Chapter five ~ Practical Applications of the New Medical Science in the Later 1800s

By the last decade of the 1800s, sepsis (infection) was recognized as a bacterial disease and the mode of transmission for these pathogens was well known. It fell in two general categories: those who were already ill and the hands and equipment of those who cared for the ill – doctors, nurses and the hospital environment, supplies and equipment. Using the same scientific principles made famous by Lister, Koch and Pasteur, microbiologists developed policies to minimize nosocomial and iatrogenic sources of infection. The medical profession was eager to implement these antiseptic measures: Patients with contagious diseases were isolated, contaminated dressings burned, instruments sterilized, hospital floors disinfected with germicidal chemicals. Visitors and visiting hours were limited. These protocols made hospitals much safer for patients than they'd ever been.

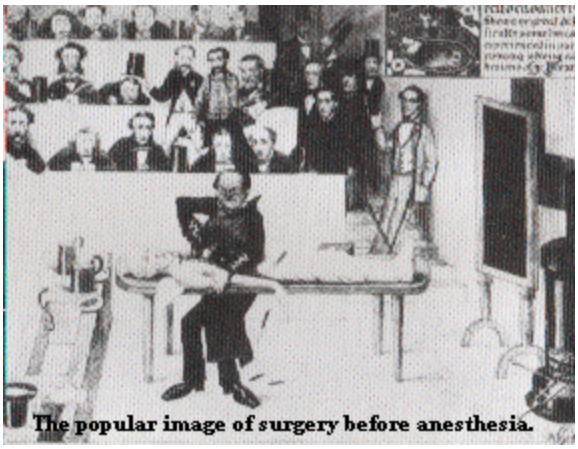
In contrast to previous centuries, the scrupulous washing of one's hands finally became the hallmark of a scientifically-trained professional. From a public health standpoint, hand washing was like pasteurization, a hugely important scientific advancement at the most fundamental level – a principle instead of a technology. Hand washing was something anyone could understand and use to the betterment of the human condition. But until Pasteur's proved the connection between a specific strain of bacteria and childbed fever in 1881, many (but not all) in the medical profession refused to take these precautions seriously. The results were predictably catastrophic.

It was two hundred years between van Leeuwenhoek's discovery of "wee beasties" and the irrefutable scientific proof by Koch and Pasteur that specific bacteria were indeed the cause of specific infectious diseases. During those critical centuries, people did not have the slightest clue that simple hygiene could prevent illness. Disease was thought by some to be punishment for sins, inauspicious astrological influences and dozen of other unlikely causes, such as bad air, getting chilled or, in the case of new mothers, milk fever or 'hysteria'. Suggesting that diseases could be prevented by soap and water might well have gotten you stoned or at least, laughed out of town.

During the Middle Ages and beyond, people were taught that bathing was actually bad for one's health. For example, once a year Queen Elizabeth I and a retinue of her servants, walked *en mass* from her castle to a special little stone building half an acre away, with great fanfare and ritual, so she could take her annual bath. Unless you were royalty, you might never get a real bath and *nobody* washed their hands, not even doctors. But everybody knew that the healing hands of a gentleman-physician could never cause anyone to become ill. Surgeons wore white butcher's aprons when they did surgery, which they didn't change for days at a time. In fact, the bloodier the doctor's white coat or apron, the higher was his status in the medical world and among his patients.

The medical profession didn't begin to seriously question this until the 1860s, when a tiny trickle of physicians wondered aloud if something in the process of providing medical care might not be causing, or at least contributing to, the transmission of infection. These few doctors tended to be surgeons or they treated maternity patients. Everyday they saw deaths from post-operative wound infections. Fifty percent of patients undergoing major surgery subsequently died from post-op infection, giving rise to the famous line that "The operation was a success, but the patient died." Doctors regularly saw patients with "hospital fever" and "childbed fever", a similar disease that affected hospitalized maternity patients.

