REVIEW ARTICLE

Preoperative Skin Antiseptic Preparations for Preventing Surgical Site Infections: A Systematic Review

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OBJECTIVE. To evaluate the clinical effectiveness of preoperative skin antiseptic preparations and application techniques for the prevention of surgical site infections (SSIs).

DESIGN. Systematic review of the literature using Medline, EMBASE, and other databases, for the period January 2001 to June 2011.

METHODS. Comparative studies (including randomized and nonrandomized trials) of preoperative skin antisepsis preparations and application techniques were included. Two researchers reviewed each study and extracted data using standardized tables developed before the study. Studies were reviewed for their methodological quality and clinical findings.

RESULTS. Twenty studies (n = 9,520 patients) were included in the review. The results indicated that presurgical antiseptic showering is effective for reducing skin flora and may reduce SSI rates. Given the heterogeneity of the studies and the results, conclusions about which antiseptic is more effective at reducing SSIs cannot be drawn.

CONCLUSIONS. The evidence suggests that preoperative antiseptic showers reduce bacterial colonization and may be effective at preventing SSIs. The antiseptic application method is inconsequential, and data are lacking to suggest which antiseptic solution is the most effective. Disinfectant products are often mixed with alcohol or water, which makes it difficult to form overall conclusions regarding an active ingredient. Large, well-conducted randomized controlled trials with consistent protocols comparing agents in the same bases are needed to provide unequivocal evidence on the effectiveness of one antiseptic preparation over another for the prevention of SSIs.

Infect Control Hosp Epidemiol 2012;33(6):608-617

Surgical site infections (SSIs) occur in approximately 2%–5% of patients who undergo clean extra-abdominal surgeries, such as thoracic and orthopedic surgery, and in up to 20% of patients who undergo intra-abdominal surgery interventions.[1] SSIs can lead to increased morbidity and mortality and are associated with prolonged hospital stay and greater hospital costs.[1] The Institute for Healthcare Improvement reports that SSIs in the United States increase the length of hospital stay by an average of 7.5 days, at an estimated cost of $130 million to $845 million per year.[2] In 2006, SSIs accounted for 14% of healthcare-associated infections in the United Kingdom, resulting in additional costs of between £814 and £6,626, depending on severity.[3]

Because microbial contamination of the surgical site is a requirement for the development of an SSI, prevention techniques aim to minimize the presence and spread of microorganisms. Prevention strategies include antibiotic prophylaxis, antiseptic prophylaxis, hair removal, perioperative glucose control, and maintenance of normothermia.[4] Topical antiseptics may be applied to the skin preoperatively to reduce SSI risk. The main types of antiseptics are iodine or iodophor (such as povidone-iodine [PI]), alcohol, and chlorhexidine gluconate (CHG).[5] CHG and PI can be mixed with either alcohol or water, which may have implications for effectiveness.

The Centers for Disease Control and Prevention (CDC) guidelines recommend that patients shower or bathe with an antiseptic solution the night before surgery and that the skin be prepared with "an appropriate antiseptic agent."[6] Clinical practice guidelines from the National Institute for Health and Clinical Excellence recommend that patients shower or bathe with soap the day before or the day of surgery and that iodophor-impregnated surgical drapes be used when incise drapes are required.[3] They also recommend preparing the skin at the surgical site with antiseptic immediately before incision, but they do not indicate a preference for CHG or PI.[3]

We conducted a systematic review of the available published data on the comparative clinical effectiveness and safety

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Received September 12, 2011; accepted February 3, 2012; electronically published April 16, 2012.

 0899-823X/2012/3306-0011$15.00. DOI: 10.1086/665723

of preoperative skin antiseptic preparations for preventing SSIs. This review is an update of a comprehensive report by the Canadian Agency for Drugs and Technologies in Health.[7]

METHODS

Literature Search Strategy

Published literature was identified by searching the following bibliographic databases through the Ovid interface: Medline, Medline Daily Update, Medline In-Process, EMBASE, and CINHAL. Parallel searches were conducted in PubMed, the Cochrane Library, Database of Abstracts of Reviews of Effects, and Health Technology Assessment. The search strategy comprised controlled vocabulary, such as the National Library of Medicine's Medical Subject Headings, and keywords, including "presurgical," "antiseptic," "disinfectant," and "preoperation." The main search concepts were preoperative and skin preparation. Literature that is not commercially published was identified by searching relevant sections of the Grey Matters checklist (http://www.cadth.ca/en/resources/grey-matters). Results were limited to English-language documents published from January 2001 until August 2011, to reflect current clinical practice. Detailed methods, including the complete search strategy and a list of excluded studies, have been described elsewhere.[7]

