

Intrinsic and extrinsic sources and prevention of infection (in surgery)

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Abstract

In 2014–2015 the NHS carried out 9.9 million operations. Hospital-acquired infection (HAI) though, continues to be a major challenge, with 300,000 patients a year affected. The human cost is enormous, but so is the financial cost; HAIs are estimated to cost the NHS approximately £1–2 billion a year, with £56 million of this estimated to be incurred after patients are discharged from hospital. Many HAI are preventable, and this article aims to support the surgeon and team in reducing HAI in the surgical pathway, by reviewing the role of intrinsic and extrinsic factors in the development of a HAI, to enable prevention/mitigation strategies to be put in place to ensure the safest possible care pathways.

Keywords Care bundles; Hand hygiene; Pre-assessment clinic; Surgical checklist; Surveillance; World Health Organization (WHO)

Introduction

Surgery in the Western setting has advanced remarkably since Claudius Amyard performed the first successful appendectomy in 1735, with the founding of the Royal College of Surgeons in 1800. New technologies, techniques and innovations, such as laparoscopic approaches, have revolutionized the manner in which surgery is performed, with advances in day-case surgery allowing the early recovery and safe discharge of patients home, saving bed days and reducing risk of HAI.

The HAIs associated with the surgical specialities include directly associated surgical site infections (SSIs), defined as deep, organ space or superficial,¹ and the associated postoperative complications of pneumonia, urosepsis, infections of indwelling devices, vascular and urinary catheters, and *Clostridium difficile* infection colitis, which can all lead to the serious complication of sepsis.

Surveillance and data

Active surveillance of SSIs¹ is the cornerstone in monitoring surgical practice; specialities such as orthopaedics lead the way in reporting SSIs.

Public Health England (PHE) publishes yearly tables on orthopaedic SSIs and is now broadening its remit to include other surgeries.

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Figure 1 shows the PHE SSI incidence data for inpatient/readmissions, for England, for a range of surgical specialities, for 2016–2017, with stratification for age.

Each surgical speciality carries its own independent risks for infections; the cumulative SSI incidence ranged from 9.2% in large bowel surgery to <1% in clean surgery such as knee prosthesis.

Before embarking on any improvement strategy, it important it is to understand your own unit's data, and be able to compare, at regular intervals, rates of your own SSI, HAI, with national data, and similar operating surgical units. This allows units to benchmark good practice and enable the development of continual improvement strategies, such as care bundles.

Intrinsic sources of infection

The current day-patient presents many challenges to the operating surgeon and team and, addressing these challenges early, allows opportunities for infection prevention, with better patient outcomes. Modern patients can have many intrinsic comorbidities when presenting for elective or emergency surgery, which can be divided into modifiable and non-modifiable. The main intrinsic (host) factors influencing surgical infection are summarized in Table 1.

