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Microbe of the Month

Breaking The Chain of Infection

MARCH 2024 NEWSLETTER

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FEATURED THIS MONTH:

Staphylococcus epidermidis

A harmless skin commensal? Not anymore!

10-minute read + QUIZ

Hello readers!

Microbe of the Month aims to provide a concise clinical resource, to help you keep up to date about pathogens of importance, in an easy-to-read and understand format.

Each issue covers the aetiology (sources) and epidemiology of topical bacteria, viruses, or fungi - their mode/s of transmission and the infections they cause; alerts on any antimicrobial resistance (AMR) capability they may have, and the relevant Infection Prevention and Control measures which should be routinely implemented for the safety of patients and healthcare personnel.

There is a quick quiz at the end of the newsletter to test your grasp of the content –
Please use this newsletter as a teaching tool in your workplace and start an 'infectious dialogue' about topical issues in infection control!

Staphylococcus *epidermidis* (*S. epidermidis or coagulase negative Staphylococcus 'CoNS'*) is a very hardy, non-motile (unable to move on its own) Gram-positive coccus, arranged in grape-like clusters – and is one of over 40 species belonging to the genus *Staphylococcus*. S. *epidermidis* is also a '*facultative anaerobe*', meaning that it can thrive under anaerobic conditions if required to do so.

It typically lives on human skin and the nasal mucosa and is **one of the five most common opportunistic pathogens which cause healthcare–associated infections (HAIs) associated with catheters, prosthetic heart valves, cerebrospinal fluid shunts, vascular implants, and surgical site infections following orthopaedic arthroplasty (i.e., the surgical reconstruction or replacement of a joint).**

It is also a **frequent contaminant of specimens submitted for laboratory culture**; and the most frequent organism found in the blood of bone marrow transplant patients and on central venous catheters for patients receiving total parenteral nutrition (TPN).[1,2]

Key words: *Biofilm, facultative anaerobe, virulence, implants, osteomyelitis, antimicrobial stewardship, infection prevention bundles.*

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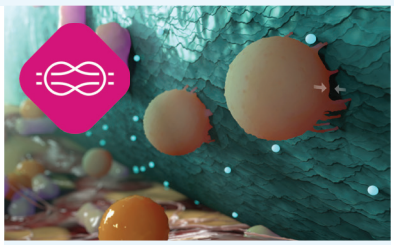
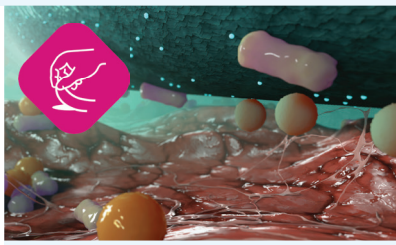
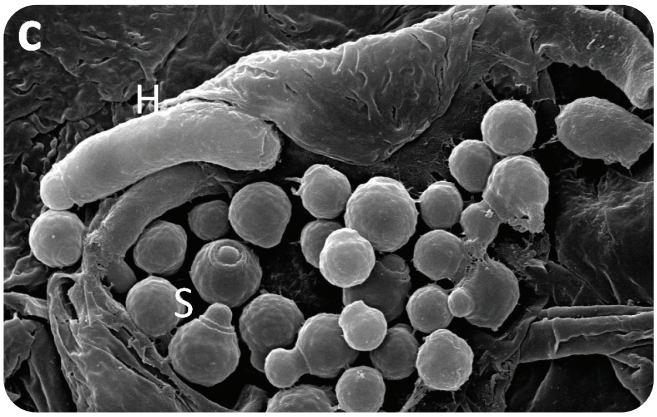
Bind:
Bacteria naturally bind and anchor to the unique Sorbact surface.