Selection Criteria

Eligible studies included adult and pediatric patients preparing for thoracic, cardiac, plastic, orthopedic, neurological, abdominal, or pelvic surgery. Three types of preoperative skin antiseptics—iodophors, alcohol, or CHG, in any preparation—were considered. The outcomes measured were SSIs, rate of reoperation and antibacterial treatments, bacterial colony counts, mortality, and patient adverse events. Noncomparative studies were excluded.

Article Selection and Data Extraction

Two reviewers (C.K. and L.M.) independently screened citations and selected randomized controlled trials (RCTs) and nonrandomized studies of preoperative skin antiseptic preparations for preventing SSIs. The reviewers independently extracted data using a structured form. Any disagreement between reviewers was discussed until consensus was reached.

Quality Assessment

Two reviewers (C.K. and L.M.) independently evaluated the quality of RCTs and nonrandomized studies using a Downs and Black instrument[8] modified to include the source of study funding. A numeric score was not calculated for each study. Instead, the assessment was described narratively. Disagreements were resolved through discussion until consensus was reached.

Data Analysis Methods

Because of clinical heterogeneity across the selected studies, a formal meta-analysis was not conducted. Individual studies were described and critically appraised using a narrative approach.

RESULTS

Quantity of Research Available

The electronic literature search and updates yielded 1,293 citations. After screening titles and abstracts, 1,228 citations were excluded, and 65 potentially relevant articles were retrieved for full-text review. An additional 11 potentially relevant reports were identified through the grey literature and hand searching. Of the 76 potentially relevant reports, 56 did not meet the inclusion criteria. Twenty RCTs and observational studies were included in this review. The study selection process is presented in a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart (Figure 1).[9]

Study Characteristics

An overview of study and patient characteristics for each included study can be found in Table 1.

The clinical effectiveness of presurgical antiseptic showers was reported in 3 RCTs and 4 cohort studies.[10-16] The clinical effectiveness of antiseptic preparation versus nonmedicated soap and alcohol or saline was reported in 2 RCTs published in 2001 and 2005.[17,18] The effectiveness of one antiseptic preparation versus another for reducing bacterial colonization and SSIs was reported in 5 RCTs and 4 nonrandomized studies published between 2002 and 2011.[19-27] Two RCTs[23,28] and 1 retrospective study[29] published between 2002 and 2005 focused on the use of iodophor-impregnated incise drapes to prevent surgical wound infection.

The sample sizes across all studies ranged from 82[14] to 3,209.[25] Twelve studies defined SSI according to CDC criteria.[10,13,14,21-29] The remainder were based on predefined microbiological or clinical criteria. One study[20] reported bacterial colony counts as the primary measure of antiseptic effectiveness and did not report SSIs. The type of surgery performed varied across the included studies. Wound classification was not reported by 7 studies.[11,14,16,20,23,26,28] Five studies[12,13,17,18,21] involved clean wounds, 3 studies[22,24,29] were clean-contaminated, and 4 studies[10,15,19,25,27] included more than 1 wound classification. Formulation (aqueous or alcoholic), strength, and application method of skin antiseptics was not consistent across studies.

Quality Assessment

Studies were of varying quality. Of the 20 included studies, 11 were RCTs, but 5 used an inappropriate or undescribed randomization method.[11,12,18,20,28] Two RCTs[13,22] reported blinding of patients, and 6 RCTs[11-13,22,23,28] reported blinding

