Health Dynamics
eISSN: 3006-5518
Publisher: Knowledge Dynamics
DOI: https://doi.org/10.33846/hd10305

Review

Surgical Site Infection Prevention Strategies in Cardiac Surgery: A Systematic Review

Angger Anugerah Hadi Sulistyo*, Ferawati, Ikha Ardianti and Mei Fitria Kurniati

Department of nursing, Faculty of health, ISTeK Insan Cendekia Husada, Bojonegoro, Indonesia

Article history
Received: 21 February 2024
Revised: 26 March 2024
Accepted: 26 March 2024
Published Online: 31 March 2024

***Correspondence:**
Angger Anugerah Hadi Sulistyo
Address: Department of nursing, Faculty of health, ISTeK Insan Cendekia Husada, Bojonegoro, Indonesia.
Email: angger.augerah@gmail.com

How to cite this article: Hadi Sulistyo AA, Ferawati, Ardianti I, Kurniati MF. Surgical Site Infection Prevention Strategies in Cardiac Surgery: A Systematic Review. Health Dynamics, 2024, 1(3), 94-103. https://doi.org/10.33846/hd10305

ABSTRACT

Background: Cardiac surgery becomes one of surgical procedure that has potential for develop several complications including surgical site infection (SSI). Despite the case is still very common, SSI can be regarded as the most preventable, especially when the treatment approach used, because there are many risk factors associated with the target. This systematic review aims to assess the effectiveness of interventions strategies used to reduce the incident of SSI in cardiac surgery. **Methods:** The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines provide a standardized framework for conducting and reporting systematic reviews. A comprehensive search was conducted across major electronic databases, The following database were PubMed, Scopus and ProQuest. The inclusion criteria were clinical and a randomized control trial published between 2018 to 2023. The primary outcome measure was SSI rates. **Results:** The studies encompassed diverse perioperative intervention strategies, such as pre operative nasal ointment, pre operative showering and shaving, chlorhexidine mouthwash, and negative pressure therapy. In total, 436.762 articles regarding SSI prevention strategies in cardiac surgery were found in this study. However, around 7 articles that were met with the criteria of this study. **Conclusion:** Actions to reduce the incidence of SSI are carried out at all perioperative stages. The action taken was modifying the intervention and also using additional therapy carried out by health workers.

Keywords: Surgical site infection; cardiac surgery; prevention strategies

1. INTRODUCTION

Surgical site infection (SSI) is a problem that often arises as a complication of surgery and it associated with morbidity and mortality.(1) Previous research has found that SSI occurred in 31% of patients being treated in hospital. (2) Moreover, almost 3,4% of patients experienced a postoperative SSI(3) and it will prolong hospital stays and raising cost.(4) SSI is ranked third of the most common cases reported by health care-associated infection (HAI), based on data taken from the Centers for Disease Control and Prevention's National Healthcare Safety Network.(5) Cardiac surgery becomes one of surgical procedure that has potential for develop several complications including SSI.

Nearly all kind of heart surgery such as heart transplantation,(6) mechanical circulatory assistance,(7) and coronary artery bypass,(8) could be a factor precipitating the advent of surgical site infection. SSI become most frequent complication after cardiac surgery which increase hospital length of stay, financial impact and even mortality.(9) Sternal wound infection is one of the most significant complication of cardiac surgery, 10,7 % mortality cases reported due to that case.(10) Contamination of the patient's endogenous flora or exogenous flora from the surgical team and operation

room in surgcal site may become a major cause of SSI.[11] Despite the case is still very common, SSI can be regarded as the most preventable, especially when the treatment approach used, because there are many risk factors associated with the target.[12]

Preventive approach to the SSI has been widely publicized. However, of the many preventive measures some approaches show results unhelpful to prevention SIS and the rest have evidance with a high degree of bias. Selection of SSI proper prenvention must be done carefully in order to be applied as evidance based prevention in hospital. Therefore, researchers are interested in reviewing articles regarding the effectiveness of interventions strategies used to reduce the incident of SSI in cardiac surgery.