Addressing intrinsic factors in the pre-assessment clinic

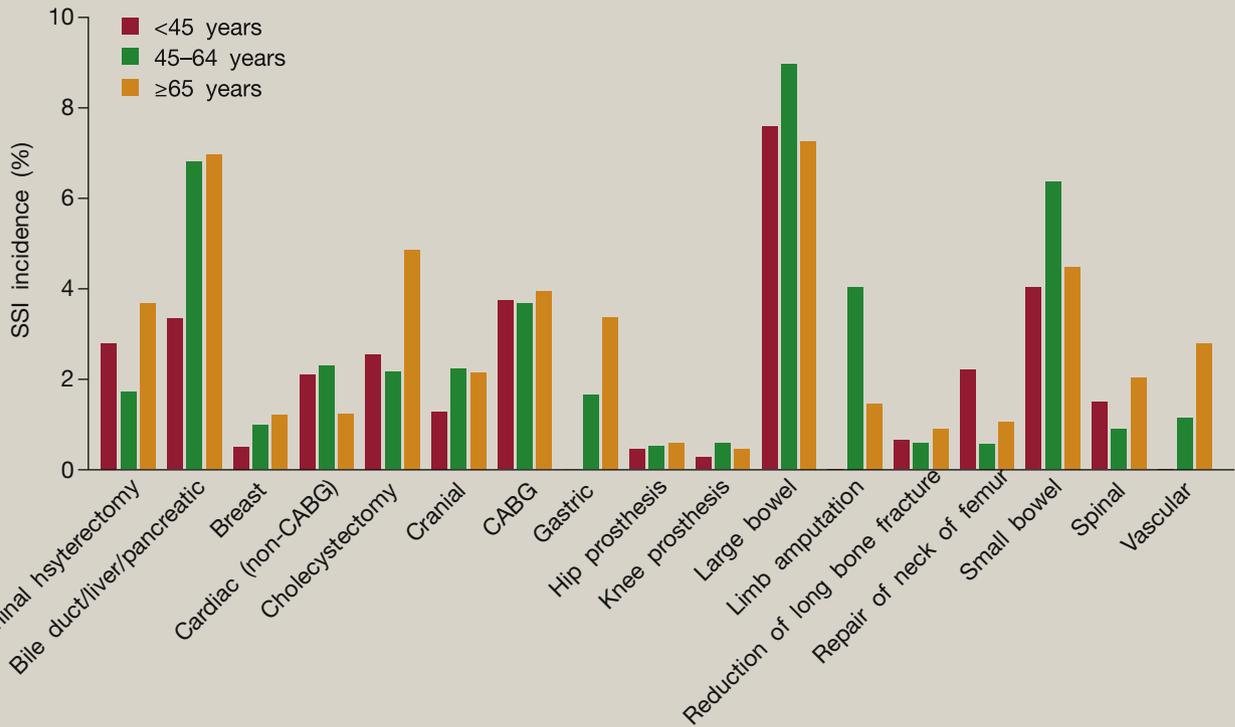
The 'one stop' preoperative assessment clinic should be done as early as possible in a patient's pathway to surgery and is pivotable to mitigating against intrinsic risks for HAI (NHS Institute for Improvement and Innovation, 2007). Examples where this works well is where anaesthetists work in parallel with the surgical team, with surgical practice specialist nurses running the clinic, after referral from the main clinic (as recommended by NICE 2015).

Depending on the type of surgery, allied health professionals, such as physiotherapists and dietitians, can contribute to the multidisciplinary team (MDT) clinic, and help empower the individual patient, by supporting postoperative recovery. The support of specialist medical colleagues is important, such as care of elderly, respiratory, endocrine, dermatology, before and during the pre-assessment clinic, if issues are found in the original surgical clinic. Mitigation of conditions be can then well before the planned surgery, allowing adjustments to be made to diabetic control, optimization of skin, respiratory, cardiac conditions, and so on.

A good clinical history, review of medications and examination is essential, and many units take base-line bloods, including HbA1C. It is no longer recommended to dip urine to investigate for infection; urine dip sticks carry a high false positive rate which result in over prescription of unnecessary antibiotics, with all the attendant risks (*C. difficile*, impact on antibiotic resistance).¹⁰ Advice is to ask about symptoms, and if the urine is turbid, send the sample directly to the microbiology lab, especially if invasive urology procedures are planned, to investigate for infection.

Screening for organisms such as meticillin-resistant *Staphylococcus aureus* (MRSA) and meticillin-sensitive *S. aureus* (MSSA) is indicated in clean surgery specialities, such as orthopaedics, with decolonization offered as appropriate. Surgical antibiotic prophylaxis for patients colonized with multidrug-resistant organisms may need to be altered to cover these

Public Health England (PHE) SSI incidence data for inpatient/readmissions, for England, for a range of surgical specialities, for 2016–2017, with stratification for age



(Reproduced with permission from PHE)

Figure 1

organisms – this should be discussed in advance before the surgical day. If the patient has a high BMI, the clinic team can ensure correct antibiotic dosing during the planned surgery, in collaboration with pharmacy and local Antibiotic guidelines.

