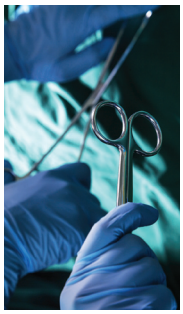

Chapter 9

Hernia and Hydrocele

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INTRODUCTION

Groin hernia and hydrocele are two of the most common surgical conditions globally. This chapter summarizes 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 estimate 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.

Groin hernia repair and hydrocelectomy are cost-effective curative therapies that can improve the 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 health care services that should be available at first-level hospitals. Training programs to improve the skills of surgical-care providers in LMICs, in combination 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 that, in men, houses the spermatic cord as it passes on its way to the testicle. Inguinal hernias may be caused either by a failure in the normal closure of the abdominal wall lining in the inguinal canal during fetal development, or by an acquired weakening of the abdominal wall, often later in life. In either case, the hernia sac, a pouch made of the membrane lining the abdomen and containing fat, ovary, bowel, or bladder, protrudes 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

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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 contents are "stuck" outside the abdomen.
- A strangulated hernia refers to an incarcerated hernia in which the entrance to the hernia sac or "neck" is constricted, limiting blood supply to the sac contents and ultimately resulting in tissue necrosis, bowel infarction, and perforation. This condition is a life-threatening emergency 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 adults (5,316 men and 8,136 women) in the United States participating in the First National Health and Nutrition Examination Survey (NHANES) between 1971–75 and followed up in 1993, male gender and increasing age were identified as important groin hernia risk factors. Black race and obesity were independently 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. 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. 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 of inguinal hernia's natural history are nearly impossible today because 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 (1977) examined data in two settings in which 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.

Using Neuhauser's figures and U.S. life-table analysis, Turaga, Fitzgibbons, and Puri (2008) calculated a hernia accident lifetime incidence of 19.4 percent in 18-year-old men with inguinal hernia in the United States. They found only a 4.4 percent lifetime incidence of hernia accident in 72-year-old men with hernia. 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 in 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 (Herszage 2004; Sanders and others 2008; Shillcutt, Clarke, and Kingsnorth 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 with 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 50 percent 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 patients' 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 hernias in LMICs often present for medical care with complications. More than two-thirds of inguinal hernia repairs at a third-level center in Kumasi, Ghana, were emergency operations (Ohene-Yeboah and others 2009). In a 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 the high disease prevalence, relatively few studies of inguinal hernia epidemiology have been undertaken, 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 18.3 percent among men in an ethnically diverse Jerusalem neighborhood (Abramson and others 1978). Of note, 7.6 percent of men had "obvious" groin hernias in this study, while the remaining 10.7 percent had hernia diagnosed as a palpable impulse at the external inguinal canal by physician examination. These data suggest that the actual hernia prevalence in Jerusalem may be less than 18.3 percent.

Studies of groin hernia incidence are particularly limited. Data from the NHANES study have 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 (2007) found an annual incidence of inguinal hernia of 315 per 100,000 population in adults in the United States.

Not surprisingly, the incidence of inguinal hernia repair is lower than disease incidence. A retrospective review of all inguinal hernia repairs in Minnesota during a 20-year period found an incidence of hernia repair of 217 per 100,000 person-years (Zendejas and others 2013). This finding 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 LICs and MICs. Published information on inguinal hernia epidemiology in low-resource settings is limited to two studies of hernia prevalence in Sub-Saharan Africa from the 1960s and 1970s (Belcher, Nyame, and Wurapa 1978; Yardov and Stoyanov 1969). Inguinal hernia prevalence in men in these studies ranged 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.

A rigorous population-based investigation of groin hernia prevalence has been recently conducted in eastern Uganda (Löfgren and others 2014). This study demonstrated a prevalence of untreated hernia of 6.6 percent in men, with an overall hernia prevalence (including repaired hernias) of 9.4 percent. Although this study is an important contribution to the literature on hernia epidemiology, 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 in both the Ghanaian and Tanzanian contexts (Beard, Oresanya, Akoko, and others 2013; Beard, Oresanya, Ohene-Yeboah, and others 2013). In their Tanzanian analysis, they adjusted incidence data from the NHANES study for the population age and gender structure of the country, and 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 attribute the lower incidence of inguinal hernia in Tanzania to the relative youth of the population compared with that of the United States.

Despite demonstrating a lower incidence of inguinal hernia, Beard and others estimated a relatively high prevalence of inguinal hernia in Tanzanian men at 12.1 percent (Beard, Oresanya, Akoko, and others 2013). 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 lack of access to surgery in the region (Lau and others 2007; Ruhl and Everhart 2007).

