.48 percent to 40.0 percent in six studies (Ohene-Yeboah and Abantanga 2011). A retrospective investigation of morbidity and mortality associated with inguinal hernia in Nigeria demonstrated an overall hernia mortality rate of 5.3 percent (Mbah 2007). Of note, while there were no deaths among patients with hernias treated electively in the Nigerian study, the mortality rate of patients with obstructed or strangulated hernias was greater than 21 percent (Mbah 2007). In Niger, mortality from hernia strangulation with small bowel necrosis may be as high as 40 percent (Harouna and others 2000).

In figure __.1, we demonstrate graphically the pronounced disparity in outcomes after inguinal hernia repair in HICs and LMICs that we found in our review of the literature. This increased risk of postoperative morbidity and mortality in LMICs is likely due to delayed presentation of large scrotal

hernias, inadequate training of surgical, anesthetic and nursing staff, and limitations in preoperative and postoperative care, hospital infrastructure, and supplies.



Box __.1 Effective Global Health Program: Operation Hernia

The U. K. nonprofit organization, Operation Hernia, is an example of an effective program aimed at combating inguinal hernia in LMICs. Years before Operation Hernia began, a "sister city" relationship was established between Takoradi, Ghana, and Plymouth, United Kingdom. In 2005, Andrew Kingsnorth and Chris Oppong, surgeons from Plymouth Hospital, initiated the first Operation Hernia mission to Ghana. With support from the British High Commissioner and the European Hernia Society, the team of surgeons repaired 130 hernias during their first one-week mission (Kingsnorth and others 2006). Since then, Operation Hernia has worked to establish a Hernia Treatment Center in Takoradi and expanded its services to 10 countries in Asia, Latin America, Sub-Saharan Africa, and Eastern Europe. This organization has supported over 85 humanitarian missions and treated over 9,000 patients with hernias worldwide (Operation Hernia 2013).

Operation Hernia has been instrumental in advocacy for recognition of the global public health significance of groin hernia. In addition, leaders of the organization have spearheaded much of the research on hernia epidemiology in LMICs, along with safety and efficacy studies of mosquito net mesh repair. Much of the literature on cost-effectiveness of groin hernia repair in low-resource settings was funded and carried out by Operation Hernia.

Teaching of mesh hernia repair techniques to local surgical care providers is a stated goal of Operation Hernia (Kingsnorth and others 2006). If this aspect of the mission was systematized and expanded, it would make the humanitarian model for the delivery of hernia surgical care even more sustainable. Alhough some might criticize Operation Hernia for being a disease-focused vertical intervention, this organization has demonstrated that its model is scalable and effective, with future plans for even more expansion.

<<end of box __.1>>

Box __.2 Local Solutions: The Ghana Hernia Society's Comprehensive Approach to Groin Hernia Care

Over the past decade, local surgeons have become increasingly interested in improving hernia care and increasing access to groin hernia repair throughout Ghana. Initially, a core group of surgeons engaged independently in surgical outreach programs focused on hernia care, working with the April-December Medical Outreach Group (AMOG), a Ghanaian nongovernmental organization whose mission is to provide free specialist care in Northern Ghana.

