

## **Geographic Factors in Surgical Practice.**

*NOTE: This paper was written by a medical mission volunteer who has joined Dr. Geelhoed on missions in recent years. The writer, Dan Vryhoff, is now a medical student at Washington University St. Louis. It is clearly written, identifies challenges, and describes potential means of overcoming obstacles in providing surgical care to third world and developing nations. Dr. Geelhoed sent it to me and I want to share it with potential volunteers from FPC and anyone with interest in medical mission. Marguerite Schondebare*

**Two mountains, on two continents, describing in two words the counterintuitive “high points” of this chapter**

### **“EQUATORIAL GLACIERS”**

Get your mind around this description for a moment. It is not a Zen Koan. It is a geographical fact I have witnessed from the bottom to the top of several continents.

We imagine that at the Equator the world is hot and humid and tropical diseases abound in an environment of snakes and insects and animals obscured in jungle vegetation. But, as seen in this image of a photograph taken on the “Roof of Africa,” I am standing precisely on the Equator at 00° 00.00 N/S. I am wearing a Gore-Tex parka and climbing boots with a glacier behind me. On subsequent visits to this same site, I have noticed the glacier has notably receded to only a fraction of what was when Ernest Hemingway described it in *The Snows of Kilimanjaro*. Nonetheless, it is an Equatorial Glacier, above an Alpine Desert, below which is a rainforest, each environment determined more by altitude than latitude.

Again, fifteen years later, I am standing near the top of a continent, the South American Andes this time, looking out from a snow cave over, again, an Equatorial Glacier. This is the summit of Chimborazo in the Cordillera de los Andes, and this glacier is even more imposing than Kilimanjaro’s on the Roof of Africa. This one is right on the line that was first drawn here by an eighteenth century group of far-sighted scientists who had determined this arbitrarily drawn geographic delineation would have significance as the “Mitad del Mundo” (see Figure\_\_ ) and subsequently gave the new name to the geographic unit around it—“Ecuador.”

# Geographic Factors Influencing Surgical Practice

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## Introduction

Geography is the scientific description of the physical features of what is our planet, and, as it is ever changing -- glaciers calve, mountains lift up, rivers widen -- we human inhabitants and curious explorers try to learn about our home and how to adapt to the changing circumstances of our environment. One of the ways we have sought to adapt to our environment is to improve our fitness for inhabiting it by controlling illness and congenital or acquired defects in form and function. The most immediate of these healing arts is surgery. This chapter explores the intersection of geography and surgery.

Surgery and its evolving techniques constitute a profession that continues to keep pace not just with the demands of the privileged populations fortunate enough to live in the more bountiful geographic parts of this ecologically sensitive space ship earth, but to spread the benefits of the healing arts over all populations inhabiting it, even the parts we least understand.

As in the case of the nearly oxymoronic term "equatorial glacier" there may be many counterintuitive things to be learned by this exploration of the earth and its diverse ecologic niches and the peoples who inhabit each. We can easily misunderstand not only the geography of these foreign environments, but also the peoples who inhabit them.

They are, after all, not at all *like us*---they *are us*.

## The Importance of Place

Human health and illness "take place." Place influences many of the conditions that result in health or illness. Indeed, place-related health factors may be the primary determinants of outcome. Geography is one of the factors in the matrix of the environment in which human and other beings are embedded, especially at the "extremes." Geography may be the principal co-factor in climatic determinants, or central to other environmental factors such as air, water, sunlight, soils, and food sources. It may also be an ancillary factor in economic, political and socioanthropologic features. The complex of these features may limit the ability of individuals and societies to adapt as they seek optimal living conditions and health-preserving environments. And the limits to adaptation are those that coerce an individual or society to seek help in health care for mitigation of illness or for health enhancement.

Medicine, surgery and public health are among the disciplines that have evolved to assist in health preservation or restoration. Access to such services can be empowering for individuals and whole societies whose health and illness "take place" even if there may be greater mobility in modern populations . Access to care becomes critical when it is not easily available, and, curiously, geographers have been the ones to define for each continent "the pole of inaccessibility," the place to which one cannot gain access. Or at least not easily. This geographic term will be extended for our purposes to represent inaccessibility that is the result

of political, economic and cultural barriers. “Inaccessibility” then becomes more widely distributed globally than at only the poles of geographic extremity.

When we consider surgical services, these “poles of inaccessibility” are areas where “place” has failed to support the population. They are often formed around the fulcrum of economics, such that a defined group of diseases have become known as “Diseases of Poverty.” These diseases (to be discussed more fully later in this chapter), are more often found in the poles of inaccessibility and are characterized by late presentation of advanced disease that otherwise might be preventable in populations with better access to health and health care. When people generalize about “third world” patterns of illness and the constrained resources with which they might be addressed, they often focus on those afflicted as the beginning and the end of the problem, neglecting the role of place in the disease.

The first-world advances in health care, so dramatically exhibited in immunizations (resulting in the near disappearance of some communicable diseases) or in the surgical repair or replacement of many organs (with functions afflicted by degenerative conditions) are as out of reach by contemporary developing world populations as completely as if they were embedded in medieval or even prehistoric times. Awareness of such truly life-saving care elsewhere leads to even greater frustration and desperation in those suffering curable illness.

### **Mortality and Morbidity**

Mortality is the loss of years from life. It is the result of lethal encounters with infectious or traumatic illnesses in younger ages or predominantly degenerative or malignant diseases in older life years. The familiar causes of loss of human life on planet earth are easy to extract from the bills of mortality, including DAMMM—Diarrhea dehydration, Acute respiratory infections, Malaria, Measles and Malnutrition. DAMMM represents the top five causes of death, still, on this planet, and often occur to those under five, resulting in large losses of human potential. For many of these acute illnesses that cause or contribute to death, we seek cures, available, if not always accessible.

Morbidity is the loss of life from years. The illnesses so described are not so much lethal as chronic and disabling, resulting in a large “burden” in prolonged life years in both individual and populations measured by “DALYs,” Disability Adjusted Life Years. (See Figure \_\_.) In addition to the degenerative diseases of older populations in the developed world—cardiovascular, neurologic or malignant, and osteoarthritic—those in the developing world experience neglected tropical diseases<sup>1</sup>. This cumulative “burden of disease” decreases life potential. We seek to mitigate such disability limitations. For these diseases of high morbidity, we seek not so much to cure, the objective for diseases of high mortality, but to control, limiting the disability burden of disease.

But again, health care designed for the cure and control of mortality and morbidity works only if it is accessible. Health care practitioners must grapple across the multiple barriers of geography, economics, political, and socioanthropologic factors that limit uptake of medical and surgical care as much, and for some even more than, our biologically limited abilities in disease control for a great many illnesses and people affected by them. Such health care access requires more than a fundamental understanding of the pathophysiology of the illnesses. For many of the world’s populations, there are more cultural barriers to access to care than there are medical ones.

### **Poverty and Disease**

Poverty is perhaps the best predictor of a person's health. Poverty comes with a litany of contributing factors that predispose a person to disease. These include crowded living conditions, unsafe water, inadequate sanitation, disproportionate occupation as sex workers, malnutrition, and poor access to health care. Poverty and disease go hand in hand because they synergize. Conditions of poverty predispose people to disease. Disease is costly and destroys productivity, bringing people into poverty and trapping them there. The cycle continues.

The poor carry a hugely disproportionate amount of disease and they are the least prepared or equipped to fight it. The three biggest poverty-related diseases are AIDS, malaria, and tuberculosis<sup>2</sup>. Developing countries account for 95%, 98%, and 90% of the prevalence of these diseases respectively. Practitioners, no matter where they serve, must know the extent of poverty present in the population to be served, and they must be able to diagnose and treat the specific diseases that accompany poverty in the area.

For example, inadequate sanitation and poor water management bring parasitic diseases such as malaria, diarrheal diseases, and schistosomiasis. According to UNICEF, contaminated water causes the deaths of over 3,000 children every day. These types of parasitic diseases can increase the risk of HIV transmission as well<sup>3,4</sup>. Malnutrition does as well. It increases the rates of HIV infection, as well as other diseases, by interfering with the system of immune response. Malnutrition can also increase the rate of transmission of HIV from mother to child<sup>5</sup>. And further, high levels of pollution, in urban areas and in areas with high exposure to indoor cooking fires, put residents at high risk for asthma and other respiratory infections.