Many hospitals have heeded the recommendations from the 2010 NCEPOD report ‘An Age Old Problem’¹¹ which supports best practice with joint surgical/medical rounds, preoperatively and postoperatively, exemplified by orthopaedic/care of the elderly practice with joint pre-assessment clinics and ward rounds.

It is worth noting that 25% of operations are performed as an emergency, and it is then down to the anaesthetist and operating team to mitigate any intrinsic factors, by choosing appropriate antibiotic prophylaxis, guided by local policy, and screening with rapid assays for organisms such as MRSA.

Extrinsic sources of infection and their prevention

Extrinsic sources of infection are those which are outwith the patient; the main factors being the hospital environment, staff hygiene standards in the interaction with the patient, devices placed in the patient such as lines, peripheral, central, urinary catheters, post-surgical drains and equipment.

Extrinsic factors affecting infection rates in the surgical pathway can be divided into:

- staff
- hospital environment

- intraoperative factors
- equipment/devices

Some factors, such as meticulous attention to basic infection control practices, such as hand hygiene, and universal infection control precautions, run throughout the surgical pathway, from the first clinic visit to eventual post-surgical discharge.

Staff factors

An estimated 20–40% of HAI have been attributed to cross infection via the hands of healthcare personnel, who have become directly contaminated from patient or indirectly by touching contaminated environmental surfaces.¹²

Hand hygiene is deemed to be central and critical to all infection control policies, and to a quality service. Hands are colonized by two categories of microbionta: resident flora and transient flora. Resident flora are found on the skin surface and are generally of low pathogenicity, such as *Staphylococcus epidermidis*. Transient flora are composed of microorganisms acquired by contact with contaminated surfaces such as the environment, patients or other people, and are easily transferred to the next patient or environment touched. These include antimicrobial-resistant pathogens such as MRSA, *Acinetobacter* or other multi-resistant Gram-negative bacteria, and viruses such as Norovirus. All of these can cause HAI if transferred on to a patient with a susceptible site such as an invasive device or wound.

Main intrinsic (host) factors influencing surgical site infections

Non-modifiable

Increasing age, frailty with associated comorbidities

Comments

The demographic is becoming increasingly older,² with hip surgery and other emergency surgeries being performed in some over 90s.

Although age in itself does not have a major influence on peri and postoperative mortality, morbidity, many older patients have co-existing medical conditions which can predispose them to postoperative infections, which can explain some of the higher risks for SSI in Figure 1 in the older age (>65 years) group. Frailty, malnutrition, functional and cognitive impairment, with patients often on multiple drugs, can impair postoperative recovery, so careful strategies should be put into the patient pathway before, during and after surgery, to support recovery.

Hosts microbiota

The patient's own microbiota can offer some limited opportunities for a prevention strategy. Patients are colonized with trillions of micro-organisms, some of which can be potential pathogens during the surgical course, and present an infection control risk on the ward, and to the postoperative wound. Screening for potential pathogens, such as MRSA, presents opportunities for decolonization preoperatively, together with infection control strategies. The PHE 2016–7 report³ showed *S. aureus* to be the predominant cause of SSI in orthopaedic and spinal surgery ($\geq 33\%$ of cases). It is suggested that combined MSSA and MRSA preoperative screening be performed for clean surgery in orthopaedics⁴ offering positive patients skin and nasal decolonization with standard antiseptics, such as chlorhexidine, mupirocin respectively preoperatively. Rapid turnaround of screening results is important, especially in emergency cases, and most laboratories now have rapid molecular diagnostics for MRSA.

With the evolution of multidrug-resistant Gram-negative organisms in the 2000s, advice from Public Health England (PHE) is to screen for multidrug-resistant Gram negative bacteria, e.g. carbapenemase-producing *Enterobacteriaceae* (CPE) in those admissions who have been hospitalized abroad and who have attended major hospitals/centres in the UK. Many referrals to specialist centres will have been in other healthcare centres previously and at higher risk of resistant organism carriage such as vancomycin-resistant enterococci (VRE), resistant Gram-negative bacteria.