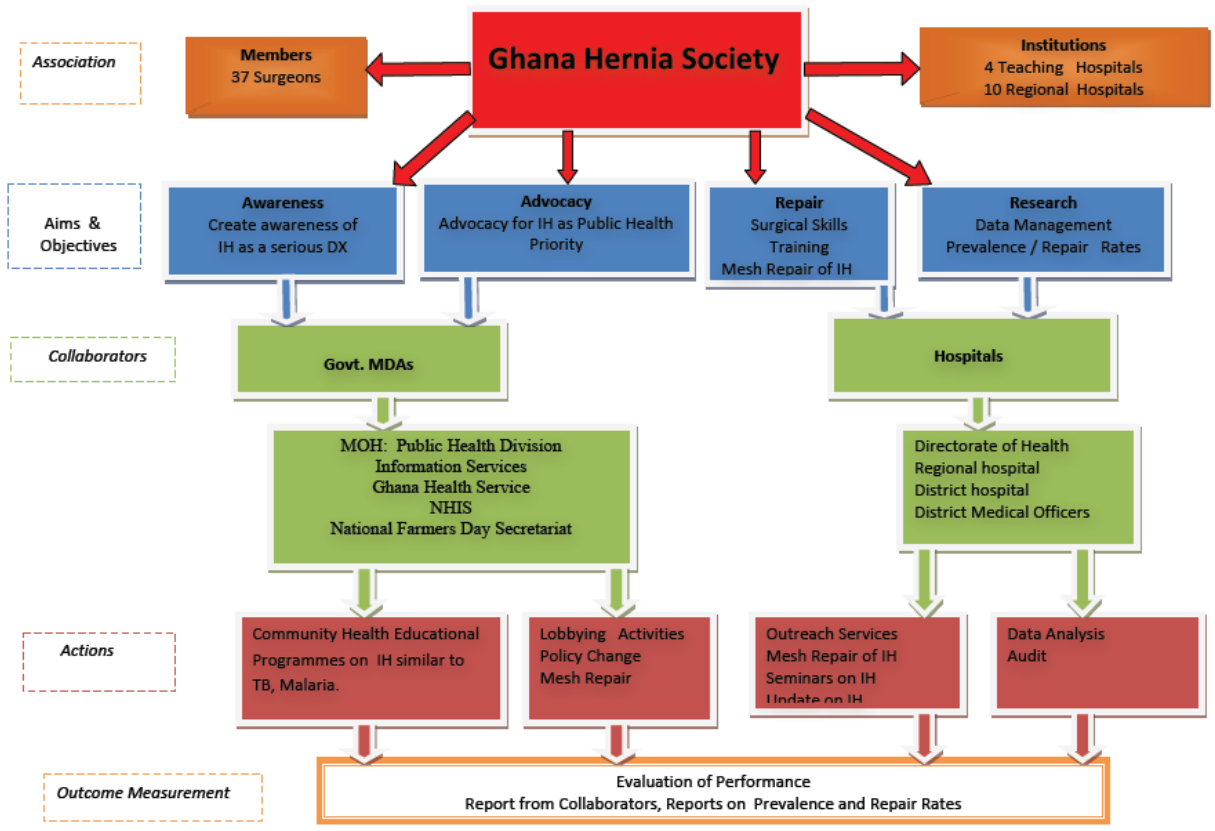
To better coordinate their individual hernia treatment efforts, Professor Michael Ohene-Yeboah and Professor F. A. Abantanga (Kwame Nkrumah University of Science and Technology in Kumasi, Ghana) along with Dr. Stephen Tabiri (Department of Surgery, Tamale Teaching Hospital in Tamale, Ghana) and others founded the Ghana Hernia Society (GHS) in February of 2013. Since its inception, GHS has held two teaching workshops on groin anatomy and mesh hernia repair techniques in Kumasi and Tamale.

Box Figure __.1 demonstrates the current structure of activities of the Ghana Hernia Society. As demonstrated by this figure, GHS employs a comprehensive public health approach to the treatment of groin hernia in Ghana, partnering with key actors in the Ghanaian government, the Ghana Health Service, and local hospitals to address hernia at multiple levels. The Ghana Hernia Society coordinates groin hernia community education programs, advocacy efforts for the prioritization of hernia care, surgical skills training in mesh techniques, and hernia epidemiology research. The GHS's ultimate goals include the development of a Pan-African Hernia Society and partnership with other international hernia organizations.

The Ghana Hernia Society's comprehensive plan could easily be adapted for use in the establishment hernia societies with similar goals in other low-resource settings. In addition, this four-pronged approach including community education, advocacy, surgical intervention (and education), and research should serve as a model for the development of local solutions for other common surgical conditions like hydrocele, traumatic injury, obstetric fistula, and others. Though in its early stages, the Ghana Hernia Society is an excellent example of a local public health solution to a common and important surgical issue and we look forward to following GHS' activities in Ghana and throughout Africa in the future.

<<end of box __.1 or box __.2>>

Box Fig __.1 Activity Flowchart of the Ghana Hernia Society



Source: Ghana Hernia Society 2013

TASK-SHIFTING IN HERNIA SURGERY: A TARGETED WAY TO IMPROVE QUALITY OF CARE

LMICs face a severe shortage of skilled healthcare providers. The global workforce crisis is especially pronounced in the fields of surgery and anesthesia. In their analysis of surgical care provided at the hospitals in Pwani, Tanzania, Beard and colleagues found only two staff general surgeons providing care in the region with a population over 1.1 million people (table 14.3). At Bagamoyo and Mkuranga District Hospitals, nearly all hernia repairs were done in 2012 by nonphysician clinicians (NPCs). At Mafia

District Hospital, located on a remote island off the coast of Southern Tanzania, there is no surgical specialist on staff; surgeons performing hernia repairs at this hospital during the study period were flown in by the nonprofit organization, African Medical and Research Foundation (AMREF). In Kibaha, the presence of a general surgeon did not increase surgical output in the district in 2012.