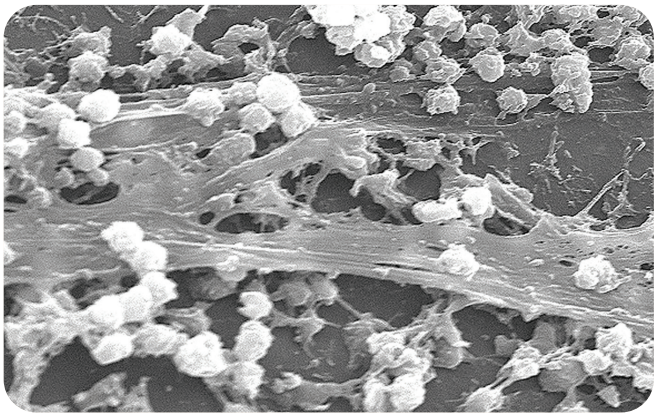
Inhibit:
Bacteria are irreversibly bound, and growth is inhibited. Development of bacterial or fungal resistance is not expected.



Remove:
Bound bacteria, fungi and endotoxins are removed.



Scanning electron microscope (SEM) image of staphylococcal bacteria on an epidermal skin cell (AKA 'squame').



Staphylococcus *epidermidis* biofilm in the lumen of a central vascular catheter.

PATHOGENESIS AND VIRULENCE OF S. *epidermidis*

When compared to other bacteria, the **peptidoglycan** cell wall of S. *epidermidis* is thicker and stronger, making it more resistant to the action of antimicrobial enzymes produced by the immune system, as well as phagocytosis by leukocytes.

Peptidoglycan is an essential component of the bacterial cell envelope.

It maintains the cell's shape and protects it from *lysozyme* – a damaging immune protein which attaches to the cell walls of microbes, resulting in lysis and destruction.[2]

One of the crucial factors allowing S. *epidermidis* to survive in a harsh environment is its ability to form biofilm – especially on invasive medical devices – and is a major virulence factor (ability to cause serious infection).

A biofilm comprises communities of microorganisms which stick to each other and often also to a surface. These adherent bacterial cells become embedded within a three-dimensional slimy matrix of polysaccharides, proteins, lipids and DNA, creating a *multilayer* biofilm.

The decreased metabolic activity of microorganisms inside biofilm results in impaired diffusion of antibiotics into the biofilm – a clever strategy whereby bacteria can tolerate and survive the effects of topical and systemic antimicrobial agents, which would otherwise be quite lethal to planktonic (free floating) bacteria.

Furthermore, mature biofilms break up – 'seeding' bacteria via the bloodstream to distant sites in the body, creating new infections.

This makes the treatment of medical device-related infections challenging – often requiring the replacement or complete removal of the contaminated device for successful treatment of the infection.[1,2,3]

