Surgical site infection prevention bundle in gynecology oncology surgery: a key element in the implementation of an enhanced recovery after surgery (ERAS) program

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ABSTRACT

Surgical site infection rates are among 5–35% in all gynecologic oncology procedures. Such infections lead to increased patient morbidity, reduction in quality of life, higher likelihood of readmissions, and reinterventions, which contribute directly to mortality and increase in health-related costs. Some of these are potentially preventable by applying evidence-based strategies in the peri-operative patient setting. The objective of this review is to provide recommendations for the individual components that most commonly comprise the surgical site infection prevention bundles that could be implemented in gynecologic oncology procedures. We searched articles from relevant publications with specific topics related to each surgical site infection intervention chosen to be reviewed. Studies on each topic were selected with an emphasis on meta-analyses, systematic reviews, randomized control studies, non-randomized controlled studies, reviews, clinical practice guidelines, and case series. Data synthesis was done through content and thematic analysis to identify key themes in the included studies. This review intends to serve as the most up-to-date frame of evidence-based peri-operative care in our specialty and could serve as the first initiative to introduce an enhanced recovery after surgery (ERAS) program.

INTRODUCTION

Surgical site infections represent 20% of all hospital-acquired infections.[1] Such infections lead to increased patient morbidity, reduction in quality of life, higher likelihood of readmission, and reinterventions, which contribute directly to mortality and increase in health-related costs. The National Health Service Network (NHSN) and National Surgical Quality Improvement Program (NSQIP) define a surgical site infection as an infection that occurs after surgery in the part of the body where the surgery took place, occurring within 30 days of surgery.[2] These are classified by depth and tissue spaces involved as follows: superficial-incisional (skin or subcutaneous tissue), deep-incisional (fascial and muscle layers), and organs/spaces deep into the incision (involves any part of the body, excluding the skin incision, fascial/muscle layers, that is opened or manipulated during the operative procedure).[2]

The surgical site infection rate is estimated at 5–35% among all gynecologic oncology procedures.[2] Predictors of surgical site infection include obesity, hyperglycemia, or diabetes mellitus, an American Society of Anesthesiologists (ASA) score ≥3, prolonged procedure duration, open approach, and wound contamination.[3 4] A prevention bundle is a set of evidence-based interventions that, when performed collectively, improve patient outcomes.[5] Noting, however, that surgical site infection prevention bundles help mitigate risks without the capacity to impact fixed risks such as presence of malignancy, obesity, procedure duration, surgical approach, or ASA score. Interventions with a high level of scientific evidence endorsed by the Centers for Disease Control and Prevention (CDC) and the different bundles in our field are patient education, skin preparation, antimicrobial prophylaxis, avoiding hypothermia, and reducing peri-operative hyperglycemia.[5–14] Many quality improvement initiatives that have applied a bundled approach in gynecologic oncology surgeries have shown a significant reduction in surgical site infection rates.[8–14]

The objective of this review is to provide evidence-based recommendations for the individual components that most commonly comprise the surgical site infection prevention bundles that could be implemented in gynecologic oncology procedures.

Impact of Implementation of Surgical Site Infection Prevention Bundles

Given the impact of surgical site infections in many countries and the gaps in evidence-based guidance, the WHO published guidelines on peri-operative interventions, valid for any country irrespective of its level

of development and resources, to ensure a universal contribution to preventing surgical site infections.[15] Several surgical subspecialties have developed care bundles addressing these interventions simultaneously to manage the multifactorial origins of surgical site infections throughout the phases of peri-operative care. It has been proven that there is an inverse correlation between the number of bundled elements utilized and the rate of surgical site infections, suggesting that each element has an additive impact on risk reduction.[16]

Implementing enhanced recovery after surgery (ERAS) protocols, designed to reduce surgical stress and facilitate recovery, includes a range of peri-operative interventions, some of which are part of the surgical site infection bundles. The Enhanced Recovery After Surgery (ERAS) Society 2019 guidelines have recommended the implementation of a surgical site infection prevention bundle for gynecologic oncology patients undergoing laparotomy.[7] Recently, a study demonstrated that implementing a surgical site infection bundle within an ERAS care pathway was associated with a reduction in surgical site infections and infectious complications, as well as a shorter length of stay in gynecologic oncology surgery.[14] Based on these recommendations, we consider that one potential strategy to introduce an ERAS program could be the implementation of a surgical site infection prevention bundle to optimize team adherence and compliance.

