Early and repeated swabbing of surgical wounds: sternal incision specimen audit

KEY WORDS
- Alert organisms
- Candida Auris
- Cardiac
- Infection control
- Swabbing

Background: In 2016, the Royal Brompton Hospital site introduced frequent/repeated swabbing of the chest wound site from 2 days after surgery to screen for alert organisms. Following this, the number of surgical site infections (SSIs) increased. **Methods:** The authors used prospective SSI data and audited the characteristics of patients who developed SSIs. They also reviewed other factors that might have an impact on SSIs to identify the possible cause. **Results:** No single surgical team, theatre/environment or product was associated with the outbreak. Audit data demonstrated an almost four-fold increase in superficial SSIs that coincided with the introduction of the intense swabbing regimen (means: 0.7% prior to and 2.6% after the introduction of screening). **Conclusion:** Early and frequent or repeated swabbing of a healthy new surgical wound may disrupt the epithelisation/healing process and increase the risk of infection by opportunistic pathogens. Further investigation and analysis is needed.

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The Royal Brompton Hospital uses the 2013 Public Health England (PHE) surgical site infection (SSI) protocol for monitoring and reporting SSIs in coronary artery bypass graft (CABG) and general cardiac surgery patients. Hospitals participating in the scheme may receive notification if their SSI rates are in the top or bottom 10% (PHE, 2013a). PHE suggests that outlier notification does not necessarily indicate that there is a problem, but rather that notification should act as a prompt to review the case mix, surveillance methodology and infection prevention practices (Rochon, 2012a).

THE INITIAL REVIEW

In 2016, the hospital received PHE notification of high outlier status. This coincided with local findings of elevated SSI rates. Practices and processes were comprehensively reviewed following an established processes for root cause analysis (Rochon, 2012a).

No common environment(s), operator(s), microorganism(s) or factor(s) were identified; however, there were similarities in SSI presentation. The majority of cases were found to be superficial incisional sternal SSIs concerning the skin and subcutaneous tissue (PHE, 2013a), see *Figure 1*. Most of the infections were caused by Gram-positive bacteria (GPB). Gram-positive SSIs are usually associated with endogenous bacteria (i.e. the patient's own "normal" bacteria), whereas Gram-negative bacterial infections indicate that clinical practices may have moved the microorganism to the surgical site. The SSIs were presenting on primary admission, as opposed to being detected on readmission. This suggested an earlier onset while the patient was still in hospital.

THE AUDITS

The surveillance team repeated audits of areas including the theatres and wards on a weekly and monthly basis. Practices, processes and products were reviewed, as well as environmental factors.

Temperature and humidity

The peak of the outbreak was in the summer months and it was suggested that the heat and humidity were affecting wound healing. To examine this, we looked at the temperature and humidity in the relevant theatres and wards for a 5-day period starting from the day of the operation for each case of SSI.

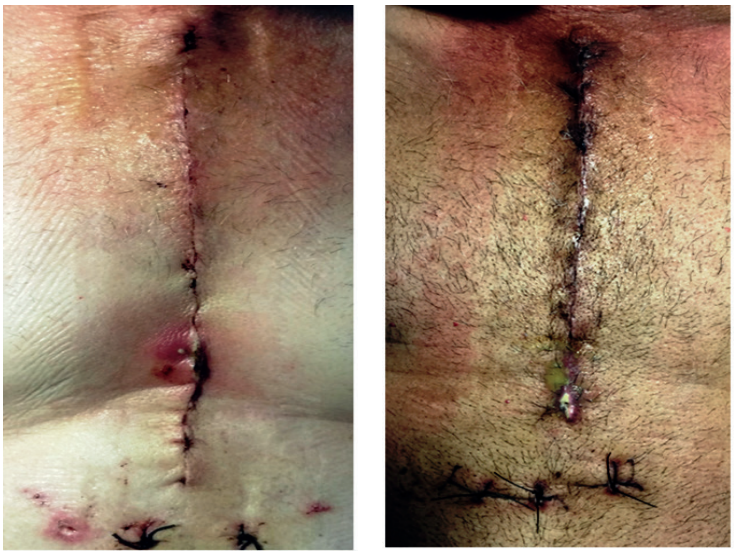

Figure 1. Examples of superficial incisional sternal surgical site infection

A study by Shuhaiber et al (2008) found that SSI rates in cardiac surgery are higher in the winter months. The authors sought information from PHE regarding national trends on SSIs and seasonal changes. PHE performed two equivalent analyses for January 2011 to March 2016. The aggregated data for the four individual seasons showed bimodal seasonality, with peaks in winter.