Global Burden of Inguinal Hernia

Estimates of the global burden of inguinal hernia are rough at best. Yang and others (2011) calculated that 58.7 million disability-adjusted life years (DALYs) would be averted by repair of all adult hernias in Sub-Saharan Africa. This figure is more than double the estimates of the total surgical disease burden for Sub-Saharan Africa calculated by Debas and others (2006). The discrepancy could be caused either by a previous underestimation of the burden of surgical disease or, more likely, by different methods used to calculate surgical DALYs. A standard metric for measuring 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 (referred to as GBD 2010), Murray and others (2012) 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). We believe that GBD 2010 underestimated the disease burden of groin hernia, and we present our estimates of inguinal hernia epidemiology and global disease burden.

To test our hypothesis, we recalculated the DALYs attributable to inguinal hernia using the method described by Beard, Oresanya, Akoko, and others (2013). We adjusted the NHANES incidence figures to the population age structures of the six World Health Organization (WHO) regions.[1] 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 Sub-Saharan African region present for surgical treatment at an average age of 45 years, whereas 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.

The results of our epidemiologic analysis are presented in table 9.1. We estimate that inguinal hernia prevalence in the general population 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 estimate 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.

Our analysis indicates that hernia prevalence is highest in the Sub-Saharan African and Western Pacific regions. Although the literature on hernia epidemiology in Africa is relatively well developed, studies of hernia disease burden and treatment in the Western Pacific are notably quite limited. More research on the burden of hernia in this region is needed in light of these findings.

Table 9.2 presents our estimate of global and regional inguinal hernia disease burden. The figures suggest that

Table 9.1 Estimated Global and Regional Inguinal Hernia Epidemiologic Figures

Region	Prevalence (%)	Yearly incidence (per 100,000 people)	Number of people with inguinal hernia (million)	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: Authors' estimates based on Beard, Oresanya, Akoko, and others (2013) and United States Census Bureau International Database (http://www.census.gov/population/international/data/idb/region.php).

Table 9.2 Estimated Burden of Inguinal Hernia by Region

Region	Total DALYs (100,000)	Estimated surgical DALYs (100,000)	Estimated inguinal hernia DALYs (100,000)	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: Authors' estimates based on Beard, Oresanya, Akoko, and others (2013); Debas and others (2006); and United States Census Bureau International Database (http://www.census.gov/population/international/data/idb/region.php).
Note: DALY = disability-adjusted life year.

inguinal hernia accounts for a small but measureable proportion of the surgical DALYs, as estimated by Debas and others (2006). Most important, 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 GBD 2010 (Murray and others 2012). This finding places the disease burden of hernia on par with that of other surgical diseases such as benign prostatic hypertrophy and ovarian cancer. 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.

Met and Unmet Need for Inguinal Hernia Repair in LMICs

Mock and others (2010) have identified improved access to safe inguinal hernia repair as a high global health priority. Studies indicate that inguinal herniorrhaphy is the most frequently performed general surgical procedure at many first-level hospitals throughout Sub-Saharan Africa (Galukande 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, Oresanya, Akoko, and others 2013; Beard, Oresanya, Ohene-Yeboah, and others 2013; Nordberg 1984). Grimes and others (2012) reported that the average first-level hospital in Sub-Saharan Africa performs only 30 hernia repairs per 100,000 population per year, illustrating the vast unmet need for herniorrhaphy in the region.

Beard and colleagues in an unpublished study investigated surgical activity at all seven first-level 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 fourteenth out of 21 regions in measures of GDP per capita (National Bureau of Statistics and Coast Regional Commissioners Office 2007).

Table 9.3 presents data from this study, specifically focusing on rates of both elective and emergency repairs in each of the Pwani districts. Our analysis found that first-level hospitals in Pwani performed a population-weighted average of 34.5 elective and emergency herniorrhaphies per 100,000 population, a number similar to the hernia repair rate calculated by Grimes and others (2012). These findings further document the surgical capacity crisis in first-level hospitals in Sub-Saharan Africa.

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 with nearly 67 repairs per 100,000 population in Kisarawe. Additional operations are possibly performed in other health dispensaries, which may account for variations in hernia repair rates. Patients from one district may also be seeking 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 9.3 Rates of Elective and Emergency Inguinal Hernia Repair in the Pwani Region, Tanzania, 2012

District	Elective hernia repair per 100,000 population	Emergency hernia repair per 100,000 population	Performed by nonphysicians, number (percent)	Performed by surgeons, number (percent)
Bagamoyo	18.5	12.1	76 (100)	0 (0)
Kibaha	7.8	2.7	8 (29.6)	11 (40.7)
Kisarawe	46.2	20.7	38 (55.9)	0 (0)
Mafia	23.3	0	4 (40.0)	6 (60.0)
Mkuranga	23.8	6.7	58 (98.3)	0 (0)
Rufiji	47.9	9.6	73 (57.9)	6 (4.8)
Weighted average	25.8	8.7		

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 per 1,000 patient-years during the 2- to 4.5-year follow-up 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 follow-up and emergency surgery.