METHODS

For the literature search, we used EMBASE and PubMed databases to look for medical topic titles related to "gynecologic surgery", "gynecologic oncology surgery", and specific topics related to each surgical site infection intervention that was chosen to be reviewed. Studies on each topic were selected with an emphasis on meta-analyses, systematic reviews, randomized control studies, non-randomized controlled studies, reviews, clinical practice guidelines, and case series. When it was not possible to find specific evidence in the field of gynecology or gynecological oncology, the search was expanded to other surgical disciplines in which major abdominal surgery is routinely performed to be able to select patients as similar as possible to our field. The reference lists of all articles were checked for other relevant studies. This literature was summarized by two authors (LR and MCS) and sent to an internal expert author for review (PTR). Institutional review board approval was not obtained as there were no patients involved. The schematic overview of the surgical site infection prevention bundle is presented in Figure 1.

Pre-operative Measures

Patient and Peri-operative Team Education

Preventing surgical site infections is the responsibility of every peri-operative team member (surgeons, anesthesia providers, and nurses); therefore, individual roles and responsibilities must be clearly established. To optimize patient engagement in the surgical procedure and reduce the risk of surgical site infection, the education process should include specific instructions and education related to pre-operative showers, not shaving before the procedure, pre-existing medical conditions, antibiotic administration, what to expect on the day of the surgery (such as monitoring devices, skin preparations, body warming devices, and wound closure). Additionally, patients should be educated on post-operative care and how to prepare their home environment for a successful recovery. Using multiple modalities, such as verbal communication, written pamphlets, instruction sheets, videos, and simulated demonstrations, can help reinforce the education process.[17] A review conducted by Tartari et al demonstrated that pre-operative instructions to reduce surgical site infections should address smoking cessation (at least 4 weeks before surgery), hair removal,

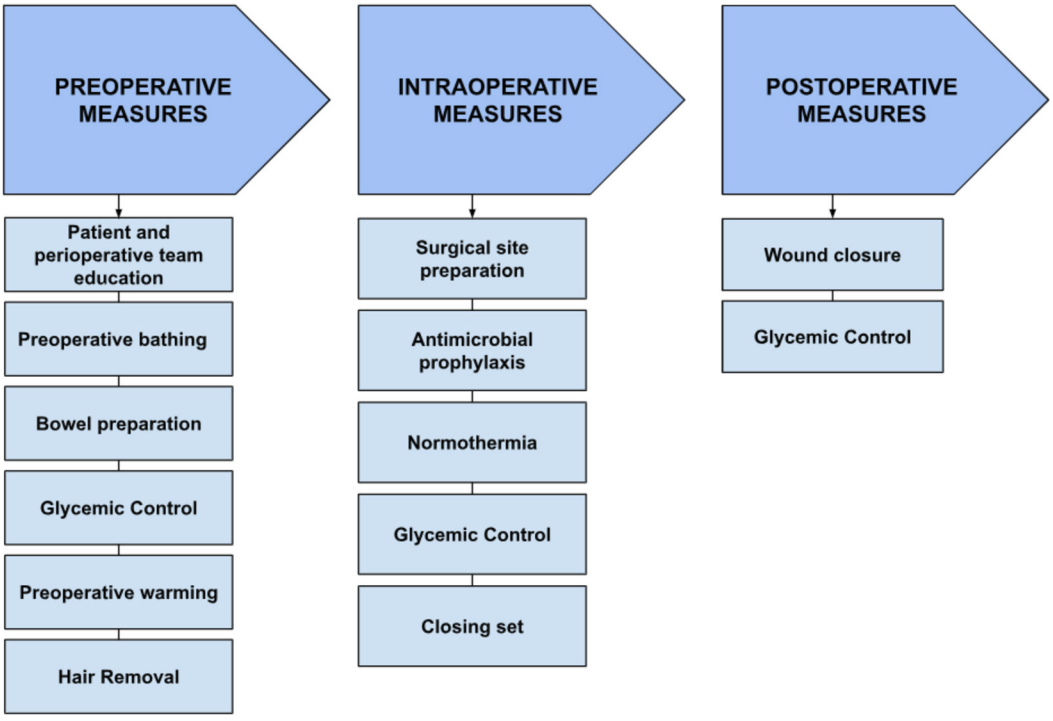

Figure 1 Components of the surgical site infection prevention bundle in gynecology oncology surgery.

pre-operative showering, and wound care.[18] Mbamalu et al carried out a review of infection-related care in surgical specialties and reported that a multimodal approach (written pamphlets and simulated demonstrations on wound care and infection symptoms) was preferred and more effective in engaging patients to improve understanding and, hence, outcomes.[19] See Online Supplemental File 1.

