Original Article

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A Study of Methods Used to Reduce Surgical Site Infections

Stuart R. Walker[1], Tara Anderson[2]

Abstract

Objective: Surgical site infections (SSI) remain a cause for concern. The aim of this audit was to assess current practise in an Australian Teaching Hospital when compared to guidelines issued by NICE (UK).

Methods: A prospective audit of cases passing through the operating theater complex of a teaching hospital over four weeks. Practise was assessed against criteria designed to reduce the incidence of SSI.

Results: 570 surgical cases were analyzed. In 126 cases (22%), hair was removed pre-operatively, 84% via clippers and 15% via razor. There was a large variation in the type of skin preparation used, with aqueous betadine/iodine being the most common (377 cases). In 340 cases (61%), the skin preparation was allowed to dry prior to skin incision. In 161 cases, an occlusive drape was used (28%). 339 patients (59%) received prophylactic antibiotics. The appropriateness of antibiotic prophylaxis was reviewed in relation to local guidelines. In the 238 cases where the timing of the antibiotics was recorded, the mean time prior to incision was 18 mins (the range was 180 minutes to 15 minutes after the incision). 248 patients had no active warming in theater. Their mean temperature on arrival in recovery was 36.6°C. 292 patients had active warming. Their mean body temperature on arrival in recovery was 36.7°C (Student T test p = 0.222, 95% confidence interval -0.137 to 0.032).

Conclusion: In this hospital there was poor compliance when measured against the NICE recommendations.

Keywords: *Surgical site infection, prevention*

[1]Department of Vascular and Endovascular Surgery, Royal Hobart Hospital, AUSTRALIA
[2]Department of Infectious Diseases and Microbiology, Royal Hobart Hospital, AUSTRALIA

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Corresponding Author
Stuart Walker
Department of Vascular and Endovascular Surgery,
Royal Hobart Hospital,
Liverpool Street,
Hobart, Tasmania 7001,
AUSTRALIA
stuart.walker@dhhs.tas.gov.au

Introduction

In October 2008, the National Institute of Clinical Excellence (NICE) in the United Kingdom published a clinical guideline entitled Surgical Site Infection, prevention and treatment of surgical site infection [1]. This publication was timely; shortly after, a publication by Haynes drew widespread citations in both the medical and lay press regarding the introduction of a checklist to reduce surgical complications [2]. These two publications have focused attention on efforts to reduce the incidence of surgical site infections (SSI), which can occur in up to 27% of patients [3]. The aim of this study was to assess the current compliance with the

Table 1. Cases in which hair was removed pre operatively.

Procedure (n = total number of these procedures over the study period)	Method of hair removal (n)	Timing of hair removal (n)
Laparoscopic or open nephrectomy (2)	Clipper (2)	Theatre (2)
Gynaecological laparoscopic procedures or open laparotomy access cases (28)	Clipper (6)	Theatre (6)
General surgery laparoscopic procedures e.g. laparoscopic cholecystectomy, laparoscopic appendicectomy or open laparotomy access cases e.g. open appendicectomy, open bowel resection (54)	Razor (1) Clipper (15)	Theatre (16)
Pilonidal sinus surgery (2)	Razor (1)	Theatre (1)
Skin graft (7)	Clipper (5)	Theatre (5)
Cardiac surgery, including coronary artery bypass surgery, cardiac valve replacement, pacemaker insertions or box changes (44)	Clipper (26)	Ward (24) Theatre (2)
Craniotomy/ insertion of VP shunt (13)	Razor (3) Clipper (10)	Theatre (13)
Excision of skin lesion (23)	Razor (2) Clipper (2)	Theatre (4)
Radical prostatectomy (5)	Clipper (5)	Theatre (5)
Caesarean section (22)	Razor (2) Clipper (6) Waxed (1)	Prior to admission (2) Theatre(7)
Inguinal or umbilical hernia repair , excluding laparoscopic repairs (15)	Razor (1) Clipper (4)	Theatre (5)
Anterior cervical disc fusion, lumbar disc fusion or laminectomy (15)	Razor (1) Clipper (3)	Theatre (4)
Ankle arthrodesis (1)	Clipper (1)	Theatre (1)
Arthroscopy of any joint (7)	Clipper (3)	Theatre (3)
Femoral aneurysm repair (1)	Clipper (1)	Theatre (1)
Varicose veins surgery (2)	Razor (1)	Home (1)
Mastectomy and excision of breast lump (4)	Razor (1)	Theatre (1)
Debridement of clicking ribs (1)	Clipper (1)	Theatre (1)
Radical vulvectomy (1)	Clipper (1)	Theatre (1)
Removal of metal or infusaports (11)	Clipper (1)	Theatre (1)
Joint replacement (11)	Clipper (1)	Theatre (1)
Neck dissection or exploration (2)	Clipper (1)	Theatre (1)
Open reduction and internal fixation of fracture (24)	Clipper (6)	Ward (1) Theatre (5)
Orchidectomy/orchidopexy (5)	Razor (1) Clipper (2)	Theatre (3)
Video assisted thoracotomy (5)	Clipper (1)	Theatre (1)
Removal of lumbar drain (1)	Razor (1)	Theatre (1)
Repair tibial artery mycotic aneurysm (1)	Razor (1)	Theatre (1)
Excision nose tumour (1)	Razor (1)	Home (1)
Thyroidectomy (5)	Razor (1)	Theatre (1)