These resistant organisms can cause major issues postoperatively, as limited antibiotics are available to treat HAIs caused by them. If a patient is found to be colonized, infection control actions can be taken (end of surgical lists, to allow for theatre cleaning, side room on the ward, with contact precautions) reducing the chance of onward transmission within the surgical unit. Discussion with local microbiology/infection teams are essential to develop a local screening strategy would be a pro-active approach to this increasing problem of resistance.

The host microbiota is also of consideration when undertaking 'dirty' surgery; some studies have suggested that using a combination of non-absorbable antibiotics, as selective gastro-intestinal decolonization (SDD) to potentially reduce gastro intestinal (GI) flora, may make postsurgical anastomotic breakdown less likely. Most of the work with SDD has come from the ITU setting, with recent reviews suggesting that its efficacy is limited, in particular the concern that antibiotic resistance may be promoted. In GI tract surgery preoperative bowel preparation is critical in preventing anastomotic breakdown and allowing a clear field of view. Prudent antibiotic prophylaxis is useful at the time of surgery and this is discussed elsewhere in this edition of *Surgery*.

Respiratory/cardiac conditions

Pre-existing lung conditions, such as COPD and asthma, are common comorbidities and can predispose to postoperative pneumonia. Pneumonia is a common complication following elective surgery, with an incidence of between 2% and 20%, depending on the type of surgery. A study⁵ looked at offering preoperative physiotherapy sessions, within multidisciplinary team (MDT) pre-admission clinics demonstrated a 50% reduction in postoperative pulmonary complications, especially hospital acquired pneumonia. Giving patients some autonomy over their perioperative care, such as regimens for deep breathing, taught by preoperative staff, with an app for postoperative physiotherapy, can be useful.

Immunocompromised

Immunosuppression can take many forms in the patient being considered for surgery. Advances in medicine, with more patients on immunotherapies, such as biologics, as well as steroids, methotrexate, azathioprine, etc. for Crohn's disease, and rheumatoid arthritis, are increasingly common when presenting for surgery. Complications can be increased risk of infection or slow healing of the surgical wound. Stopping medication may place the patient at risk of flare ups of disease activity so working with specialist physicians to optimize patients preoperatively is important. Routine HIV testing should be considered in any patient presenting with malignancy, especially as early identification of HIV and early treatment is linked with better outcomes.

Table 1 (continued)