Surgical Management. Various techniques are available for surgical reconstruction of the posterior wall 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 posterior wall 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, which uses an undetached strip of external oblique aponeurosis to reconstruct the posterior wall of the inguinal canal, is an example of a tension-free tissue repair. This technique has been shown to have rates of recurrence and postoperative pain similar to that of the Lichtenstein technique (Szopinski and others 2012).

Laparoscopic approaches to inguinal herniorrhaphy were introduced in the 1990s. Although the risk of postoperative complications is slightly higher 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 and others 1997; Schneider and others 2003).

Although 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 report from Nigeria found that the mesh repair was well tolerated, with few complications at one-year follow-up (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 (Krishna and others 2012; Swadia 2011). Nevertheless, the cost of the prosthetic mesh remains prohibitive for most patients in LMICs. A study from Uganda comparing patients randomized to receive the Desarda tension-free tissue hernia repair and the Lichtenstein mesh repair demonstrated similar short-term clinical outcomes. Of note, the operating time for the Desarda repair was shorter in this study (Manyilirah and others 2012). The Desarda technique is a promising and potentially effective low-cost method to repair hernias in LMICs, and its applicability in this context 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 in HICs. However, spinal and general anesthesia are associated with higher rates of myocardial infarction and urinary retention, respectively, in patients older than age 65 years (Bay-Nielsen and Kehlet 2008).

A meta-analysis demonstrated the incredible disparity in anesthesia-related mortality in LMICs when compared with HICs (Bainbridge and others 2012). Factors associated with this disparity included few qualified anesthetists, lack of appropriate training of anesthesia practitioners, and limited supplies for safe monitoring and administration of anesthesia in many LMICs (Walker and Wilson 2008). No pulse oximeters were found in any of the 14 government hospitals surveyed in a study from Uganda (Linden and others 2012). Given these limitations in anesthesia care and the inherently higher risk associated with a general anesthetic, we recommend that groin hernia repairs in LMICs be carried out under local or spinal anesthesia whenever possible.

Mosquito-Net Mesh Hernia Repair. 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. Tongaonkar and others (2003) reported a series of 359 hernias that were repaired with a copolymer mosquito-net mesh (polyethylene and polypropylene) in multiple hospitals throughout India. On short-term follow-up, the minor wound infection rate was less than 5 percent; there were no mesh infections and one hernia recurrence.

These promising preliminary 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, Africa. The feasibility and safety of this technique have been demonstrated for nylon and polyester mosquito-net mesh in Burkina Faso, Ghana, and India (Clarke and others 2009; Freudenberg and others 2006; Gundre, Iyer, and Subramaniyan 2012). In addition, experimental research in goats has shown that nylon mesh leads to a similar amount of tissue fibrosis when compared with 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).

Newer studies have investigated the molecular characteristics and associated infection risk of mosquito-net mesh compared with commercial hernia prosthetics. In one study, Sanders and others (2013) inoculated polyethylene mosquito-net and industry meshes with staphylococcus epidermidis and staphylococcus aureus. They found no difference in the mean number of adherent bacteria to mosquito-net mesh when compared with commercial polypropylene-based meshes. These results suggest that implantation of mosquito-net mesh should not increase the risk of surgical site infection. Sanders, Kingsnorth, and Stephenson (2013) investigated the macromolecular structure of polyethylene mosquito-net mesh using electron microscopy and spectroscopy, demonstrating that the material and mechanical properties of mosquito net, including tensile strength, are equivalent to those of common lightweight commercial meshes.

Although the results of these studies are promising, sample sizes are small and follow-up is limited. Further investigation into the efficacy and safety of mosquito-net mesh for inguinal hernia repair is needed before widespread implementation. The United Kingdom's nonprofit organization Operation Hernia (see box 9.1) 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). (See box 9.2 for a description of a successful local initiative.)

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 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 hernia repair 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 syndrome may occur in up to 53 percent of patients and is often difficult to prevent and treat (Poobalan and others 2003).

Mortality following groin herniorrhaphy is difficult to measure. Primatesta and Goldacre (1996) observed the rate of postoperative deaths following elective and

Box 9.1

Effective Global Health Program: Operation Hernia

Operation Hernia, a nonprofit organization based in the United Kingdom, is an effective program aimed at combating inguinal hernia in low- and middle-income countries (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 established a Hernia Treatment Center in Takoradi and expanded its services to 10 countries in Africa, Asia, Eastern Europe, and Latin America. This organization has supported more than 85 humanitarian missions and treated more than 9,000 patients with hernias worldwide.[a]

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.