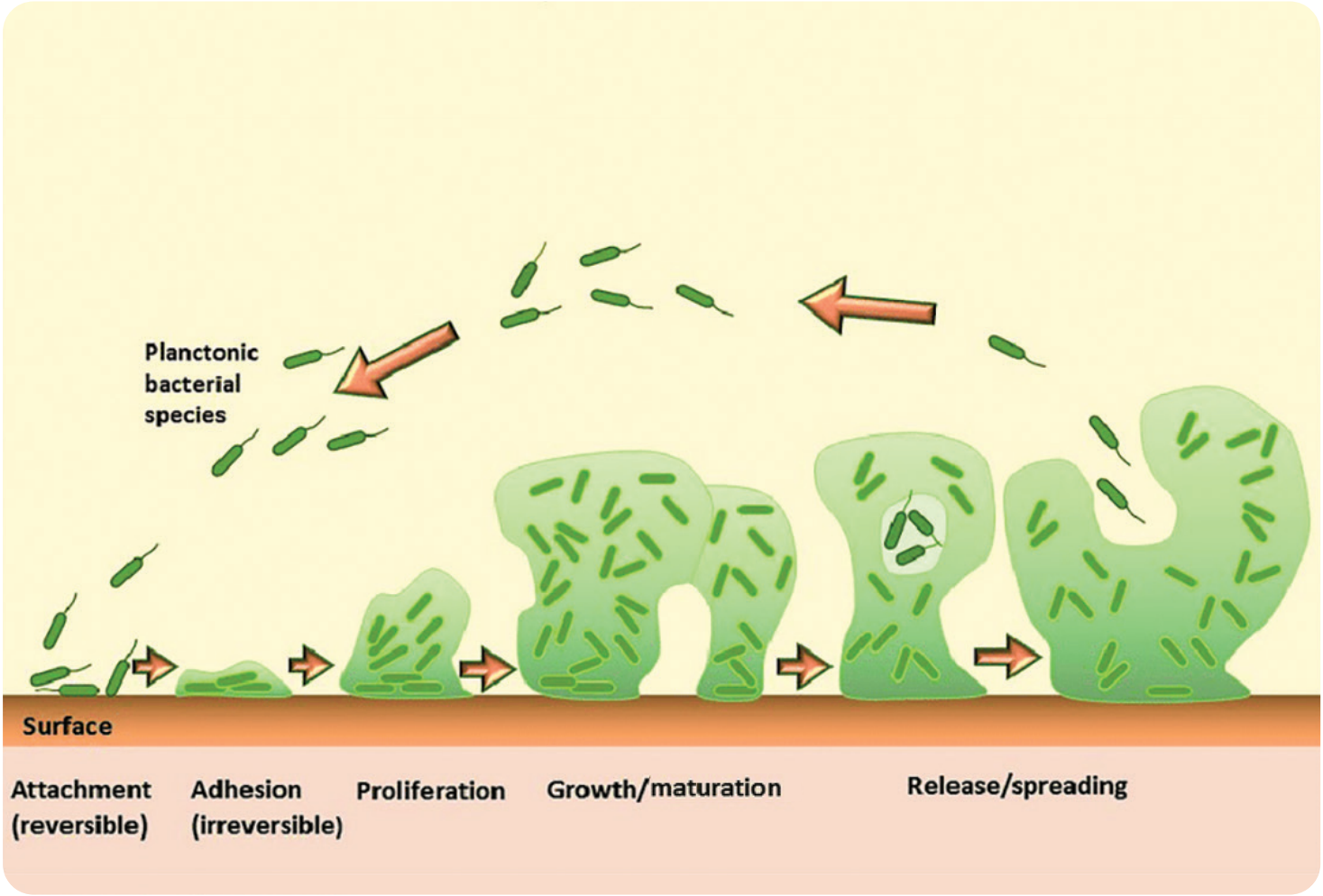


Figure 1. **Schematic image of biofilm formation.**

MODES OF TRANSMISSION

The modes of transmission of S. *epidermidis* in the hospital setting are via **direct and indirect contact and the airborne routes**, since it is a ubiquitous commensal of the human skin, and will also be present in large numbers on used linen and in environmental dust (from disseminated skin squames).

THE SPECTRUM OF INFECTIONS CAUSED BY S. *epidermidis* [1,2,3,4]

- **Catheter associated bloodstream infections**. These are defined as bacteraemia originating from a vascular catheter. The primary organisms associated with CRBSI are usually the normal resident flora of the skin at the insertion site, which may lead to colonisation of the catheter.

  The majority of CRBSIs are associated with central venous catheters (CVCs) and the relative risk for CRBSI is up to 64 times greater with CVCs than with peripheral venous catheters! [4]