Neglected tropical diseases (NTDs) are another huge source of morbidity in the developing world. They are called "neglected" because they receive a disproportionately small amount of funding for research and treatment than do other tropical diseases. NTDs include soil-transmitted helminthic parasites, African trypanosomiasis, Chagas disease, Leishmaniasis, Lymphatic filariasis, Guinea worm, Onchocerciasis, Schistosomiasis, and Trichomoniasis. These diseases are very common among the poor and in the developing world, but they remain "neglected" because they do not result in large numbers of fatalities compared to, for example, malaria, respiratory infections, or HIV.

In addition, it should be noted that NTDs and non-neglected diseases are often co-morbid with each other. One disease can make the other disease worse or, at least, increase the likelihood of infection. NTDs also account for a large amount of lost DALYs (Disability Adjusted Life Years). Even if the disease is not deadly, it can rob people and populations of productivity, deprive children of healthy development and school attendance, and cause a great deal of suffering and misery.

### **Population Dynamics**

Populations in the third world tend to be younger due to higher rates of mortality as well as higher birth rates. The higher death rates seen in developing countries can be caused by a number of factors ranging from disease prevalence and lack of available healthcare to political instability and conflict. The birth rate of a country is often inversely related to its level of wealth and development. Higher income countries, where the life expectancy is longer and the average level of formal education received is higher, are associated with lower birth rates. Low income countries with low levels of education are associated with high birth rates. There are also cultural and religious factors that affect birth rates.

Being aware of the age distribution in the country is the first clue to understanding what types of surgical problems will most likely be encountered. Trends in population dynamics can be visualized through the use of population pyramids. There are four main classes of pyramids that describe the stages by which countries generally develop. The first stage is very wide at the

base indicating a high birth rate and curves up to a very sharp point indicating a high death rate and a short life expectancy. Countries with this type of age distribution have a low median age (Figure: PyramidNiger). As the life expectancy of a country rises slightly and the death rate declines, the middle of the pyramid expands. This represents stage two in development. These countries have a higher percentage of people between the ages of 15 and 65.

Stage three involves a continued increase in life expectancy and decline in death rate as well as a declining birth rate. In the course of population development, the pyramids may have lost their triangle shape as a greater percentage of the populace is surviving to old age, but the base is still the widest point indicating large numbers of people in their youth. This stage of development is marked by the end of population growth, "ZPG" or Zero Population Growth (Figure: PyramidUSA).

Stage four happens when the birth rate actually falls low enough that the population pyramid becomes top heavy. This is often combined with a low death rate and high life expectancy. These types of pyramids are being seen in some developed countries of Europe and in Japan (Figure: PyramidJapan). Whereas a country in stage one or two may have problems with an abundance of children and uneducated youth to support, countries in stage four are beginning to struggle to support an aging population that is no longer in its productive years but still has a long time to live.

A country's development usually progresses from stage one to stage four, and health needs and societal issues can be predicted as a reflection of these demographics. Countries in stages one and two have high rates of morbidity and mortality from infectious disease. Their health care delivery infrastructure is probably underdeveloped and ineffective. They are supporting a large population of children with a moderate number of working age people. By stage four the population has shifted to an older median age. The largest healthcare problems become related to old age and degenerative disease and to paying to support a larger percentage of retirees in the population. In both stages one and four, a squeeze is being put on the working population.

### **Population Distribution**

Besides a changing age distribution occurring with development, the geographic distribution within the developing world is changing. Relatively speaking, people in the developing world (and the entire world in general) are moving from rural areas into cities. This migration results in some interesting epidemiological changes. With a move from a rural setting to the city come changes in lifestyle and diet that are associated with an increase in obesity and all of its associated health problems as well as metabolic diseases like diabetes and cardiovascular disease<sup>6,7,8</sup>. Such diseases of affluence and lesser physical activity are not the only diseases seen to be on the increase.. As urban populations quickly expand in the developing world, crowded unsanitary conditions outstrip the health and sanitation infrastructure in place, leaving the cities vulnerable to epidemics of communicable disease.

An interesting example is the spread of Dengue Fever in urban areas<sup>9</sup>. Unplanned urban expansion leads to water management and hygiene problems. *Aedes* mosquitoes that transmit Dengue thrive in the dirty water of city slums. This can be contrasted with the *Anopheles* mosquitoes that transmit malaria which prefer clean water for breeding. What is being seen is that people growing up in urban areas do not develop as much resistance to malaria as their rural counterparts because the *Anopheles* mosquitoes do not breed well in the dirty city water. When such urban dwellers do get malaria, they are more susceptible to its deadly complications. High concentrations of both people and disease vectors result in high levels of Dengue fever as well as rising levels of cerebral malaria<sup>10,11</sup>.

Places in urban Africa are unique in that they represent the intersection between first and third world health problems. As a surgeon you may find yourself going straight from a strictly third-world procedure like a sigmoid volvulus repair to a strictly first-world procedure like an appendectomy. In cities of the developing world there is an overlapping intersection of wealth, poverty, and geography that allows horses and zebras to run together.

Urban Africa is not the only example of such an intersection. In the sense that illnesses and surgical care “take place,” they do so because they are very much part of an interaction with peoples who identify themselves with characteristic homelands. These people are physiologically adapted to the environments in which they live—from Eskimos to desert nomads to rainforest pygmies to altitude-born montagnards—and this may have some genetic basis in their metabolic adaptations over a long period of accommodation. Examples are easy to list, from agriculture to achieve food security, architecture to secure shelter, and even clothing and costuming for advantages in various climatic and social conditions<sup>12</sup>.

There may be as many, and often more, anthropological reasons for the uptake of health care practices than for medical ones. The truth of this statement is ever more apparent in the management of large-scale public health problems like HIV/AIDS or the emergence of multi-drug-resistant tuberculosis in marginalized societies. The critical role of culture in disease patterns and their control was apparent already to the father of anatomic pathology when he wrote: “Whenever mass disease occurs, it is a result of ‘disturbance of human culture’” -Rudolph Virchow MD<sup>13</sup>.

### **Diagnosis and Treatment**

It is important to note the differences in presentation of morbidity in the third world. In general, diseases and surgical cases are going to present at a much later stage. Patients who have been living with ever-present disease their whole lives are less likely, or are unable, to seek care until the situation becomes truly dire. This is a wide-ranging problem for multiple reasons. In the case of many diseases, e.g., typhoid or Kala Azar, the window for therapeutic intervention may have passed. The same goes for malignancies that, if diagnosed earlier, would have been treatable either surgically or medically. The one silver lining of this phenomenon is that in the third-world clinic there is likely to be less diagnostic uncertainty. Diagnostic equipment and laboratory tests are often scarce in a developing world setting, but when the disease has progressed longer it often presents with more distinctive symptoms. For instance, it is easy to diagnose a hernia when it is the size of a football.

The same is true for determining surgical needs. In surgery, like medicine, there is a difference between what is seen in the developing world and the developed world. Many of the problems are the same, but in the developing world they often present in later stages or in worse conditions. In third-world situations, the operating room practitioner will encounter hernias that have been unrepaired and growing for twenty years, malignancies that have grown and metastasized hopelessly, and surgical cases with comorbid infectious diseases.

One type of surgical procedure that is in great demand in the developing world is the repair of obstetric fistulas. These fistulas between the bladder or rectum and the vagina are caused by trauma during childbirth and, if left unrepaired, leave the woman open to infections and other complications. Often the result is a painful condition that comes with a horrible smell of infection and urinary or rectal incontinence. Affected women are often ostracized from their families and communities as unclean and they suffer greatly without support. This problem is common in some developing countries because of a tendency for young, often malnourished and underdeveloped girls to marry or become pregnant. The bodies of these girls are not ready for childbirth. Also the lack of obstetrical care and intervention during complicated deliveries leads to a higher incidence of fistulas<sup>14</sup>.

Another type of procedure that is common in certain parts of the developing world is the removal of goiters. A goiter forms from the thyroid in response to a lack of iodine in the diet, which causes hypothyroidism. This problem is often seen in places of the world that are far inland and have low iodine concentrations in the soil. Hypothyroidism is a condition with a litany of symptoms that include a decreased metabolic rate, infertility in women, depression, muscle cramps, fatigue, and goiter. In the case of hypothyroidism secondary to iodine deficiency, iodine replacement therapy is quite effective. Often though, the patient's goiter (a mass of hypofunctional thyroid tissue in the front of the neck) is too big, and won't go away with the iodine replacement therapy. In these cases, for either cosmetic reasons or because the patient is having trouble breathing or swallowing, removal of the goiter in thyroidectomy may be performed.