Skin Preparation

Pre-operative Bathing

Although there is no evidence to confirm that pre-operative bathing decreases the incidence of surgical site infection, the WHO Guidelines on the Prevention of Surgical Site Infection supports pre-operative bathing.[15] The Association of Perioperative Registered Nurses (AORN) guidelines note that the benefits of pre-operative bathing outweigh the potential harms and, therefore, also recommend intervention.[20]

To reduce the concentration of resident and transient bacteria on the skin and thus limit the risk of wound contamination, an antiseptic shower or skin-cleansing process is recommended prior to patient admission for elective surgery.[6 21 22] Nevertheless, the CDC guidelines do not make recommendations regarding agents, optimal timing of washing, or number of applications.[6] A randomized prospective study by Edmiston et al evaluated the efficacy of a standardized pre-admission showering regimen for patients undergoing elective surgery. The study included a precise dose (118 mL of volume) of chlorhexidine gluconate 4%, timing (1 min pause before rinsing off), and duration of treatment (two showers at night and morning before surgery). They found that the standardized process achieved a high and sustainable level of skin antisepsis to reduce the risk of intra-operative wound contamination ($p<0.001$).[23] The 2% chlorhexidine gluconate-coated polyester cloths are an equally effective alternative.[24] Lippitt et al and Schiavone et al conducted two prospective trials as part of a surgical site infection reduction bundle for gynecologic cancer patients undergoing a colorectal procedure. Both proved that implementing pre-operative wash with 4% chlorhexidine gluconate, with the combination of other interventions, was associated with a significant reduction in surgical site infection rates ($p<0.001$).[8 9]

In case of the antecedent of hypersensitivity reaction to chlorhexidine gluconate, no pre-operative skin preparation was recommended, and an alternative antiseptic (such as povidone-iodine) skin preparation must be used in the operating room.[25] See Online Supplemental File 1.

Recommendation

- Use a pre-admission shower with 4% chlorhexidine gluconate soap the night before and the morning of surgery.
- The 2% chlorhexidine gluconate-coated cloths are an alternative.

Bowel Preparation

Bowel preparation is a topic of debate in gynecologic oncology surgery, not only due to the lack of randomized clinical trials supporting the use but also due to the uncomfortable and side effects it entails (electrolyte imbalance, dehydration, abdominal pain, bloating, and fatigue).[26] However, several studies have found that bowel preparation prior to colorectal surgery significantly reduces surgical site infections.[27] The American College of Surgeons (ACS) and Surgical Infection Society (SIS) recommended the use of a combination of mechanical and oral antibiotic bowel preparations. Also, the authors discouraged the use of mechanical bowel preparation alone, oral antibiotics alone, or intravenous (IV) antibiotics alone because they do not decrease surgical site infections.[1] The American Society of Colon and Rectal Surgeons (ASCRS) clinical practice guidelines strongly recommend mechanical bowel preparation with oral antibiotics for elective colorectal resections because it reduces the rates of surgical site infection in comparison with other methods of bowel preparation.[28] A systematic review of 21 randomized clinical trials in elective colorectal surgery compared combined mechanical and oral antibiotic bowel preparation with either mechanical bowel preparation alone, oral antibiotics alone, or no bowel preparation. They demonstrated that mechanical and oral antibiotic bowel preparation reduced the risk of surgical site infection compared with mechanical bowel preparation alone (odds ratio (OR) 0.56; 95% CI 0.42 to 0.74, $p<0.0001$). However, there was no difference in the risk of surgical site infections between mechanical and oral antibiotic bowel preparation with the oral antibiotics alone group (relative risk (RR) 0.87; 95% CI 0.34 to 2.21, $p=0.76$).[29]

The ERAS Society Guidelines in gynecology oncology recommend against the routine use of mechanical bowel preparation alone and highlight that oral antibiotics alone should be combined with mechanical bowel preparation in cases of colon resection.[7] A second analysis from a randomized clinical trial by Moukarzel et al reported the impact of bowel preparation on patients undergoing colorectal resection during gynecologic oncology surgery. They found that mechanical bowel preparation plus oral antibiotics and oral antibiotics alone were associated with decreased surgical site infection compared with no preparation ($p=0.004$). However, there was no significant difference between the antibiotic groups ($p=0.44$).[27]