NPCs and nonsurgeon physicians clearly play a key role in the delivery of surgical care for inguinal hernia in Tanzania. Reports from other countries in Sub-Saharan Africa, including Mozambique, Malawi, and Niger indicate a similar function of nonsurgeons in the provision of surgical care (Kruk and others 2010; Sani and others 2009; Wilhelm and others 2011). Several studies have documented the safety of task-shifting of emergency obstetric procedures to nonphysicians in Mozambique, Tanzania, and Ethiopia (McCord and others 2009; Gessessew and others 2011; Pereira 1996).

Studies on outcomes after general surgical procedures performed by non-surgeons, specifically hernia, are notably lacking from the literature. In 2011, Wilhelm and colleagues found similar outcomes after repair of strangulated inguinal hernia with bowel resection performed by surgeons and clinical officers (COs) at Zomba Central Hospital, a large teaching center in Malawi (Wilhelm and others 2011). While promising, these results may not be generalizable to other LMICs. At Zomba Central Hospital, clinical officers were often directly proctored by fully qualified surgeons, which may explain the good results. In Tanzania, NPCs and nonsurgeon physicians often operate independently with no oversight from a surgical specialist. More studies on outcomes after nonobstetric general surgical procedures performed by NPCs are urgently needed to guide policy and program planning.

There are almost no continuing education programs in surgical care at the district hospital-level in LMICs. This would be an ideal level at which to intervene with an inguinal hernia educational program targeted to nonsurgeons providing surgical care. Tension-free mesh repair techniques with mosquito net could be taught through short courses at district hospitals. Hopefully, the introduction of these educational programs and tension-free techniques would improve outcomes.

Cost-Effectiveness of Groin Hernia Repair

Inguinal hernia repair is one of the most cost-effective general surgical procedures performed in HICs. Data from a randomized trial of laparoscopic repair versus open-mesh inguinal hernia repair conducted in the United States indicate that both types of herniorrhaphy are cost-effective (Hynes and others 2006). In this study, investigators used the generally accepted threshold of cost-effectiveness in the United States of US$50,000 per Quality-Adjusted Life Year (QALY).

In a recent analysis of inguinal hernia repair using nationally collected patient-reported outcome measures from the National Health Service (NHS) in the United Kingdom, Coronini-Cronberg and colleagues calculated the cost per QALY of open and laparoscopic inguinal herniorrhaphy to be £1746 and £1540, respectively, (Coronini-Crongberg and others 2013). The United Kingdom's National Institute for Health and Clinical Excellence (NICE) committee routinely uses a cutoff of £20,000 to £30,000 per QALY to determine treatment cost-effectiveness and define the scope of NHS therapies. These findings suggest that inguinal hernia repair is an especially good buy in the United Kingdom.

In Sweden, Nordin and colleagues found that inguinal hernia repair performed under local anesthesia had significant cost-advantages when compared to the use of spinal and general anesthesia techniques (Nordin and others 2007). This result has important implications for inguinal herniorrphaphy in LMICs, where the use of local anesthesia may represent an important cost-saving strategy for hernia repair in low-resource settings.

Inguinal herniorrhaphy with mosquito net mesh has been demonstrated to be cost-effective in LMICs even when compared to more traditional public health interventions. In a study using Operation Hernia data from Ghana, Shillcut and colleagues found that inguinal hernia repair with mosquito net mesh costs approximately US$12.88 per DALY (Shillcut and others 2010). This figure means that inguinal herniorrhaphy with low cost mesh in Ghana is as cost-effective as a vaccine and 10 times as cost-effective as HIV treatment (Ozgidez and Riviello 2008). Of note, approximately 70 percent of hernias in the Shillcut study were repaired under local anesthesia, a technique that likely increased the cost-effectiveness of hernia repair in this patient cohort.

In India, low-cost polyethelyne mesh has been shown not only to be safe and effective for use in inguinal hernia repair but also 2,808 times cheaper than commercially available polypropylene mesh (Gundre and others 2012). Mosquito net mesh represents the ultimate in herniorrhaphy cost-saving: one polyester mosquito net can repair approximately 3,000 hernias (Shillcut and others 2010), and all symptomatic hernias in Ghana could be repaired today for an estimated US$15,000 worth of mesh (Beard and colleagues 2013).

Shillcut and colleagues have also demonstrated the cost-effectiveness of mosquito net mesh hernia repair in a middle-income country (MIC): Ecuador. Mean cost-effectiveness for herniorrhaphy in this study was US$78.18 per DALY, a good buy considering Ecuador's Gross National Income of US$3850 (Shillcut and others 2013). These data are strong evidence of the cost-effectiveness of hernia repair with low-cost mesh in LMIC contexts and the need to prioritize surgery for inguinal hernia when allocating scarce resources.