One of Operation Hernia's stated goals is to teach mesh hernia repair techniques to local surgical care providers (Kingsnorth and others 2006). If this aspect of the mission were to be systemized and expanded, it would make the humanitarian model for the delivery of hernia surgical care more sustainable. Although some might criticize Operation Hernia for being a disease-focused vertical intervention, this organization has demonstrated that its model is scalable and effective.

a. Operation Hernia Website 2013. http://www.operationhernia.org.uk.

Box 9.2

Local Solutions: The Ghana Hernia Society's Comprehensive Approach to Groin Hernia Care

During 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 Apridec Medical Outreach Group, a Ghanaian nongovernmental organization whose mission is to provide free specialist care in northern Ghana.

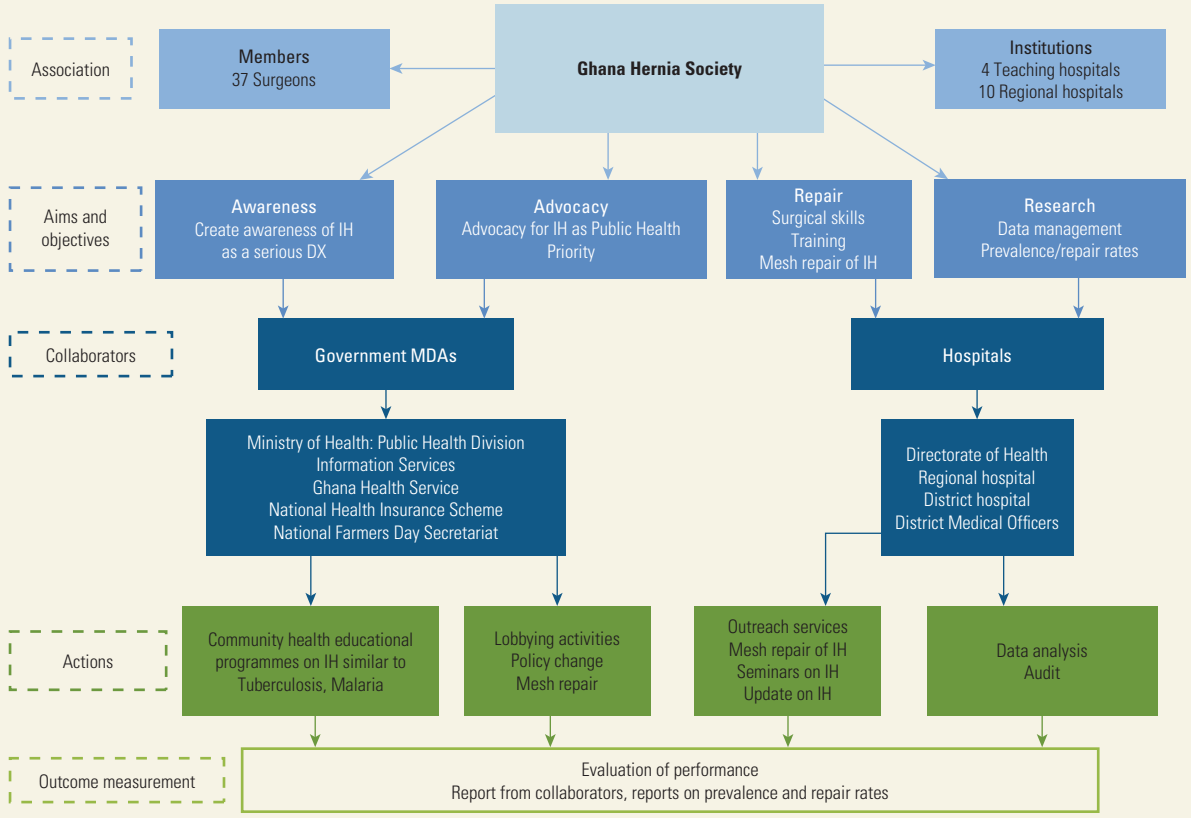
To better coordinate their individual hernia treatment efforts, Michael Ohene-Yeboah and F. A. Abantanga (professors at Kwame Nkrumah University of Science and Technology in Kumasi, Ghana) along with Stephen Tabiri (Department of Surgery, Tamale Teaching Hospital in Tamale, Ghana) and others founded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

Figure B9.2.1 demonstrates the current structure of activities of the GHS. The 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 GHS 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.

box continues next page

Box 9.2 (continued)

Figure B9.2.1 Activity Flowchart of the Ghana Hernia Society



Source: Correspondence to authors from S. Tabiri and M. Ohene-Yeboah of the Ghana Hernia Society, 2013.
Note: IH = inguinal hernia; MDA = ministries, departments, and agencies.