2. METHODS

The study was conducted in accordance with the 2015 PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols) statement 28 and was registered with PROSPERO (CRD42021259090).

2.1 Eligibility

Studies involving cardiac surgery in any healthcare setting were eligible as long as they were RCTs. Data from studies with fewer than 20 or no primary outcomes on SSI rates in patient with cardiac surgery were excluded from the review.

2.2 Literature search

The following databases were used in the search:

a. PubMed
b. ProQuest
c. Scopus

2.3 Search terms

(Cardiac-surgery OR heart-surgery OR cardiovascular-surgery OR coronary-artery-bypass OR cardiopulmonary-bypass) AND (surgical-site-infection OR wound-infection OR mediastinitis) AND (prevention OR control OR guideline)

The article had to be available and published after January 1, 2015. Only articles in English and indicated potential relevance were permitted for review. Figure 1 summarizes the literature search and study selection process. In December 2023, researchers conducted a literature search and found 7 RCT articles (Figure 1).

3. RESULTS

The output of retrieved records from literature search in different databases are represented in Table 1 and Figure 1.

3.1 Description of included study

There were 7 articles used for the systematic review in this research. All articles reviewed hance different study setting. Apart from that, the selected research had a minimum number of respondents of 30 respondents. All selected research ere clinical trial and RCT.

3.2 Design of the study

All articles in this research are experimental studies. Of the total articles, 3 articles are RCT's [13–15] and the other 3 articles use clinical trial [16–18]. Meanwhile, Raja et al., (2018) used Retrospective analysis to analysed the research.

3.3 Intervention

Of the 7 articles that have been reviewed, 5 articles provide interventions to reduce the incidence of SSI at the preoperative stage.[13,15,17,19] Meanwhile, one article used post operative intervention.[14] Frenette et al., (2016) uses more comprehensive interventions at pre, intra and post operative.[16]

In its research, Frenette et al., (2016) compared actions after changes were made to standard operational perioperative procedures with those before the changes were made.[16] Meanwhile, Reiser et al., (2017) made preoperative preparations with nasal application of octenidine nasal ointment and showering with chlorhexidine before surgery. This is different from research conducted by Gombert et al., (2018) who prevented SSI by carrying out continuous negative pressure for 5-7 days post-operatively.

3.4 Sample

In the articles reviewed the sample size varied from 39 to 6.518 respondents. The article from Frenette et al.[16] does not clearly state the separation between the experimental group and the control group. However, all articles use power analysis to calculate the sample size.

3.5 Outcome

The intervention given in research in 3 articles showed a significant reduction in SSI rates after manipulation was given.[14,16,18] Two other articles also

showed a decrease in SSI rates but did not show a significant difference between the control group and the intervention group.[13,19] The intervention provided by Kline et al., (2018) did not show a reduction in SSI rates, but the intervention showed a reduction in the number of *Staphylococcus aureus* (SA) colonization at 4 different operation sites.[15]