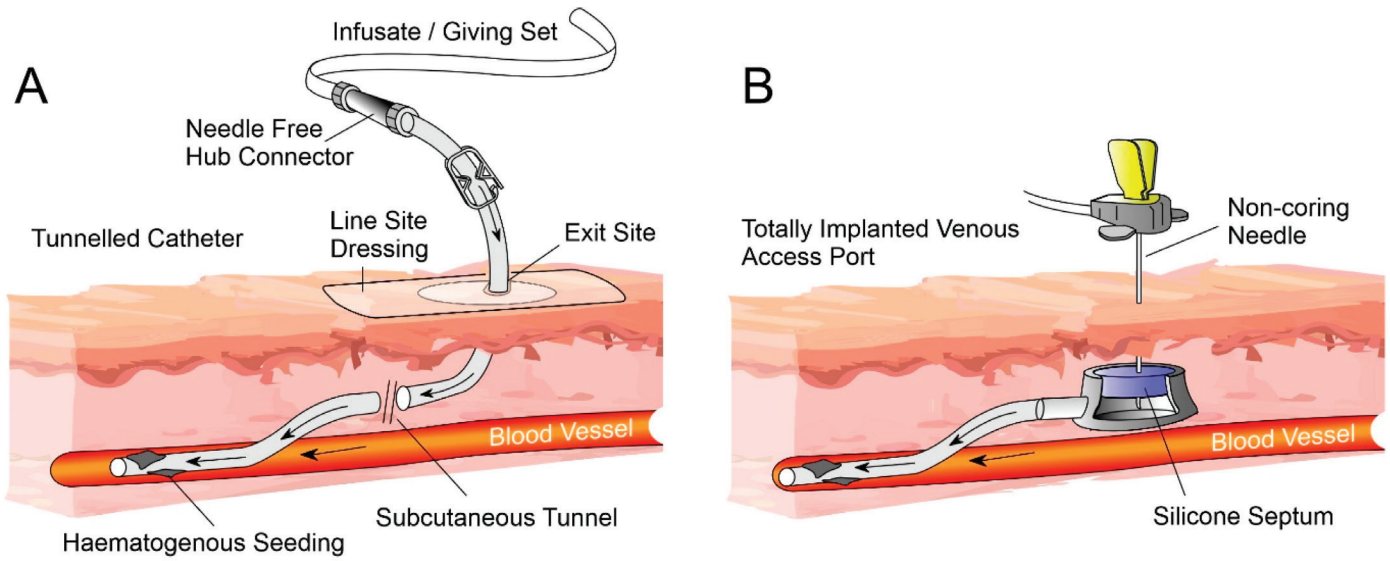


Figure 2. **Pathogenesis of catheter-related blood stream infection.**

Exit-site infection is indicated by the presence of erythema, swelling, tenderness, and purulent drainage around the catheter exit site.

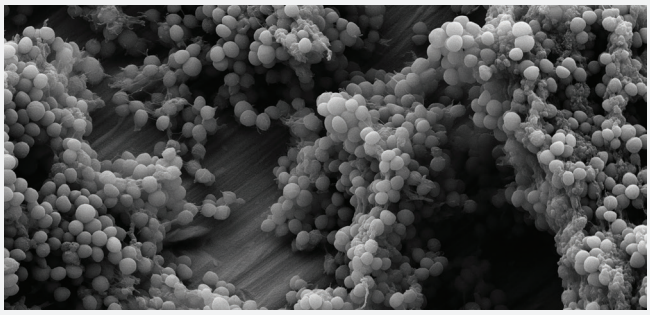
The diagnosis of CRBSI requires the clinical manifestations of blood stream infection (i.e., fever, chills, and/or hypotension), and at least two sets of positive blood cultures – taken simultaneously from the catheter and from a peripheral venous site. Culture of the same microorganism (with a matching antibiogram) will confirm CRBSI.

Catheters should always be removed from patients with CRBSI, and empiric antibiotic therapy initiated as soon as possible, pending preliminary microbiological culture results.

- **Septic arthritis** – bacterial arthritis is potentially the most dangerous and destructive form of acute arthritis. In most cases, it results from haematogenous spread to the joint, but can also result from direct inoculation into the joint from bites, trauma and joint surgery.

  Predisposing factors include prior joint pathology such as rheumatoid arthritis, gout, osteoarthritis, recent joint surgery, etc. The knees, hips, ankles and wrists are the joints most commonly involved.

Prosthetic joint infection: S. *epidermidis* is transferred from the skin adjoining the surgical site and contaminates the prosthesis. Colonisation and biofilm formation ensue with subsequent attachment to the device. *Bacterial biofilm is such a complex and impervious structure, that it resists the protective action of leukocytes and antibodies, and infection develops.* Treatment involves long–term antibiotic therapy – however, it is important to note that antibiotics are usually ineffective in clearing biofilms unless the biofilm is physically disrupted or removed by surgical debridement. Unfortunately, removal and/or replacement of the infected implant is usually necessary.



Electron micrograph depicting the typical clusters of S. *epidermidis* and biofilm formation on the surface of a titanium prosthesis.

Resorbable antibiotic beads inserted around a septic knee prosthesis.