The findings of Shillcut's Ghana and Ecuador studies should be interpreted with some caution as DALYs averted per hernia repair were based on expert opinion and may be overestimated (Shillcut and others 2010; Shillcut and others 2013). In addition, both studies included hernias repaired on Operation Hernia missions, which may not represent the typical herniorrhaphy scenario in a low-resource-setting. Further research is needed to characterize the cost-effectiveness of inguinal hernia repair performed by local practitioners, using both low-cost mesh and traditional tissue techniques to get a clearer picture of herniorrhaphy cost-effectiveness in LMICs.

HYDROCELE

DEFINITIONS OF HYDROCELE

A hydrocele is an abnormal accumulation of fluid most commonly occurring in the scrotum in men, or the labia majora in women:

- A *communicating hydrocele* is similar to hernias except that the sac connecting the abdomen to the scrotum or labia majora only contains fluid, rather than abdominal contents.
- A *noncommunicating hydrocele* is a collection of scrotal fluid that is isolated from the abdomen. This type of hydrocele is caused by an imbalance between secretion, absorption and drainage of fluid in the scrotal sac. Increased scrotal fluid secretion may be caused by local inflammation from bacteria or viruses, while poor absorption commonly results from thickening of the sac or lymphatic malfunction. Noncommunicating hydroceles are the most common type of hydrocele globally, affecting more than 30 million men and boys (WHO 2013).

Risk Factors for Hydrocele in Adults

Obstruction of the testicular venous or lymphatic vessels is associated with acute hydrocele development. Venous or lymphatic obstruction can be caused by torsion of the testicle, lymphoma, or the death of parasitic filarial worms. In the temperate climates of Europe, North and South America, and China, most primary hydroceles of adult males are idiopathic. In tropical regions, mainly in LMICs, lymphatic filariasis (LF) is the most significant risk factor for the development of noncommunicating hydrocele. LF is caused by infection with the mosquito-borne worm, *Wuchereria bancrofti* (Michael, Bundy, and Grenfell 1996; WHO 2005).

LF is a complex disease affecting several parts of male genital anatomy. The biological predilection of the adult filarial worms to live and reproduce in the lymphatic channels of the scrotum means that greater than 50 percent of infected men will, with age, develop chronic hydrocele (Addiss and others 1995; Eigege and others 2002; Mathieu and others 2008). Hydroceles caused by LF are sometimes called *filariceles.*

In tropical or subtropical zones, the *Culex*, *Aedes*, and *Anopheles* mosquitoes carry the filarial parasite. The cycle of infection requires that mosquitoes deposit larvae on the host skin, and these migrate through the puncture site to the venous system and lymphatics, where they mature into adults. Nests of the male and female adults are most commonly identified in the male scrotal lymphatics, where they produce the first-stage larvae (microfilariae) that are subsequently consumed by mosquitoes.

Clinical Features of Filarial Hydrocele

Studies have identified living adult worms within the scrotal lymphatics in a large cohort of patients with hydrocele in northern Brazil (Dreyer and others 2002; Noroes and others 1996; Noroes and others 2003). Filarial parasites can be identified by ultrasound (the "filarial dance sign") or by visual examination during surgery. In practice, clinical demonstration of the living adult parasite confirms the filarial origin of the hydrocele and can be useful in distinguishing actively evolving disease from residual scrotal disease after medical treatment.

Filarial hydroceles can be either acute or chronic. Acute hydroceles are associated with painful, inflammatory nodules caused by death of adult worms (Dreyer and others 2002; Figueredo-Silva and others 2002). They are often seen after medical treatment of LF but can also be unrelated to treatment. In

these cases, they are a response to acute lymphatic inflammation or infection known as acute adenolymphangitis (ADLA).

Chronic hydroceles are thought to correlate with chronic dysfunction of the lymphatic drainage system of the testicular cord, the sac, or both, and this pathology may be a result of intermittent attacks of ADLA over a number of years. Hydrocele patients, on average, suffer two episodes of ADLA per year, resulting in scrotal nodules (Chu and others 2009; Dreyer others 2002; Noroes and Dreyer 2010). Chronic filarial hydroceles are associated with dilation and malfunction of the lymphatics (known as *lymphangiectasia*), rather than chronic lymphatic obstruction; lymphangiectasia can be identified by ultrasound and direct observation. The ultrasound may have a similar appearance to a varicocele. Hydrocele fluid in these patients contains lymphatic fluid leaked from damaged lymphatic vessels (Dreyer and others 2000; Pani and Dhanda 1994).

Epidemiology and Burden of Disease of Lymphatic Filiarisis and Hydrocele

In many LMICs, including India and countries in Sub-Saharan Africa, LF accounts for a significant portion of the total burden of disease. Approximately 1.3 billion people—over one-seventh of the world's population—are at risk for LF in 83 countries (Chu and others 2009; Michael, Bundy and Grenfell 1995; WHO 2013). The Southeast Asian region is home to 65 percent of LF cases, while 30 percent of patients live in Sub-Saharan Africa.