Non-modifiable	Comments
Obesity	<p>Obesity is a potentially modifiable condition, when presenting to the pre-assessment clinic. It has reached epidemic proportions in the UK and the West, and is defined by the WHO as ‘an abnormal or excessive fat accumulation that presents a risk to health’. In 2007, the UK Government’s Foresight Report predicted that 50% of the UK population would be clinically obese by 2050. Obesity can increase the risk of nosocomial infections, directly being associated with respiratory conditions, such as obstructive sleep apnoea, cardiovascular and peripheral vascular disease and diabetes, as well as offering challenges intra operatively to the surgical team. Data gathered in the UK, by PHE³ demonstrated that risk of SSI increased among patients who were obese (BMI $\geq 30\text{kg/m}^2$) in the majority of surgical categories.</p> <p>The theatre list also must have the case noted carefully, as part of the surgical checklist, so as to inform the teams that additional time, equipment and preparation may be needed, with an anaesthetist experienced in bariatric anaesthesia.</p> <p>There is evidence that 2–6 weeks of intense preoperative dieting can improve respiratory function and may be worth considering⁶. Addressing nutrition issues, in the preparation stages of surgery, with supportive education on how obesity is affecting their health, can empower and motivate the patient, as does information on postoperative care of wounds.</p>
Diabetes mellitus (DM)	<p>DM is a common comorbidity presenting to pre-assessment surgical clinics and is rising in incidence. Data from the World Health Organization (WHO) 2016 estimates the prevalence of DM at 60 million Europeans (10.3% of men and 9.3% of women over the age of 25). Of note, 5–10% of patients presenting for surgery are have previously unrecognized diabetes; screening for HbA1c in important. DM is a well-established risk factor for postoperative infection, with published data showing the odds of patients with diabetes having an SSI being 1.5 times greater than those without.⁷ Patients in the later stages of diabetes may well have complications therein of micro (eye, renal) and macro (cardiac, peripheral vascular disease) angiopathies, neuropathy, renal disease, gastrointestinal and urinary dysmotility.</p> <p>Careful attention to good diabetic control is advised throughout the patient’s surgical pathway with the support of the secondary care provider/diabetic nurses, notwithstanding the often urgent need for surgery.</p>
Malnutrition	<p>Malnutrition in surgical patients is known to be associated with poor wound healing, and poor post-operative recovery. This is especially so in the elderly and should be addressed preoperatively where possible, with early dietitian input; patients receiving surgery who are malnourished have been shown to have an impaired systemic and intestinal immune function⁸ and at more risk of developing postoperative infective complications, such as SSIs.</p> <p>Certain planned surgeries, such as complex GI, will need careful preoperative and postoperative attention to nutrition, with dedicated dieticians and vascular access teams if transperenteral nutrition (TPN) is planned, especially in intra-abdominal surgery. This can reduce rates of postoperative infection, improve recovery, reduce stays.</p>
Co-existing infection at presentation to the acute take	<p>25% of surgical cases present to the emergency setting, and presentations with concurrent community acquired infection (CAI) are not uncommon. The elderly patient who fell, resulting in a fractured neck of femur, may have sustained the fall secondary to an infection; such as a pneumonia, urinary tract sepsis, and will need stabilizing ready for theatre. This is where having access to on site medical team support, such as the on call medical, or care of the elderly, microbiology/infection team, is important.</p>
Social habits such as smoking	<p>Preoperative discussion can promote smoking cessation, especially if being considered for cardiac surgery, vascular surgery. A recent meta-analysis of spinal surgery and smoking, showed SSIs to be higher in the smoking group⁹</p>

Table 1

Although there remains a lack of evidence around the NHS and DH approved ‘bare below the elbows’, or as many Trusts have developed, ‘roll up your sleeves’ in clinical areas, this has been adopted as policy in many UK Hospitals, and the Care Quality Commission (CQC). Randomized controlled trials (RCTs) are needed to explore this area, which would involve 1000s of moments of hand hygiene, patient interaction, etc. However, it is in the author’s view that it is a pragmatic approach and simple common sense to be able to wash hands and wrists effectively

(as per WHO guidelines¹³), unencumbered by cuffs and sleeves that can come into contact with clinical areas and patients, and thus present a transmission risk.

Uniform policies should reflect this, with attention to any attire which may come into contact with the clinical area and patient, being fit for purpose, and easily cleanable. Theatre attire is designed to minimize the transfer of micro-organisms from the surgical team to the patient. It also provides the surgical team with some protection from bodily fluids. Stethoscopes and hand-

held telephones should be cleaned regularly, with the former between each patient encounter.

All staff are bound by the hospital's occupational health/infection control policy, and are advised not to come into work unwell, and to be up to date with vaccinations. Any skin conditions must be assessed by the occupational health department, to see if the staff member is suitable for surgical work.

Staff preparation for theatre should be meticulous, including removal of jewellery and donning of clean scrubs and a single-use theatre cap covering the hair. Clothing does get colonized by bacteria during a 12 hour shift, both the wearer's own and the patient's in which she/he is in contact. Shedding of skin cells is a continually natural process, and these cells are colonized with bacteria that can disperse into the environment. Fresh theatre clothes per shift should be the norm, changing if they are soiled during the shift. Theatre shoes need regular cleaning (immediately when soiled, otherwise weekly), and should stay in the theatre area, with support provided for the busy staff to do this.