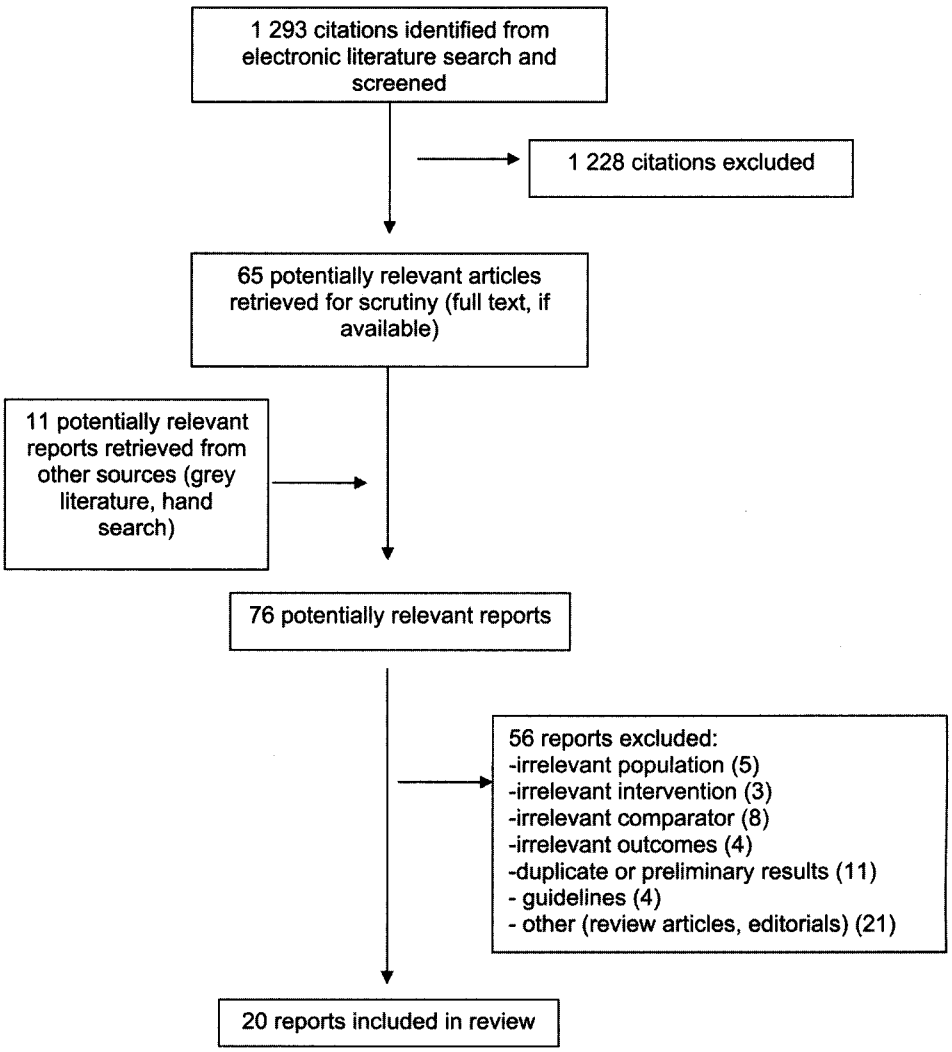

FIGURE 1. Selection of included studies.

of outcome assessors. Eight included studies were cohort or case-control studies and were not subject to randomization or blinding.

Interventions and comparators used varied across studies and were incompletely described in 6 studies.[17-19,23,26,27] The issue of incomplete data was poorly addressed. Patients lost to follow-up were described in 3 studies.[13,22,24] Four studies[10,11,15,25] reported poor compliance with the assigned intervention. Two of these[10,15] used patients who failed to comply with antisepsis instructions as controls. Three of the 20 included studies used an intention-to-treat analysis.[11,22,25]

Six studies included power calculations to determine sample size,[11,18,22,23,25,28] but 1 study[25] failed to reach the required number of patients. In the remaining 14 trials, it was unclear whether the study population was large enough to detect clinically relevant effects.

Other potential sources of bias were present. One study[14] was conducted in a military medical academy, 1 study[17] was performed in a hospital in a developing nation, and 1 study[28] included only the first and second case patients of the day. These patients and their treatment may not be representative of the general population or the treatment that they would receive. One study[29] reported wound infection but did not consider wound infections associated with intra-abdominal infections, which may result in underreporting of SSIs. Three included studies[14,24,25] did not recruit patients for each study group over the same time period; 1 study[25] noted the opening of new operating rooms in the study hospital, which may have altered the patient population seen in 1 study group. Source of funding was disclosed in 5 of the included studies.[11,15,22,25,28]

Data Analysis and Synthesis

Detailed study findings are presented in Table 1 and are summarized in Table 2.

https://doi.org/10.1086/665723 Published online by Cambridge University Press

Bacterial colonization. Skin colonization was reported by 7 RCTs[11-13,19-21,28] and 1 observational study.[16] Studies considered any bacteria when determining colonization. Two RCTs reported that presurgical showering with PI[12] or CHG[11] resulted in a statistically significant reduction in preoperative skin colonization. One RCT[13] showed no statistically significant reduction in preoperative colony counts with CHG showering compared with control or placebo. In a cohort study, twice-daily 5-day topical 4% CHG scrubbing reduced preoperative perineal colonization 4-fold compared with usual hygiene in patients undergoing artificial urinary sphincter placement.[16] One RCT[19] showed a statistically significant reduction in presurgical bacterial colonization in patients prepared with 4% CHG in 70% isopropyl alcohol compared with patients prepared with PI.