Trauma operations are also much needed in the developing world. There is a high incidence of traffic-accident-related injuries as well as burns. Motor vehicle accidents (MVAs) are common in overcrowded cities where traffic laws are non-existent or unenforced. The situation is worse when large numbers of pedestrians, bicyclists, and even livestock compete for use of narrow unmaintained roads. Also, most cooking in the developing world is done over fires, often made using charcoal or paraffin-based burners. Cooking accidents and house fires are not uncommon.

Something that should be noted about trauma surgery in the developing world is that in many places the infrastructure is not in place to get patients to the hospital in time for the necessary intervention. With MVAs, burns, or violent injuries like gunshot or machete wounds, there may be a high volume of cases, but the worst cases will probably never reach the practitioner in the hospital.

### **Seeing People and Place**

The point of these descriptions of reality is that poverty creates a perfect storm of disease. Living in poverty often entails malnutrition, which increases susceptibility to parasites and vice versa. Parasites increase the risk of HIV infection. HIV increases the risk of tuberculosis infection (the number one cause of death by infectious disease worldwide). And any of these diseases can by itself push a person or a family into poverty. And the cycle continues, perhaps generation to generation.

Breaking the cycle in an effort to achieve health and productivity is made even more difficult by a tragic lack of available health care. People are forced to live with the burden of untreated disease far longer than their counterparts in the developed world. Their diseases and surgical needs are not cured and ever more productivity is lost. But this is the factor that doctors are best equipped to reverse. If effective and equitable health care can become available to the poorest people of the developing world, the seemingly never-ending cycle of poverty-disease-poverty can be broken.

It begins with seeing people and place. A good clinician treats patients. A great physician cares for people, individually and collectively, in their environmental, social, and political context. Many of those people are probably unlike the practitioner in many ways -- language, other components of culture, nutrition, religion. And often the patients and the problems they carry are "foreign" to the practitioner who learned the healing arts in a quite different environment.

It begins with sensitivity. Although practitioners have learned that a patient should never be identified by the disease (the crude reductionism of referring to the "gall bladder in bed five"), they may be less reluctant to identify a patient by socioeconomic status, often referring to them collectively as "the poor." Relying on and reinforcing the stereotypes of the "haves" and "have nots," the giver and the receiver, the caregiver and the care recipient, the rich West and the

resource-poor Third World, limits the practitioners ability to fully grasp the healing possibilities of the situation. Being labeled “poor” should not be the fundamental characteristic of any one because it limits options, ignores what the patient and the culture bring to the situation, and prevents practitioners from fully seeing both people and place.

### **Improvisation and Ingenuity**

Often in developed-world care practices, futile care is expended on patient problems simply because it is available. Even though a cure is improbable or impossible, and the patient’s morbidity symptoms are extended, perhaps worsened, the “technological imperative” prevails: “We have it, and you are going to get it, whether or not it works to resolve your problem.” The developing world rarely has such an option. Practitioners who treat late-stage disease advanced at its first presentation must employ a method that is rare in the developed world: rationing care according to the greatest good for the largest number.

One of the benefits of working along with and learning from the local clinicians who have had a long history of coping with shortages in supplies and skills is learning their improvisations. They make care possible by applying principles, not necessarily along with all the plumbing of modern surgical care products and features. Those used to working in the limited health care environment of developing countries live by the aphorism “We have no money; therefore we must think.” Improvisation and ingenuity rule the day.

One of the standard operating principles that applies invariably is the re-use of everything considered single-use and disposable in the developed world. Due to product liability concerns and claims of patient safety, rather good equipment is consigned to disposal in the developed world, making a larger market for consumption. It is true that the re-use of such items as electrocautery units, suction tips and tubing, and various surgical instruments designed for one-clip firing and then disposal requires special care (thorough cleaning and sterilizing) to make it safe for repeat service. But this simply illustrates the inevitable difference between a labor-intensive economy and a materials-intensive economy. The medical features of such distinction are probably a more easily understandable and justifiable extension of these economic realities than many others.

As an example, in some areas of the world rubber surgical gloves are too precious for a single use. They can be washed and hung out to dry (see figure) and prepared for re-sterilization and re-use. The hot steam of a pressure cooker neutralizes any possibility of transmission of communicable disease agents, but it can degrade some of the equipment so re-sterilized. When the items are torn or otherwise unfit for their usual intended purpose, the ingenious “entropy industries” of third world economies (the “breaking down” of “found parts” to reduce them to some other less organized function they might still perform) takes over and the no longer usable surgical gloves may re-appear as surgical drains, flutter valves, or patches in repair of surgical sheets or gowns.

Some of the political/cultural aspects of current medical practice actually assist in making available cast-off or redundant supplies for re-use in remote medical mission settings. For example, in order to minimize the threat of liability risk, it is assumed by US litigant lawyers that no nurse can count to ten. When a machine-counted pack of ten laparotomy pads is placed on the Mayo stand in a first-world operating room, and only one is used, the remaining nine are disposed of, since any re-use might introduce the human error of a discrepancy in the automated count. Such discards and “found parts” and “indispensable disposables” can supply the developing world if would-be practitioners make the scavenging effort.

On the field in remote missions even laparotomy pads can be wrung out, washed, and autoclaved to see a much prolonged service use than their first world fate of being incinerated. The same bonanza for the developing world occurs with the redundant layout of sutures, mesh,

catheters, drains, staples and many other “single-use” items destined for multiple usages in multiple further patients once transported beyond the medical-legal systems which would have made them disposable. Such is a quite legitimate, if unwitting, redistribution of the first world redundant resources.

In addition to extending the usable life of various items to be recycled in the same purpose, there may be substitutions for others in short supply or which are prohibitively expensive at the point of purchase. Such substitutions might include the use of monofilament nylon fishing line of various pound-test strengths in substitute for non-absorbable suture. Locally available honey is a good substitute for more expensive purpose-made topical antiseptic treatments, such as in burn dressings or in chronic ulcer debridement. “Re-rod” of concrete re-enforcement supplies can be used as external framework for orthopedic traction suspension. Used bags or bottles of intravenous fluids can be re-constituted with reverse osmosis water and the desired quantities of salts and sugars mixed in. Ultraviolet light irradiation can sterilize the solutions in the translucent containers, particularly in the high intensity radiation of high altitude environments as seen in this example of Himalayan surgical care in Manali, Himachal, India.

## **Polar Medicine**

“Poles of inaccessibility” include, of course, the poles—the extreme margins of the globe in Arctic and Antarctic, which are characterized by extreme variation in light and other irradiations, and temperature extremes. The massive residuals of the last ice age remain, even if retreating in size, and can be many kilometers thick from all the snow that has fallen over millennia. Ice cores may give a calendar of earth’s climate history, and an account of certain artificial or natural events that have occurred in the deep archives of these records—such as spores from faraway biomes and the advent of certain non-degradable man-made elements such as plasticizers and fluorocarbons.

The poles are unique for another reason. Green plants in the tropics produce oxygen, but the organic detritus is also oxidizing. That, along with the slash-and-burn practices of forest clearing, may result in net zero oxygen production. The consumption of combustibles subtracts from the positive oxygen production of photosynthesis. Much of the oxygen repletion of earth’s atmosphere must come, therefore, from the sea and the upper layers of the oceans where the phytoplankton live. That air circulates globally, bringing the necessary elements of life around the entire planet. That atmospheric circulation occurs nowhere as violently as it does at the poles where the mass of cold polar air sinks rapidly owing to its increased density. On reaching the icy surface of the flat Antarctic shield, there is little in the way of structure to impede it (there are no trees or buildings to dissipate the force of the falling air) and these Catabatic winds reach high velocities, sweeping most loose objects before them.

Although the massive Antarctic ice continent imprisons a lot of the globe’s fresh water, the continent is officially a desert. Less than ten inches of precipitation fall per year from the cold arid air near the poles. Almost all of that has remained there minus the quantity that has sublimated or “calved” off the edges of the ice sheet as glaciers push to the Antarctic Ocean.