The surgical scrub is based on the WHO 'Guidelines on Hand Hygiene in Healthcare' and its role is to reduce the bioburden of hand flora, using a timed wash. Hands should be free of dirt and organic material, and any scrub agent must come into contact with all surfaces of the hand; A Cochrane review in 2015¹⁴ comparing different methods on the rate of SSIs and bacterial count showed limited evidence that a 3-minute scrub was better than a 2-minute scrub. The choice of surgical scrub agents available include chlorhexidine and povidone-iodine in either an aqueous or alcohol base. In the same review, the authors discussed that alcohol-related rubs reduced CFU (bacterial colony forming units), more effectively, and that chlorhexidine-based rubs reduced CFU slightly more than the povidone-iodine. The latter is associated with more allergic reactions.

Tepid water is preferred as hot water can be damaging to the skin, and only single-use nailbrushes/nail files should be utilized.

Fluid repellent face masks are recommended despite limited data for prevention of SSIs, but do provide an additional barrier against body fluids, as do single-use only eye visors. Gloves (CE marked) provide a barrier against body fluids; double gloves are sometimes worn, but there is little evidence for a reduction in SSI with double gloving. Any contamination would necessitate a re-scrub or new gloves. Gloves should not be used as a substitute for poor hand hygiene. Surgical gowns are necessarily water repellent. When removing surgical clothing, hands must be washed/decontaminated afterwards.

Staff movement in operating theatres should be tightly monitored. Only the necessary staff for the planned surgery should be present, as having increased staff within the theatre at the time of surgery increases the amount of skin cells that are shed throughout the surgical procedure, and therefore increasing the risk of surgical site infection. Staff should be encouraged to ensure doors are shut, to maintain the positive pressure and often laminar flow, from the operating table area.

Hospital environment

The hospital environment¹² can be a source of infections such as MRSA, VRE, norovirus, *C. difficile* and resistant Gram-negative bacteria, such as *Acinetobacter* spp. Multiple studies strongly suggest that environmental contamination plays an important role in the transmission of these organisms.

Environmental cleaning is another essential measure to prevent the spread of some pathogens, particularly *C. difficile* and VRE, and should not be neglected. All wards should have adequate hand washing facilities, with the provision of hand gel in every patient clinical space.

The environment of the operating theatre can have an impact on the increased risk of infection. Tight cleaning schedules, which are auditable with on-call cleaning staff and protocols ensure rapid and safe management of the surgical case load. The theatres should have policies on etiquette, clothing, traffic and cleaning, and audit them regularly. Doors must remain closed in order to maintain recommended temperature, humidity and positive air pressure. Theatre staff must be diligent that the ventilation is working prior to the operating list starting.

Cases where a resistant organism has been identified can be placed at the end of a list, for a full deep clean of the theatre afterwards.

Ventilation quality in theatres is bound by health technical memoranda (HTM), under the care of Estates and Infection Control teams, and clean theatres, such as orthopaedic, have laminar flow to allow the clean delivery of HEPA-filtered air flowing over and away from the clean surgical field. The design of theatres is key, to allow air to move from clean areas to less clean and to ensure that the temperature and humidity of the space is controlled. Set-up rooms should have filtered, clean air and be contiguous with the main operating theatre.

Water quality and cooling systems are regularly monitored by the hospital estates and infection control teams, who will alert the theatre teams if any issues.

Intraoperative factors

Before the surgery is commenced, it is important to go through a surgical check list as recommended by WHO, including whether there are any additional features to the case, which may increase the risk of an infection, such as planned duration of surgery (may need additional antibiotic dose if > 8 hours), presence of any multidrug resistant organisms, high BMI, diabetic, planned antibiotic prophylaxis and maintenance of normothermia.