Three RCTs[20,21,28] examined postsurgical skin colonization. One RCT[20] reported that patients who were scrubbed with CHG-cetrimide had a higher proportion of positive skin cultures after surgery than those who also received PI. This corresponded to a higher number of patients developing bacteremia or septicemia (8 [7.1%] vs 3 [2.6%]; $P < .01$).[20] In another RCT, postoperative *Staphylococcus* and hemolytic skin colony counts were significantly higher for patients prepared with PI than for those prepared with CHG.[21] One study[28] reported on culture growth in patients prepared with incise drapes and found no difference in the number of patients with positive surgical wound cultures among those prepared with DuraPrep (3M) and Ioban 2 (3M) drapes and those prepared with PI solution and Ioban 2 drapes.

Infection. SSIs were reported in 3 RCTs[11-13] and 4 cohort studies[10,14-16] examining presurgical showering. Three RCTs suggested that there is no difference in postoperative infection rates between patients who undergo presurgical showering with PI[12] or CHG[11,13] and patients who receive no showering instructions,[12,13] receive placebo,[13] or are instructed to shower with soap and water.[11] Two cohort studies reported a reduced infection rate in patients who washed with CHG-impregnated cloths compared with that in patients who were not compliant with skin preparation; however, of these only 1 provided statistical analysis, and it found that this trend was not statistically significant.[10,15] In 1 study, SSIs were reported in 3 (7%) and 10 (25.6%) CHG and control patients, respectively, after abdominal surgery (odds ratio, 4.76 [95% confidence interval, 1.2–18.8]).[14] The fourth cohort study reported 1 SSI in a patient who performed usual hygiene before undergoing artificial urinary sphincter placement.[16] No SSIs were noted in CHG scrub recipients in this study. Statistical analysis was not performed.

Two RCTs[17,18] reported that SSI rates were the same in patients who received PI antiseptic skin preparation and those who were prepared using soap and methylated spirit or saline irrigation.

Three RCTs[19,21,22] and a cohort study[24] reported reduced SSI rates in CHG-prepared patients versus PI-prepared patients, but this difference was not statistically significant in 1 RCT.[21] Two RCTs comparing CHG-alcohol with PI antisepsis showed an approximate 40% reduction in SSIs with CHG use.[19,22] The cohort study showed a roughly 3-fold increase in SSIs with PI antisepsis.[24] In contrast, 2 cohort studies[25,26] suggested that PI is more effective than CHG for reducing SSIs. In particular, 1 reported that patients prepared for surgery with CHG had statistically significant higher rates of infection because of a higher rate of superficial incisional infection.[25] The other study performed a multivariable logistic regression analysis of risk factors for case and control patients undergoing spinal surgery and found that the use of PI alone was protective against SSIs (odds ratio, 0.16 [95% confidence interval, 0.06–0.45]).[26] In a similar analysis, 1 case-control study[27] found that skin preparation solution was not an independent risk factor for SSI. In 1 study,[23] no statistically significant difference in SSI rates was observed between patients receiving PI paint, PI scrub and paint, film only, or film and drape preparations. In a secondary analysis, the 2 aqueous iodine groups (PI paint and PI scrub with paint) and the 2 insoluble iodine groups (1-step film and film with incise drape) were combined, showing reduced SSIs in the insoluble iodine group ($P = .02$).

When comparing the number of SSIs among patients prepared with DuraPrep to those prepared with PI solution in combination with iodophor-impregnated drapes, 1 study[28] reported no SSIs in either group. Similarly, 1 study[23] found no statistically significant difference in the number of SSIs among patients prepared with a 1-step iodophor-and-alcohol water-insoluble film with or without iodophor-impregnated drapes. In contrast, 1 study[29] found statistically significant lower rates of wound infection with the use of Ioban 2 drapes compared with surgeries without drape use (12.1% without drapes vs 3.1% with drapes; $P = .0096$).