The second analysis of national data examined quarterly trends over the period of interest. SSI incidence peaked in winter periods (calendar quarter 4 or 1). Over the 5-year period, a peak in calendar quarter 2 occurred only once in CABG and cardiac non-CABG, but in separate years. Thus, from local and national data, it did not appear that high temperature or humidity were responsible for the outbreak.

Air quality

Environmental screening was reviewed. The theatre air samples, which were obtained by an external contractor, were reassuring. Sampling on the wards, including fans, was undertaken with the agreement of a consultant microbiologist. Wilson (2012) found that environmental screening is difficult to interpret as bacteria will be present in the environment at varying levels. Although fans can potentially make microbes airborne and disperse them, Wilson notes that there is no evidence that fans pose any risk. Our fan results were unremarkable. Coagulase-negative *Staphylococcus* was most commonly found them, but no results appeared to be linked to the microbiology results from SSIs and/or by time or location.

Table 1. Characteristics of patients who developed surgical site infection during a 2-month period

Gender *	Theatre †	Age	Diabetes ‡	Smoking status	Urgency	Team	Pre-op ward	Post-op ward	Cardiac procedure	Return to theatre	Pre-op stay (days)	Dur op (min)	Days to SSI onset	SSI microorganism**
F	4	76	Y	Never	Elective	1	A	A	CABG	N	1	134	9	*Staphylococcus*, coagulase-negative (CNS)
M	4	80	Y	Previous	Elective	2	B	A	CABG + other	N	9	270	18	Missing/null
M	4	48	Y	Previous	Elective	2	A	C	CABG	N	2	240	6	*Staphylococcus epidermidis*
M	5	79	N	Never	Urgent	3	A	A	Valve + other	N	3	250	4	*Staphylococcus*, coagulase-negative (CNS)
M	4	68	Y	Previous	Elective	1	A	A	CABG	N	5	250	6	*Staphylococcus epidermidis*
M	6	73	N	Never	Urgent	1	C	C	CAGB + other	N	1	250	5	*Staphylococcus epiderimidis*
M	5	56	N	Never	Elective	2	C	C	CABG + other	N	1	200	17	*Klebsiella pneumoniae* (*aerogenes*)
M	1	82	N	Previous	Elective	4	C	A	Valve	N	17	220	11	Missing/null

* P=0.7; † Percentage of cardiac cases: theatre 1: 20%, theatre 2: 2%, theatre 3: 0%, theatre 4: 53%, theatre 5: 14%, theatre 6: 11; ‡ P=0.2; ** Where microorganism is the same, no same strains were found. CABG = coronary artery bypass graft; CNS = central nervous system; Dur op = duration of operation; Post-op = postoperative; Pre-op = preoperative; SSI = surgical site infection

Box 1. Alert organisms and the risks they pose

Acinetobacter

This group of Gram-negative bacteria are commonly found in the soil. All of the species in this genus may cause disease (PHE, 2008). Alsan and Klompas (2010) report that this genus can be a key source of infection in debilitated patients. Outbreaks of *Acinetobacter baumannii* infections typically occur in intensive care units.

Candida auris

This is a species of fungus that grows as yeast. It has caused outbreaks in healthcare settings. For this reason, it is important to quickly identify *C. auris* in a hospitalised patient so that special precautions can be taken to stop its spread (PHE, 2017a). *C. auris* can cause invasive infections, including bloodstream infections (candidaemia). It is often multi-drug resistant and tends to infect patients who have been in an intensive care environment for an extended period of time and those who have received antibiotics or antifungal medications (Schlenz et al, 2016).