Preoperative shaving of areas is no longer recommended, as it increases SSIs, per NICE Quality Standard QS49, which also recommends patients shower preoperation.

The main agents used to sterilize the patient's skin are single-use chlorhexidine or povidone-iodine preferably in an alcohol solution, allowing the skin to dry, and pre draping. Extending the field is wise, if there is the possibility of other areas being explored during the surgery. Care must be taken to avoid pooling of the skin preparation, which must be applied methodically using single-use, sterile swabs. Wound protection devices are in use in some surgery, but it is doubtful whether they reduce SSIs.

The National Institute for Health and Care Excellence (NICE) has published surgical guidelines advocating normothermia throughout surgery to help prevent surgery related infections (NICE 2016). Wound healing depends on adequate perfusion and oxygenation which are both influenced by the patient's temperature.

Equipment/devices

The theatre operating table, should be well maintained and cleaned between each case. Having access to the correct, sterile, equipment is part of the essential theatre preparation, for any

surgical lists. These are supplied in tracked, sterile packs from the HSSU (hospital sterile service unit), which can be based on or off site. Electronic tracking of all kits is essential to maintain kits and to ensure cleaning and sterilizing standards are kept. Retained equipment such as swabs, needles and instruments are an important recurring adverse event worldwide. Using standardized HSSU packs and lists of instruments helps the counting process.

Sterile single-use equipment, such as suction catheters, drains and endotracheal tubes, should only be opened onto a sterile field and used as soon as possible. Shared pieces of equipment used in the delivery of patient care (e.g. blood pressure cuffs) must be cleaned and decontaminated after each use with products recommended by the manufacturer.

Specialist surgical equipment, such as water cooling units in cardiac surgery, can be a source of postoperative SSIs. Contaminated heater cooler units used for cardiopulmonary bypass, have been found in rare instances to transmitting infection to the surgical field, from their water tanks via generation of a contaminated aerosol, resulting in post operative infections with *Mycobacterium chimaera* as a report by PHE in 2017.

Implants such as orthopaedic devices, meshes, can be a source of infection, some orthopaedic surgeons advocate antibiotic impregnated cements, made up in a sterile manner intra-operatively; these include gentamicin and vancomycin. Indwelling vascular devices can be a potential source of infection, leading to bacteraemia and sepsis. Catheters with the minimum number of ports needed should be inserted by trained personnel, with consideration to tunnelled catheters if long-term use is anticipated. Ultrasounds are advised for internal jugular central venous insertion, which need to be cleaned before and after cases. Every hospital should have a vascular access policy for safe aseptic sterile insertion, surveillance and removal of vascular access devices, with appropriate skin preparation, e.g. single-use 2% chlorhexidine gluconate in 70% isopropyl alcohol (or povidone iodine in alcohol for patients with allergy) allowing skin to dry, with preparation of the sterile field. Transparent, semi-permeable polyurethane dressings should be reviewed daily, kept up to 7 days, and changed if they are no longer intact or if moisture collects under the dressing.

The duration of central vascular lines depends on the type of surgery, varying from immediately postoperative to several days if being used for transparenteral nutrition (TPN) in complex GI surgery. If TPN is required, it is recommended that a designated single-lumen catheter is used. It is essential that central line ward care is exemplary, with daily review of site and temperature as per EPIC three guidelines,¹⁵ in the patients notes. Many hospitals have vascular access teams, who provide support, training, and can help with surveillance.

Peripheral vascular catheter insertion sites should also be inspected daily by ward staff, and the patient asked on insertion, if awake, to mention if there are issues, such as redness, pain at the site. A Visual Infusion Phlebitis (VIP) score should be recorded.