Cold. Ice. Wind. Desert. This harsh environment is not lifeless, but it has only a few vegetations consisting of moss and algae with their long lives and short growing seasons, putting the poles among the more fragile of earth’s plant ecosystems. Well-insulated aquatic birds and penguins abound, with cetacean mammals, also insulated by thick blubber layers. All are subsisting on the same base of the food chain in the crustacean ocean krill.

For human visitors (there really are no “inhabitants” -- people subsist in re-supplied research stations dependent upon the outside temperate world) there are many dangers to exposure in this climate. One is obvious in that exposed skin would freeze in a very short time given the winter time ambient temperatures of minus 40-50\* (it is hardly necessary to add C or F since they are nearly equivalent at this extreme). This danger is compounded by the wind-chill factor if the catabatic winds are also factored in. In winter there is a near absence of sunlight for periods of several months with implications for temperatures and other effects of light, e.g., human mood swings (the SAD Syndrome—Seasonal Affective Disorder) and Vitamin D deficit (usually requiring concentrations up through the food chain of fat soluble vitamins or otherwise synthetically replaced).

In the other extreme of summer at the poles, other problems present themselves. Sunlight is constant and circadian rhythm is lost with disturbances in human sleep patterns and affect as well. Combined with the sense of isolation in a massive, disorienting, often featureless wilderness of hostile extreme conditions, some Arctic hunter-gatherers or explorers have succumbed to psychotic breaks. They have been known to strip off clothing and expire due to exposure in a syndrome with the Eskimo name “Piblotek.” A more common condition of very painful sun exposure is the burned retina of snow blindness. Prevention requires a means of filtering out the highly intense irradiation with pinhole apertures or smoked glass.

An ironic combination of burns can occur in exposed skin at polar conditions—frostbite and sunburn. An even more exposed and delicate environmental interface is the tracheobronchial and alveolar membrane. The desiccated air can dry out mucous membranes and chilled air can freeze the unprotected membranes, especially at higher respiratory rates as with exertion. Heat loss from the body can be rapid in such environments even given completely adequate skin-protective clothing if tachypnea is accelerating heat loss.

### **Special Conditions: High Altitude**

Many of the problems seen with exposure in polar environments are also common to high altitude physiology. And such can be further compounded by diminished atmospheric pressures and the hypoxia of diminished partial pressures of rarified atmospheric oxygen, often when greater oxygen consumption is called upon in climbing. Snow and ice and frigid air may be common as well as the additional high exposure from steep inclines and angles of attack in ascent, and, especially, descent.

No one “lives” above 7,000 meters elevation; it is a very hostile environment for habitation. If one is keen on visiting for whatever purpose, this is done not in a steady state of equilibrium but by borrowing heavily into the reserves of energy stores and compensatory mechanisms. The glycolysis of hypoxia is skewed and oxyhemoglobin dissociation is shifted during hyperventilation. Higher ventilation rates needed to increase the rate and tidal volume of breathing given the decreases in FIO<sub>2</sub> results in the alkalinization of blood.

Another consequence is the rapid desiccation of the mucous membranes of the tracheobronchial tree. When this occurs, an almost diphtheria-like membrane crusts the respiratory passages and when it sloughs it is difficult to clear. A characteristic hacking cough is common in these conditions and is so characteristic of Everest trek summiteers that it has acquired the name of the “Kumbu Cough”. Climbers in some instances have been incapacitated by breaking ribs in intense fits of coughing to clear these respiratory tract plugs. On at least several occasions in my own experience and in the literature confirming this experience, a Heimlich maneuver has been required to help clear the airway obstruction of the dried mucosal membrane occluding the upper airway, (Kenneth Kamler Doctor on Everest, and other references, High Exposure.)

Another hazard that is not frequently reported is unexpected sunburn on the palate and inner nares. With nostrils flared and open mouthed deep breathing, a climber can experience a burn from the sunlight glare reflecting right off the glacier being climbed. The ulceration from daytime exposure may give problems in eating, compounding the decreased appetite generally experienced at altitudes sufficient to give relative hypoxia.

Even extensive exertion short of technical climbing -- such as trekking to Everest Base Camp -- can produce annoying minor disabilities which are magnified as the altitude increases. Putting a glove back on once removed becomes a very major undertaking, or getting anything back into a backpack. The closing of a zipper can take concentrated effort. Loss of coordination is particularly critical in footing, often most problematic on descent, when the anticipation of the next movements toward summiting are behind one and an almost lackadaisical carelessness can set in. Because judgment impairments are common in hypoxia, and as the implications of modification are more difficult to see without the third order thinking often missing due to the single-minded push during exhaustion, climbers should adhere to a well thought-out plan.

As passengers traveling in a commercial jetliner, we can be sitting comfortably as the outside temperature may be recorded as minus forty degrees (either F or C!) and with a headwind of 100 knots at an altitude of 8,000 meters. We may be told "we are crossing the atmospheric jet stream." If one is sitting uncomfortably at the identical altitude on any of the fourteen of earth's eight thousand meter peaks, it is the same jet stream we might be exposed to without benefit of a pressurized temperature-controlled airliner cabin. The calculation of that same wind speed and atmospheric temperature leads to a daunting determination of the wind-chill!

Under conditions approaching such extremes, even minor irritants grow into major problems. An annoying toothache may get worse as a signal of an expanding air pocket trapped in a maxillary sinus or a filled dental cavity as the atmospheric pressure decreases with ascent. These are the kinds of individual problems that can occur at altitude which might be self-manageable.

The more sinister problems of AMS, HAPE, and HACE require help in both personnel and devices for rescue and descent. AMS is acute mountain sickness, which is characterized by headache, nausea and loss of strength and well-being. Those afflicted are robbed of strength for exertion and AMS can culminate in vomiting and dehydration. It is often the product of too rapid a rate of ascent, and accommodation is sometimes reached by a rest day allowing for further acclimatization. Acetazolamide (Diamox) has been recommended for prevention to shift the oxyhemoglobin dissociation curve with this carbonic anhydrase inhibitor. (Note: I have not used it prophylactically, reserving it instead for the early onset of AMS, while modifying my rate of ascent.) Not everyone with the sniffles is a victim of AMS which is almost always over-diagnosed as HAPE because of acute awareness of the latter condition which can be lethal.

HAPE is high altitude pulmonary edema, diagnosed as is most pulmonary edema by the characteristic decrease in peripheral breath sounds and rales in the bases of the lungs. Late stages exhibit frothy pink sputum, anxiety, and breathlessness. HACE is high altitude cerebral edema and is an acute emergency, requiring immediate repressurization and evacuation to a more accommodating altitude. The edemas in both cases of HAPE and HACE are hypoxia-induced, and most all require corticosteroids in membrane-stabilizing doses and an increase in oxygen tension. This might be affected by the use of a pressure suit such as a Gamow Bag or administration of supplemental bottled oxygen.

Both emergencies require evacuation for stabilization. There is a conundrum in this as well, since the very high altitudes at which such emergencies might occur are also at the extreme limits of the lift that can be expected for helicopter rescues. Often evacuation is a very rough overland trip of the same precipitous trek the climber has come up. Intensive nursing care is required, hardly conducive to a rock-face recovery.

A simple means to detect early changes and to head off some of the altitude problems has been the widespread use of pulse oximetry to measure oxygen saturation. A slowed rate of ascent is indicated by any precipitous decrease in O<sub>2</sub> saturations that suggests the need for a slower rate of ascent. Oximetry readings can indicate that acclimatization has occurred and that it is safe to proceed.

Operating at altitude should happen only in emergency temporizing procedures, and can involve such useful devices as insertion of chest tubes or airway clearing through tracheostomy or endoscopic lavage. For most practical purposes, the rule of thumb will be rapid evacuation to a lower altitude to a more advantageous facility. Rather than attempt any definitive care on the precarious mountain slope, a "scoop and run" response is best and could include external stabilization of fractures or Gamow bag and O<sub>2</sub> administration.

If an environment is available to attempt an operation, simple "cold sterilization" or immersion for a period of time in antiseptic of iodine or another antimicrobial solution may be adequate for surface sterilization of solid steel surgical tools. But other items may require heat and pressure sterilization. It is important to recognize that the statement reads "sterilization" and not "boiling." While most vegetative organisms would be killed by a period of immersion at the temperature water boils at sea level, a practitioner, when conducting surgical clinics in the Himalayas, must remember that if water boils at 80° C at that level of altitude, that is hardly an adequate temperature for killing spores that might transmit disease. So several atmospheres of pressure must be added to make for a much higher temperature for adequate steam sterilization.

