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 EDITORIAL

## Bacteria of surgical importance

Many scholars suspected microorganisms, but in the late 18th century it was the development of compound microscope which helped the microbiologists of the nineteenth century to describe the multitude of bacterial and fungal organisms and their relationship to infection. Pasteur developed the germ theory of disease by demonstrating that bacteria. Koch described the postulates by which infection from a particular microorganism have been defined. He was awarded the Nobel Prize in 1905 for his description of the *Mycobacterium tuberculosis bacillus*.

The Hungarian obstetrician Ignaz Semmelweis, who practiced in Austria in the mid nineteenth century, demanded that his residents and students wash their hands in sodium hypochlorite before touching patients and also had his obstetric instruments soaked in the same solution.

Lord Lister, a general surgeon who did mostly orthopedics, was the first to use an antiseptic agent, carbolic acid, in 1865, to reduce the risk of surgical site infection (surgical site infection). These early measures have been refined to the modern aseptic and antiseptic techniques used today, and with appropriate use of prophylactic antibiotics,<sup>1</sup> the overall surgical site infection rate has been reduced to approximately 5%.<sup>2</sup> All pathogenic organisms are made up of cells. Cells are distinct entities of cytoplasm that are bound by a cell membrane and consist of genetic (DNA) material. Bacterial cells are known as prokaryotes and all other cells are known as eukaryotes. Prokaryotes lack a distinct nuclear compartment, have DNA in the form of a single circular chromosome (additional bacterial DNA may be carried in plasmids), and are able to undergo simultaneous transcription and translation without mRNA.

Bacterial cell walls are complex and divide bacteria into two classes: gram-positive and gram-negative cells by Gram staining, developed by the Danish scientist Hans Christian Gram in 1884, tests the ability of bacteria to retain a violet stain after washing with iodine and alcohol, with purple indicating a positive Gram stain and pink indicating a negative one. In gram-positive bacteria, the outer wall is made of peptidoglycan, whereas gram-negative species have little peptidoglycan but possess an additional outer layer rich in polysaccharides. Bacterial cell wall layers provide complex protective defense shields against immune cells and antimicrobial agents. Fungi

are eukaryotes that are very different from human and plant cells. They are multicellular multinucleate organisms that grow either in filaments (hyphae) to form a mycelium.

The commonest Gram-Positive Cocci is *Staphylococcus aureus* which is a catalase and coagulase-producing gram-positive organism that is a comoncel of human nasal passages, mucous membranes, or skin of carriers. *Staphylococcus Aureus* It is traditionally identified by its characteristic golden yellow grapelike clumped colonies on culture (staphule – Greek for grapes; aureus – Latin for gold). This organism is arguably the most important pathogenic organism in evolving surgical infections. *Staph aureus* constitutes the majority of skin and soft tissue infections encountered in the surgical population, accounting for up to 20% of surgical site infection isolates but also 13% of all nosocomial infections.<sup>3</sup> This facultative anaerobic organism was first reported in 1880 in Aberdeen, Scotland, by the surgeon Sir Alexander Ogston, in pus drained from infected abscesses. Since then, an estimated 500,000 patients a year are the sufferer due to staph aureus.<sup>4</sup> In the nonsurgical population, it is the cause of pneumonia, endocarditis, disseminated bacteremia, toxic shock syndrome, and food poisoning among many other disease entities in adult and pediatric populations.

*Staph aureus* is capable of producing several exotoxins, including enterotoxins and superantigens, which result in the organism's virulence. Following the introduction of penicillin by Sir Alexander Fleming in 1943, antibacterial sensitivity of *Staph aureus* to penicillin has been gradually replaced by resistance. By the 1960s, resistance was thought to near 80%. Resistance to penicillin is mediated by penicillinase (beta-lactamase), an enzyme that degrades the beta-lactam ring of penicillin. MRSA is now understood to consist of two exclusive subtypes: a nosocomial, or hospital-acquired, type (HA-MRSA) and a community-acquired type (CA-MRSA). with sensitivity restricted to vancomycin, teicoplanin, or the newer oxazolidinones such as linezolid. HA-MRSA appears to affect patients in hospitals with open wounds, those who undergo invasive procedures, and ones with weakened immune systems. Transfer is predominantly staff- and instrument-related, awareness of which has resulted in the development of strict hand-washing and barrier-oriented infection control policies that are now in place. Although most MRSA

