ACS asepsis/antisepsis
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Title Slide 1: Today antisepsis and asepsis are central to surgical practice. We know that any intervention into the living body carries with it the risk of wound infection. Many of the typical features of modern surgery, the operating rooms, the surgical scrub, exist in order to prevent such a thing from happening. But this was not always so. In this module we tell the history of this change. Among other images, we are using pictures of the spaces in which surgery took place. As we move through the past 200 years, theses spaces will look more and more like modern operating rooms.

Slide 2: There has always been a risk of secondary complications from injuries and surgical interventions, such as wound suppuration, putrefaction, gangrene, fever and death. In traditional surgery, however, these complications were not seen to be connected with dirt. Microorganisms were unknown. Thus, surgeons did not pay special attention to cleanliness or keeping wounds uncontaminated. In fact, creamy pus ("laudable pus") was considered a natural sign of healing. Surgery was not performed in special, separate spaces. This image from Hans von Gerssdorff's surgical textbook from 1517 shows a traditional surgical intervention, the use of the hot iron (cautery).

Slide 3: In the nineteenth century, there was a general feeling that the problem of septic wound complications had become more urgent than ever before. There are several factors to explain why: With growing technical confidence, surgery was performed more often and more extensively. For example, amputations were done better and more often. Another reason was the introduction of anesthesia, which made surgery easier to tolerate and easier to perform. The image is a caricature of an amputation pre-anesthesia. Note how the whole group of people involved had to engage with the patient - a situation, which would not lend itself to aseptic precautions. In addition, patients were more often concentrated in the same places such as in hospitals.

Slide 4: This is a photograph of the first successful ether anesthesia in Boston in 1846 (it was actually re-enacted a short time after the event for the photo). Compared to the previous image, the whole situation is very different, more controlled and calmer. However, surgeons are operating in their street clothes, they touch the patient, there are no visible antiseptic or aseptic measures.

Slide 5: Surgeons reacted to the increased incidence of wound disease by following a number of strategies. This slide shows the typical appearance of what was known as hospital gangrene. As the name suggests, many surgeons attributed the problem to the hospital environment. Therefore, one approach adopted the ideas of the contemporary sanitation movement and aimed at improving the location of hospitals, their size and reducing overcrowding. Surgeons, such as James Young

Simpson in Edinburgh, fought against the great evils of smell, dirt and poor ventilation.

Slide 6: Others attempted to control gangrene and wound sepsis by technical means, for example, with various chemicals, through rigorous cleanliness, or open wound treatment. An early example is Ignaz Semmelweis, a Hungarian doctor who worked on a maternity ward in Vienna. In the 1840s Semmelweis was able to drastically reduce the rate of puerperal fever on his wards by forcing the doctors to wash their hands in a solution of chlorinated lime after performing post mortems and before attending the women at birth. However, Semmelweis' ideas were not taken up widely at the time.

Slide 7: Other surgeons in the 1860s and 70s developed veritable technologies of cleanliness including detailed provisions about hand washing, use of clean towels and clean dressings etc. One of them was the so-called "cleanliness and cold water" school of surgery proposed by the eminent British surgeon Thomas Spencer Wells in the second half of the nineteenth century, which was very successful for abdominal surgery.

Slide 8: One of the surgeons who took up Wells' approach was Robert Lawson Tait in Birmingham, England. With cleanliness he was able to remove gall-bladders safely in the 1870s with low mortality rates. His key principles were cleanliness, simplicity and speed. He removed all dead tissue from the wound and cleaned it. In addition he propagated general hygiene, good ventilation of the wards, and spacious living quarters in hospitals.

Slide 9: As another example, George Callender at St. Bartholomew's Hospital in London advocated a system of what he called "clinical precision". Callender considered a multiplicity of causes for septic complications. He paid attention to managing the patient's constitution and pre-operative state, he made sure that the air in the hospital was pure, and that the operation proceeded with utmost care and cleanliness. The local wound management consisted of rest of the operative site to promote early closure, as well as cleanliness and irrigation with water or chlorine. Callender's program of clinical precision thus extended from the wound, to the patient and to the cleanliness of the wards. As a special feature of his system camelhair brushes were used to clean wounds. Each patient had his or her own brush, to prevent cross-contamination. He holds one in the caricature in the slide. In summary, effective action to reduce wound infections did not require knowledge of the germ.

Slide 10: The British surgeon Joseph Lister was the first to connect wound infections with germs. Lister used a disinfectant, carbolic acid, to treat wounds and soak the dressings. To explain the effect of this procedure he adopted the germ theory of French scientist Louis Pasteur. According to Pasteur's theory, based on laboratory experiments as shown in the slide, the environment including the air is filled with microscopic living organisms – "germs" or "microbes". Lister reasoned that if germs

got into the wound they will propagate there, feeding on wound secretions and blood, leading to suppuration, wound fever and other problems, in the same way as, according to Pasteur, germs would start fermentation in the production of wine or beer. This is why all of the germs in the wound and around it needed to be killed with carbolic acid. In Lister's system the germ became the all-important cause of septic wound complications.