Unfortunately, political and social factors continue to complicate delivery of medical care to these extreme environments. Practitioners have long had to do considerable explaining in checking in some of the drugs and devices that go into the cargo hold of aircraft when traveling to remote areas. And it has long been impossible to carry narcotic or anesthetic agents in the passenger compartments. And now, since the 2013 Boston Marathon bombing incident, it is difficult to transport even such a utilitarian device as a pressure cooker.

### **Special Conditions: Diving and Decompression**

At most geographic points at sea level, we humans are subject to one atmospheric pressure and one G of gravitational pull. For most of us, the only time we experience higher than atmospheric pressure is when we leave the air environment and descend through the denser medium of water. We might seem to escape that gravitational pull by submersion in neutral buoyancy, but we are under considerably more pressure in the water than in the atmosphere. The higher density of seawater is apparent when we effectively double the weight of the entire column of earth's atmosphere bearing down on us at the surface of the sea within five meters under its surface. We can go down to recreational diving's limits of four or five atmospheres more pressure, but the air compression this pressure increment causes limits the amount of time we can visit these depths given the capacity of the compressed air cylinders that are carried in self-contained underwater breathing apparatus (SCUBA.) It is not just a matter of capacity for compressed gas in the tank, but also for the gases compressed within us as the explorers of such depths, since there are physiologic consequences of such pressure changes.

In the first few meters of descent, a diver can identify problems of any body cavities with entrapped gases such as the middle ear. If one cannot rapidly clear the Eustachian tube and add air by Valsalva maneuver to increasingly pressurize the middle ear, the water pressure might continuously depress the tympanic membrane to the point of an implosion. The equilibration of pressures across such a mobile membrane is easier than that for fixed cavities such as in the cranial sinuses or teeth or parts of the gastrointestinal tract. "Clearing" this imbalance by equilibrating pressures as one descends is relatively easy at the beginning of the

dive. What is often less apparent during the ascent, at the time that air supplies are running low and there is a push to get to the surface, that these same processes must occur in reverse, as the compressed gases inside the body expand on ascent from the depths.

While under pressure, the amount of gas in solution in body fluids such as blood increases. If one is at depth for an extended period, these increased gas tensions in the blood are themselves problematic and may cause confusion and the enrapture of “nitrogen narcosis.” Unless special gas breathing mixtures displacing some of the nitrogen with an inert gas such as helium are employed, breathing compressed regular air will result in a large amount of nitrogen dissolved in the bloodstream. Even without evidence of such “raptures of the deep” disturbance with “safe limits” of nitrogen in the blood at depth, on ascent, particularly if rapid, the dissolved gases “bubble out” and obstruct small arteriole blood flow in the condition referred to as the “bends.” A slow ascent is necessary to de-gas the bloodstream along with “hang time” at a depth of about one additional atmosphere.

In addition to the danger from compressed gasses in the bloodstream is the danger of rapidly expanding air in the lung during ascent. To prevent this, a nearly constant “air leak” of bubbles should be continuous on ascent to decompress the expanding lungful of air. Failing to do so, and in a rapidly distending lung, the lung might rupture, particularly if there were any congenital or acquired defects such as an emphysematous bleb. The result would be a pneumothorax and the accumulated air in the pleural space would likewise expand, but it would not be able to escape the chest cavity. As it expands, it would collapse the lung still further and might even shift the mediastinum over to the opposite side compromising the function of the lung on the unaffected side. This tension pneumothorax compromises not only ventilation but venous return to the heart, and constitutes an emergency that is relieved only by allowing the air trapped under tension to escape—a thoracostomy by needle or chest tube.

Similar compression/decompression disruption of viscera can happen from underwater explosions in which the compressive shock wave travels through the water with considerably more force than it would from the same dissipation in compressible air. The hydraulic fluid wave can rupture viscera through which it passes.

The extremes of pressure -- from the hyperbaric submarine exposures to the less than half atmospheric air pressures of high altitude mountaineering -- have been the limits of the extreme conditions faced by human beings. The shifts in such pressures were only as rapid as ascent from ocean depths to the surface or up to mountain altitudes. But aerospace travel, with its high rates of speed and very large and much faster pressure shifts, has led to considerable equilibration discomfort ranging from distressing to major organ damage in sudden decompression and blast injuries. Mountain altitude and diveable depth are no longer the limits to pressure/decompression injuries.

### **Addressing Inaccessibility**

A principal barrier to surgical care that makes for very late presentation of nearly all illnesses seen in the developing world is inaccessibility to health care. The patient may have ignorance as to the condition from which he or she suffers, and that ignorance might even be shared by the primary care-givers if and when the problem can be brought to whatever primary medical attention exists, usually at some large remove from where the patient lives. This means that the patient must travel precisely at the time of the growing disability to attain access, and from that point be referred again to someone who might be equipped to address the problem. It would be a far more efficient system if the care could come to where the patients live, obviating the requirement for them to travel to find it, when they might not even be aware of a need to seek out help or that there is anything that can be done for their problem.

This is the rationale behind the concept of mobile surgical missions. Mobile surgical vehicles bring specialized care to the people most afflicted, a “workaround” for the problems of geographic inaccessibility. The vehicle brings care to the patient in the milieu in which the patient lives, carrying the equipment and expertise to the primary care clinic into which it might “dock.” The practitioners can at the same time work to indigenize the skills by teaching the local health care workers about the surgical conditions that might be electively repaired. Regular visits to the community bring residents not only the awareness of the problem but its fixability and the means by which this might be done. In other words, hope.

Deployment of mobile surgical vehicles brings care to the people afflicted rather than expecting them to know enough to make their way to achieve care on their own, often into environments that might be quite foreign to them. When such mobile surgical care has been done, the isolated peoples in remote rural areas have been quite receptive to their new access to health care. Patient preparation and permission for surgical problems that might be repaired on an elective basis is obtained for a scheduled interval visit by the primary care unit. Then the specialized vehicle can come to “dock” with their primary care unit for days or weeks, delivering the needed care and “working around” inaccessibility.

The problem of access then becomes a problem of logistics: shifting the focus and energy from somehow getting the patient to a fixed center for care to, instead, getting a somewhat cumbersome unit to the field site where it can access the patient population. If such a unit were carried in a road-based vehicle, it could soon become apparent that the areas where it might be needed are often isolated from any recognizable “road.” But accommodations can and have been made. In the interior of Ecuador the vehicle to deliver surgical care is designed to accommodate the narrow Andean Mountain roads and rocky overhangs and still navigate successfully for reaching the patient care sites. In the region of South Sudan, the roads are rudimentary in almost all sites where such care would be needed. Indeed, at the time such a mobile surgical unit was proposed in the new nation-state of the Republic of South Sudan, the whole country possessed less than twenty kilometers of paved roadway. But rugged off-road vehicles such as those used in military operations with appropriate clearances and suspensions have made it possible to deliver such surgical care units over even primitive conditions of roadways, often navigating by GPS and performing stream crossings by fording small rivers.

Access to some areas will be seasonal, such as in the high mountain passes of the Himalayas or Andes. The drivers refer to the road surface as “black top” (crushed rock and gravel) or “white top” (the frozen snow and ice of the long winter) in the province of Himachal, in Himalayan India, with each condition presenting its own set of hazards. High snow pack often interrupts delivery when the passes are closed for many months each winter, but the drivers welcome the harder surfaces of the frozen surface when the stability is greater than during the annual snowmelt which carries a high hazard of avalanche.

Along the equatorial beltline of the globe, the perpetual equinox is accompanied by only two major seasonal changes---the wet and the dry. Assuming the rudimentary roads are navigable in the dry season half of the year, such roadways are inundated during the rainy season, particularly in the floodplains of two of the greatest river systems---the Nile and the Amazon. There is no way that a wheeled vehicle can get to remote sites during the rainy season in South Sudan when the largest wetland on earth, the Great Sudd, is under two meters or more of the overflow along the Nile River floodplain. Facts will have to be faced. Neither the patients moving to a fixed site nor the caregivers dependent upon dry land vehicles to access them are mobile during the extended period of the annual inundation.