The GHS's plan could easily be adapted for use in the establishment of 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 could serve as a model for the development of local solutions for other common surgical conditions such as hydrocele, traumatic injury, and obstetric fistula. Although in its early stages, the GHS is an excellent example of a local public health solution to a common and important surgical issue.

emergency inguinal hernia repairs during a 10-year period in the United Kingdom. They found a significantly increased risk of death after emergency compared with elective herniorrhaphy (1.6 percent and 0.1 percent, respectively). Inguinal hernia was listed as the cause of death in only 17 percent of cases of early postoperative mortality after emergency hernia repair, suggesting underestimation of the risk of death from this condition in the United Kingdom (Primatesta and Goldacre 1996).

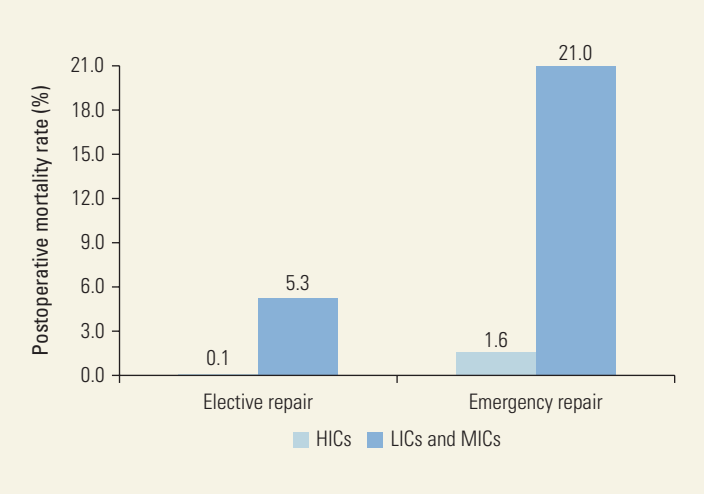
A study of the mortality rate after groin hernia surgery in Sweden found similar results. The mortality rate after elective hernia repair was similar to that of the background population, but it increased 7-fold after emergency operations and 20-fold if bowel resection was required (Nilsson and others 2007).

Repair Complications in LMICs. Although the literature on the subject is sparse, complications after groin hernia repair in LMICs appear to be higher than in HICs. In Senegal, Fall and others (2005) 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, were likely to be related to surgical technique. In Jos, Nigeria, rates of wound infections after elective inguinal hernia repair approach 8 percent, significantly higher than the rate of less than 2 percent reported in the United States (Ramyil and others 2000). Reliable data on the rate of hernia recurrence are not available in LMICs.

A review of the literature on inguinal hernia epidemiology and management in Africa 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, although 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).

Figure 9.1 demonstrates the pronounced disparity in outcomes after inguinal hernia repair in HICs and LMICs 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.

Figure 9.1 Disparity in Outcomes in Inguinal Hernia Repair in HICs and LICs and MICs



Sources: Mbah 2007; Primatesta and Goldacre 1996.
Note: HICs = high-income countries; LICs = low- income countries; MICs = middle-income countries.

Task-Shifting in Hernia Surgery: A Targeted Way to Improve Quality of Care

LMICs face a severe shortage of skilled health care 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 others (2014) found only two staff general surgeons providing care in the region with a population of more than 1.1 million people (table 9.3). At Bagamoyo and Mkuranga District Hospitals, nearly all hernia repairs in 2012 were done by nonphysician clinicians (NPCs). Mafia District Hospital, located on a remote island off the coast of southern Tanzania, has 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. 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 Africa, including Malawi, Mozambique, and Niger, indicate a similar function for NPCs in the provision of surgical care (Kruk and others 2010; Sani and others 2009; Wilhelm and others 2011). Several studies document the safety of task-shifting of emergency obstetric procedures to nonphysicians in Ethiopia, Mozambique, and Tanzania (Gessessew and others 2011; McCord and others 2009; Pereira and others 1996).

Studies on outcomes after general surgical procedures performed by nonsurgeons, specifically hernia, are notably lacking in the literature. Wilhelm and others (2011) found similar outcomes after repair of strangulated inguinal hernia with bowel resection performed by surgeons and clinical officers at Zomba Central Hospital, a large teaching center in Malawi. Although 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 other Sub-Saharan African countries, NPCs and nonsurgeon physicians often operate independently with no oversight from a surgical specialist. Although one retrospective study showed similar outcomes after major surgery performed by NPCs and physicians in

Tanzania, more studies on outcomes after nonobstetric general surgical procedures performed by NPCs are urgently needed to guide policy and program planning (Beard and others 2014).