infections remain health care-associated, a rising incidence of community-acquired infection is apparent. Community-acquired infection incidence rates in the United States in 2005 were estimated at 13.7%<sup>5</sup> in a recently published large series. Consequently, community-acquired MRSA (CA-MRSA) is gaining increased attention among microbiologists and health care workers today. MRSA has recently been treated with newer antimicrobial agents such as clindamycin and linezolid. Preliminary reports of *Staph aureus* resistance to linezolid are available and pose serious future concern. Another frequently encountered bacterium in surgical infections is the skin commensal *Staphylococcus epidermidis*. This facultatively anaerobic, catalase-positive and coagulase-negative organism, along with *Staphylococcus saprophyticus* and *Staphylococcus capitis*, are collectively referred to as *Staphylococcal albus*.

Classically, *S epidermidis* is isolated from infected surgical wounds, particularly sternal wounds, where it is the most common isolate.<sup>21,22</sup> Other common operations where this organism is implicated include that that use prostheses, such as joint replacement and vascular graft procedures. In 2003, approximately 90% of all coagulase-negative staphylococcal species were resistant to Methicillin.

The second most commonest gram-positive organism is streptococcus which is facultative anaerobic cocci play a significant role in surgical infections such as erysipelas and type II necrotizing fasciitis (streptococcal fasciitis), despite being commensal organisms of the mouth, throat, skin, and human intestine. Their name is derived from their twisted chain-like pattern of growth following cellular division (strepto – Greek for twisted). Alpha-hemolytic species cause partial breakdown of blood, which results in an impartially degraded green haem halo surrounding the streptococcal colony in blood agar. Beta-hemolytic organisms cause complete hemolysis of red cells in agar, and, therefore, form a white area surrounding the colony. They are further divided into Lancefield Types A-T. Non-hemolytic streptococcal species, often referred to as gamma-hemolytic, rarely account for serious human disease. Enterococcal species, which cause a variable degree of hemolysis, must not be confused with non-hemolytic streptococci, an entirely different bacterial genus.

*Streptococcus pyogenes*, also known as group A *Streptococcus* (GAS), was traditionally regarded as the main pathogen of complicated skin and soft tissue infection. Its presence in cellulitis, and more specifically, erysipelas, which primarily affects the upper dermis, is well documented. In a recently published series of 165 patients with necrotizing fasciitis, overall mortality was reported at 17% with 25% requiring amputa-

tion of the affected extremity in addition to surgical debridement. Central to pathogenic mechanisms is the production of extracellular toxins, of which two are hemolytic and three pyrogenic. Streptokinase, an enzyme produced by the bacteria, is used as a cardiovascular thrombolytic agent following myocardial infarction (MI), more often than its staphylococcal counterpart. Treatment is with penicillin and its various derivatives. However, appreciation that this organism often coexists in polymicrobial disease indicates that additional broad spectrum coverage is frequently required. For example, type I necrotizing fasciitis often includes highly virulent clostridial anaerobes among other organisms. Enterococcal species include both *Enterococcus faecalis* and *Enterococcus faecium*, commensals in the adult gastrointestinal tract.

Among the positive bacilli rod-shaped bacteria are obligate anaerobes that are capable of spore formation, and include *Clostridium perfringens*, *Clostridium difficile*, *Clostridium tetani*, and *Clostridium botulinum*. The latter two are known for producing tetanus and botulinum toxins respectively but otherwise have a limited role in surgical disease. *C perfringens* causes the rare surgical disease known as gas gangrene, a rapidly spreading surgical emphysema mediated by the enterotoxin alpha-toxin. Its presence has been shown to be an independent predictor of mortality and limb loss among affected cases in the recently published series described earlier. Other clostridial species, such as *C septicum*, may also cause gas gangrene.

*C difficile* is frequently seen on surgical wards in patients on prolonged antibiotic therapy. This organism has recently gained attention in public health circles because of increasing incidence rates and severity of the symptomatic pathognomic disease, pseudomembranous colitis. Eradication of the normal colonic flora with previously administered antibiotics combined with *C difficile* ingestion may result in the formation of pseudomembranes. A severe hemorrhagic inflammation often ensues, resulting in a profound and rapidly transmissible diarrheal state in hospitalized patients. In the elderly, frail, and immunocompromised, sequelae may be life-threatening. Classically, abdominal radiographs fail to demonstrate evidence of obstruction. Risk factors for disease development include antimicrobial therapy and proton pump inhibitors (PPIs). Cell damage in the colon are mediated via the secretion of two toxins, known as toxin A and toxin B. Effective treatment of clostridial species is with metronidazole. Oral vancomycin is also effective in the treatment of symptomatic *C difficile*. There are several other Gram-positive bacilli such as *Bacillus*, *Corynebacterium*, *Lactobacilli*, and *Listeria*, which may cause serious disease in humans but are less relevant to surgical readers.