But there is a solution, even an opportunity. The high water of the rainy season provides access to people and sites along the largest navigable rivers on earth through the simple conversion of floating the same mobile vehicle on a barge to make stops along the high water ports. This method of care delivery has been used on the Amazon and lake-based primary care sites, such as Lake Victoria, and is proposed for the Volta, Nile and Congo Rivers.

An important feature of the mobile surgical care concept is the container in which the personnel and equipment can be set up to care for the patients. Such container-clinics often contain their own generators, solar, wind and/or petrol-powered. Fuel and water storage and filtration systems are used while needed for sustained practice until re-supply, often when moving on to another docking site. The propulsion system for the platform can be in the form of a tractor-trailer, railroad car, cargo aircraft, or tugboat. And they can be interchangeable independent leasable units.

The mobile surgical mission concept has been successfully implemented in a number of places. An extended experience in mobile surgical practice in which the authors have participated was under the combined leadership of Drs Edgar Rodas and Edgar B. Rodas Jr and the CinterAndes Foundation. This organization has performed over 6,550 surgical procedures over twenty five years in Ecuador in both remote and inner urban settings. The total experience has exhibited a surgical mortality of zero, a surgical infection rate of less than 1.0 % and morbidity less than contemporary and comparable inpatient urban hospitalization experience. The patients are returned to their home environment immediately in which recovery has been dramatically enhanced. At the same time as the surgical clinics are being held, the medical screening clinics, instructional sessions, public health outreaches, and the maternal and child care clinics have constituted a rising tide which has lifted all aspects of community health through the periodic visits of the mobile surgical unit.

Almost none of the patients so treated could have found their way into a modern urban hospital center or afforded the care potentially denied to them but made more accessible over both the geographic and economic barriers breached by the mobile surgical practice. This model in blanketing all regions of a single South American nation with four distinctive geographic zones—the Amazon jungle, the Andes Mountains, the Pacific Coastal Plains and the Galapagos littoral—have all been made accessible through the mobile surgical vehicle which has also incorporated the features of telemedicine back to urban hospital centers and Ministries of Health for follow-up care and consultation.

## **Conclusion**

The single factor of low income can mire those so afflicted into a high risk population in terms of nutritional status, educational, employment and life prospects. Poverty is also the most common factor in several acquired illness patterns such as the water-borne illnesses or soil transmitted helminths, birth rates, and infant mortality. Poverty and disease pattern, as well as life potential, are interdependently linked in the dismal science of resource-constrained environments, both as cause and effect. Despite a wide variety of methods tried to cover the expenses of health care, the resources brought to bear on health related problems varies widely over many parts of the world. Usually some combination of public or private payment for needed services accounts for the scarcity of skilled modern healthcare in almost all areas of the developing world. It is an ironic but easily understood free-market fact that the regions of the world with the highest disease burden are most often the same regions that attract the fewest health care practitioners.

The authors have partnered with CinterAndes Foundation in combination with Mission To Heal to extend the successful experience of mobile surgical unit principles. Their hope is to internationalize this model to multiple other sites in the developing world, to bridge still further barriers geographic and otherwise, and to provide greater access to care, even at the alleged African “Pole of Inaccessibility.” [See Mission to Heal: Sharing Medical Knowledge at Africa’s Pole of Inaccessibility, Greenleaf Book Group, Austin, TX, 2014]

## **Case Study: an Unknown Lethal Fever at a Place that Has Now Made It an Eponymic Entity: Helping to Illustrate the Connections of Geography, Health and Illness**

There are geographic “addresses” that have been identified with health and longevity and they have been described with dubious claims to be “healthful locations.” Ponce de Leone considered that the Timiquan Indians he encountered around the Bay of St Augustine in what would become Florida were unusually fit and long-lived in comparison to their Spanish counterparts, which induced him to go in search of the elixirs of the Fountain of Youth that must have been the reason for their good health. We have not escaped these hopes and contemporary investigators seek out the “keys to longevity” in the healthy elders of the Caucasus, or the “stress-free lifestyle” of the citizens of Vilcabamba Ecuador to try to borrow or adapt whatever the place confers upon its residents in long-lived health.

There are also geographic locations with bad reputations for association with diseases and death. Rome was built on Seven Hills to get above the “miasmas and rheums” of the lowland swamps around the ports over which hung “bad air” from which they attributed the fevers of “*mal aria*.”

In the myriad of biologic diversity that the tropics represents, some of these places are micro-endemias from which emergent illness can arise and may even take the place name as its designation.

I was a young and ingenuous clinician working in my first-ever entry into tropical Africa in January 1968 when I encountered a disease pattern certainly never before seen by me and I attempted to describe and characterize it, being unaware that the illness had not yet been identified by others besides me.

I had entered the Nigerian north through Jos, after having been delayed by the harmattan winds that bring down sandstorms from the Sahara blotting out visibility for flying in light aircraft. On arrival in Jos I had been introduced to a young woman physician named Susan Troup who with her two nurses Penny and Char was managing a small hospital at Hillcrest. I made rounds with Dr. Troup and the nurses at the Bingham Hospital and they had hosted me at their home showing me around their rose garden; each of them was an avid gardeners and had the rose thorn wounds to prove it.

I went on to be working in what would become Benue River State after the Biafran War in the Nigerian north, based at Takum Christian Hospital, making brief sorties into the Nigerian bush to remote rural villages to hold clinics and give immunizations. The Sudan United Mission had made available a Piper Comanche light aircraft to reach some of the villages beyond road access, and on one occasion, the missionary pilot Ray Browneye and I had flown to a remote airstrip to hold the promised clinic at an adjacent village. On approach to the airstrip (Figure ) I could see upstart mountains rising from the guinea savannah behind the village surrounded by dry season bush, and considered the stark scenery hauntingly memorable. On arrival I could not continue in those reveries, since there was great consternation in the village population and the planned clinic with orderly review of scores of patients was disrupted by an emergency. The crisis involved the head man of the village who, uncharacteristically, had not been at the front of the greeting party since he had recently fallen ill himself. He was a very prominent citizen of this Hausa community, and was so well traveled that I was told he had even been to Germany at one time in his life. He was unable to communicate with me or the translators, however, since he had a very high fever and had lapsed in and out of unconsciousness before he began to seize.

The fever had been consistent for thirty six hours but the seizures had just begun. Before the fits, an attempt had been made to take his temperature reading on an oral glass thermometer, which could only register up to 105\* F, and his temperature had exceeded that calibration. He had already bitten his tongue during one of his seizures and I attempted to

insert an oral airway through his foamy sputum and bloody lips to prevent him from losing his airway in his unconsciousness. I used up the whole bottle of rubbing alcohol I had brought in bathing him to bring down the fever and had injected a barbiturate through the intravenous line started to deliver what other medicines we carried which included one ampoule of diazepam. As I watched rather helplessly, he suffered an apneic seizure and then his spasms drew him into head-to heels opisthotonus and he collapsed with dilated pupils. I attempted mouth-to-mouth ventilation using the oral airway and intermittent chest compressions, but there was no return of vital signs.

This event brought about great ululation among the mourning villagers and I withdrew to the quieter airstrip to use the radio in the Comanche single-engine aircraft to call Hillcrest to speak to Dr Troup for advice. After my description of the terminal events, there was a long pause following which she said, "I believe you should get up here as soon as possible and we will start you on the series of anti-rabies injections." Perhaps fortunately for me, as I had little enthusiasm for the encephalitis that I had heard might often follow the series of rabies anti-serum made from a crude preparation of an extract of mashed primate brains, nightfall was upon us which would not allow the flight under VFR (visual flying rules) and any possibility of flying the following day was again shut down by the impaired visibility of the dry season harmattan. I went about seeing the list of patients, selecting those with surgically fixable problems such as hernias and hydroceles and one cryptorchid eight year old boy, to be scheduled when these patients could make their way to Takum, and treated the inflammatory and infectious problems as well as de-worming the villagers.

