From the perspective of a surgeon working in Poland it is difficult to imagine young people dying commonly of diseases for which there are well known treatments, such as appendicitis or incarcerated hernia. However certain complications of common diseases are still characterized by dramatic outcomes in other parts of the world. Currently almost three billion people worldwide do not have access to basic surgical care and the closest, usually rural, hospital is usually inadequately equipped and poor (fig. 1, 2), lacking trained staff, exposed to common disturbances in water, power, fuel or oxygen supply (1).

Every year several thousand physicians from the USA and Western Europe participate in medical missions in developing countries. Providing help as volunteers, they must cope with difficulties unknown in current modern medical centers in the developed countries (2). Physicians from Poland also are involved in helping people from the Third World by participating in humanitarian medical projects – short- or long-term ones. Recently short-term missions have gained popularity due to ability to obtain clear results of intensive work without bearing enormous social and economic costs. Well planned and solid surgical relief missions result in efficient achievement of their aims. Operation Hernia is a good example of such project. This project involves periodical (2-3 times per year) travels of groups of several volunteers for 1-3 weeks to a local hospital. On site they perform surgical procedures using materials provided by the program participants. Concurrently they train the local staff. Since the mission is repeated, this provides an opportunity to treat possible long-
term complications. On the other hand, the trained staff is able to provide care of the patients between subsequent missions. The rationale is to repeat the travels until the center becomes fully independent, both with regard to training and equipment. The first hernia center in Africa (Takoradi-Sekondi, Ghana) was founded by Operation Hernia in 2005 (fig. 3, 4) (2, 3).

The disorders to be treated as part of the humanitarian medical missions should fulfill the following criteria: 1) a chronic disease, since usually several months elapse between the planning and actual travel; 2) a disease that can be easily diagnosed by the local staff before the arrival of the specialists; 3) a pathology that can be managed under local anesthesia, since no other anesthesia is available; the procedure has to be relatively simple and require minimal equipment and resources and carry relatively low complication risk; 4) a common disease that affects high percentage of the population and constitutes a major social problem.

The inguinal hernia meets all these criteria. Thus it is the most commonly treated disorder in Africa by surgeons from Europe. Based on a study conducted among residents of 50 villages in Ghana Kingsnorth found hernia in 1400 subjects per 100,000 inhabitants, i.e. 2.7% adult males. This prevalence was almost ten-fold higher than in the developed countries (150-200 per 100,000). However, this figure is markedly lower than previous estimates suggested (from 7.7% to more than 30% on the Pemba island at Tanzania coast) (4, 5, 6). Beard estimated that currently 800,000 Ghanaians has the inguinal hernia. In view of current incidence of this disease in Africa (210 per 100,000 inhabitants) and current number of repair procedures (30 per 100,000), in 10 years the number of patient who require treatment of Hernia in Ghana itself will be 1 million! This deficit in access to surgical care could be reduced only if an annual rate of surgical procedures would be 420 per 100,000 inhabitants. If we compare these needs with current efficiency of the health care system in the USA that ensures treatment of hernia for 275 patients per 100,000 inhabitants – this seems unlikely. For the sake of comparison – only 100 hernia operations are conducted annually per 100,000 inhabitants in the United Kingdom, while this figure is 180 in Sweden (7, 8, 9).
Inadequate surgical potential and existing deficiencies can be indirectly indicated by the rate of emergency procedures as well as the rate of indirect hernia procedures. Emergency procedures of incarcerated hernias constitute more than 2/3 of hernioplasty procedures at the university hospital in Ghana. In Uganda the rate of operated incarcerated hernias is even bigger, 76%. The situation is more favorable in Sierra Leone (33%) and Nigeria (25%). However, these figures are many fold higher than in developed countries. In Europe and the USA, the rate of emergency procedures does not exceed 1-3% (5). The rate of oblique hernias in Ghana (82.9%) is much higher than in countries with high national income (60%). This may indirectly indicate that congenital hernias in children (juvenile type) remain untreated for many years (4).

Another potential cause of such low number of surgical procedures may be avoidance of surgical treatment due to its high costs, both direct costs related to utilized resources as well as costs of medical care. For poor inhabitants of Africa who constitute vast majority of the population, treatment costs are beyond their capacity. Despite cheap universal health insurance for the employed subjects, there are no real treatment opportunities based on this system. Corruption effectively limits access to treatment, making the insurance system a fiction. In view of this, some patients decide to use nonconventional treatment methods offered by traditional popular healers. Naive patients can be easily manipulated in a society lacking basic education when offered cheap methods of non-surgical hernia treatment based on sorcery and incantation among others. This also leads to delayed decision to use adequate treatment, making some patients visit the hospital only with incarcerated hernia.