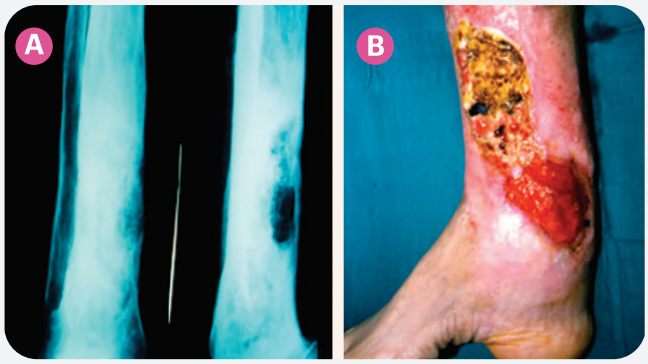
Osteomyelitis (bone infection): S. *epidermidis* may be introduced in three main ways:

Acute haematogenous osteomyelitis is primarily a disease of children, with 85% of cases occurring in children younger than 17. Most adult cases are seen in patients over 50, and usually involve the vertebral, sternoclavicular, and sacroiliac joints. Predisposing risk factors in adults which contribute to bacteraemia include recent gastrointestinal or urinary tract surgery and intravenous drug abuse.

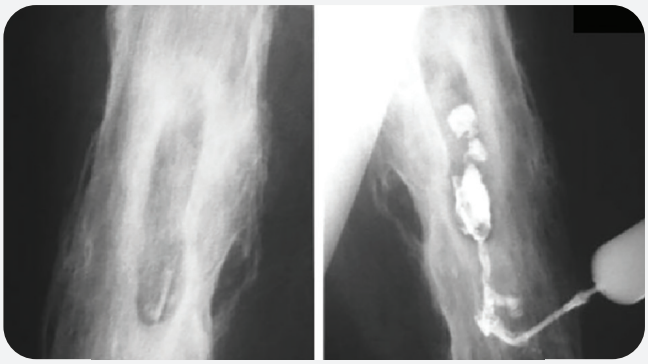
Post-traumatic osteomyelitis develops from contaminated open fractures or surgical treatment of closed fractures (insertion of pins, plates, etc.). Microorganisms are introduced into the bone in the trauma setting or from nearby injured tissue.

Local invasion – osteomyelitis can result from periodontal disease, or from a nearby lower limb or deep pressure ulcer.

Treatment includes bone, periosteal, bone marrow space, synovial fluid and/or blood culture; and intravenous antibiotics followed by oral therapy for at least 4-6 weeks (liaison with a medical microbiologist is recommended). Surgical management includes drainage of the wound abscess, tissue debridement and removal of devitalised bone.



(A) X-ray depicting 2˚ osteomyelitis of the tibia from a chronic venous leg ulcer.
(B) Malignant transformation of a chronic leg ulcer into squamous cell carcinoma.



X-ray sinogram illustrating the sinus tract to chronic osteomyelitis of the femur.

ANTIMICROBIAL RESISTANCE [2,3]

Methicillin resistance (MRSE) is widespread because microorganisms living freely on the skin as commensals are routinely exposed to the antibiotics secreted in sweat. Resistance to other antibiotics also include rifamycin, fluoroquinolones, gentamycin, tetracycline, clindamycin, and sulphonamides.

The antimicrobial agent of choice for most infections caused by S. *epidermidis* is vancomycin – but strains with decreased susceptibility or resistance to vancomycin have also been reported. The antibiotics daptomycin and tigecycline have demonstrated efficacy towards methicillin-resistant staphylococci.

Rifampicin may be recommended for the treatment of infections involving prosthetic devices due to its activity against staphylococci in biofilms. However, rifampicin should always be used in combination with other active antimicrobial agents due to the rapid development of resistance to rifampicin when it is used as monotherapy. ***Resistance to linezolid*** *is being increasingly reported and may be* ***plasmid-mediated****.*

THE IMPLICATIONS FOR ANTIMICROBIAL STEWARDSHIP (AMS) [8]

The increasing prevalence of antibiotic-resistant strains of S. *epidermidis* highlights the need for prudent use of first-line agents and the importance of **antimicrobial stewardship**. Treatment options should be guided by local epidemiological surveillance data, the patient's history, underlying comorbidities, and individual antimicrobial susceptibility test results for each patient's isolates.