A significant decrease in the surgical site infection rate from 10.6% to 2.4% among ovarian cancer patients undergoing cytoreductive surgery with colonic resection ($p=0.19$) was found by Johnson et al in their surgical site infection reduction bundle without bowel preparation as part of the interventions.[12] Nevertheless, Lippitt et al incorporated combined oral antibiotics with mechanical bowel preparation in their surgical site infection bundle and demonstrated that infection rates decreased to 7% ($p<0.001$) in the ovarian cancer population who had colon surgery.[8] Schiavone et al developed a bundle with pre-operative oral antibiotics and optional mechanical bowel preparation, resulting in a decreased surgical site infection rate from 37% to 12% ($p\leq0.001$).[9]

The heterogeneity of the published guidelines and the lack of conclusive randomized trials in gynecology oncology surgery leads to controversy surrounding the issue of bowel preparation.

Oral Antibiotic Regimen

Neomycin/erythromycin-based oral antibiotic bowel preparations have been shown to achieve high intraluminal concentrations, reduce the concentration of both aerobic and anaerobic bacteria in the flora of resected bowel after colorectal surgery, and even eliminate the evidence of the existence of microflora on bowel mucosa.[30] A systematic review and meta-analysis that evaluated different regimens of oral antibiotics in patients undergoing elective colorectal surgery reported a similarly significant effect on surgical

site infection rate with the combination of pre-operative oral aminoglycoside and erythromycin (OR 0.40; 95% CI 0.25–0.64, p<0.001) or metronidazole (OR 0.51; 95% CI 0.39–0.68, p<0.001).[31]

One of the main arguments against using pre-operative oral antibiotics was the potentially increased rate of *Clostridium difficile* infection. However, studies in colorectal surgery populations may offer some insight. Khorasani et al, in a systematic review and meta-analysis that compared bowel preparation regimens in patients who underwent colorectal surgery, concluded that the incidence of *C. difficile* infection is very low, regardless of the bowel preparation regimen used.[32] Additionally, the ASCRS guidelines indicate that recent analyses suggest a protective effect from oral antibiotic bowel preparation against *C. difficile* infection.[33]

Recommendation

- Neomycin 500 mg - total dose 3000 mg the day prior to surgery.
- Metronidazole 500 mg - total dose 1500 mg the day prior to surgery.

Mechanical Bowel Regimen

Recommendation

- MiraLAX - one bottle of 119 g the evening prior to surgery before midnight.
- Bisacodyl 5 mg tablets - total dose 20 mg the evening prior to surgery. See Online Supplemental File 1.

Glycemic Control

Insulin resistance, expressed as hyperglycemia (blood glucose levels >140 mg/dL in hospitalized patients), is a common phenomenon caused by the hypermetabolic stress response from surgical trauma and is a known risk factor for surgical site infection. Hyperglycemia impairs the cellular immune system, increasing the risk of infection, particularly in the context of a healing wound. Additionally, diabetic patients are particularly prone to surgical site infection, even independent of hyperglycemia occurring during or after surgery, likely attributable to a diabetes-induced immunocompromised state.[34]

A prospective randomized control trial in critically ill patients, the NICE-SUGAR study, showed that intensive glucose control (80–110 mg/dL) had no significant advantage compared with moderate glycemic targets (140–180 mg/dL) and that very strict control leads to moderate and severe hypoglycemia, both of which are associated with an increased risk of death. In these patients, insulin therapy should be initiated starting at a threshold of 180 mg/dL and maintained in the range 140–180 mg/dL.[35] According to the Endocrine Society clinical practice guideline, for non-critically ill adult patients with diabetes who are undergoing elective surgical procedures, it is recommended to aim for pre-operative glycated hemoglobin (HbA1c) levels below 8% and blood glucose concentrations between 100 and 180 mg/dL. Additionally, for patients with hyperglycemia (whether or not they have type 2 diabetes), scheduled insulin therapy (neutral protamine Hagedorn (NPH)-based insulin or basal-bolus insulin (BBI) regimens) should be used for glycemic management instead of non-insulin therapies such as metformin. They suggest initial therapy with correctional insulin over scheduled insulin therapy (defined as basal or basal/bolus insulin) to maintain glucose targets in the range 100–180 mg/dL. For patients with persistent hyperglycemia (≥2 point-of-care blood glucose measurements ≥180 mg/dL in a 24-hour period on correctional insulin alone) they suggest the addition of scheduled insulin therapy.[36]