Forty million people are estimated to have symptomatic manifestations of filariasis; one-third of these live in India. In tropical regions, an estimated 25 to 27 million men have filarial hydroceles (Pani, Kumaraswami and Das 2005; WHO 2013). In many communities, the majority of men with LF eventually develop symptomatic hydroceles (Addiss 2013; Babu, Mishra and Nayak 2009; Dreyer and others 1997; Wijers 1977; Zeldenyk and others 2011). In a summary by Haddix and Kestler, a high prevalence of hydrocele was demonstrated in several LMICs. On the coasts of Tanzania and Kenya, 90 percent and 60 percent of men, respectively, were reported to have hydrocele at age 70. In Pondicherry, India, 45 percent of men have hydroceles by age 60 (Haddix and Kestler 2000). Hydrocele is also common in young men and has been identified in a large number of military recruits in northern Brazil (Noroes and others 1996).

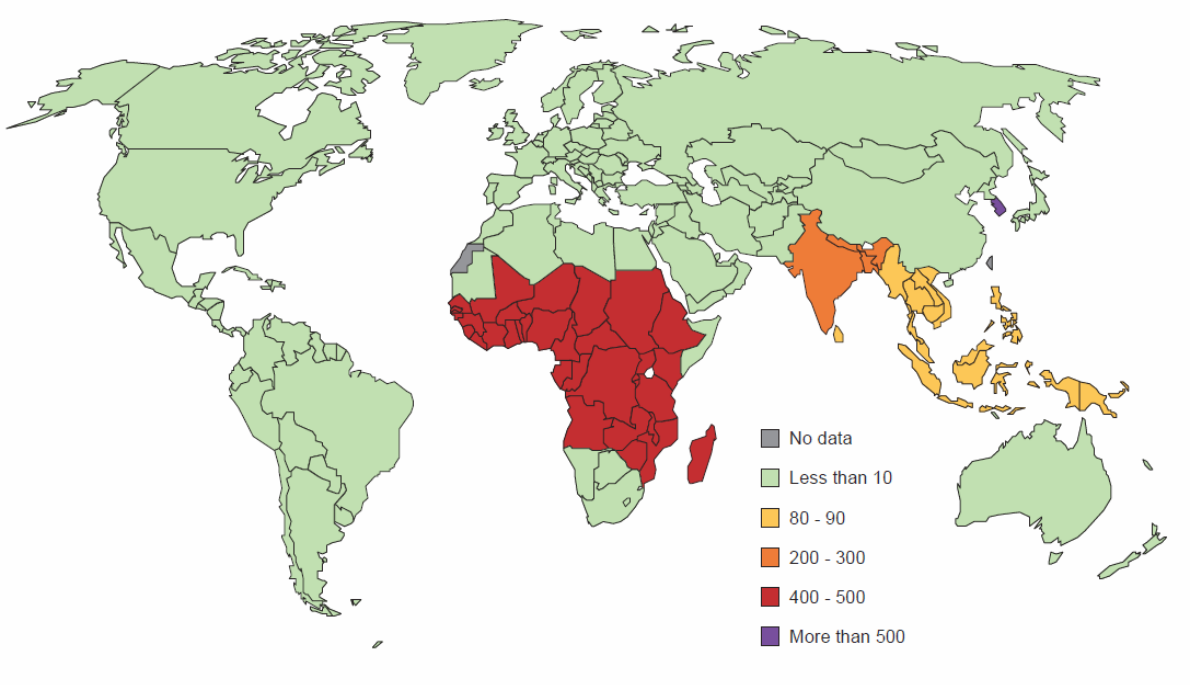
Studies indicate that population-based and household surveys consistently underestimate the true prevalence of hydrocele and disability from the disease (Eigege and others 2002; Mathieu and others 2008). Personal modesty often impedes accurate reporting of hydroceles in household surveys. Clinical mapping by patient examination is the only precise method of hydrocele prevalence measurement (Mathieu and others 2008; Eigege and others 2002; Pani, Kumaraswami and Das 2005). Spot mapping of children for LF may produce imprecise estimates of hydrocele disease burden, while spot maps of men with hydrocele generally correlate highly with local LF prevalence.

Global Burden of Lymphatic Filiariasis and Hydrocele

Map __.1 illustrates that the global DALYs attributable to LF are concentrated in tropical regions in Sub-Saharan Africa and Southeast Asia, some of the poorest areas in the world. The Global Burden of Disease Report 2010 (GBD 2010) ranks disability from LF at 105.2, with a slightly higher disability ranking of the disease in men at 87. According to GBD 2010, the number of DALYs attributable to LF (2.8 million) is approximately one-half the estimate made by the WHO Global Burden of Disease, which found a total of 5.9 million DALYs associated with the disease (Murray and others 2012; Vos and others 2012; WHO 2005). Clearly these estimates are significantly different, though the reasons for this variation in disease burden are not yet understood.