Slide 11: Over time, Lister developed his method into a complex system. By 1871 layers of carbolized gauze were being laid onto or into the wound. Unless an abscess cavity was being packed, a piece of oiled silk was first placed over the wound. The gauze had an insoluble resin to hold the carbolic acid and paraffin to prevent adhesion over time. A sheet of rubberized (macintosh) cotton was placed between the seventh and eighth layers as an impermeable barrier between wound and air, one that required any drainage to traverse all layers of the gauze. A bandage completed the dressings that extended some distance from the wound. To provide a further barrier, Lister introduced the carbolic acid spray in 1870. Both operations and dressing changes were conducted under the spray. Lister's methods followed logically from his theory – prevent the airborne germs that caused sepsis from entering the wound.

Lister was less interested other factors such as the patient's condition or even the cleanliness of the wards or the operation itself. As you can see in the picture, Listerian surgeons kept operating in their traditional soiled frock coats.
Many surgeons, for example Tait and Samuel Gross of Philadelphia were not convinced by Lister's technique, which they found too complicated and wasteful. Nor were they convinced by the germ theory, which they thought irrelevant for surgical practice. They stuck to meticulous cleanliness, which, according to their documentation, worked well without the idea of germs.

In the event, many of those surgeons, who followed their own strategies of dealing with wound disease, eventually added elements from Lister's antiseptic system to their procedures. For example both Wells and Callender did that. In the 1880s and 1890s all of their successful systems were subsumed under the umbrella term "antisepsis" and attributed to Lister.

Slide 12: In the 1880s and 90s, Pasteur's germ theory was developed into a new science, called bacteriology. The main protagonist here was the German doctor and scientist Robert Koch, who attributed specific diseases to specific microorganisms. He ~~also~~ developed new staining and culturing techniques to identify different species of microorganisms and relate them to specific diseases in animal experiments. The image shows Koch at the microscope, his iconic tool, surrounded by culturing vessels. Koch's approach was adopted by many surgeons, at first in Germany, and provided the basis for what came to be known as "asepsis". In asepsis the principle is to avoid germs in the first place, instead of killing them.

Slide 13: Septic wound complications were now seen as infection of the wound by specific bacteria. In the image you can see how Robert Koch represented this process as a microscopic invasion of the host, here represented by the tissue of a rabbit's ear on the left hand side, by bacteria. So at this point, septic wound complications were defined as infections in our modern sense of the word. Because of Koch's work, by the late 1880s a surgeon like Lawson Tait who never accepted the germ theory was now well outside the medical mainstream.

Slide 14: The methods of the bacteriological laboratory were adopted by surgeons. They now made use of heat sterilization instead of disinfection with chemicals, employed bacteriological culturing techniques for monitoring potential sources of surgical infection. An example is the Petri dish cultures from swabs taken from hands washed with different methods, shown in the image.

Slide 15: One of these surgeons was Ernst von Bergmann in Berlin. He worked directly with Koch and used bacteriological knowledge to devise techniques for keeping germs out of the operating field. This celebratory painting shows him as the head surgeon of the Ziegelstrasse University Hospital in Berlin (in the center, with a beard). The setting is a semi-public amphitheatre with an audience in the background. The surgical team wears sterile white gowns. The sterilized instruments and the iconic device to sterilize them – the autoclave – is shown in the foreground on the left hand side. This was just one of numerous variations in the use of aseptic techniques – veritable local cultures of asepsis.

Slide 16: In Breslau, for example, the local head surgeon Johannes Mikulicz (of the Heineke-Mikulicz pyloroplasty) invented the surgical mask to prevent droplet infection from the surgeon's mouth and nose. He also used elbow-long cotton gloves. The use of gloves, made of various materials, remained very controversial long into the twentieth century. Many surgeons thought that their preventative effect on wound infection did not outweigh the loss in agility and touch. They also worried that if the glove broke accumulated perspiration would contaminate the wound.

Slide 17: Rubber gloves were first introduced in surgery at the Johns Hopkins Hospital in Baltimore in 1889 by William Halsted. Halsted was known for his painstaking exactness in his operations and his pioneer role in introducing aseptic technique and higher standards of surgical training in North America. The photograph of him and his operating teams shows the gloves, also gowns and hats, but no masks reflecting the considerable local variation in aseptic techniques at the time. The setting here is a separate operating room with no audience.

Slide 18: This operating room scene from the 1930s is familiar to us today, bringing together various elements of the aseptic equipment as it is now used in a standardized way. [image still missing for copyright reasons]

Slide 19: Armed with the tools of antisepsis and asepsis, surgeons in the late nineteenth century developed a sense of control about the outcome of their

interventions that had never existed before. They now compared their field with other quintessentially modern areas, for example transport and industry. In 1897 Mikulicz noted in words still true today: ‘In the same way as in other areas of technology - in the operation of railways, in mining and in the metal industry – it can be demanded of us that we improve as much as possible the arrangements for the safety of the people who are entrusted to us’.

This module has traced the evolution between 1850 and 1910 of one of the key surgical technologies– asepsis and the prevention of surgical infection. As we move into an era of increasing antibiotic resistance we should remember the lessons of strict cleanliness and meticulous aseptic technique that made modern surgery possible before antibiotics.