By the next day, the village head man had been buried and we were ready to fly back to Takum, with many more unresolved questions carried back from this village which had appeared so haunting on my first approach. I later heard from pilot Ray Browneye that he had returned several weeks after our visit to the same village and had done a medical evacuation for another man with a similar high fever. Ray had delivered the patient to Bingham Hospital where Dr. Troup and her nurses tried many of the same things I had tried with considerably better inpatient facilities, but with the same outcome. With my report to her from the field and this puzzling similar case before her from the same village, Susan Troup assisted by nurses Penny and Char set about doing a limited post-mortem examination, collecting blood and biopsy samples for later microscopic staining, culture and histology. The hubris of the rose thorn punctures is memorable in retrospect for these three heroes, as each of them became ill with a high fever shortly thereafter, to which both Susan and Char succumbed.

Penny struggled through the delirium of high fever and could only be given supportive care against this unknown illness which had already claimed the lives of her two closest friends. In a slow and gradual recovery, her own convalescent serum along with the blood and tissue biopsy specimens she had helped obtain were examined at Columbia College of Physicians and Surgeons in New York which made it possible eventually to identify the causative agent of this severe illness, described and named [see the book "Fever" published later from this experience] only after each of us had encountered it first hand as an unknown. It was Penny's convalescent serum that became the therapeutic agent that salvaged the next patient from this region who presented with the same mysterious until-that-moment unknown contagion. I remember well my own encounter with this mysterious plague, but recollect more vividly those who stood up against it.

And the name of the village?

LASSA.

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**Photo captions as Legends for "Final Photos" in "Geographic Factors in Surgical Care"**

[These will need to include a couple photos from sources such as the Calvin J-Series and previously published texts]

1. This goat herder in Ethiopia had developed swelling in the orbit and came for care when he could no longer see out the eye affected with cellulitis--a Gram stain revealed Gram Positive rods and a diagnosis of anthrax was made with a full response to Ciprofloxacin
2. Surgical gloves may be a resource to scarce to be disposed after a single use for a single patient in some areas of the world--here in rural North Luzon in the

Philippines, they are hung out on a rack to dry after washing and then will be re-wrapped and sterilized in a pressure cooker

3. In Old Fangak in the Upper Nile Province of South Sudan an epidemic of Kala Azar (visceral leishmaniasis) had been controlled with daily Antimonial injections for those febrile children with a positive serologic reactivity on the "LeishKit"
4. "Mitad del Mundo" (the "Center of the Earth") is the site where the Equator was drawn in establishing the fundamental unit of linear measurement according to the geography of the globe at its midline--the Ecuador--which would mean that the poles are equidistant at 10,000 kilometers north and south respectively, from which the linear dimension of the "meter" was scratched on a platinum bar to become the new standard of measure
5. The population pyramid of Japan--a matured developed world population
6. Niger's population pyramid reflects the broad base of the developing world with a high death rate, particularly in infancy and childhood
7. The population pyramid of the USA reflecting a considerable control of the infant death rate and a modification of the shape through a high immigration rate
8. Offloading supplies brought in by air and dropped on an island in the Nile in Upper Nile Province through chartering aircraft for access
9. An earlier stage of Ainhum shows a deviation of the little toe and a constricting band causing it to become ischemic
10. Tuberculosis takes many forms besides pulmonary, and in one part of Africa along the White Nile in Upper Nile Province, 29% of the new Tb cases are Pott's Disease, tuberculous osteomyelitis of the spine, with this man also exhibiting extrapulmonary Tb in lymph nodes as "cold abscesses" of caseous granulomatous disease
11. A dramatic transformation occurs in the lives of those patients who are blinded by progressive cataracts, as seen in this man who has just undergone bilateral cataractectomy in Obo Central African Republic and who will have his dressings removed and vision restored in four more hours
12. The CinterAndes team stands beside the Mobile Surgical Vehicle in an Andean mountain village upon completion of a short-term mission in Guadaloupe
13. Congenital defects such as cleft lip and palate are often seen at advanced age when no facilities have been repairing them; repair at the age of this child is different than as an adult when the defect has already been accommodated for a longer life period
14. Cutaneous leishmaniasis is a result of the parasitic leishmania trypanosomes that may be ulcerated, but typically does not involve the viscera; the cutaneous form is a disfiguring nuisance, but the visceral form (Kala Azar) may be lethal
15. Pneumonia is the second leading killer of children under five years of age in the developing world and this Sudanese child has an organizing pneumonia which has given rise to empyema, drained by thoracentesis
16. A rare form of congenital malformation of the cartilage produces multiple enchondromas, which can degenerate as seen here into chondrosarcomas
17. Filariasis can give the lymphedema of the genitalia by parasitic lymphatic obstruction, sometimes leading to the deformity known as the "hanging groin;" the lymphangitis may be due to a co-morbid condition as seen here in which the filaria harbor a bacterium *Wolbachia*, which is treated with tetracycline for a month before the filaricide is given to control the *Wucheria bancrofti*
18. Gangrene of the lower extremity resulted after six weeks of traditional splinting for an open fracture sustained in a motor bike accident in the unpaved roads of Bor, South Sudan; the only treatment at this point was an amputation

19. Washing the feet of lepers on New Year's Day on an island in the White Nile in Jonglei Province South Sudan was the first step in creating a cushioned sandal to protect their remaining insensate extremities from further auto-amputations
20. Some indirect inguinal hernias in the developing world have become so extensive in the amount of gut resident or incarcerated in the scrotum, as in this case seen in Ghana, that the abdomen has "lost domain" and reduction of the bowel back into the peritoneal cavity may cause respiratory insufficiency by elevating the diaphragms; the timing and advisability of the hernia repair may involve consideration of peritoneal air insufflation to increase abdominal capacitance pre-op
21. Hydrocele is a marker of the endemicity of filariasis in the community as it often correlates with the parasitic burden of this neglected tropical disease
22. In a large outbreak of kala azar in the Upper Nile Province, South Sudan, a wholesale lineup of injection therapy for this disorder in which daily doses of antimony compound is given--as can be seen in the bucket of used syringes
23. Keloids may result from scarification by accidental or purposeful skin incision for operations or tribal markings, and the resulting hypertrophic scarring may be re-excised, as seen with this patient in the Western Province of Ghana, with still further growth; for this reason it is a better plan to inject triamcinolone to reduce the inflammatory response and reduce the scarring potential.
24. Decorative skin incisions to make an identification with tribal groupings of as ornamental tattooing can also result in keloid formation
25. Protein/calorie malnutrition (Kwashiorkor) is often seen along with parasitic infestation, with abdominal distension from both worm burden and also decreased albumin in extracellular fluid giving rise to ascites
26. [Use the M2H mobile unit photo with the students standing around it at its presentation in Toledo OH]
27. Devastating conditions that may be obvious early in their course may be neglected to much later stages of presentation because of ignorance that treatment might be necessary or available, or alternative futile traditional therapies may be prolonged, such as for this nasopharyngeal epithelial carcinoma seen in West Africa
28. Neurofibromatosis is an autosomal dominant familial trait with expressivity varied, such as in this lamellar form ("the Elephant Man Syndrome") encountered in two families in Western Province, Ghana
29. A second family seen in Ghana with neurofibromatosis ("von Recklinghausen's Syndrome") not to be confused with much more common breast lumps, and to be checked for hypertension or any evidence that one or more lesions might degenerate to neurofibrosarcoma over time
30. Our screening clinics are often held outdoors as "Clinic Under a Tree" in reviewing large numbers of patients as seen here among the Murle people in PiBor, Jonglei Province, South Sudan
31. {NO!} A benign mandibular tumor which has not maligned the teeth or given evidence of spread is handled conservatively; some of these which present this way may be bone cysts
32. The large number of patients who assemble seeking care when the access is made possible by removing the item of cost and transportation to the site by bringing the care to them makes for a new logistic problem--the demand for such care at a purchase price of zero is insatiable, and each patient and family should contribute some portion to elective preventive care while the barrier to curative care for emergency and acute illness should be made as low as possible