First-level hospitals in LMICs offer few continuing education programs in surgical care. 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 first-level hospitals. The introduction of these educational programs and tension-free techniques should 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 an 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 others (2013) calculated the cost per QALY of open and laparoscopic inguinal herniorrhaphy to be £1,746 ($2,970) and £1,540 ($2,620), respectively. The United Kingdom's National Institute for Health and Clinical Excellence committee routinely uses a cutoff of £20,000 to £30,000 ($34,000 to $51,000) per QALY to determine treatment cost-effectiveness and define the scope of NHS therapies. These findings suggest that inguinal hernia repair is especially cost-effective in the United Kingdom.

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

Inguinal hernia repair with mosquito-net mesh has been demonstrated to be cost-effective in LMICs even when compared with more traditional public health interventions. In a study using Operation Hernia data from Ghana, Shillcutt, Clarke, and Kingsnorth (2010) found that inguinal hernia repair with mosquito-net mesh costs approximately US$12.88 per DALY averted. This figure means that inguinal hernia repair 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 Shillcutt, Clarke, and Kingsnorth (2010) 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 polyethylene 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, Iyer, and Subramaniyan 2012). Mosquito-net mesh is the ultimate in surgical cost savings: one polyester mosquito net can repair approximately 3,000 hernias (Shillcutt, Clarke, and Kingsnorth 2010), and all symptomatic hernias in Ghana could be repaired today using an estimated US$15,000 worth of mesh (Beard, Oresanya, Ohene-Yeboa, and others 2013).

Shillcutt and others (2013) also demonstrated the cost-effectiveness of mosquito-net mesh hernia repair in Ecuador, a middle-income country. The mean cost-effectiveness for herniorrhaphy in this study is US$78.18 per DALY, a good buy considering Ecuador's gross national income of US$3,850. These data are strong evidence of the cost-effectiveness of hernia repair with low-cost mesh in LMIC contexts and of the need to prioritize surgery for inguinal hernia when allocating scarce resources.

The findings of Shillcutt's Ghana and Ecuador studies should be interpreted with some caution because the DALYs averted per hernia repair were based on expert opinion and may be overestimated (Shillcutt, Clarke, and Kingsnorth 2010; Shillcutt and others 2013). In addition, both studies included hernias repaired on Operation Hernia missions, which may not represent the typical 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 a hernia except that the sac connecting the abdomen to the scrotum or labia majora contains only 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, whereas 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 2013a).

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 in 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 the male genital anatomy. The biological predilection of adult filarial worms to live and reproduce in the lymphatic channels of the scrotum means that more 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; the larvae 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; Norões and others 1996; Norões 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 the death of adult worms (Dreyer and others 2002; Figueredo-Silva and others 2002). They are often seen after medical treatment for 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 suffer two episodes of ADLA per year, on average, resulting in scrotal nodules (Chu and others 2010); Dreyer and others 2002; Norões 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 Filariasis and Hydrocele

In many LMICs, including India and countries in Africa, LF accounts for a significant portion of the total burden of disease. Approximately 1.3 billion people—more than one-seventh of the world's population—are at risk for LF in 83 countries (Chu and others 2010; Michael, Bundy, and Grenfell 1996; WHO 2013a). The Southeast Asia region is home to 65 percent of LF cases, and 30 percent of patients live in Sub-Saharan Africa.

Some 40 million people are estimated to have symptomatic manifestations of filariasis; one-third of these people live in India. In tropical regions, an estimated 25 million to 27 million men have filarial hydroceles (Pani, Kumaraswami and Das 2005; WHO 2013a). In many communities, the majority of men with LF eventually develop symptomatic hydroceles (Addiss 2013; Babu, Mishra, and Nayak 2009; Dreyer, Norões, and Addiss 1997; Wijers 1977; Zeldenryk and others 2011). In a summary by Haddix and Kestler (2000), 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 found 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 (Norões and others 1996).