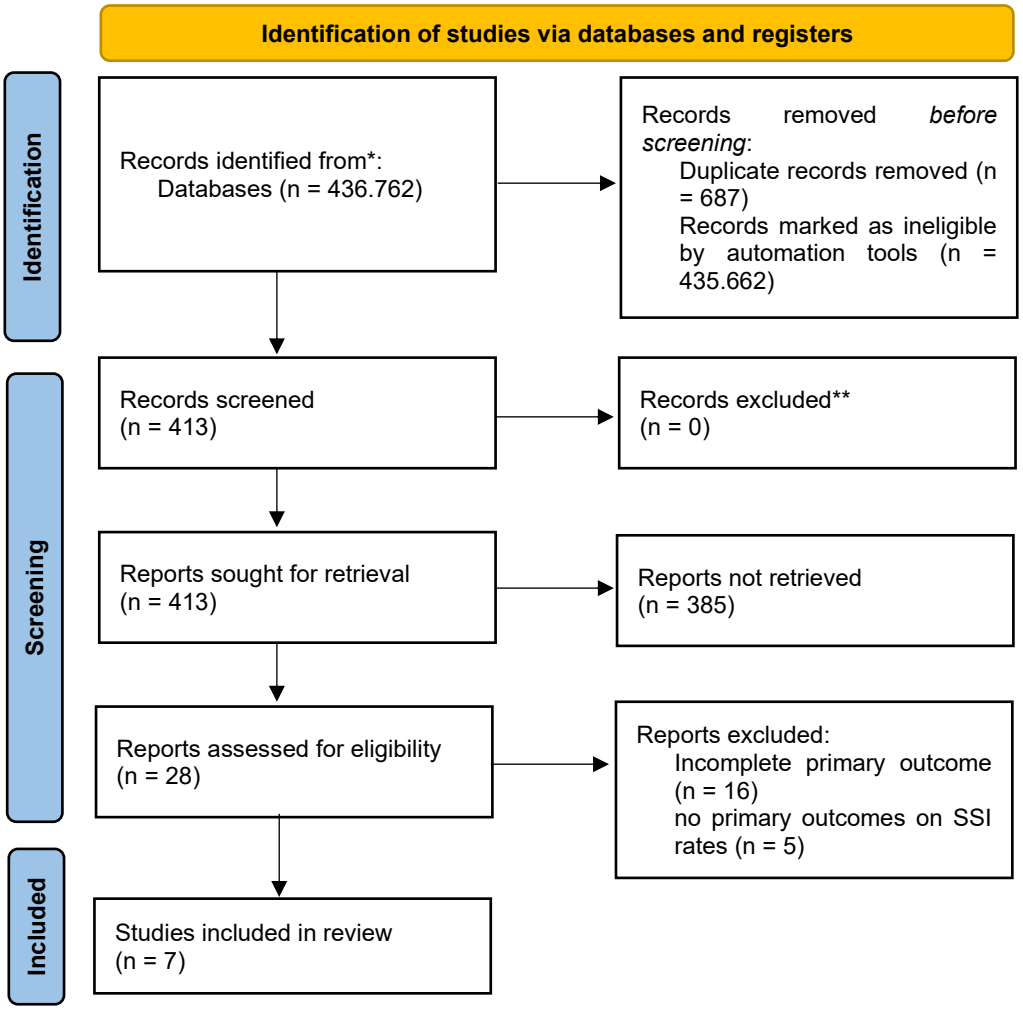

Figure 1. PRISMA (Preferred reporting Items for Systematic Review and Meta-Analysis) flow diagram

Table 1. Literature found on Database

Database	Keyword	Articles Found	Relevant Article
ProQuest	Cardiac-surgery OR heart-surgery OR cardiovascular-surgery OR coronary-artery-bypass OR cardiopulmonary-bypass AND surgical-site-infection OR wound-infection OR mediastinitis AND prevention OR control OR guideline	436.724	5
Pub Med	Cardiac-surgery OR heart-surgery OR cardiovascular-surgery OR coronary-artery-bypass OR cardiopulmonary-bypass AND surgical-site-infection OR wound-infection OR mediastinitis AND prevention OR control OR guideline	38	**2**
Scopus	Cardiac-surgery OR heart-surgery OR cardiovascular-surgery OR coronary-artery-bypass OR cardiopulmonary-bypass AND surgical-site-infection OR wound-infection OR mediastinitis AND prevention OR control OR guideline	0	**0**
Total		436.762	7