Carbapenemase-producing/carbapenem-resistant *Enterobacteriaceae*

This group of Gram-negative bacteria is resistant to the carbapenem class of antibiotics. These organisms produce enzymes called a carbapenemase that prevent these antibiotics from working (PHE, 2013b). The *Enterobacteriaceae* family includes disease-causing bacteria such as *Salmonella*, *Escherichia coli*, *Klebsiella*, *Shigella*, *Enterobacter*, *Serratia* and *Citrobacter*. Carbapenem-resistant bacteria are an emerging cause of hospital-acquired infection. They pose a significant threat to public health. These bacteria are difficult to treat due to high levels of antimicrobial resistance and are associated with high mortality (Peleg and Hooper, 2010).

Risk of infection:

- All of these alert organisms have the potential to spread infection via person-to-person contact or from contact with contaminated surfaces.
- These organisms are unlikely to pose a risk to healthy individuals.
- The immunocompromised may be more susceptible to infections with these organisms, particularly ventilated patients in intensive care units, those with a prolonged hospital stay, those who have open wounds, and any patient with invasive devices such as urinary catheters (Peleg et al, 2008, PHE 2013; PHE 2017a).

Staff

When patients' treatment and recovery were compared, no common operator(s), surgical team, theatre or ward was identified. Repeated theatre audits indicated a high level of theatre traffic and frequent door openings, but this finding was in keeping with audits from other years.

Products

The Medicines & Healthcare products Regulatory Agency (2015) indicates that contaminated or out-of-date stock poses a risk to patients. Products such as alcohol hand gel, drapes, skin preparation solutions, dressings and sutures were examined to ensure they were intact and in date. All stock was found to be in good condition.

Processes

Processes that may contribute to hospital-acquired infection were monitored. These included decontamination of equipment (Dancer, 2014), hand hygiene (Boyce and Pittet, 2002; Pratt et al. 2007), aseptic non-touch technique and dressing compliance. The scores were unremarkable, and in some cases showed improvement on the results from the previous year.

Patient characteristics

Table 1 gives an overview of the characteristics of patients who developed SSIs over a 2-month period. There were no significant trends identified in this subset of patients or the larger group of patients who developed SSIs.

Practice

One significant change in practice affecting the patient group was an increase in the implementation of infection prevention and control screening for alert organisms, see *Box 1*. Alert organisms require infection control management, such as source isolation. In response to concerns over alert organisms (unrelated to

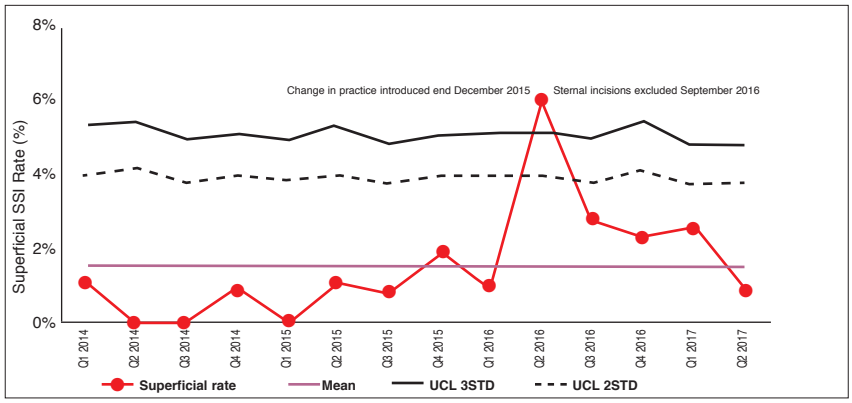

Figure 2. Three-year overview of the percentages of surgical site infections

SSI), the Royal Brompton Hospital had introduced an intensive screening regime, including the nose, axillae, groins, rectum and any surgical wound. Thus, cardiac surgical wounds were included and subsequently samples were taken from the chest wound, commencing day 2 and repeatedly/frequently swabbed thereafter. This new practice coincided with the rise in SSI rates, see *Figure 2*.

Patient characteristics and operational risk factors for SSIs are highlighted in the 2014 Scottish Intercollegiate Guidelines. Epithelial cells tend to bridge surgical incisions in the first 48–72 hours, see *Figure 3*. This may not be the case with cardiac patients, however, as they often have additional factors that impede healing, such as the use of bilateral mammary arteries, diathermy or cardiopulmonary bypass and pharmaceutical support, such as sympathomimetic agents and vasopressors. Healing may also be compromised by mechanical forces, such as those caused by additional fluid around the wound site. Local unpublished data found the average weight gain due to fluid retention on day 2 was 5.7 kg (range: 1.2–14.4 kg). Additional fluid at the inframammary folds during sitting or medial-lateral pull from breasts can put the median sternotomy incision under pressure. For these reasons, the new cells are still delicate and need protecting (Ross, 2004).