Ensuring the consistent application of good infection prevention and control practices - particularly the aseptic insertion and care of medical devices - is crucial for the prevention of S. *epidermidis* infections.[3]

THE BOTTOM LINE...

Staphylococci and their biofilms are a great threat to patients with CVCs and those undergoing prosthetic surgery!

PRACTICE POINTS FOR INFECTION PREVENTION

The CLABSI (Central Line Associated Bloodstream Infection) Bundle [9]:

- High-level hand hygiene.
- Maximal sterile barrier precautions.

- Non-sterile cap and face mask (all hair should be under cap and the mask should cover nose and mouth tightly).
- Sterile gown and gloves.
- Cover the patient's head and body with a large sterile drape.

- Skin disinfection and catheter care with 2% chlorhexidine in 70% isopropyl alcohol.
- Optimal catheter site selection, with subclavian vein as the preferred site for non-tunneled catheters in adults.
- Daily review of line necessity and prompt removal of unnecessary lines.

Perioperative care should include the following:

- **Timeous preoperative work-up**, preferably via the hospital's Pre-admission Clinic.
- **Screening for Staphylococcal carriage** (nose/oropharynx and/or groin swabs) for high-risk cases, and decolonisation if appropriate.
- **Adherence to the SSI (surgical site infection) prevention bundle:**
  - Bathe/shower the night before, and the morning of surgery.
  - Removal of hair at the surgical site with clippers (NO shaving).
  - Disinfection of the surgical site with chlorhexidine (CHG) in 70% alcohol.
  - Appropriate intraoperative antibiotic prophylaxis; for example:
    - → Administered intravenously by the anaesthetist within 60 minutes of the surgical incision to ensure high blood/tissue levels.
    - → A single preoperative dose of antibiotic that has the same efficacy as multiple doses, and the current recommendation is to administer a second dose only if the procedure lasts for more than 3 hours.
    - → Two hours are allowed for the administration of vancomycin and fluoroquinolones.
    - → Adjust dosing on the basis of patient weight (e.g., morbidly obese patients).
    - → Re-dose prophylactic antimicrobial agents for long procedures, and in cases with excessive blood loss.
  - Keep the patient's core temperature > 36.5°C during the perioperative period.
  - Control blood sugar levels between 8 – 11mmol/L.
- **Practice meticulous aseptic intraoperative techniques, sterile attire, drapes and supplies, and limit foot traffic in the operating theatre.**
- **Use absorbent, occlusive perioperative dressings** which permit visualisation of the wound, and a topical antimicrobial (not antibiotic) product for patients at risk of SSI (e.g., DACC bacteria-binding dressings).
- **Provide post-discharge advice to patients** regarding the care of their wound in the immediate postoperative period.
- **Postoperative dressing changes:** for closed, clean incisions, dressing removal may be undertaken 2-7 days later, as per the surgeon's preference.
  - Although some haemoserous wound exudate is a normal feature of post-surgical wound healing; it is vital that patients be given adequate discharge information and advised to report signs such as strikethrough or dressing leakage as soon as possible.
  - Wound cleansing: sterile normal saline and aseptic technique should be used for dressing changes up to 48 hours after surgery. Patients may shower safely 48 hours after surgery; and boiled tap water used for wound cleansing thereafter.
- **Perform surveillance for SSIs:** especially high-risk, high-volume operative procedures, based on risk assessment of patient populations, and the category of operative procedures performed.

Supply the correct answer!

1. Staphylococcus *epidermidis* is a normal resident or _____ of human skin.
2. Aerobic microorganisms which can survive without oxygen if required to do so, are termed _____ _____.
3. One of the crucial factors allowing S. *epidermidis* to survive in a harsh environment is its ability to form _____.
4. Staphylococcus *epidermidis* causes opportunistic healthcare–associated infections associated with _____ and _____.
5. Strict _____ technique for the insertion and care of vascular catheters is necessary to prevent secondary bacteraemia.

ANSWERS: 1. Commensal. **2.** Facultative anaerobes. **3.** Biofilm. **4.** Catheters and implants. **5.** Aseptic.

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