A retrospective study in gynecologic oncology patients who had known diabetes or post-operative hyperglycemia (≥150 mg/dL or ≥200 mg/dL if they received steroids during surgery) demonstrated that initiating intensive post-operative glucose control through insulin infusion for 24 hours (target blood glucose <139 mg/dL) had lower surgical site infection rates compared with those managed with intermittent subcutaneous insulin. Also, they showed lower hypoglycemia rates after adopting the continuous insulin infusion compared with intermittent insulin use (0.7% vs 5.4%, p=0.05). Remarkably, treated patient's surgical site infection rates were equivalent to those without diabetes or post-operative hyperglycemia.[37] A quality-of-care glycemic control initiative was implemented in patients undergoing major gynecologic oncology surgery to prove that maintaining normoglycemia throughout the peri-operative period reduces surgical site infection rates. The intervention included pre-operative HbA1c measurement and rigorous pre-, intra-, and post-operative glucose monitoring to maintain blood glucose levels ≤180 mg/dL. All patients flagged with an HbA1c ≥6% were pre-operatively referred to their general practitioner to optimize the intra-operative management. They received intensive intra-operative glucose monitoring every 2 hours starting from the beginning of surgery or from the last correction dose of insulin. Intra-operative glucose was to be corrected to a value <180 mg/dL with subcutaneous rapid-acting insulin and was checked on arrival to the post-anesthesia care unit (PACU) and once transferred to the ward, four times per day. This approach showed a significant decrease in the incidence of surgical site infection rates from 14.6% to 5.7% (p=0.001). Additionally, HbA1c screening identified 35% of dysglycemic patients (HbA1C ≥6.0) who were unaware of their diagnosis and benefited from intensive blood glucose monitoring and management.[34]

Recommendation

- All patients should undergo a pre-operative HbA1c test.
- If HbA1c is >8.0%, refer to a primary care physician or endocrinologist for pre-operative optimization.
- Strict glycemic control to keep blood sugars <180 mg/dL.
- If blood glucose levels ≥180 mg/dL, treat with a correction scale and proceed to surgery with glucose measured every 2 hours in the operating room.
- If blood glucose levels are >300 mg/dL, an evaluation for diabetic ketoacidosis is performed. If positive, postpone surgery and treat. If negative, treat with a correction scale and proceed to surgery, with glucose measured every 2 hours in the operating room.

Pre-operative Warming

Maintaining normothermia (median temperature >36°C or >96.8°F) prevents subcutaneous vasoconstriction, subsequent tissue hypoxia, and surgical site infections. A Cochrane systematic review assessed the effectiveness of pre- or intra-operative active body surface warming systems, as well as the different types and techniques. They concluded that forced air warming seems to have a beneficial effect in terms of surgical site infection and complications, at least in those undergoing abdominal

surgery, compared with not applying any active warming system (RR 0.36; 95% CI 0.20 to 0.66, p=0.008). Between different types or modes of administration, they found no superiority of any system in terms of clinical outcomes. Also, they found that extending systemic warming to the pre-operative period in patients undergoing major abdominal surgery had additional beneficial effects in terms of complication rates, including surgical site infection (32% vs 54%, p=0.027).[38] A randomized clinical trial performed in elective major abdominal surgery showed that extending the warming period to 2 hours before and after surgery reduced the incidence of surgical site infection from 27% to 13% (p=0.027).[39] Another trial in ovarian cancer surgery demonstrated that prewarming with forced air reduces the drop in body core temperature, which maintains normothermia and preserves microperfusion.[40] Fossum et al studied outpatients undergoing gynecological, orthopedic, and urological surgical procedures to evaluate the effect of prewarming. Core temperatures were measured and recorded every 15 min for a minimum of 45 min during the patient's stay in the pre-operative holding area, immediately before the transfer to the operating room, on return to the PACU, and continued until the patient was ready for discharge. They demonstrated that patients who were prewarmed with forced air had a significant increase in their body temperature during the pre-operative stay and maintained higher mean temperatures on arrival to the PACU from the operating room compared with those who were warmed with cotton blankets.[41] Also, the NICE guideline recommends that baseline temperature should be measured and documented prior to the patient leaving the pre-operative phase, defined as an hour before induction of anesthesia.[42]

The American Society of PeriAnesthesia Nurses (ASPAN) guideline recognizes that the measurement of core temperature (eg, pulmonary artery, distal esophagus, nasopharynx, tympanic membrane) is the best indicator of thermal status. However, core temperatures are frequently not feasible during the peri-anesthesia period, and near-core measures of oral temperature are recommended.[43]

Recommendation

- Prewarm patients in the pre-operating room using a forced air warmer at least 45 min before surgery.
- Document the patient's temperature on arrival to the pre-operative area and immediately prior to transfer to the operating room.