RESULTS

The superficial rates of SSI from the start of 2014 to August 2017 were compared, see *Figure 2*. Despite this, there was a significant, almost fourfold increase (3 above sigma) in the second quarter of 2016. The average superficial SSI rate increased from 0.7% prior to implementation of the infection control and prevention screening regimen to 2.6% just afterwards.

The increased frequency of swabbing — to a daily basis at times — was concentrated in the summer months of 2016. The proportion of SSIs detected on primary admission rose steeply from just under 40% beforehand to >60% during this period (June and July 2016 data). We received infection prevention and control advice to exclude sternal wound swabs September 2016.

There was a sharp increase in the number of SSIs associated with GPB in 2016, see *Figure 4*. The calendar year accounted for the highest incidence and proportion of GPB infections. There was no common species. GPB identified included coagulase-negative *Staphylococcus*, *Staphylococcus epidermis* and *Staphylococcus warneri*. Where common species were identified, the sensitivity and resistance patterns suggested that the strains were distinct.

The numbers of cardiac operations included in the surveillance were similar in 2015 (823) and 2016 (801). In 2016 there was a 98% increase in the number of swabs taken for routine screening purposes from sternal incisions compared to 2015 (1,005 *versus* 23 swabs, respectively). An average of 2.6 swabs were taken from each patient (390 cardiac swabs from 148 patients). During June and July 2016, one in six of the sternal swabs were taken on or before day 4.

None of the samples obtained for screening purposes were found to be positive for alert organisms. Cultures from samples taken over a period of time frequently presented a similar pattern: they were initially negative, and then became positive for resident bacteria (not normally reported) although the wound did not have evidence of clinical infection. Audit was unable to determine how samples that had positive results were obtained, but a difference in technique was found:

- 58% (7/12) swabbed the length of the surgical incision
- 42% (5/12) only swabbed the deepest part of the incision
- 42% moistened the swab prior to swabbing
- 50% (6/12) used a dry swab
- 8% (1/12) sometimes moistened the swab.

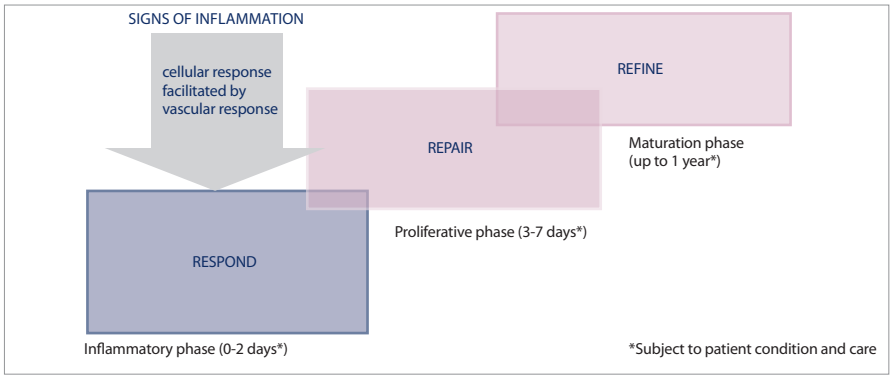

Figure 3. Response to trauma, foreign material, wound breakdown or infection (adapted from Rochon, 2012c)

DISCUSSION

Multiple contributing factors are often responsible for SSI and it is not possible to draw on retrospective audits for causal inference. However, this outbreak of SSIs coincided with an intensive screening regimen related to alert organisms including *Acinetobacter*, carbapenem-resistent *Enterobacteriaceae* and *Candida auris*.

Our local policy defines SSI outbreak as two or more SSIs with or without the same causative agent identified over a defined period of time and in the same geographical area. Patients' own microflora appear to be responsible in the majority of superficial inpatient SSIs. Initially reviews focused on patient washing or showering facilities, but this did not reveal any issue. Resident bacteria are not usually associated with infection unless transferred to unhealthy or breached tissue, when commensals can become opportunistic pathogens (Rochon, 2012b).