33. A phenomenon associated with Leishmaniasis is a characteristic exfoliation called PKAD --Post Kala Azar Dermatopathy--which is a skin condition that may follow the acute phase of Kala Azar, whether or not treated; it resolves spontaneously
34. A resolving PKAD in a successfully treated child recovering from visceral leishmaniasis
35. Posterior cervical and occipital lymph nodes are readily seen in this extra-pulmonary tuberculosis--the presenting sign which got this child started on DOTS therapy-- multi-drug Directly Observed Therapy System
36. An anterior myelomeningocele also known as rhinoccephalocoele which should be approached with care in an elective tertiary referral center
37. Two pre-packaged radioimmunoassay kits which can differentiate the febrile illness of children between Falciparum malaria (FalcipKit) and Leishmaniasis (LeishKit); a sample of each is seen in use in which there is a seropositive result next to a negative result for each condition--encountered in our screening clinics in Upper Nile Province in South Sudan
38. Dramatic results may be achieved in a few patients who may be "index cases" which demonstrate hope to the community in which they live; in this instance a young mother of five children had a rapid onset of a squamous cell carcinoma and salivary fistula, later found to be HIV seropositive--after resection and reconstruction she and a number of her community have been further tested and are on HAART (Highly Active Anti RetroViral Treatment) DOTS therapy.
39. Tetanus neonatorum from cattle dung placed on the umbilical stump in traditional birth attendant practice exhibits the spasms of opisthotonus in this newborn in Northern Nigeria; all through sub-Saharan Africa may be seen the classic appearance of tragic loss of human potential as a young child leads a grandparent by a stick with the imposition of heavy responsibility as the "guide child" for acquired blindness, often preventable and treatable from such sources as trachoma, cataracts, glaucoma and river blindness
40. In the dry season a plague of flies seeks moisture in the eyes and noses of children and adults transmitting *Chlamydia trachomatis* in the corneal-scarring entropion of the conjunctivitis that results; it is for that reason that trachoma is associated with "Five F's": Flies, Fingers, Families, Feces, Fomites; trachoma was the largest source of acquired blindness in the Upper Nile Province of South Sudan and can be prevented by face and hand washing, hygiene practices, azithromycin, eyelash plucking and a simple eversion procedure to reduce the corneal scarring of the contracted eyelashes in entropion
41. Long neglected deformities may have lethal consequences--this Sudanese patient had a lump in his leg which was thought to be a benign condition such as a lipoma or an inflammatory process (though non-tender) which continued to progress and has proven to be a large sarcoma, no longer confined to the lower extremity
42. Solar irradiation is a means of sterilizing intravenous fluids and also for preparation in the re-use of surgical gloves to be re-sterilized in the high altitude of the Himalayas, here seen in use at Lady Willingdon Hospital in Manali, Himachal, India
43. The equivalent of the local "ambulance" delivers a man with African Sleeping Sickness (Trypanosomiasis) to Old Fangak Clinic in the Upper Nile Province of South Sudan
44. A thick blubber layer insulates the mammals of Antarctica as seen in these crab-eating seals lounging on ice floes in the Antarctic Ocean
45. Minke Whales, a species of cetaceans that practice group "bubble netting" of the ocean krill, circle near the calving Antarctic glaciers

46. An Antarctic penguin rookery is a dense cluster of aquatic avian life on the ice shelves near their Antarctic Ocean krill-feeding grounds
47. Man is a rare intruder on this "seventh continent" of liquid rock and solid water
48. The seventh continent is formed from solidified liquid rock and liquifying solid water
49. Glaciers "calve" directly from the ice shelf in an inexorable push to the sea from the Central Antarctic ice shield
50. Antarctica is made of rock and ice with very few plant species including only long-lived moss and algae with very short growing seasons during the long periods of cold summer daylight
51. Calving of Antarctica's ice shelf produces the icebergs which decrease the salinity and temperature of the surrounding seas
52. In the continental wilderness of Antarctica, man's presence is rare and transient
53. In Mindanao's volcanic mountains, the fresh water lakes are sources of aquaculture which sustains a denser human population than most agriculture.
54. The aboriginal Tiboli people continue a lifestyle more adapted to their Mindanao mountain environment than the colonial influences of later arriving European and Asian migrants
55. Volcanic caldera contain lakes in the tropical latitude of Mindanao which may sustain populations with abundant macronutrients, but with micronutrient iodine insufficiency
56. Thyroidectomy is a frequent operation for relief of airway-compressing goiter in the iodine deficiency areas of Mindanao
57. Only one generation later than their parents who used stone-age implements, the Tasaday peoples of Mindanao remote mountains have accommodated modernity
58. A bamboo bridge is constructed to carry pedestrian and hooped stock across the streams that are outlets of the rainforest of Mindanao mountains
59. Salivary gland tumors, as in this Parotid tumor (A) are found with frequency associated in the same iodine-deficient populations afflicted by goiter and cretinism
60. Another parotid gland tumor (B) seen in this patient; not the ambient OR fauna in the butterflies, a pleasant distraction while operating
61. Higher altitude hypoxia can occur at a faster rate than the ascension of mountain climbing in several forms of aviation, in this instance, in hot air balloon ascension
62. Altitude gain exposes the unprotected climber to hypoxia, cold, excess radiation and the exposure risk of an unstable environment
63. Antarctica, despite its very extensive ice cap which imprisons much of the planet's fresh water reserves, is officially a desert, since it receives less than ten inches of annual precipitation, most of which is still present
64. Indigenous animals are adapted to the environment in which they are found, as seen in this Black Tail Deer native to British Columbia mountains; human visitors to the same environment must adapt through substituting cultural and technical means for the long periods of species adaptation characteristic of endemic life
65. Denali is the North American High Point of this continent, with each continent having both high and low points in addition to each having a "Pole of Inaccessibility"
66. The headwaters of the Amazon in the Ecuadorian Andes give rise to a river system so vast that of all the fresh water on earth that is not ice, the majority of it at any time is present in the Amazon River alone
67. Dr. Edgar Rodas, former Minister of Health of Ecuador and founder of CinterAndes has pioneered the use of Mobile Surgical Missions in all parts of Ecuador, including the Amazon basin, the Andean Cordillera, the Pacific Coastal plains and the Island Littoral, making accessible surgical care for those remote from population development centers

68. Operating in the portable conveniences of the Mobile Surgical Vehicle, the surgical care is brought to the people rather than having them seek out surgical services at a distance when they may be unaware of the availability of such services for their needs
69. The Center of the World--"Mitad del Mundo" is the place where the geographers drew the line dividing the hemispheres and defining the metric measures which continue to the present and gave the new name to the place where they were drawn "Ecuador".
70. In the Upper Nile Province at Old Fangak, an isolated population of people in what is now South Sudan have had recent exacerbations of endemic leishmaniasis ("Kala Azar") among their tropical illnesses
71. In Nigeria in Abia Province the population of Ibo peoples has been centered since their migration from Benin in earlier precolonial times to settle in the area which became known as Biafra
72. Everest from a view over the Khumbu Ice Fall on approach to the second base camp along the Khumbu route
73. Everest and its sister eight thousand meter peaks viewed in panorama over the Khumbu Ice Fall emerging from its southern valley
74. Family caregivers are the cooks, nurses, orderlies and support system for most African indigenous care makeshift facilities
75. The Karen of Burma have been a persecuted group of people who are mostly still in the confines of the re-named nation-state of Myanmar, making them internally displaced peoples (IDP's) in contrast to the lesser numbers who have managed to cross an international border to become recognized as "refugees"
76. The Khumbu Ice Fall is both a route to the Everest summit and an environment which carries with it its own particular hazards
77. Open cooking fires-- ubiquitous throughout the developing world--are sources of seizures and burns, the one perhaps inducing the other
78. Prayer flags of Buddhist incantations on Pumari in Nepal, showing both the geographic and human cultural features of this high altitude environment
79. "Raptures of the deep" are hazards of air-breathing subjects who might acquire "nitrogen narcosis" from excessive hyperbaric tensions at unsustainable depths to which aquatic species are not at risk
80. Scuba diving, here on Australia's Great Barrier Reef< adds many atmospheres of pressure within a short distance in submersion due to the higher density of water over the atmospheric air column at sea level
81. The view on summiting a mountain may be rewarding, as seen here atop the Grand Teton, but it should be remembered that most climbing accidents occur on *descent* when the anticipation of the summit goal has already been achieved
82. In the descent phase of mountain climbing, seen here on return from the summit of Mount Rainier (Tacoma), the care with which the steep exposure risks are navigated is shared in roped-in "team arrest" to mitigate individual problems with accommodation of altitude-associated problems
83. Hazards in the tropics include user-unfriendly reptiles like this disturbed Mozambican cobra encountered in Zambia during post-operative rounds
84. Everest Base Camp is at an elevation in Nepal higher than the summit of any of the vaunted "Fourteeners" in the contiguous US 48 states, and is floating on the Khumbu Glacier for annual reconstruction