Table 2. Skin preparation.

Skin preparation	Number (%)
Povidone-iodine aqueous solution, no strength stated	326 (57)
Alcoholic iodine solution – 2.5% iodine, 2.5% potassium iodide in 86% ethanol	57 (10)
Povidone iodine 10% aqueous solution	29 (5)
Chlorhexidine no strength stated in alcohol 70%	26 (5)
Betadine – 10 % povidone iodine in 30% ethanol	21 (4)
Chlorhexidine 0.5% and cetrimide 150mg/30ml aqueous solution	24 (4)
Povidone iodine 5% aqueous solution	19 (3)
Chlorhexidine 0.02% aqueous	19 (3)
Chlorhexidine 0.05% and cetrimide 0.5% aqueous solution	7 (1)
Chlorhexidine aqueous no strength stated	10 (0.5)
Chlorhexidine 2% in alcohol 70%	3 (0.5)
Povidone-iodine aqueous solution, no strength stated PLUS Chlorhexidine 0.02% aqueous	2
Povidone-iodine aqueous solution, no strength stated PLUS Chlorhexidine 0.05% and cetrimide 0.5% aqueous solution	3
Povidone-iodine aqueous solution, no strength stated PLUS Chlorhexidine 0.5% and cetrimide 150mg/30ml aqueous solution	2
Povidone-iodine aqueous solution, no strength stated PLUS chlorhexidine in aqueous solution but no strength stated	4
Povidone-iodine aqueous solution, no strength stated PLUS chlorhexidine no strength stated in alcohol	2
Povidone iodine 5% aqueous solution PLUS chlorhexidine no strength stated	1
Povidone-iodine aqueous solution, no strength stated PLUS Betadine – 10 % povidone iodine in 30% ethanol,	2
Betadine – 10 % povidone iodine in 30% ethanol, PLUS chlorhexidine in alcohol, no strength stated	4
Chlorhexidine 0.05% and cetrimide 0.5% aqueous solution PLUS chlorhexidine in alcohol, no strength stated	1
Betadine – 10 % povidone iodine in 30% ethanol, PLUS Chlorhexidine 0.5% and cetrimide 150mg/30ml aqueous solution	2
Normal saline	1
No skin preparation was recorded or the skin preparation recorded does not exist	13

List of trade names and manufacturers:
Povidone iodine 10% aqueous solution - Riodine, Orion Laboratories, Balcatta, Australia
Povidone iodine 5% aqueous solution - Riodine, Orion Laboratories, Balcatta, Australia
Alcoholic iodine solution – 2.5% iodine, 2.5% potassium iodide in 86% ethanol, Orion Laboratories, Balcatta, Australia
Betadine – 10 % povidone iodine in 30% ethanol, Orion Laboratories, Balcatta, Australia
Chlorhexidine 0.02% aqueous, Baxter, Old Toongabbie, Australia
Chlorhexidine 0.05% and cetrimide 0.5% aqueous solution, Baxter, Old Toongabbie, Australia
Chlorhexidine 0.5% and cetrimide 150mg/30ml aqueous solution, Pfizer, Bentley, WA, Australia.
Chlorhexidine 2% in alcohol 70%, Orion Laboratories, Balcatta, Australia

Table 3. Cases where an occlusive drape was used.