We postulate that an intensive, repeated swabbing regimen commencing 48 hours post-operatively can disturb the newly-epithelialised surgical wound. Thus, the wound bed is not sealed against pathogenic invasion during the postoperative period (Raja, 2013). It is possible that cardiac patients are particularly vulnerable to this, as many have comorbidities or other factors that may compromise healing. The advice to swab all cardiac wounds on alternate days or a daily basis changed over a period of months and tracing this advice is problematic because of general guidance versus patient-level advice. Although we have attempted to use audit to provide clinical groups with a picture of patient care and to challenge practice (Dixon and Pearce, 2011), we are hypothesising and further investigation and analysis is required.

It was interesting that over time our screening results often changed from negative, before evidence of host response/disturbed healing, to positive due to colonisation with an opportunistic pathogen. The earlier Gram-stain may show repair, i.e. the presence of epithelial cells (Woolf, 2000), in response to mechanical disruption caused by the swab. From snap-shot audit data, it is not possible to ascertain whether the swabbing technique (length or "deepest part of the wound") made a difference, as staff reported different techniques. In theory at least, swabbing the deepest part of the wound may cause more damage, as the nurse would swab an unhealed or vulnerable area.

The cardiac department uses antimicrobial sutures, which should offer protection for approximately 11 days. These sutures are used for subcuticular stitches only millimetres from the skin's surface. The review identified no new and/or common operator(s) or combination of operators who were not following the skin closure protocol.

The National Institute for Care and Excellence 2017 guidance on SSI prevention includes the recommendation to cover the surgical wound for the first 48 hours to protect the healing process. There is no evidence that keeping a surgical wound covered for longer reduces the risk of infection (Blazeby, 2016), even for solely superficial SSIs (relative risk 0.64, 95% confidence interval 0.32–1.28) (Toon et al, 2015). Our experience, however, suggests that early and/or repeated swabbing of the incision may extend the period of vulnerability and risk introducing resident bacteria and may therefore increase the time wounds need to be covered.

The purpose of the increased number of screening samples taken from surgical wounds was to obtain information on colonisation of the wound bed. The surgical wounds were dressed with an interactive dressing, which should prevent bacterial ingress if well applied and intact. None of the surgical wounds healing by primary intention were found to contain *Acinetobacter*, carbapenemase-producing *Enterobacteriaceae* (CPE) or *C. auris*. Interestingly, had a wound sample been positive, there was no routine topical treatment for colonisation for these microorganisms.

National guidance for CPE does not recommend routine screening of surgical wounds, since it is commonly associated with the gut rather than

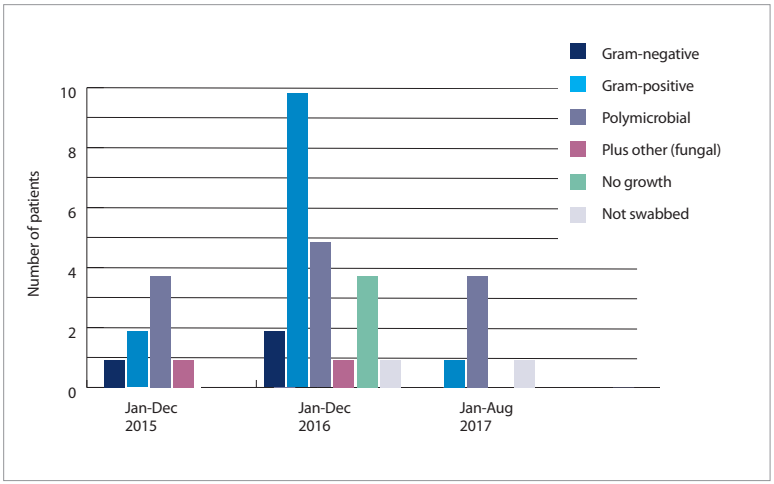

Figure 4. Microorganisms causing surgical site infections

skin flora (PHE 2013; 2014). It is noted, however, that Health Protection Scotland's 2017 CPE risk assessment suggests that a bacteriology swab (in addition to the rectal swab or stool sample) should be taken from patients with wounds or lesions.