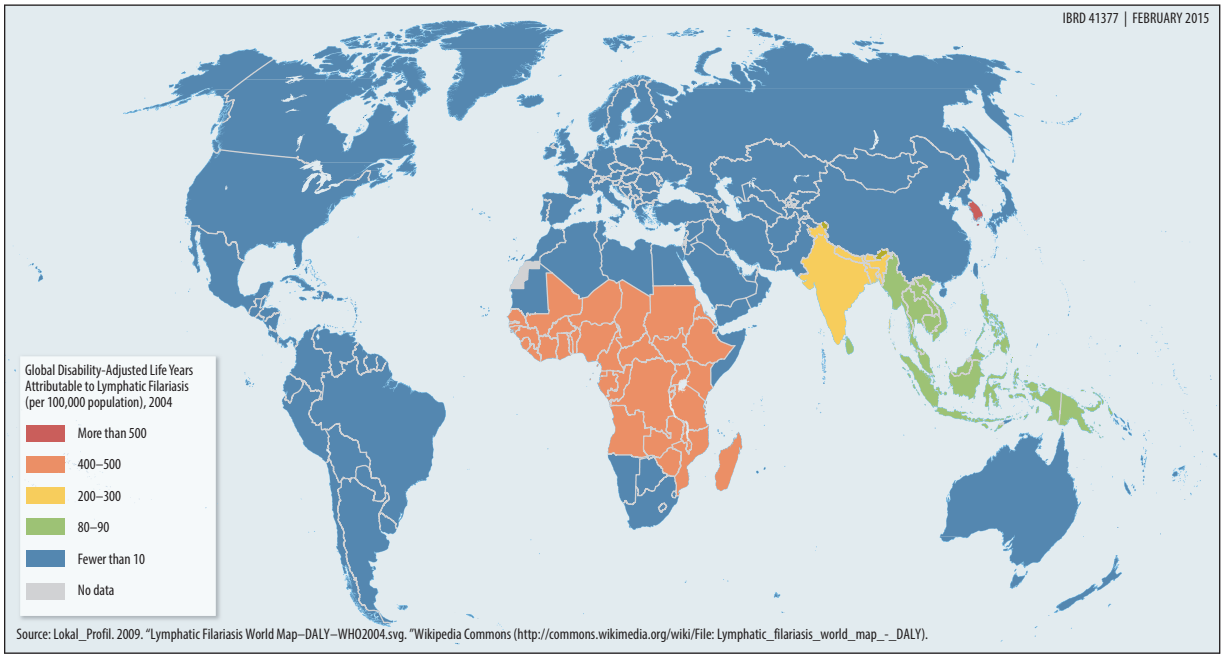
Studies indicate that population-based and household surveys consistently underestimate the true prevalence of hydrocele and disability from the disease (Eigege and others 2002; Mathieu and others 2008). Personal modesty often impedes accurate reporting of hydroceles in household surveys. Clinical mapping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

Global Burden of Lymphatic Filariasis and Hydrocele. Map 9.1 illustrates that the global DALYs attributable to LF in 2004 were concentrated in tropical regions in Sub-Saharan Africa and Southeast Asia, some of the poorest areas in the world. GBD 2010 ranks disability from LF at 105.2; in men, the disease has a slightly higher disability ranking of 87. According to GBD 2010, the number of DALYs attributable to LF (2.8 million) is approximately one-half the estimate in the WHO Global Burden of Disease study of 2004, 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 GBD 2010 acknowledged that the world's population is aging, and therefore years lived with disability is increasing, it did 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* (Jamison and others 2006) did not consider the burden of filarial hydroceles in its calculation of global surgical DALYs (Debas and others 2006).

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

Map 9.1 Global Disability-Adjusted Life Years Attributable to Lymphatic Filariasis (per 100,000 population), 2004



Source: Lokal_Profil. 2009. "Lymphatic Filariasis World Map–DALY–WHO2004.svg. "Wikipedia Commons (http://commons.wikimedia.org/wiki/File: Lymphatic_filariasis_world_map_-_DALY).

GSDPM Map Design Unit

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productivity of individuals, reduced productivity due to changes in the economies of affected communities, and costs to government-funded health care 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 to be 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 in coco fiber processing in Sri Lanka are at increased risk of LF because of 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 in Orissa, India, by 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 was seen as a last-choice marriage prospect. Because of the severity of the psychological impact on patients, Addiss (2013) has argued for an "uprising of compassion" for people disabled with LF. He noted that the 1997 World Health Assembly resolution charged the 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 disabilities have largely not received international attention to the extent that some other disabilities, yet they affect at least 15 times as many people (Addiss 2013; Addiss and others 1995; Zeldenryk and others 2011). The impact of hydroceles on communities also has been grossly underestimated, especially when the psychosocial impacts 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. In 1997, the WHO listed it among the six communicable diseases that could potentially be eliminated worldwide. Recognizing this, World Health Assembly Resolution 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).