Urinary catheters should be for short-term use and assessed daily, with reasons for continued catheterization documented and removal as soon as possible.¹⁵ Daily urinary catheter charts, with bladder ultrasound scanners to assess and manage urinary retention, can help prove the quality of use. If concerned re

Definitions

App: this is a mobile application which is a computer program designed to run on a mobile device such as a phone/tablet

BMI: Body mass index

A care bundle: this is a group (3–5) of five evidence-based practices which, when they are done consecutively, have been proven to improve patient outcomes

CAI: Community-acquired infections are those which present within 48 h of hospital admission

CFU: colony forming units

CPE: Carbapenem-resistant Enterobacteriaceae

HAI: Hospital-acquired infection is that which occurs after 48 h of hospital admission

MRSA: Meticillin-resistant *Staphylococcus aureus*

MSSA: Meticillin-sensitive *S. aureus*

NICE: National Institute for Health and Care Excellence, UK

PHE: Public Health England is a national body, within the Department of Health

SSIs: Surgical site infections

Surgical Checklist: This is a safety checklist advised for every patient undergoing surgery, introduced by the World Health Organization (WHO), in an effort to improve communication, and patient safety

TPN: trans-parenteral nutrition

infection, check the turbidity of the urine, if turbid send a culture, and consider a catheter change, if still needed.

Drains inserted inter-operatively under sterile conditions, should be monitored daily for signs of infection, and removed as soon as is possible.

Dressings are used to cover the surgical wound, and should be of low adherence, ideally transparent polyurethane dressings, which offer wound protection, and allow the checking of the surgical incision site for any signs of wound infection without having to disturb the dressing itself. They can be left in place for between 3 and 5 days, during which time epithelialization has occurred, to allow the wound to heal by primary intention.

Endoscopes used in the operating theatre must be transported safely in a designated container to a central reprocessing unit, and tracked.

Discussion

Not all HAI in surgery can be prevented, but by putting in place good evidenced-based pathways of care, MDT pre-assessment

clinics and surgical checklists, most can be pre-empted, recognized early and often prevented.

Tool kits such as the PHE SSI allow an active SSI surveillance system to be set up, ensuring that SSIs occurring post discharge are picked up which are often missed. Patient information leaflets, with an emergency number to call, are useful. Data submitted to PHE contributes to the UK healthcare-associated infections surveillance network (HAI-Net) to enable inter-country comparisons of SSI rates. Surveillance of SSIs, with careful look for an organism trend, is important to identify if there are similar organisms causing the SSIs; if so, consult with the microbiology/infection control team, to send related isolates for further typing to determine if they related. It is useful to have MDTs in the infection/microbiology team, as this is an opportunity to discuss any complex cases, and any issues around SSIs rates, linked infections, and so on, to enable shared learning and improvements to be instigated.

Care bundles can be utilized to improve patient outcomes by putting together evidence-based elements in the surgical pathway, such as antibiotic prophylaxis according to local guidelines, no hair removal, normothermia and 'hygiene discipline' in the operating room (i.e. number of door movements). In a study by Koek, using this approach, the SSI risk was significantly lower for surgeries with complete bundle compliance compared to surgeries with lower compliance levels.

Undertaking local audits, as well as participating in national audits, mandatory reporting and initiatives, help drive up quality and improve patient care. An initiative led by an orthopaedic surgeon, 'Getting it Right First Time (GIRFT)' has been piloted by the NHS. Several other specialities, both medical and surgical, have adopted this approach, which has led to substantial savings and improvement of surgical outcomes.

Patient empowerment in their own care, especially around weight loss, diabetic control, perioperative self physiotherapy and wound surveillance, can be an additional effective strategy in reducing HAI.

Self-reporting, with a postoperative surgical information leaflet, and reporting symptoms to the surgical team via a phone line, is helpful. PHE are in the process of developing an electronic patient questionnaire system as an extension to the existing surgical infection reporting system.

It is hoped that by reading this review, which does not claim to be exhaustive, that the surgeon can be aided in reducing HAI in the surgical pathway of their patients, by understanding a bit more of the role of intrinsic and extrinsic factors in the development of a HAI, to enable prevention/mitigation strategies to be put in place to ensure the safest possible care pathways. ♦

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