Table 2. Study characteristics of N: 7 included study

No.	Author(s)	Study	Methods	Dependent variable/ outcome measure	Subjects (n)	Design	Results	Remark Strength/ weakness
1	Kohler et al., (2015)	Analyzed the effect of mupirocin plus antiseptic body wash on SSI rate and aetiology	-Patients were to receive a twice daily application of mupirocin ointment (Bactroban, GlaxoSmithKline, Brentford, United Kingdom) in both nares and a once daily whole body washing or showering using a liquid soap with chlorhexidine digluconate 4% (Lifo-Scrub; B. Braun Medical AG, Melsungen, Germany) Intervention at pre operative	Group 1: Chlorhexidine showering and a nasal ointment containing mupirocin Group 2: General care	- Control group : undergoing surgery between June 2009 and December 2010 constituted the control cohort n : 945 - Intervention group : undergoing surgery between April 2011 and July 2012 were assigned to the intervention cohort. n : 842	Prospective study with control	- Overall SSI rate was 8.6% (81 out of 945) for the control and 6.9% (58 out of 842) for the intervention cohort (P = 0.19) But significant different result shows in superficial infection (P =0.001)	Strenght: - sufficient samples - Weakness: not clearly mention about what intervention in control group
2	Kline et al., (2018)	To determine the efficacy in eradicating *Staphylococcus aureus* (SA) carriage of a 5-day preoperative decolonization bundle compared to 2 disinfectant soap showers, with both regimens self-administered at home.	Participants randomized to the decolonization bundle were given decolonization supplies: CHG soap, mupirocin ointment, and (after October 3, 2013) CHG mouthwash. They were instructed to apply all the prescribed medications, irrespective of which site(s) demonstrated SA colonization, for 5 days immediately prior to the scheduled operation date. Intervention at pre operative	Group 1: 5 days decolonization bundle Group 2: General care	- Control group: 53 respondents - Intervention group : 57 respondents	single-center, randomized clinical trial	Pre operative antiseptic decolonization bundle aimed at 4 body sites was significantly more effective in eradicating SA than the usual disinfectant showers	Strenght: clearly mention about what intervention in control group Weakness: NR -

Table 2. (*continued*)

No.	Author(s)	Study	Methods	Dependent variable/ outcome measure	Subjects (n)	Design	Results	Remark Strength/ weakness
3	Gombert et al., (2018)	Assess the potential benefits of ciNPT application after groin incisions for vascular surgery	Prevena was applied under sterile conditions in the operation room (OR) following the manufacturer's instructions. Prevena exerts a continuous negative pressure of 125 mmHg on the closed incision during the time of application. Intervention at post operative	Group 1: Negative pressure therapy Group 2: General wound dressing	- Intervention group : 98 vascular surgery patients Control group: 90 vascular surgery patients	RCT	The control group experienced more frequent SSIs (33.3%; 30/90) than the intervention group	Strenght: clearly mention about what intervention in control group Weakness: lack of blinding of this surgical study
4	Tsai et al., (2021)	Evaluate whether preoperative skin preparation performed with chlorhexidine was not inferior to a conventional hair removal method	Patients in the experimental group engaged with 2% chlorhexidine wipes cleaning the skin of inguinal and pubic area 2hours and incorporating with iodine tincture antiseptic wiping before femoral artery catheterization puncture Intervention at pre operative	Group 1: 2% chlorhexidine Group 2: conventional hair shaving	- Intervention group : 39 percutaneous coronary intervention patients - Control group: 39 percutaneous coronary intervention patients	RCT	In PCI, preoperative skin preparation with 2% chlorhexidine was not inferior to conventional hair shaving in terms of the wound infection rate and SSI rate. There was no statistically significant difference in SSI rate between 2 skin preparations	Strenght: clearly mention about what intervention in control group Weakness: NR

Table 2. (*continued*)