Procedure	Number
Cardiac surgery – coronary artery bypass grafting, cardiac valve replacement, aortic arch surgery, pacemaker box exchange, implanted defibrillator, pericardial effusion drainage, sternal rewire	47
Craniotomy including ventriculo peritoneal and subdural shunts	12
Total hip or knee replacement	12
Laparoscopic appendicectomy or cholecystectomy	10
Cervical or lumbar disc surgery	9
Laparotomy	9
Video assisted thoracoscopy	5
Radical prostatectomy	5
Carotid endarterectomy	3
Cataract surgery	3
Caesarean sections	2
Gynaecological laparoscopy	2
Dynamic hip screw	3
Femoral artery exploration, aneurysm repair or endarterectomy	3
Bowel resection	3
Insertion of Hickman's catheters	2
Incisional hernia repair	2
Wound debridement or skin laceration repair	2
Laparoscopic anterior resection	2
Laparoscopic hiatus hernia repair and laparoscopic incisional hernia repair	2
Open reduction and internal fixation of limb fracture	2
Lung lobectomy or thoracotomy	2
Removal of metal or screw change	2
Single and separate cases of bone graft, revision of Lap Band port, reversal of Hartmann's procedure, repair of tibial mycotic aneurysm, removal of lumbar drain, hip arthroscopy, open and laparoscopic nephrectomy, open cholecystectomy, laparoscopic repair of perforated duodenal ulcer, laparoscopic adrenalectomy, pelvic osteotomy, Ivor Lewis oesophagectomy, debridement of clicking ribs	15

NICE guidelines on SSI in an Australian teaching hospital.

Table 4. Antibiotic prophylaxis used in 339 patients.

Antibiotics	Number
Cefazolin	246
Cefazolin and metronidazole	27
Vancomycin	19
Flucloxacillin	10
Cefazolin and gentamicin	6
Amoxycillin, gentamicin and metronidazole	4
Cefazolin, gentamicin and metronidazole	3
Ceftriaxone and metronidazole	2
Ceftriaxone	2
Gentamicin	2
Ticarcillin and potassium clavulanate (Timentin, GlaxoSmtihKline, Australia)	2
Not stated	2
Amoxycillin	1
Amoxycillin and metronidazole	1
Amoxycillin and gentamicin	1
Cephalothin	1
Cefazolin and topical gentamicin	1
Cefotaxime	1

Method

Prospective audit data were collected on all patients coming through the operating theaters of the Royal Hobart Hospital over a four-week period in November 2009. Patient demographics, including age and sex, were recorded. The type of surgery was recorded, including urgency (elective or emergency). The consultant surgeon responsible for the patient was recorded, as was the operating surgeon. Whether or not hair was removed from the operative site was recorded. If the hair was removed, the mechanism of removal and the timing in relation to the operation were recorded (prior to admission, on the ward or in theater). The type of pre-operative skin preparation was recorded and whether this skin preparation was allowed to dry prior to skin incision. The use of an occlusive drape during the operation, e.g. Ioban, was recorded. The use of prophylactic antibiotics was recorded as well as the timing of the administration in relation to the skin incision. An assessment was made of the appropriateness of antibiotic prophylaxis according to national guidelines [4]. Finally, a note was made of the active body warming as well as what the patient's temperature was on arrival in the recovery ward.

Results

Over the four-week period, a total of 769 cases came through the operating theater complex. One hundred and ninety-nine cases were excluded from subsequent analysis, as they did not involve a skin incision, e.g. cystoscopic procedures, dental procedures, insertion of grommets, a closed reduction of a limb fracture or dislocation etc. Of the remaining 570 cases, 380 were elective surgery, 294 were males and the mean age was 46 years (the range was 0 – 97 years).

In 126 cases (22%), hair was removed pre-operatively. These results are summarized in Table 1.

Table 2 shows the skin preparation used in the surgical cases.

Of the 570 cases, if the 14 are excluded where the skin preparation was not recorded (n = 13) or normal saline was used (n = 1), in 340 cases (61%) the skin preparation was allowed to dry prior to the skin incision; in 133 cases (24%) the skin preparation was still wet at the time of skin incision, and in the remaining 83 cases (15%) it was not recorded as to whether the skin preparation was allowed to dry or not prior to skin incision.

Of the 570 cases, no occlusive drape was used in 370 cases (65%). In 161 cases (28%) an occlusive drape (Ioban, 3M Australia or Opraflex, Lohmann & Rauscher International, Germany) was used as listed in Table 3. In the remaining 37 cases it was not recorded whether an occlusive drape was used or not.

Of the 570 patients, 339 (59%) received prophylactic antibiotics; 214 (38%) received no antibiotics, and in 17 cases it was not recorded whether or not antibiotics had been given. Table 4 shows the combinations of antibiotics used and Table 5 shows the appropriateness of antibiotics administered.