Hair Removal

Hair at the surgical site can limit the view of the operative field, interfere with the placement or later removal of sutures or incision site dressings, and possibly increase the risk of surgical site infection. The American College of Obstetricians and Gynecologists (ACOG) recommends that hair should not be removed pre-operatively unless the hair at or around the incision site interferes with the operation, and any necessary hair removal should be done immediately before the operation, preferably with electric clippers.[44] A Cochrane meta-analysis of surgical procedures concluded that if hair has to be removed, it should be done using clippers or depilatory cream on the day of surgery rather than the day before because it probably results in fewer surgical site infections and other complications compared with shaving using a razor.[45] A prospective study in patients undergoing gynecology oncology surgery that includes hair clipping as part of a preventive bundle showed a decrease from 12.1% to 5.4% in surgical site infection rates (p=0.008).[10]

Recommendation

- Hair removal by electric clippers in the pre-operative area.

INTRA-OPERATIVE MEASURES

Surgical Site Preparation

The aim of intra-operative skin preparation is to reduce the microbial load of the patient's skin before surgical incision. A prospective randomized trial in clean-contaminated surgeries, which included colorectal and gynecologic procedures, compared the occurrence of surgical site infection between 2% chlorhexidine gluconate and isopropyl alcohol with 10% povidone-iodine. The chlorhexidine-alcohol group was superior in preventing surgical site infections (p=0.004).[46] Similar results were obtained in a retrospective study of patients who underwent abdominal hysterectomy and received pre-operative chlorhexidine-alcohol-based skin antisepsis compared with povidone-iodine (adjusted OR (aOR) 0.56; 95% CI 0.37 to 0.85). To avoid irritation, solutions that contain lower alcohol concentrations (4% chlorhexidine gluconate solution with 4% alcohol) are usually well tolerated and may be used for vaginal preparation.[44]

Recommendation

- Abdominal preparation with 2% chlorhexidine gluconate plus 70% isopropyl alcohol formulation (ChloraPrep; Becton, Dickinson and Company, Franklin Lakes, NJ, USA).
- Vaginal preparation with a 4% chlorhexidine gluconate solution with 4% alcohol formulation.

Antimicrobial Prophylaxis

Antimicrobial prophylaxis is defined as a brief course of an antimicrobial agent that is initiated within 60 min of a procedure's start time to reduce intra-operative microbial contamination. In several randomized clinical trials performed in patients undergoing hysterectomy, a single dose of IV cefazolin (2 g) was demonstrated to be more effective in preventing infectious complications, and it should be initiated within 60 min, ideally 10 to 25 min before incision. Additionally, antimicrobial prophylaxis may be adjusted in three circumstances: weight (≥120 kg), length of procedure (after 4 hours), and blood loss (>1500 mL).[44 47 48] Morrill et al conducted a systematic review of the use of antimicrobial prophylaxis in benign gynecologic procedures other than hysterectomies. The authors concluded that laparoscopic operations not contaminated by the genitourinary or digestive tracts do not require antimicrobial prophylaxis.[49]

Gynecologic oncology surgeries include a wide range of procedures, and several could involve bowel resection. In a retrospective cohort of gynecology surgeries study that included 18 255 patients, it was shown that in case of high risk of gastrointestinal involvement (such as gynecologic malignancy or metastases, history of prior abdominal surgery, and other causes of adhesions or distortion of pelvic anatomy like endometriosis), the combination of cefazolin plus metronidazole reduced the risk of surgical site infection (OR 2.30; 95% CI 1.06 to 4.99).[50]