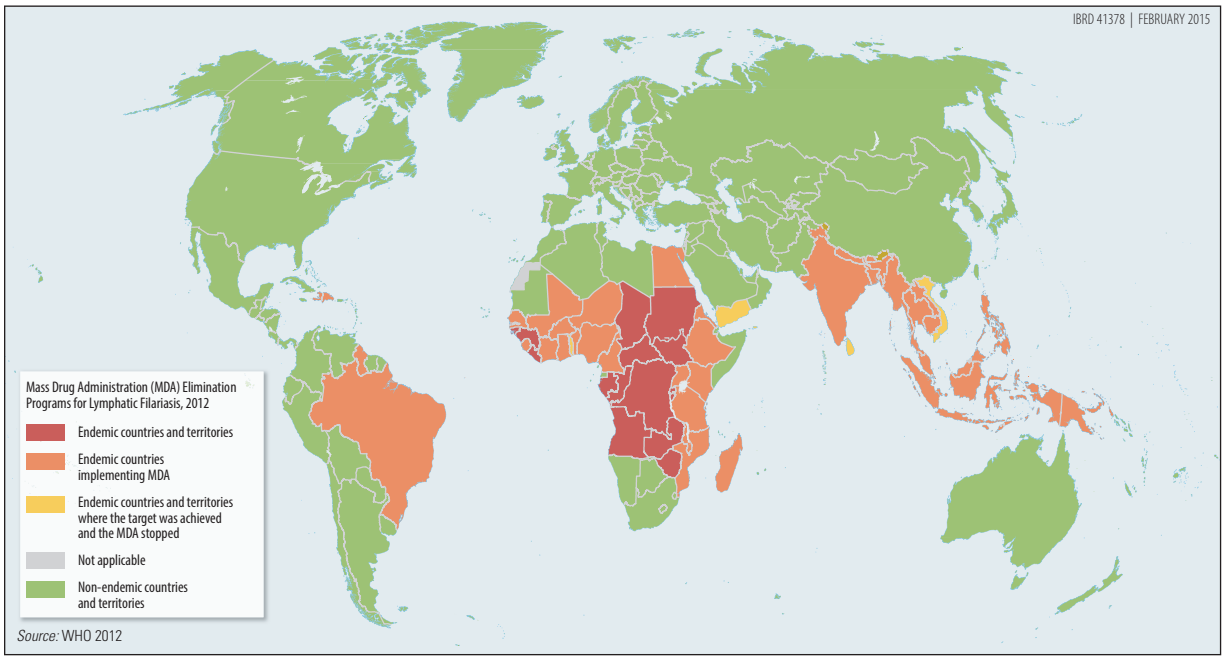
Although MDA, mosquito control, and bednets have effectively eliminated LF in some countries, MDA has been less successful in others, for social, economic, and geographic reasons (WHO 2011). Moreover, even when transmission has been effectively prevented at a population level, large numbers of people will still suffer disability from filarial hydrocele because of 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 9.2). Economic benefits have been measurable. This effort has rendered an estimated US$21.8 billion of economic benefit for affected individuals and US$2.2 billion in health systems savings. 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 its 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, which would save 58.35 working days per year and improve wages by 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

Map 9.2 Mass Drug Administration (MDA) Elimination Programs for Lymphatic Filariasis, 2012



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).

Surgical Management of Hydrocele

Idiopathic Hydrocele. The surgical management of benign idiopathic hydroceles can be complex. Although 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 Fortuño 1981). Complication rates after hydrocelectomy are high, even in HICs. In a retrospective series during the period 1998–2004 in the United States, a posthydrocelectomy complication rate of 20 percent was found (Swartz, Morgan, and Krieger 2007), including 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 is superior to complete excision. However, the generalizability of this study is limited because there was no standardization of perioperative care or surgical technique.

Filarial Hydrocele. Surgical management of filarial hydrocele is especially critical. In LMICs, patients may present with massive, disfiguring hydroceles requiring more specialized care. 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, 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; recurrence was as high as 19 percent in a large series of patients who underwent sac-sparing surgery for LF (Norões 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 with those of a group of 218 patients with "sac-sparing" subtotal

excision of the sac, done elsewhere. With a mean follow-up of 8.6 years, recurrence rates for complete excision were 0.3 percent compared with 19 percent in sac-sparing surgery. Although 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 care 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 lymphovenous shunts for hydroceles and lymphedema secondary to LF have also been reported in the Indian literature (Manokaran 2005).

The surgical management of filarial hydroceles in LMICs is largely not standardized. 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 estimate 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 with 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 Africa. Programs to expand the capacity for inguinal hernia repair and hydrocelectomy at first-level hospitals should use 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 health care services that should be available at first-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.

NOTES

The World Bank classifies countries according to four income groupings. Income is measured using gross national income (GNI) per capita, in U.S. dollars, converted from local currency using the *World Bank Atlas* method. Classifications as of July 2014 are as follows:

- Low-income countries (LICs) = US$1,045 or less in 2013
- Middle-income countries (MICs) are subdivided:
  - Lower-middle-income = US$1,046 to US$4,125
  - Upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more

1. International Database, 2013, United States Census Bureau, Washington, DC. http://www.census.gov/population/international/data/idb/region.php.

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