Adverse events. Four included studies[11,13,19,22] reported adverse events related to skin antisepsis. In a study[11] comparing preoperative application of CHG with showering with soap and water, 12 patients receiving CHG (24%) and none undergoing normal showering ($P < .0002$) reported mild itching or dry skin. All patients in 1 RCT[13] comparing CHG showering with control or placebo completed a 30-day follow-up, and none experienced an adverse reaction. Of 2 RCTs comparing CHG to PI, 1 trial[22] reported 4 deaths (1.0%) not due to infection in the CHG group and 3 deaths (0.7%) in the PI group related to sepsis due to organ-space infection. Three patients (0.7%) in each group had pruritus, erythema, or both around the wound. No fire or chemical skin burns occurred in the operating room.[22] The other RCT[19] reported skin irritation in 2 PI patients (0.8% [2/250]), but there were no allergic reactions detected in patients treated with CHG-alcohol in the study. Among studies using incise drapes, 1 study[28] reported adverse events in 9 patients (11%) prepared with DuraPrep and in 8 (9.1%) receiving PI. A total of 11 serious adverse events were recorded across both groups, and none were judged by the investigators to be treatment related.

TABLE 1. Study Characteristics and Results

Author, year	Country, design, setting (sample size)	Wound type, surgery type	Intervention (no. of patients)	Comparator (no. of patients)	Patient age in years, gender	Results
Presurgical showering						
Murray et al,[11] 2011	USA, RCT, hospital (100)	NR, orthopedic shoulder	2% CHG-impregnated cloth for use night before and morning of surgery (50)	Shower with soap and water the morning of surgery (50)	Mean: 49.0 ± 16.2 CHG, 52 ± 16.7 control M: 72% CHG M: 50% control	CHG: 33 positive cultures (66%) Control: 47 positive cultures (94%) $P = .0008$ No infections observed in either study group
Veiga et al,[13] 2009	Brazil, RCT, hospital (150)	Clean, plastic thorax	4% CHG liquid detergent shower (50)	Placebo: liquid detergent, no active ingredient (50); control: given no showering instruction (50)	Mean: 38.3 ± 13.9 M: 32 (21%) F: 118 (79%)	CHG: 1 *S. aureus* (2%) Placebo: 2 *S. aureus* (4%) Control: 4 *S. aureus* (8%) $\chi^2 = 2.10$, $P = .35$ Mean bacterial counts were lower in CHG patients ($P < .001$) CHG: 1 superficial SSI (2%) Placebo: 1 superficial SSI (2%) Control: 0 SSI (0%) $\chi^2 = 1.01$, $P = .6$
Veiga et al,[12] 2008	Brazil, RCT, hospital (114)	Clean, plastic abdominal or thorax	10% PI liquid detergent shower (57)	No showering instruction (57)	Mean: 38.3 (18–65) M: 26 (23%) F: 88 (77%)	PI: 1 *S. aureus* (1.8%) No instruction: 12 *S. aureus* (21%) $P = .0019$, 95% CI NR No SSIs observed in either group
Johnson et al,[15] 2010	USA, cohort, hospital (1,054)	Mixed, orthopedic hip arthroplasty	2% CHG-impregnated cloth for use night before and morning of surgery (157)	Noncompliance (no CHG) based on placing adhesive stickers from package on data sheet (897)	Mean: 58 M: 50% compliant M: 53% noncompliant	Colonization: NR CHG: 0 SSIs (0%) Noncompliant: 14 SSIs (1.6%) $P = .231$, 95% CI NR
Zywiel et al,[10] 2010	USA, cohort, hospital (912)	Mixed, orthopedic knee arthroplasty	2% CHG-impregnated cloth for use night before and morning of surgery (136)	Noncompliance (no CHG) based on placing adhesive stickers from package on instruction sheet (711); partial compliance (65)	Mean: 63 M: 34% compliant M: 31% noncompliant	CHG: 0 SSIs (0%) Partial compliance: 1 SSI (1.5%) Noncompliant: 21 SSIs (3.0%) *P* value, 95% CI NR
Dizer et al,[14] 2009	Turkey, cohort, hospital (82)	NR, abdominal surgery	CHG soap showering on admission and night before surgery (43); enrolled Feb 2004 to May 2005	Normal hygiene (39); enrolled Nov 2004 to Jan 2005	20 (51.3%) CHG and 22 (51.2%) control patients were >51 years M: 58% CHG M: 74% control	CHG: 3 SSIs (7%) Control: 10 SSIs (25.6%) OR = 4.76, 95% CI = 1.2–18.8, $P = .026$
Magera et al,[16] 2007	USA, cohort, clinic (100)	NR, pelvic artificial urinary sphincter implant	Twice-daily 5-day topical 4% CHG scrub; first 50 men enrolled May 2003 to Nov 2005	Normal hygiene; last 50 men enrolled May 2003 to Nov 2005	Median: 74.1 CHG, 73.2 control M: 100%	4-fold reduction in preoperative positive perineal bacterial culture rate with CHG vs hygiene OR = 0.24, 95% CI = 0.08–0.65 CHG: 0 SSIs (0%) Usual hygiene: 1 SSI (2%)