CHANGES AFTER THE AUDIT

The audit helped update national guidance on suggested screening sites for *C. auris*. The 2016 PHE guidance included wound swabs in its recommended sites for screening, since this fungal pathogen has been found in wound infections. The guidance has since been changed to screen for *C. auris* if clinically indicated on appropriate multidisciplinary advice (PHE, 2017a).

Reducing unnecessary laboratory testing is an important way of reducing healthcare costs (Khalifa and Khalid, 2014). The change in screening has been associated with monthly pathology savings equivalent to £961.41 for microscopy, culture and sensitivities and £29,878.17 for *C. auris* screening of sternal wounds at Royal Brompton Hospital.

As a result of the SSI outbreak audits, our infection control policy and guidance has changed. Surgical wounds has been removed from recommended sites for screening; only surgical wounds with clinical concerns about infection now require a specimen for microbiological testing. Our dressing guideline has also been changed to advise avoiding unnecessary and repeated wound swabs.

RECOMMENDATIONS

A number of recommendations have arisen following the SSI outbreak at Royal Brompton Hospital. First, cardiac surgical wounds should be excluded from routine screening if these wounds appear healthy and are not showing clinical signs of infection. Surgical wounds should only be swabbed if there is a clinical indication of infection or following a specific request from the consultant microbiologist. The aim of swabbing a clinically-suspected infection is to improve upon an empirical course of treatment. Whether antimicrobial sutures are used should be recorded.

More generally, avoid repeated swabbing due to superficial wound concerns. Ask yourself:

- Is the therapy appropriate based on the last results?
- Has the therapy had time to work (2–3 days)?
- Is there deterioration? If so, is this deterioration deep, i.e. is a tissue sample required at theatre level?

In cases of deep incisional and organ/space cardiac SSI, obtain tissue sample(s) in theatre so they can be tested for mycobacterial infection. Refer to mycologist as necessary. Directly test any non-repeatable samples from these patients (e.g. valve tissue, bone or other surgical samples) for mycobacteria by mycobacterial culture and 16S rRNA gene sequencing. If testing for differential diagnosis is required, for instance with infective endocarditis, take three sets of mycobacterial blood cultures in appropriate bottles (PHE, 2017).

If *Aspergillus* or fungal infection is suspected, beta-glucan testing is recommended. Refer the patient to the consultant physician if an infectious disease is present and arrange for medical mycology. For *C. auris*, refer to PHE guidance (2017b).

CONCLUSION

Our audit data suggest that early and excessive swabbing of surgical wounds may disrupt healing and inadvertently increase the risk of infection. Bacteria will rarely breach intact skin, but mechanical disruption may lead to the introduction of opportunistic pathogens, usually harmless bacteria, in a vulnerable patient and may cause SSI. Correct dressing management and basic infection control measures will reduce the risk of SSI. Our dressing guideline and infection prevention advice were updated to reflect our learning. WUK

REFERENCES

Alsan M, Klompas M (2010) Acinetobacter baumannii: An emerging and important pathogen. *J Clin Outcomes Manage* 17(8): 363–9

Blazeby JM; Bluebelle Study Group. (2016) Do dressings prevent infection of closed primary wounds after surgery? *BMJ* 353: i2270

Boyce JM, Pittet D; Healthcare Infection Control Practices Advisory Committee; HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. (2002) Guidelines for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Infect Control Hospital Epidemiol* 23 (12): S3–40

Dancer SJ (2014) Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. *Clin Microbiol Rev* 27(4): 665–90

Dixon N, Pearce M (2011) *Guide to Ensuring Data Quality in Clinical Audits. Healthcare Quality Improvement Partnership* Healthcare Quality Improvement Partnership. Available at: www.hqip.org.uk/resources/hqip-guide-to-ensuring-data-quality-in-clinical-audits/ (accessed 6 February 2018)

Khalifa M, Khalid P (2014) Reducing unnecessary laboratory testing using health informatics applications: a case study on a tertiary care hospital. *Procedia Computer Science* 37: 253–60

Health Protection Scotland (2017) Toolkit for the early detection, management and control of carbapenemase-producing Enterobacteriaceae in Scottish acute settings. HPS. Glasgow. Available at: http://bit.ly/2E5CMWb (accessed 6 February 2018)

Medicines & Healthcare products Regulatory Agency (2015) Managing Medical Devices: Guidance for healthcare and social services organisations. Medicines & Healthcare Products Regulatory Agency. April 2015. Available at: http://bit.ly/1mpoAtA (accessed 6 February 2018)