This high mortality rate is not so surprising when you take into account the circumstances of the era. First off, it was part of that oceanic period of human history before the discovery of either germs or antibiotics or the invention of disposable exam gloves. Starting from this dismal place, surgeries were performed in the middle of the ward, with 20, 30 or 40 other sick and/or infected patients watching and coughing! Surgical instruments were not sterilized and surgeons didn't do a five-minute surgical scrub that included careful cleaning under their nails. In fact, they didn't even wash their hands with ordinary soap and water before embarking on the most invasive operations. They didn't gown and glove up, wear a scrub hat or cover their nose and mouth with a mask. Equally to the point, they would have ridiculed anyone who did.


The popular image of surgery before anesthesia.

Dr Joseph Lister was the first surgeon to see the medical value in cleanliness. After a long and contentious uphill battle, he created the universal standard for surgery as a sterile procedure that we still use today. Medical historians refer to him the father of modern surgery, but in the series of serendipitous events, Dr Lister was both a recipient and a contributor. It was his good fortune (and ours!) that he was the son of Joseph Jackson Lister, the well-known physicist who invented the compound microscope. Joseph junior grew up with a unique window on the world of microorganisms. Born in Essex, England in 1827 to a prosperous Quaker family, he was sent to Quaker school, where he became fluent in French and German. Since these were the leading languages of medical research, he was unusually well read in the scientific literature of his day, including the work of Louis Pasteur in his original language.

As a medical student, he attended the University of London, one of the few to accept Quakers. After graduating with a Bachelor of Medicine in 1853 he was accepted by the Royal College of Surgeons and became first assistant to and friend of the famous surgeon James Syme at the University of Edinburgh in Scotland. He eventually married Syme's daughter Agnes. She was so enamored by medical research that she was a partner with her husband in the laboratory for the rest of her life. Given these fortunate circumstances, it is not surprising that Dr. Lister had a distinguished teaching career and became surgeon to the Queen of England. But his most historically important contribution was recognizing the absolute need for surgery to be performed under absolutely sterile conditions.

When Lister was professor of surgery at the University of Glasgow, the official explanation for why a surgical incision got infection was exposure of the incised tissues to damaging substances in the atmosphere or by a *"miasma"* – a horrible smell in the air. However, it was not bad air that made sick wards smell awful, but the putrefaction caused by infected wounds. Nonetheless, there were no arrangements for washing either the doctor's hands or the patient's wounds. It was not considered necessary to wash one's hands before examining or treating patients. These potential discoveries failed to meet up with any prepared minds.

However, there were at least two exceptionally well-prepared minds that preceded Lister's, ones that may have contributed in some measure to Lister's own scientific brilliance. One was Ignaz Semmelweis, an Austrian professor of obstetrics and American physician Oliver Wendell Holmes, who incidentally was the father of our US Supreme Court Justice of the same name. On opposite sides of the ocean and within three years of one another (1847 and 1843 respectively), Semmelweis and Holmes both identified purulent organic material to be the primary source of childbed fever. This describes human cells and other tissue infected with pus-forming bacteria.

Holmes and Semmelweis identified infected tissue and other visible residue but did not mention the presence or importance of any microscopic organisms. We don't know if they understood that bacteria were the direct cause of puerperal sepsis, but they were certain of the method of transmission, which was described in stomach-churning detail: decaying organic material picked up under the fingernails of medical students and physicians during autopsies on women who had died from puerperal sepsis. This purulent material was then carried on the unwashed, ungloved hands of the professor and med students when they did vaginal exams on all the healthy women in labor that day. To our 21st century sensibilities, this is simply too ghastly to contemplate, but in fairness, it must be seen from the perspective of medical science, circa 1840 BC, that is, Before Common-knowledge-of-the-germ-theory-of-disease.

The thoroughly B.C./P.C., but nonetheless influential men of medicine who determined the policies and the practices of the day paid absolutely no attention to either of these men or any of their crazy ideas. This was not unusual behavior for the human species. The historical record of scientific advance is a four-part pattern (the four horsemen of the apocalypse!) that inevitably starts with initial resistance. At first there is denial and a dismissive attitude toward the idea (yawning!). This is followed by a mounting resistance and relentless ridiculing of the idea (name-calling). If the person promoting this new idea is still undeterred, opposition progresses on to attacking, belittling and humiliating the *person* (a shooting war) and if the opposition is organized by politically powerful group, it escalates into a vitriolic hostility by hired guns, with repeated attempts to publicly discredit the miscreants as heretics of the lowest order (dropping the A-bomb). When all the ammo has been spent, part four of the scientific progression is an about-face, after which the new way is enthusiastically embraced. Often the nay-sayers begin to promote the new order as if they were the same brilliant minds that first recognized this as a big scientific breakthrough. This last stage usually takes place only after the quantity and quality of facts can no longer be denied or ignored or, more often, when the over-my-dead-body older generation has finally died off.