Antiseptic preparation vs non-medicated soap						
Meier et al,[17] 2001	Nigeria, RCT, hospital (200)	Clean, abdominal hernia surgery	5-minute PI scrub, towel, and paint with PI (102)	5-minute soap scrub, towel, and paint with methylated spirit (98)	Mean: 33 M: 182 (91%) F: 18 (9%)	PI: 6 SSIs (5.9%) Soap: 5 SSIs (5.1%) $P = 1.000$, 95% CI NR
Kalantar-Hormozi et al,[18] 2005	Iran, RCT, hospital (1,810)	Clean, plastic	Shower with soap followed by PI scrub and paint (905)	Shower with soap followed by normal saline irrigation (905)	Mean: 33 PI, 34 saline M: 648 (36%) F: 1,162 (64%)	PI: 0 SSIs Saline: 0 SSIs *P* value NR
Comparison of antiseptics						
Darouiche et al,[22] 2010	USA, RCT, hospital (849)	Clean-contaminated, mixed	2% CHG + 70% IPA scrub (409)	10% aqueous PI scrub then paint (440)	Mean: 53 M: 487 (57%) F: 362 (43%)	CHG: 39 SSIs (9.5%) PI: 71 SSIs (16.1%) $P = .004$ RR = 0.59, 95% CI = 0.41–0.85
Paocharoen et al,[19] 2009	Thailand, RCT, hospital (500)[a]	Mixed, mixed	PI scrub then paint (250)	4% CHG and 70% IPA scrub then paint (250)	Mean: 50.5 PI, 56.2 CHG M: 297 (59%) F: 213 (43%)	PI: 78 positive skin cultures (31.2%) CHG: 36 positive skin cultures (14.4%) RR = 2.69, 95% CI = 2.15–3.55 PI: 8 SSIs (3.2%) CHG: 5 SSIs (2%) OR = 1.61, 95% CI = 1.40–1.81
Kehinde et al,[20] 2009	Kuwait, RCT, hospital (231)	NR, urological	3 × CHG-cetrimide scrub (114)	2 × CHG-cetrimide scrub + PI scrub (117)	Mean: 54 CHG, 55 CHG + PI M: 231 (100%)	CHG: 13 (11.4%) positive postoperative cultures CHG + PI: 3 (2.6%) positive postoperative cultures $P < .001$, 95% CI NR
Veiga et al,[21] 2008	Brazil, RCT, hospital (250)	Clean, plastic	0.5% CHG paint (125)	10% PI paint (125)	Adults >18 years M: NR F: NR	Mean CFUs (*S. aureus*): CHG: 2.7 ± 26.9 PI: 7.9 ± 45.5 $P = .006$ Hemolytic colonies: CHG: 7.8 ± 46.1 PI: 17.6 ± 64.7 $P = .014$ CHG: 0 SSIs (0%) PI: 4 SSIs (1.6%) $P = .06$, 95% CI NR
Segal and Anderson,[23] 2002	USA, RCT, hospital (209)	NR, cardiac	PI paint (56); PI scrub then paint (52)	One-step iodophor and alcohol film (50); film plus iodine incise drape (51)	Mean: 60.9 M: >75%	PI paint: 7 SSIs (12.5%) PI scrub then paint: 7 SSIs (13.5%) Film only: 1 SSI (2%) Film plus drape: 3 SSIs (5.9%) $\chi^2 = 5.889$, $P = .117$ Aqueous iodine: 14/108 SSIs (13%) Insoluble iodine: 4/101 SSIs (4%) $\chi^2 = 5.3$, $P = .02$