Among gram negative bacilli, the most notable gram-negative cocci are the *Neisseria* species, *Neisseria meningitidis* and *Neisseria gonorrhoeae*, which commonly cause meningitis and gonorrhoea respectively and do not feature in surgical disease. *Bacteroides fragilis*, an anaerobe that frequently affects surgical patients. Gram-negative bacterial species tend to occur as intestinal commensals in humans, and, as such, infection related to these organisms usually follows abdominal bowel surgery, particularly colonic surgery, where there is breach of an abdominal viscus. Gram-negative bacteria account for a significant proportion of surgical site infection isolates and all nosocomial infections. *Enterobacter* spp, *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis* account for 21% of all surgical site infection alone.

Enterobacteriaceae Include *Enterobacter* species, *E coli*, *Klebsiella pneumoniae* and *Proteus* species. *E coli* is arguably the most intensively studied bacterial organism since its discovery in 1885. Without acquiring virulence factors, it is an unharmed colonic commensal that often protects bowel against overgrowth of pathogenic species. However, virulent strains of *E coli* account for several types of gastroenteritis and often result in food poisoning. Easily transmissible through the fecal-oral route. Following colonic surgery, *E coli* may result in surgical site infection and peritonitis where illness may be profound. Fortunately the organism remains very sensitive to gentamicin as well as other antimicrobial agents such as cephalosporins, carbapenems, aztreonam, ciprofloxacin, trimethoprim-sulfamethoxazole, and nitrofurantoin.

*Pseudomonas aeruginosa* is a gram-negative rod generally associated with opportunistic infections and most commonly accounts for infections of the urinary tract, ventilator-associated pneumonias (VAP), and wound infections. It plays a role in the formation of bacterial biofilm and is the most frequent colonizer of medical devices and catheters. Community-acquired disease is only rarely caused by *P aeruginosa*. This organism has recently gained microbiological attention because of emerging multidrug resistance. Aminoglycosides and third-generation cephalosporins also remain effective at this time.

In Curved, Spiral, or Helical Organisms the important is *Campylobacter jejuni*, via the production of a cholera-like enterotoxin, *Campylobacter jejuni* is now recognized as the most common cause of food-borne gastroenteritis in the developed world, and results in epithelial cell damage in jejunal and ileal segments of affected patients. This organism will rarely result in the Guillain-Barre neuropathy several weeks following gastroenteritic symptoms in affected individuals.

*Helicobacter pylori* is a classic helical organism that was only identified as late as 1982 by the Australian Nobel Prize winners Robin Warren and Barry Marshall. *H pylori* is currently thought to infect half of the world's population and is a recognized risk factor for gastric carcinogenesis. Through its ability to produce urease, this organism is able to evade the hostile acidic environment of the stomach where it most commonly resides and contributes to 90% of peptic ulcer disease. Antacid treatments following successful isolation of the organism and classically includes two of amoxicillin, clarithromycin, tetracycline, or metronidazole with the newer and more potent PPIs.

Among other Gram- Negative Species *Acinetobacter* spp is gaining a lot of importance. This strictly aerobic non-fermenting cocco-bacillus is a nosocomial organism that accounts for serious life-threatening infection in debilitated patients. Last resort carbapenems, which were previously highly effective against this organism, are now susceptible to evolving resistance mechanisms as reported by the CDC. Recent promise has been shown using Polymyxin B in highly resistant species. *Bacteroides fragilis* is a normal component of the human bowel flora, and the most common anaerobic species involved in intra-abdominal infections. Etiologic role in the formation of appendicitic abscesses. Current sensitivities include metronidazole, carbapenems, and penicillinase-resistant penicillins.

The Fungi are the organisms are not typical surgical pathogens, they are seen in surgical patients who are debilitated as a result of comorbid disease, prolonged hospitalization, or extensive antibiotic treatment. Fungal mycoses are broadly divided into superficial and deep infections. Superficial infections include skin, hair, and subcutaneous tissue layers, such as nails and deeper skin planes. Although these organisms are not typical surgical pathogens, they are seen in surgical patients who are debilitated as a result of comorbid disease, prolonged hospitalization, or extensive antibiotic treatment.

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