Although the GBD 2010 acknowledges that the world's population is aging, and therefore years lived with disability is increasing, it does not consider that the burden of filarial hydrocele may actually increase in many regions, or that other diseases such as depression, may be directly attributable to hydrocele (Vos and others 2012). In addition, the previous edition of *Disease Control Priorities in Developing Countries* (DCP2) did not consider the burden of filarial hydroceles in its calculation of global surgical DALYs (Debas and others 2006).

Map __.1 Global DALYs Attributable to Lymphatic Filariasis (per 100,000 population)



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Note: DALY = Disability-Adjusted Life Year.

Economic Burden of Lymphatic Filariasis and Hydrocele in LMICs

A number of studies have attempted to estimate the economic burden of LF. It is clear that the disease not only predominantly affects the world's poor, but it also perpetuates poverty (Haddix and Kestler 2000). The burden can be measured as direct disease-related costs to individuals and households, lost

productivity of individuals, reduced productivity due to changes in the economies of affected communities, and costs to government funded healthcare systems.

In 2000, more than 10 million people in India sought medical care for symptoms associated with LF (Haddix and Kestler 2000; Ramaiah and others 2000). However, the number of people who seek treatment varies from community to community, depending on availability of care and other factors. The economic loss due to disability from LF in India alone is estimated at US$1 billion to US$1.5 billion per year, with another US$1 billion attributable to LF in Sub-Saharan Africa. In Sub-Saharan Africa, 83 percent of this economic loss is due to hydrocele (Gyapong and others 1996; Haddix and Kestler 2000; Pani, Kumaraswami, and Das 2005). Entire communities have had to adapt their economic structure from fishing to agriculture on the eastern coast of Sub-Saharan Africa because of the high prevalence of LF in this region (Muhondwa 1983).

Industry both suffers from, and in some cases is responsible for the perpetuation of conditions conducive to LF. For example, workers in large irrigation projects in Ghana and coco fiber processing in Sri Lanka are at increased risk of LF due environmental exposure to mosquitoes carrying the filarial parasite. Migration of infected individuals and crowded living arrangements complicate disease eradication efforts.

Social Burden of Filarial Hydrocele in LMICs

The social burden of filarial hydroceles has been explored by Babu and others in Orissa, India (Babu, Mishra and Nayak 2009). In their ethnographic study, the authors interviewed hydrocele patients, their wives, and the general public to understand how hydroceles impact sexual and married life. A high rate of depression accompanied the loss of a satisfactory sexual life in these patients and their spouses. An unmarried man with a hydrocele seeking a wife is seen as a last-choice marriage prospect. Because of the severity of the psychological impact on patients, Addiss has argued for an "uprising of compassion" for people disabled with LF (Addiss 2013). He notes that the 1997 World Health Assembly (WHA) resolution charged the Global Programme to Eliminate Lymphatic Filariasis (GPELF) with two missions: the elimination of filarial transmission and the alleviation of infection-related disability.

Stories of suffering due to the consequences of LF, including hydrocele, from Brazil, the Dominican Republic, Ghana, Haiti, and India highlight the very human cost of these disabilities. These have largely not received international attention to the extent that other disabilities such as vesico-vaginal fistula have, yet they affect at least 15 times as many people (Addiss 1997; Addiss 2013; Dreyer, Noroes, and Zeldendryk and others 2011). The impact hydroceles on communities also has been grossly underestimated, especially when the psychosocial impact of disfiguring hydroceles are considered; the preventive role of hydrocele surgery for the human and monetary costs of DALYs attributable to depression is potentially huge (Wynd and others 2007).

Global Efforts to Combat Lymphatic Filariasis and Hydrocele

LF is categorized as a neglected tropical disease (NTD). In 1997, the World Health Organization (WHO) listed it among the six communicable diseases that could potentially be eliminated worldwide. Recognizing this, the World Health Assembly (WHA 50.29) identified LF as a significant source of global disease burden and called for its elimination. In 2000, the GPELF launched a program for LF elimination by 2020 (Ottesen 2000). The GPELF set the parallel goals of alleviating disability from LF,

including hydrocele, lymphedema, and ADLA, and interrupting transmission of the disease with mass drug administration (MDA).

While MDA, mosquito control, and bednets have effectively eliminated LF in some countries, MDA has been less successful in others, for social, economic, and geographic reasons (WHO 2011). Moreover, even when transmission has been effectively prevented at a population level, large numbers of people will still suffer disability from filarial hydrocele due to cumulative damage to scrotal lymphatics.