TABLE 1 (*Continued*)

Author, year	Country, design, setting (sample size)	Wound type, surgery type	Intervention (no. of patients)	Comparator (no. of patients)	Patient age in years, gender	Results
Bucher et al,[27] 2011	USA, case-control, hospital (447)	Mixed, mixed	Alcohol (case, 0; control, 3); iodine (case, 146; control, 277); CHG (case, 1; control, 0); other (case, 7; control, 31)	NA	Pediatric population (mean age, NR) Case: 72% M, 28% F Control: 69% M, 31% F	Skin preparation solution was not an independent risk factor for SSI in logistic regression analysis (OR, 95% CI, *P* value NR)
Levin et al,[24] 2011	Israel, cohort, hospital (256)	Clean-contaminated, pelvic	10% PI scrub then 3 × 10% PI/65% alcohol paint (145)	2% CHG scrub then 3 × 70% alcohol paint (111)	Mean: 51 PI, 53 CHG F: 100%	PI: 21 SSIs (14.6%) CHG: 5 SSIs (4.5%) *P* = .011 OR = 3.25, 95% CI = 1.13–9.30
Swenson et al,[25] 2009	USA, cohort, hospital (3,209)	Mixed, general	7.5% PI soap followed by 1 × 70% IPA scrub, 3 × 10% PI paint (1,514)	2% CHG and 70% IPA scrub (827); iodine povacrylex (794); other (74)	Mean: 53 M: 1,245 (39%) F: 1,964 (61%)	PI: 72 SSIs (4.8%) CHG: 68 SSIs (8.2%) Iodine povacrylex: 38 SSIs (4.8%) *P* = .001 pairwise with CHG OR = 1.35, 95% CI = 0.97–1.87, *P* = .073 (CHG vs iodophor-based preparations)
Boston et al,[26] 2009	USA, case-control, hospital (133)	NR, orthopedic	Iodine and DuraPrep (case, 39; control, 79); iodine only (case, 5; control, 84); CHG (case, 1; control, 2); other (case, 3; control, 7)	NA	Median 44.5 M: 38% F: 62%	Iodine alone found to be protective against SSIs OR = 0.16, 95% CI = 0.06–0.45, *P* < .001
Incise drapes						
Jacobson et al,[28] 2005	USA, RCT, clinic (179)	NR orthopedic	DuraPrep plus Ioban 2 drapes (87)	PI plus Ioban 2 drapes (92)	Mean: 67.5 DuraPrep, 67 PI M: 93 (52%) F: 86 (48%)	Positive wound culture: DuraPrep: 23 patients (28%) PI: 32 patients (36.4%) 95% CI = −22.4% to 5.6% SSIs: no infections reported in either group
Segal and Anderson,[23] 2002	See above	See above	See above	See above	See above	See above
Yoshimura et al,[29] 2003	Japan, cohort, hospital (296)	Clean-contaminated, abdominal	Iodophor only (174)	Iodophor plus Ioban 2 drape (122)	Mean: 61.1 drape, 63.1 no drape M: 244 (82%) F: 52 (18%)	Iodophor only: 21 SSIs (12.1%) Iodophor plus drape: 4 SSIs (3.1%) *P* = .0096 Regression coefficient: −0.075 95% CI = −0.139 to 0.011 *P* = .0218

NOTE. CFU, colony-forming unit; CHG, chlorhexidine; IPA, isopropyl alcohol; NR, not reported; OR, odds ratio; PI, povidone-iodine; RCT, randomized controlled trial; RR, risk ratio; SSI, surgical site infection.

[a] Sample size does not match the number of patients reported (510). This is a discrepancy in the original study, with no explanation provided.

TABLE 2. Clinical Effectiveness of Preoperative Skin Preparations

Intervention	Evidence	Results
Presurgical showering	3 RCTs, 4 cohort studies	Presurgical antiseptic showering is effective for reducing skin flora; the effect on SSI rates is inconclusive
Antiseptic versus hygiene	2 RCTs	PI antisepsis is no better than soap and water or saline irrigation for preventing SSI
Choice of antiseptic	5 RCTs, 2 cohort studies, 2 case-control studies	Antiseptic choice is unclear because of mixed results on comparative effectiveness
Incise drapes	2 RCTs, 1 cohort study	Results are mixed on the effectiveness of iodophor-impregnated drapes for reduction of SSI rates

NOTE. PI, povidone-iodine; RCT, randomized controlled trial; SSI, surgical site infection.