High rate of hernias in a young population significantly affects poor economy of the developing countries. Based on a study conducted in Ghana, Sanders found that daily activity was limited in 64.4% of subjects in a group with hernia and 16.3% of them were unable to work. Concurrently, scrotal hernia constituted as many as 67% of cases, and 37% of patients had hernia for more than 5 years (12). Thus, inguinal hernias, after many years of heavy physical labor, become exceptionally large and painful, eventually making the employment impossible among patients who are often the only source of income in large families (13).

Although benefits of tension-free Lichtenstein method such as early return to work and low recurrence rate, are known and recognized by surgeons in Africa, traditional tension procedures (e.g. Bassini hernioplasty) account for the majority of operations (14). This mainly results from unavailability of hernia mesh in developing countries due to lack of funds and poor distribution network (6, 15, 16). In search of a compromise between the need to propagate tension-free methods and practical lack of availability of modern mesh in poor African countries, other substitute materials were emphasized. Recently mosquito net as an alternative for conventional hernia mesh has been emphasized by many authors (17-22).

In 2013 a paper was published that documented long-term outcomes of mosquito net implantation, by one of the originators and pioneers of this method. For 10 years Tongaonkar performed 713 hernia operations using Low Density Polyethylene (LDPE) from generally available mosquito net. The follow-up period was 6-18 months and only 4.9% of patients were lost to follow-up. The postoperative complications included superficial infections in 0.9%, 1 seroma (0.1%), 2 patients with chronic pain (0.3%), 2 hematomas treated medically (0.3%). These results indicate possibility of effective and long-term safety of using sterilized mosquito net to tension-free hernioplasty (15). Stephenson – one of the leaders of Operation Hernia – found that both clinical and experimental data indicated that implantation of patches of locally purchased mosquito net to strengthen hernioplasty, resulted in outcomes similar to that obtained with hernioplasty with hernia mesh in developed countries (14).

The term “mosquito net” can be misleading due to multiple materials used locally (nylon, polypropylene, polyester, polyethylene). Furthermore they can be impregnated and differ with regard to their physical, chemical and mechanical properties, which raises the issue of their biocompatibility (15, 23). Sanders attempted to systematize various types of mosquito nets that could be used as implants during the inguinal hernia repair procedures. He proved in in vitro tests that there were no differences in physicomechanical properties of the tested materials. He confirmed lack of dif-
ference in the number of infections in the early and late postimplantation period between the implanted polyethylene mosquito nets and conventional monofilament polypropylene mesh. The risk of infections following implantation of commercial polyfilament mesh proved to be even higher (16, 23-26).

The polyethylene mosquito nets widely available in the countries of global South, seem to be the most appropriate substitute for the light monofilament, macroporous hernia mesh (23). Since 2004, poorly available composite mosquito net (polypropylene and polyethylene) was replaced by polyethylene mosquito net by Indian surgeons. The only drawback of this new mosquito net is its lower melting temperature (122°C) as compared to that of the composite net (144-159°C). Because of that the polyethylene mosquito nets may not be sterilized in high-pressure horizontal autoclaves, where the temperature reaches 134°C (27). Since 2007 the polyethylene mosquito nets are used by Operation Hernia (1). It must be noted the first generation of Marlex nets (“Marlex-50”) proposed by the pioneer of implantation of synthetic material, Francis C. Usher, in 1958, was made of polyethylene. It provided adequate resistance and bioneutrality. However, difficulties with sterilization led to replacement of polyethylene with polypropylene that was introduced in 1962; it shared the benefits of polyethylene, but could be sterilized in higher temperatures.

However, in majority of hospitals in developing countries, only simple vertical sterilizers are available, where the temperature never exceeds 121°C. Concurrently, a fifteen-minute steam sterilization at 121°C is an acceptable management, recommended by Medical Device Agency in the United Kingdom as well as institutions from other countries (1, 16). At 121°C LDPE contracts by 25-30%, but remains elastic, soft and easy to handle during implantation. Furthermore, as the report of Automotive Research Association of India indicated, tensile strength increased after sterilization from 190 N to almost 350 N, which could be perceived as a benefit of the process of the net preparation (1). Ethylene oxide sterilization is also acceptable, although its high cost limits its availability (16).