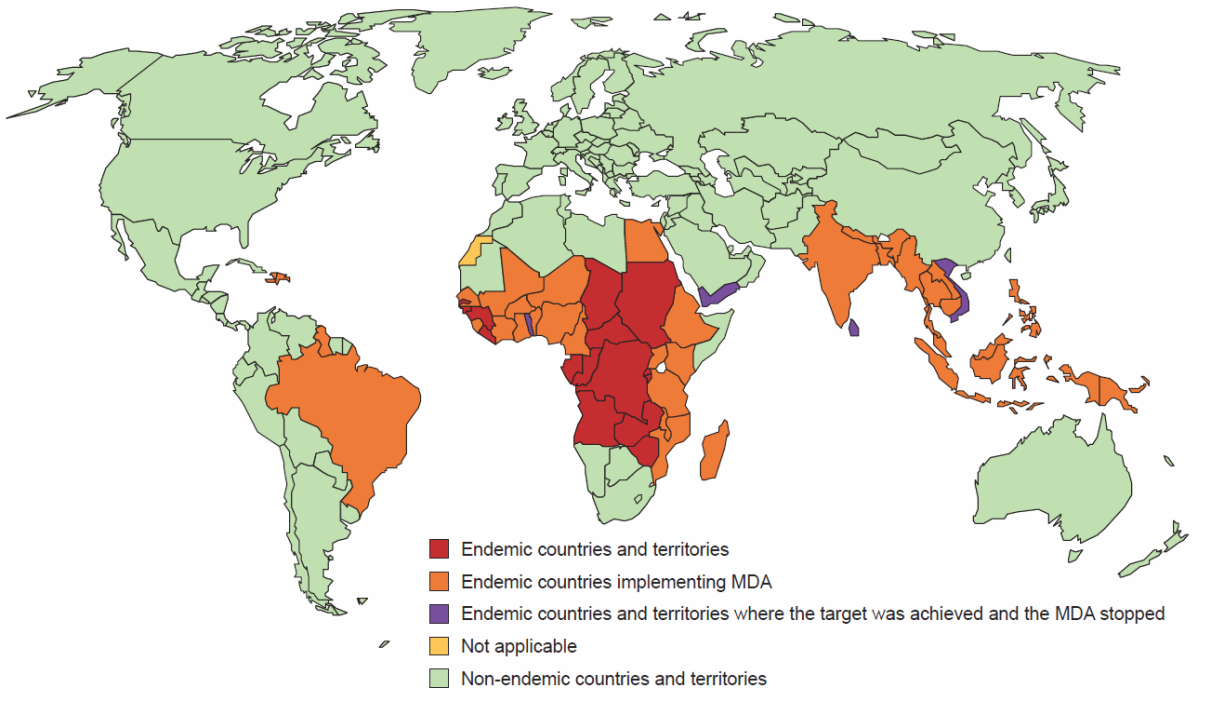
Economic Effects of Global Elimination Efforts

In the first eight years of MDA supported by the GPELF, more than 570 million at-risk individuals were treated for four to six years. More than 1.9 billion treatments were given in 48 of the 83 endemic countries (map __.2). Economic benefits have been measurable. It is estimated that this effort has rendered US$21.8 billion of economic benefit for affected individuals and US$2.2 billion in health systems saving. Approximately 6.6 million newborns have been protected from 1.4 million symptomatic hydroceles. Among those already affected with LF and subclinical disease, MDA is expected to prevent their progression (Chu and others 2010).

In individual terms, the cost of preventing one case of hydrocele, ADLA, or lymphedema in India has been calculated to be US$8.41 with the saving of 58.35 working days per year and improved wages of US$39.39. The cost-benefit ratio has been calculated to be 52.6, which is among the most cost effective of any disease control program (Remme and others 2006).

The potential economic benefit of hydrocelectomy has not yet been calculated but may be similar to that of hernia surgery, scaled to the known number of cases of existing disease. Unfortunately, access to hydrocelectomy in LMICs is limited. The waitlists for hydrocele repair in government-sponsored health programs annually exceed 2,000 to 5,000 in endemic Sub-Saharan African countries. The need for hydrocelectomy in these areas clearly exceeds the surgical capacity (Odoom, personal communication 2013).