One study[29] reported no evidence of allergic reaction among 296 patients prepared with iodophor solutions.

DISCUSSION

Twenty studies of the comparative clinical effectiveness of preoperative skin antiseptic preparations provided information about presurgical showers,[10-16] antiseptic preparation compared with nonmedicated soap,[17,18] comparison of antiseptics,[19-27] and draping.[23,28,29] Two previous systematic reviews[30,31] examined the effectiveness of presurgical showering for the reduction of skin flora and SSIs. The findings in these reviews were mixed. One[30] found no evidence of the benefit of presurgical bathing with CHG, and the other[31] found CHG bathing to be effective for reducing skin flora. These reviews were based on literature published before 2001. This review, which is based on more recent clinical trials, supports the idea that presurgical showering with CHG is effective for reducing bacterial burden, but the effect on SSIs was inconclusive. In 1 study,[12] PI was used as a presurgical showering solution, and 2 studies[17,18] compared PI surgical site preparation to soap and water or saline wound irrigation. None of these studies found a reduction in SSIs with PI use. Current clinical practice guidelines from the United Kingdom[3] found that CHG showering or bathing reduces SSIs but is no more effective than soap and water.

Current Canadian practice guidelines[4] recommend the use of CHG in alcohol for infection prevention; however, UK guidelines[3] do not indicate a preference for a particular antiseptic. This review has been unable to draw conclusions about which surgical site antiseptic is most effective for reducing SSIs. These results are in contrast with those of 2 systematic reviews[32,33] that suggest that CHG is more effective than PI for skin disinfection before surgery. These previous reviews considered some studies that were excluded from this review on the basis of a lack of postoperative assessment or inappropriate population or procedures of interest.[34-36] The findings of this systematic review, however, agree with those of a previous review[5] that indicated that there is insufficient evidence to support one antiseptic over another and with those of UK clinical practice guidelines[3] that recommend the use of either CHG or PI for preoperative skin preparation.

Three studies[23,28,29] described the use of iodophor-impregnated incise drapes with mixed results. Current UK evidence-based clinical practice guidelines[3] also found mixed results and recommend iodophor-impregnated drapes when drapes are required. The guidelines also recommend against the use of nonantimicrobial drapes, but no studies making that comparison were identified for inclusion in this review.

The methodological quality of the studies was mixed. Evidence was drawn from RCTs and nonrandomized trials, although the method of randomization was generally poorly reported. Efforts were made to blind outcome assessors, but patients and surgeons often were not blinded, compromising internal validity. One study was performed in a pediatric population. Studies included a spectrum of surgical procedures and wound classifications, so the ability to form generalizations for all surgical patients is limited. Interventions and comparators were not always well described, and antisepsis methods varied between studies. This limits the ability to draw conclusions about specific concentrations and protocols but does provide information on the effectiveness of each antiseptic. Disinfectant products are sometimes mixed with an alcohol or an aqueous base. Because alcohol has antiseptic properties, this makes it difficult to make direct comparisons and form overall conclusions about a particular disinfectant.

Direct comparison of each study is difficult because of heterogeneity in antiseptic preparation, application technique, patient population, and study design. Estimates of the effectiveness of PI scrub or scrub and paint compared with soap and water are inconclusive; more research is needed to determine the optimal preparation, number, and timing of applications. Moreover, future research can assess the cost-effectiveness of the various antiseptic agents and preparation, since it remains to be determined.

In conclusion, the evidence suggests that preoperative showers with an antiseptic agent are effective at reducing bacterial colonization of the skin and may reduce SSIs. Because CHG was primarily used as the antiseptic with varying showering regimens and compliance rates in the included trials, the results remain inconclusive. Disinfectant products are often mixed with alcohol or aqueous base, which makes it difficult to form overall conclusions about an active ingredient. Large, well-conducted RCTs with consistent protocols are needed to pro-

vide evidence on the effectiveness of one antiseptic preparation over another for the prevention of SSIs.

ACKNOWLEDGMENTS

The research questions and protocol were developed in consultation with Dr Trevor Schuler and Dr Paule Poulin of Alberta Health Services.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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