This resistance happens in all walks of life, but it does seem that the medical men of yore were particularly prone to reject new scientific knowledge whenever it refuted the favored theory of the day or required a change of practice. Joseph Lister made himself very unpopular by doing plenty of both. First he swept away the familiar idea that surgical patients lived or died simply as a result of God's will. In its place he inserted the very uncomfortable idea that a failure in the sterile technique by the surgeon was responsible for postoperative sepsis. If the patient died, it was his doctor's fault. Ouch! Lister also demanded drastic changes in the way surgeons conducted themselves, requiring them to abandon long-standing practices and replace them with things that were inconvenient, uncomfortable and personally dangerous to themselves.

This all stared when Dr. Lister became aware of a paper published by Louis Pasteur which

showed that rotting flesh and fermentation could occur without any oxygen if microorganisms were present. Thanks to his Quaker school education in foreign languages, Lister was able to read Pasteur's thesis in its original French. He promptly conducted his own experiments and was able to personally confirmed Pasteur's theories. The immediate scientific problem that Lister tackled was how to get rid of the microscopic bacteria already present in an infected wound? Pasteur suggested only three possibilities, the first two of which couldn't be used on a living human. Given the choice of filtering the bacteria out, killing them with heat, or exposing them to chemical solutions, Lister made the only choice -- chemical antiseptics.

People had long recognized that creosol, one of the active constituents of creosote, could deodorize sewage and cure parasites in cattle. Creosote is a coal-tar derivative used to preserve railway ties and ships' timbers. A close cousin of creosol is carbolic acid. This is now known as phenol. In addition to its antibacterial properties, **Phenol** is a toxic, colorless aromatic solid with a sweet tarry odor. Today, it is used in the production of herbicides and synthetic resins. Most people are familiar with Bakelite, which is a polymer of phenol and formaldehyde. Concentrated solutions of phenol on the skin can cause severe chemical burns.

This unlikely chemical was chosen by Lister as the first antiseptic. He always referred to it by its older name: carbolic acid. He sprayed it on surgical wounds and then dressed each incision with bandages soaked in carbolic acid. He noticed that when he swabbed carbolic acid on traumatic wounds, the incidence of gangrene was reduced. By using these antiseptic techniques, Lister was able to keep his hospital ward in Glasgow free of infection for nine months – an *unheard* of accomplishment for his time.

Building on this success, Lister broadened his sights to include techniques for antiseptic surgery. Agreeing with Pasteur's recommendations, he required surgeons to wash their hands before and after operations with in 5% carbolic acid and sterilize their instruments in the same solution. He also had assistants spray the solution around the operating room during the surgery. Cloud of carbolic spray drenched everything and everyone, including the surgeon. It was believed that this technique killed bacteria before they had a chance to invade the surgical incision. The most frequent operation of the day was amputation, which had a 40% death rate before Lister applied antiseptic principles to surgery. In March 1867, Lister published the first articles in the journal *The Lancet* on the *Antiseptic Principle of the Practice of Surgery*. Thanks to Lister's influence, the death rate from amputation had dropped to less than 3% by 1910.

However, this strong chemical was caustic to human skin and other body tissue and could poison both the patient and the hospital staff. These effects were particularly a problem for the surgeon. Their unprotected hands became bleached and numb and their fingernails cracked. Every time they performed surgery they inevitably breathed in large quantities of carbolic acid mist sprayed around the OR. This damaged their lungs and made some doctors and nurses so ill they could no longer use the chemical.

Acknowledging this serious problem, Lister remarked that it was "a necessary evil incurred to attain a greater good." However, he started looking for ways to reduce the risks to his surgeons and the OR staff. One was the introduction of latex surgical gloves, which originally were used to protect doctor's hands from the chemical burns of the phenol, rather than to provide sterility. Lister

eventually decided that boric acid was a better choice for wound dressings, as it was antiseptic without the harmful qualities of carbolic acid. The skin irritation and pulmonary damage to the hospital staff and surgeons from constant exposure to phenol prompted Lister to continue looking for other methods to eliminate germs without harming the medical staff.