Map __.2 Mass Drug Administration Elimination Programs for Lymphatic Filariasis



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SURGICAL MANAGEMENT OF HYDROCELE

IDIOPATHIC HYDROCELE

The surgical management of benign idiopathic hydroceles can be complex. While the technical drainage of hydrocele via a scrotal incision appears to be straightforward, the complexity of vascular and lymphatic anatomy is often underappreciated (Gottesman 1976; Ku and others 2001; Rodriguez, Rodriguez, and Fortuno 1981). Complication rates after hydrocelectomy are high, even in HICs. In a retrospective series from 1998−2004 in the United States, a post-hydrocelectomy complication rate of 20 percent was found (Swartz, Morgan, and Krieger 2007). These included recurrences of hydrocele, hematoma, infection, and testicular infarction. The surgical techniques used in this series included sac partial excision and eversion (47 percent), sac eversion alone (22 percent), and excision alone (18 percent). The authors concluded that subtotal excision of the sac was superior to complete excision. However, the generalizability of this study is limited, as there was no standardization of perioperative care or surgical technique.

FILARIAL HYDROCELE

The surgical management of filarial hydrocele is especially critical. In LMICs, patients may present with massive, disfiguring hydroceles requiring more specialized care (figure __.5). Scrotal skin and lymphatics are damaged by the parasitic infection, leading to increased inflammation in the operative field and poor wound healing. Given this situation, it's easy to see why complications after repair of filarial hydroceles including infection, recurrence and hematoma, have been shown to be even higher than

those after surgical repair of benign idiopathic hydroceles (deVries 2002; Fasana 1982; Thambugala 1971; Thomas and others 2009; WHO 2002).

In Brazil, postoperative infection rates after filarial hydrocelectomy have been reported to be as high as 30 percent, while recurrence was as high as 19 percent in a large series of patients who underwent sac-sparing surgery for LF (Noroes and Dreyer 2010). In this series, a total of 1,128 surgical patients with hydroceles received complete excision of the hydrocele sac. Postoperative outcomes in these patients were compared to those of a group of 218 patients with "sac sparing" subtotal excision of the sac, done elsewhere. With a mean followup of 8.6 years, recurrence rates for complete excision were 0.3 perent compared to 19 percent in sac-sparing surgery. While resection of the sac is more challenging and requires special care for hemostasis, it has become the standard of care in Brazil, Haiti, and the West African Filariasis Program (Mante 2012; Mante and Seim 2007;).

Particular consideration must be taken when the skin of the scrotum is thickened, especially when dripping with lymphatic fluid—a condition known as "lymph scrotum." These cases require reconstructive surgery. Simple hydrocelectomy is contraindicated. Successful lympho-venous shunt for hydroceles and lympedema secondary to LF have also been reported in the Indian literature (Manokaran 2005).

The surgical management of filarial hydroceles in LMICs is largely unstandardized. In our experience, protocols for LF hydrocelectomy appear to improve outcomes by standardizing the use of antibiotics, surgical techniques, dressings, and perioperative management, although little published data on this topic are available.

CONCLUSIONS

The global burden of groin hernia and hydrocele is significant. We have estimated that 223 million people in the world, equivalent to about two-thirds of the population of the United States, have inguinal hernia, while nearly 30 million men suffer from filarial hydrocele. Elective hernia repair and hydrocelectomy are curative public health interventions. Herniorrhaphy prevents life-threatening complications from hernia accidents, and both procedures improve quality of life. Hernia repair is also cost-effective, even when compared to more traditional public health interventions.

Many people in the world do not have access to safe groin hernia surgery or hydrocelectomy. This disparity results in higher levels of morbidity and mortality from hernia in LMICs. Limited access to hydrocelectomy in LMICs perpetuates the continuing suffering of the world's poorest people from disfiguring filarial hydroceles. Although tension-free mesh repair is the standard of care for groin hernia in HICs, it is unavailable to most patients in LMICs. Mosquito net mesh may be a safe and cost-effective way to correct this disparity. However, pending widespread availability of a proven safe option for mesh, increased access to well-established tissue techniques of groin hernia repair should be promoted.

Task-shifting of herniorrhaphy to NPCs and nonsurgeon physicians is occurring throughout Sub-Saharan Africa. Programs to expand the capacity for inguinal hernia repair and hydrocelectomy at district-level hospitals should utilize existing human resources and focus on skills training for surgeons, physicians, and NPCs already performing these repairs. Local organizations such as the Ghana Hernia Society could

be instrumental in spearheading training efforts. Infrastructure investment to build hospital capacity for essential surgeries like herniorrhaphy and hydrocelectomy is needed to ensure access to these procedures.

Addressing inguinal hernia and filarial hydrocele should be a high priority on any global surgery agenda. Basic surgical care, specifically, essential procedures like groin herniorrhaphy and hydrocelectomy, is a crucial part of primary health care services that should be available at district-level hospitals. Working toward equitable provision of hernia repair and hydrocelectomy in LMICs has the potential to strengthen health systems and ultimately increase much-needed hospital capacity.

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