No.	Author(s)	Study	Methods	Dependent variable/ outcome measure	Subjects (n)	Design	Results	Remark Strength/ weakness
5	Raja et al., (2018)	Assesses the efficacy of two alcohol-based solutions, 2% chlorhexidine-alcohol and 10% povidone iodine-alcohol, on the incidence of cardiac SSI	The skin at the surgical site was either preopera- tively scrubbed with an applicator that contained 2% chlo-rhexidine gluconate in 70% isopropyl alcohol or preoperatively painted with 10% povidone–iodine in 30% industrial methylated spirit, applied with a sterile swab in a sterile Rampley's Sponge Holder using a sterile gallie pot. Intervention at pre operative	Group 1: 2% chlorhexidine Group 2: Povidone-iodine	- Intervention group : 738 cardiac surgery patients - Control group: 738 cardiac surgery patients	Retrospective analysis	Rate of SSI was similar in the chlorhexidine–alcohol and povidone–iodine–alcohol groups	Strenght: Big number of participants Weakness: NR
6	Reiser et al., (2017)	Evaluate the effect of pre-operative octenidine (OCT) decolonization on surgical site infection (SSI) rates	The intervention consisted of nasal application of OCT ointment three times daily, beginning on the day before surgery, and showering the night before and on the day of surgery with OCT soap. Intervention at pre operative	Group 1: octenidine (OCT) decolonization Group 2: General Care	- Intervention group : 428 cardiac surgery patients - Control group: 475 cardiac surgery patients	Quasi-experimental	Pre-operative decolonization with OCT did not reduce overall SSI rates in patients undergoing an elective isolated CABG procedure but the rate of harvest site SSIs was significantly lower in patients in the intervention group	Strenght: Big number of participants Weakness: NR

Table 2. (*continued*)

No.	Author(s)	Study	Methods	Dependent variable/ outcome measure	Subjects (n)	Design	Results	Remark Strength/ weakness
7	Frenette et al., (2016)	To assess the influence of a 5-year serial infection control and antibiotic stewardship intervention on SSIs.	5-year serial comprehensive infection control and antibiotic stewardship intervention Intervention at pre, intra and post operative	Group 1: 2-year preintervention period (2007-2009) Group 2: 1-year postintervention period (2014-2015)	- A total of 6,518 procedures were included (January 2007-September 2009), during (October 2009-March 2014), and after (April 2014-March 2015) the interventions, were 1,957, 3,689, and 872 surgeries	Quasi-experimental	Long-term, serial comprehensive infection control and antibiotic stewardship interventions decrease overall SSIs in patients undergoing CABG and valve replacement procedures. 60% decrease SSI rates	Strenght: Big number of participants Weakness: The comparison is no equal between group 1 and 2

NR = Not reported

4. DISCUSSION

Prevention Strategies on SSI

Several articles that have been reviewed mention several types of SSI that occur in patients undergoing cardiac surgical procedures. One study stated that the combination of several interventions given could reduce the rate of deep sternal SSI by up to 60%.[16] Meanwhile, Reiser et al., (2017) stated that superficial incisional SSIs, deep incisional SSIs, organ/space SSIs had decreased in the intervention group, although not all of them showed significant values. [17] Superficial incisional SSIs, deep incisional SSIs, organ/space SSIs were also reported to have decreased, but only superficial incisional SSIs were statistically significantly different from the control group.[18] According to the NHSN (National Healthcare Safety Network), complications related to SSIs can occur during cardiac surgery. There are several types of SSI that can occur during heart surgery, including: BONE (osteomyelitis); MAP (myocarditis or pericarditis); DIP (deep incision primary); ENDO (endocarditis); IAB (intraperitoneal); pulmonary (other lower respiratory tract infections) not otherwise specified; MED (mediastinitis); SIP (primary superficial incision) and VASC (arterial or venous infection).[20]

Minimizing bacterial contamination forms the foundational approach for preventing SSI [21]. Numerous studies, involving diverse procedures at different stages (pre, intra, and post-operative), that have been conducted in clinical settings. Moreover, the scope of prevention extends beyond patients as subjects, including surgeons and nurses in these studies. Various investigations have demonstrated that certain strategies yield positive outcomes in reducing SSI rates.[22]

Preoperative strategies

There are 5 articles providing interventions to reduce the incidence of SSI at the preoperative stage.[13,15,17–19] Prevention strategies in preoperative more focus on bacterial control, risk factor control and appropriate asepsis prcedure for surgical team. Hair removal around surgical site should be avoided.[16] If it necessary it will be better immadiately before surgery. Before surgery patient can be showering with antiseptic agent.[15,17,18] However, showering before surgery was not the sole intervention in every article reviewed. Preoperative showering combined with nasal mupirocin and CHG mouthwash (Kline and Kohler); and nasal octanidine ointment.[17] Antimicrobial prophylaxis should be selected besed on most common pathogens in surgical site. This approach should be administer via intravenous, it is to ensure within few hour the bactericidal concentration established in tissue and serum when surgery undergone.