Although implantation of the polyethylene prosthesis itself seems not to increase the infection rate, the overall risk of postoperative wound infection remains high (10-39.9%) versus the US (2.6%) and European (3%) data (23). This results from inadequate financing of the health care, hospital overcrowding, inadequate number of nurses, lack of adherence to aseptic standards and procedures and lack of hygienic practices in the society, among others. Surgical procedures performed in Africa by local staff are often of low quality, in particular in rural regions – both due to lack of information of infections and technical skills and possibly due to negligence of the medical teams.

Data from Senegal indicated 21% complication rate after inguinal hernia operations in adults. The complications included iatrogenic injury of the bladder, accidental skin injury with an electric knife, meningeal irritation, urinary retention, scrotal hematoma, superficial infections, ileus and early recurrence (28). Thus it is so important to educate and emphasize the need for meticulous antiseptic procedures during implantation of the mesh by local surgeons. The issue of mesh sterilization, which seems simple, is of equal importance. However, variability of available autoclaves, temperature ranges and sterilization times may be the source of problems. In this context periprocedural antibiotic prophylaxis should be recommended as an additional protection against hygiene deficiencies (14).

The main advantage of the polyethylene mosquito net is its low cost as compared to the prices of conventional hernia mesh. The price of a mosquito net with dimensions adequate for a single implantation is 0.0072 USD, i.e. it is over 4000-fold cheaper than the cheapest commercial mesh (22). The cost of sterilization and packaging of an implant in the United Kingdom in 2009 in the Operation Hernia project was 1.46 USD per single mesh (4). In summary, a pre-cut, packaged and ethylene oxygen sterilized mosquito net mesh costs less than 2 USD and is even cheaper when sterilized with steam (29).

Hernia operations are not considered as a priority of health care in developing countries. Costs of training and equipment requirements markedly exceed rational logistic possibilities and available resources. Thus treatment of inguinal hernia is not a common focus of interest for the governments or various non-profit external initiatives that tend to focus on infectious diseases, maternity and pediatric health (4). However, we must emphasize that political
decisions concerning health care in a given country should be supported by objective data that has already been collected for the hernia epidemiology. We have evidence that supports surgical treatment of hernias using implantation of locally purchased mosquito net mesh. DALY (disability adjusted life-year), proposed by World Health Organization, measures the health status of a society and facilitates economic simulations and making political decisions concerning health care. It is a measure of overall years lost due to premature death or health damage as a result of an injury or disease.

Total DALY in a population is a measure of population burden of the disease (18).

An estimated 11% of global disability adjusted life-years result from disorders that require surgical treatment (7). One DALY is an equivalent of loss of 1 year of working with complete health. In this context DALY can be used to support or abolish economic benefits of treatment (15). Shillcutt demonstrated that patients operated by Operation Hernia avoided an average 9.3 DALY per subject with resource utilization less than 13 USD per one avoided DALY versus the hypothetical lack of treatment (an overall treatment cost of 120 USD) (30)! This cost can be compared to costs of cataract surgery (DALY = 9 USD), basic vaccination (10 USD), malaria prevention and treatment (24 USD), oral hydration with diarrhea (1062 USD) or antiretroviral therapy (up to 1500 USD) (1). Considering the prevalence of inguinal hernia in the adult population of sub-Saharan African males (2.7%), this equals to 58.7 million avoidable DALY with general availability of surgical treatment of hernia (18, 31, 32).

CONCLUSIONS

Evidence reported in this paper demonstrates that use of adequate mosquito net mesh in tension-free inguinal hernioplasty is safe as compared to use of commercial mesh. Concurrently popularization of this solution in developing countries, as a substitute of expensive materials from Europe and the United States is rational from economic point of view, in particular in view of lack of other effective modern treatment methods. Currently recommended polypropylene mesh with Lichtenstein procedures are used in no more than one in five inhabitants worldwide, while for the others such treatment is unavailable. Possibly the standards regulating utilized materials should include wealth of inhabitants of individual parts of the world and be different for developing and moderately developed countries. Further analyses of treatment outcomes of hernias utilizing cheap substitutes will answer the questions of rationality of high prices of currently used hernia mesh and verify arguments that justify such excessive prices.

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