In the 339 cases in which prophylactic antibiotics were administered, the time before skin incision when the antibiotics were given was recorded in 267 cases. In 29 cases this was simply recorded after the incision or after the baby had been delivered in the case of a caesarean section. In the remaining 238 cases where the timing of the antibiotics was recorded as an actual time, the mean time prior to incision was 18 minutes, median 15 minutes, and range 180 minutes to 15 minutes after the incision.

Two hundred and forty-eight patients had no active warming in theater. Their mean temperature on arrival in re-

covery was 36.6°C. 292 patients had active warming. Their mean body temperature on arrival in recovery was 36.7°C. Using a student T test, there was no significant difference between the two groups (p = 0.222, 95% confidence interval -0.137 to 0.032). Of those who had warming, 226 were by using a Bair Hugger (Arizant, Healthcare, MN, USA), 1 blow kit, 24 by heat exchanger on a cardiac bypass, 1 by plastic sheet, 1 by the patient's own dressing gown and the remainder with a warm blanket.

Discussion

The present study has shown the enormous variation in practise within a single teaching hospital regarding methods recommended in the available literature to reduce SSI. There is clearly a need for more widespread dissemination of evidence-based guidelines. Not only will this potentially result in improved patient outcomes but will also simplify and reduce the number of variations in peri-operative practise. Potentially, there could also be cost savings with a reduction in the number of skin preparations kept in stock. The use of chlorhexidine has not only been shown to be more effective than iodine-based skin antiseptic solutions but has also been shown to be more cost effective [5-7].

The issue of occlusive drapes is complex. Some surgeons would use these drapes, stating that they reduce the incidence of SSI. There is however little evidence to support this. The NICE guidelines summarize that non-iodophor-impregnated incise drapes should not be used routinely for surgery as they may increase the risk of surgical site infection. If an incise drape is required, an iodophor-impregnated drape should be used (unless the patient has an iodine allergy); however, the guideline reported that there was no statistically significant difference in the SSI rate between those cases where an iodophor-impregnated incision drape was used and those where

Table 5. Appropriateness of peri-operative systemic antibiotics.

	No.	[1]Procedures Where Systemic Antibiotic Prophylaxis Is Indicated					[2]Procedures Where Systemic Antibiotic Prophylaxis Is Not Indicated	
		Antibiotic not given	Antibiotic given	Pre skin incision	Correct antibiotic	*Correct dose	Antibiotic not given	Antibiotic given
Cardio-Thoracic	56	3	53	46	49	49	0	0
ENT	3	0	0	0	0	0	3	0
Eye	22	0	0	0	0	0	0	0
General Surgery	119	4	53	50	40	40	57	4
Head + neck	9	0	4	4	4	4	5	0
Neurosurgery	35	2	28	26	26	25	1	4
Obstetrics (CS)	29	8	19	10 A 6 B 3 U	19	19	0	0
Gynae surgery	43	19	18	18	10	10	6	0
Orthopaedic	77	3	45	44	43	43	14	15
Plastic surgery	122	0	31	30	29	29	70	21
Urology	19	1	8	7	3	3	8	2
Vascular surgery	29	1	7	6	6	6	17	4

[1]Antibiotic prophylaxis indicated as the Therapeutic Guidelines Antibiotic Version 14

[2]Antibiotic prophylaxis not indicated as per hospital guideline and/or the Therapeutic Guidelines Version 14

no drape was used. However, one of these authors, like other surgeons, used occlusive drapes in cases where conventional surgical drapes create gaps through which instruments and sutures can fall, potentially into a non-cleaned area. Good examples of this are during carotid endarterectomy. These occlusive drapes are also useful when attempting to keep mobile structures away from the wound, e.g. when operating in the groin of male patients.

This study has neither assessed the use of drains nor the type of skin closure. Both of these interventions have been shown to influence SSI [8,9]. This is not the first report of the lack of adherence to guidelines for surgical prophylactic antibiotics. There have been similar reports of poor guideline adherence to treatment of infections by surgeons [10].

The UK NICE guidelines strongly support keeping patients normothermic in order to reduce the risk of SSI. A recent publication has questioned the validity of this and highlighted the poor evidence base behind it [11]. Our retrospective review showed that there was no difference in the patients' temperature on arrival in the recovery room of those patients who received active warming and those that did not. This might reflect the fact that patients undergoing a longer operation or those at greater risk of loss of body temperature received appropriate warming, but it might also question the effectiveness of methods used to maintain normothermia.

Conclusion

Currently, there is poor adherence to published guidelines on methods to reduce SSI. Improved dissemination and education programs are urgently required.

Conflict of interest statement

The authors do not declare any conflict of interest or financial support in this study.

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