As the germ theory of disease became more widely accepted, the medical profession began to better understand the exact nature of contagion and realize that some of the original ideas for antiseptic surgery were flawed. Doctors initially believed that ordinary room air harbored the bacteria that caused supplicating (pus-forming) infections. This accounted for the clouds of carbolic acid sprayed all over. But it turns out that each specific type of bacteria also has specific requirements and most could only survive in warm, dark, moist places. Understanding where pathogens *actually* were, also meant realizing where they *weren'*t. A lot of Lister's burdensome even dangerous protocols turned out not to be necessary. In the end, it became obvious that the very best choice of all was to avoid surgical infections by *preventing bacteria from getting into the incision* during surgery. This led to the rise of aseptic technique and surgery as a sterile procedure.

Lister's ideas for antiseptic surgery were a mid-way point in a progression of medical discovery that started with van Leeuwenhoek's wee beasties, Pasteur's early experiments linking fermentation and microorganisms, Koch (and later Pasteur's) ability to prove a direct link between a specific strain of bacteria and a particular disease. As applied by Lister in the practical realm of antiseptic surgery, they finally came to fruition in the idea of *aseptic technique*. This is another and particularly important instance of a principle, instead of a product, that has given humanity a valuable and lasting gift. As a simple principle, aseptic conditions and techniques continue to be used around the world in large and small healthcare institutions and clinics each time the nurse or doctor uses a sterilized needle and syringe before giving an injection, puts on a sterile pair of gloves before doing an internal exam or lays the required sterile instruments on a sterile towel before starting to suture that little cut over your child's eye.

These principles of aseptic technique are also used in maternity care for healthy women. No matter where the baby is to be born – high tech city hospital, low tech community clinic or rural maternity home or the family's home in a million-dollar mansion or mud walled yurt in Mongolia -- professional birth attendants always conduct normal childbirth under aseptic conditions. Doctors and midwives are always responsible for not introducing any pathogen into the birth chamber (hand washing and clean clothing), for using aseptic techniques and supplies during labor (lots of exam gloves and clean linens!) and for making sure that anything that comes in contact with the childbearing woman's birth canal or any lacerated tissue be sterile. The simple equipment necessary for a normal birth are a pair of sterile gloves, sterilized scissors to cut the cord and sterile umbilical clamp to tie it off and a sterile surface to set these things on during the birth.

In the decade following the publication of Lister's research and his successful methods of preventing post-operative infection, hospitals gradually began to adopt the sterile procedures promoted by Lister. A lot of resistance had to be over come by hospital boards and the physicians in charge of each department – those four stages of denial, resistance, ridicule and finally "it was our idea all along!" Every major medical miracle is accompanied by the minor miracle that people willing give up ideas held dearly for decades, centuries or even thousands of years and make drastic changes in their everyday behavior.

In 1892, Pasteur was 70 years old and nearing the end of his life (he died at 73). The medical profession invited the great personalities of the surgical world to a formal event held in honor of Pasteur. While standing at the podium, accepting the richly deserved accolades of his peers, Pasteur tipped his head towards Dr. Joseph Lister and said: “the future belongs to him who has done the most for suffering humanity.” He was acknowledging the necessity to apply the scientific principles of microbiology at a practical level and the personal cost to those who make these accidental discoveries that so benefited humanity.

People tend to think of scientists and inventors as living a wonderful life above the fray, one full of gratitude and appreciation by the public and their professional peers. Unfortunately, human nature often extracts a large personal price from those who are on the leading edge of discovery. They battle not only the ruthless nature of the biological world, but unfriendly political systems, public prejudice and the professional jealousy of colleagues.

Lister is considered by some to be the father of modern surgery, by others to be the father of modern antisepsis, but its more accurate to consider him as having created the standard for aseptic technique and the principle of surgical sterility. For that, we are all benefactors of his prepared mind, his extraordinary human intelligence and his great heart for humanity.