National Institute for Health and Care Excellence (2008) Clinical Guideline 74. Surgical Site Infections: Prevention and Treatment. Available at: www.nice.org.uk/guidance/cg74 (accessed 6 February 2018)

Peleg A, Hooper D (2010). Hospital-acquired infections due to Gram-negative bacteria. *N Engl J Med* 362(19): 1804–13

Peleg A, Seifert H, Paterson D (2008) Acinetobacter baumannii: emergence of a successful pathogen. *Clin Microbiol Rev* 21(3): 538–82

Public Health England (2008) Acinetobacter species. Available at: www.gov.uk/guidance/acinetobacter-species (accessed 6 February 2018)

Public Health England (2013a) *Protocol for Surveillance of Surgical Site Infection: Surgical Site Infection Surveillance Service. Version 6 [June 2013] r1.* PHE, London. Available at: http://bit.ly/2ATrPlw (accessed 6 February 2018)

Public Health England (2013b) Carbapenemase-producing Enterobacteriaceae: early detection, management and control toolkit for acute trusts. Available at: https://www.gov.uk/government/publications/carbapenemase-producing-enterobacteriaceae-early-detection-management-and-control-toolkit-for-acute-trusts(accessed 6 February 2018)

Public Health England (2014) *Acute trust toolkit for the early detection, management and control of carbapenemase-producing Enterobacteriaceae: Frequently Asked Questions for Health Professionals.* PHE, London. Available at: http://bit.ly/2sblGAt (accessed 6 February 2018).

Public Health England (2016) *Guidance for the laboratory investigation, management and infection prevention and control for cases of Candida auris.* PHE, London.

Public Health England (2017a) *Guidance for the laboratory investigation, management and infection prevention and control for cases of Candida auris. August 2017 v2.0.* PHE, London. Available at: http://bit.ly/2BZqVmC (accessed 6 February 2018)

Public Health England (2017b) *Mycobacterium chimera Infections Associated with Cardiopulmonary Bypass: Clinical guidance for secondary care. Version 1.* PHE, London. Available at: http://bit.ly/2BdYzbH (accessed 6 February 2018)

Pratt RJ, Pellowe CM, Wilson JA et al (2007) epic2: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. *J Hosp Infect* 65: S1–64

Raja SG (2014) Letter to the editor: Is it possible to eliminate sternal wound infection after cardiac surgery? *Kardiochirurgia i Torakochirurgia Polska* 11(2): 230–2

Rochon M (2012a) SSI: using root cause analysis. *Clinical Services Journal* November: 25–8

Rochon M (2012b) Wound healing and surgical site infection. In: Woodhead K, Fudge L, eds. *Manual of Perioperative Care: An Essential Guide*. Wiley-Blackwell, London

Rochon M (2012c) SSI surveillance: a combined approach. *Clinical Services Journal* August: 42–5

Ross G (2004) Surgical wound care: current views on minimising dressing-related pain. *Nurs Times* [online] Available from: http://bit.ly/2sgvYj2 (accessed 6 February 2018)

Schelenz S, Hagen F, Rhodes J et al (2016) First hospital outbreak of the globally emerging Candida auris in a European hospital. *Antimicrob Resist Infect Control* 5(1): 35.

Scottish Intercollegiate Guidelines Network (2014) *Antibiotic Prophylaxis in Surgery: National Guideline 104. July 2008, updated April 2014.* SIGN, Edinburgh. Available at: www.sign.ac.uk/assets/sign104.pdf (accessed 6 February 2018)

Shuhaiber J, Goldsmith K, Nashef S (2008) The influence of seasonal variation on cardiac surgery: A time-related clinical outcome predictor. *J Thorac Cardiovasc Surg* 136(4): 894–9

Toon CD, Lusuku C, Ramamoorthy R et al (2015) Early versus delayed dressing removal after primary closure of clean and clean-contaminated surgical wounds. *Cochrane Database Syst Rev* (9): CD010259

Wilson J (2012) *Infection Control in Clinical Practice.* 4th Edn. Baillire-Tindall, London

Woolf N (2000) *Cell, Tissue and Disease: The Basics of Pathology.* 3rd edn. W B Saunders, London

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