Oropharyngeal rinse and nasal ointment

Staphylococcus aureus revealed become the most frequent pathogenic microorganism that responsible for develop SSI cases.[23] Anterior nares is part of respiratory tract which become most common revervoir of nasal carriage of *S. aureus*.[24] Based on Kohler et al., (2015),[18] there are low number of infections in post operative cardiac surgery caused by *S aureus*. It also stated by Reiser et al., (2017) that octenisan nasal ointment can reduce the site infection caused by *S aureus*.[17] The best recommendation for the usage of nasal ointment is 5 days before cardiac surgery done.[15,17]

Based on Kline et al., (2018) studies, 10 ml chlorhexidine gluconate solution was applicated for as a mouth rinse in buccal, pharyngeal, gingival, and tooth surfaces sites around 30 seconds application. [15] Nose ointment applied in both nostrils. Both of these two strategies applied in patient 4 times daily. These approach was continued usualy until a day after surgery.[25]

Preoperative Bathing and Skin Preparation

Many studies use showering strategies to prevent SSI. But based on,[19] preoperative showering or bathing with chlorhexidine was found to be no more effective than placebo, soap or no washing but preoperative showering appeared to reduce skin surface bioburden.

However, the combination showering and nasal ointment proved reduce SSI particularly in superficial infection. [18]prospective study proved the intervention group significantly effective to reduce superficial infection with p-value .001. In this study patients imadiately treat with showering and nasal ointment after decision of surgery was made. Mupirocin ointment applicate twice daily in both nostrils and showering with chlorhexidine digluconate 4% liquid soap applicate to whole body once daily.

Intraoperative strtegies

Management of operation theatre regarding ventilation necessary to maintain positive pressure. Appropriate air filters in operation room should be done

to refresh and recirculated the air. Operating theratre door must be closed during operation, except if needed to passage the equipment. One article used an intervention that started in the intra-operative phase.[14] However, that intervention continued in the form of negative pressure therapy until the 5-7th post-operative day. Negative pressure therapy (ciNPT) proved reducing skin tension in the incision area.[26] In addition pressure that provided in site of operation could minimize the production of wound fluid.[14] The CDC guidelines affirm the good surgical procedure and asepsis precaution to reduce SSIs emergence. Good procedure and asepsis technique to ensure no contamination of microbial. Appropriate using universal precaution (Gloves, facemasks, caps, gowns and sterile drapes) should be applied to prevent transmission of potential pathogens to surgical site.

Postoperative

The research conducted by Frenette et al., (2016) required modifications throughout the perioperative period. In post-operative procedures, modifications are made to the wound dressing procedure.[16] Dressing exchange, which is usually carried out 48 hours after surgery, is modified by changing the dressing depending on the condition of the dressing. Initial dressing should be nonocclusive and changed 24 h after operation. If it is soaked and soiled with blood, it can be changed earlier. The dressing should be removed definitely after 48 h. Dressing change recommend to close the incision with sterile dressing within 24-48 hour postoperatively to protect from potential pathogens.[27] Asepsis procedure during wound dressing should be applied by wash hands before and after changing wound dressing.[28]

5. CONCLUSION

Actions to reduce the incidence of SSI are carried out at all perioperative stages. The action taken was modifying the intervention and also using additional therapy carried out by health workers. Based on the results of the review article, preventive measures for SSI at the preoperative stage include sterilization with 2% chlorhexidine, hair shaving, nasal mupirocine ointment, chlorhexidine mouthwash, and preoperative showering. At the intra-operative stage, antiseptic selection such as the use of 2% chlorhexidine with 70% alcohol is also used in some articles. Meanwhile, in the post-operative stage, the use of negative pressure has also been proven to reduce the incidence of SSI.

Conflict of Interest

The authors declare no conflict of interest.

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