Penicillin Allergy

Approximately 10% of patients report a history of reacting to a penicillin-class antibiotic. However, true IgE-mediated allergies

with anaphylaxis or other severe reactions are rare, and up to 90% of these patients are able to tolerate penicillins.[51] Even if an allergy to penicillin is suspected based on the history, the rate of dual penicillin and cephalosporin allergy is only 0.7%.[52] The degree of cross-reactivity between cephalosporins and penicillins depends on the generation of cephalosporins, being higher with earlier-generation cephalosporins. Cross-reactivity between penicillin and second- and third-generation cephalosporin is low and may be lower than the cross-reactivity between penicillin and unrelated antibiotics.[53] Recognizing the low risk of cross-reactivity and the higher rates of surgical site infection when alternative antibiotics are used for surgical prophylaxis due to a reported allergy to penicillin, the CDC and the Joint Task Force on Practice Parameters (JTF-PP) from the American Academy of Allergy, Asthma and Immunology (AAAI) have issued statements recommending use of most cephalosporins, carbapenems, monobactams, and β-lactamase inhibitors in patients with a reported history of penicillin allergy.[51 54]

A retrospective review of patients who underwent hysterectomies (including for malignant indications) found that in patients who received β-lactam antibiotic alternatives (clindamycin/gentamicin or metronidazole/gentamicin) the risk of surgical site infection was higher (OR 1.7, 95% CI 1.27 to 2.07). One possible explanation is that β-lactam antibiotics are highly effective against skin flora (*Streptococcus* species, *Staphylococcus aureus*, and coagulase-negative staphylococci), which are the predominant organisms that cause surgical site infections.[55]

Recommendation

- For patients <120 kg: cefazolin 2 g IV × 1 dose within 60 min of incision.
- For patients ≥120 kg: cefazolin 3 g IV × 1 dose within 60 min of incision.
- Cefazolin should be redosed every 4 hours and/or if estimated blood loss >1500 mL.
- In cases of a high risk of gastrointestinal involvement, add metronidazole 500 mg × 1 dose within 60 min of incision.
- For penicillin allergy, cefazolin or another β-lactam (cephalosporins, carbapenems, monobactams) must be used.

Normothermia

Maintaining normothermia intra-operatively is likely to decrease the incidence of surgical site infections. The best monitoring device should be accurate in measuring core body temperature, reliable (±0.1°C or ±0.018°F), and accessible. The patient's temperature must be continually evaluated and monitored in the record as part of the vital signs. Also, the temperature of the immediate environment is recommended to be in the range 20–25°C (68–77°F).[56]

In a prospective randomized study of colorectal surgery, it was found that intra-operative hypothermia triples the incidence of wound infection (p=0.009).[57] In a quality improvement project in gynecology surgery, Kumar et al adopted a combination of interventions to avoid intra-operative hypothermia. They found that combining intra-operative temperature regulation (digital thermostats in the operating room set in the range 21.1–23.3°C (70–74°F) and forced-air warming blanket) with a second method (prewarming with a forced-air warming gown) was an effective alternative to maintaining normothermia.[58]

Recommendation

- The operating room thermostat should be set at least 20°C (68°F) between cases or overnight.
- An upper body forced-air warming blanket is to be applied to all.
- An esophageal and nasopharyngeal temperature probe should be used on all patients undergoing general anesthesia.
- The patient's temperature must be measured and documented before entering the operating room, continuously during the surgery, and every 15 min in the PACU.

Closing Set

Routine changes of gloves and instruments before wound closure in abdominal surgeries could potentially reduce surgical site infections. A multicenter, cluster-randomized trial developed in seven low- and middle-income countries in patients undergoing abdominal surgery showed a reduction in the rate of surgical site infections when changing gloves and instruments before wound closure was performed (p=0.003).[59] Bruce et al implemented an abdominal wound closure bundle in patients who underwent exploratory laparotomy with suspicious or confirmed gynecologic oncology disease. A statistically significant reduction in surgical site infection rates was found in those who had malignant disease (p=0.049), International Federation of Gynecology and Obstetrics (FIGO) stage III or IV (p=0.028), and those who underwent a tumor debulking surgery (p=0.017).[60] The adoption of sterile techniques (gown and glove change after intestinal surgery and change of instruments for wound closure) in ovarian cancer patients as part of a surgical site infection bundle conducted by Lippitt et al was associated with a reduction in surgical site infection rates (33% prebundle vs 7% postbundle, p<0.001).[8]

Recommendation

- Change instruments and supplies for wound closure (separate closing set).
- Change gloves prior to closure of the fascia.
- Change gown and gloves after intestinal surgery.

POST-OPERATIVE MEASURES

Wound Closure

The ideal skin incision closure technique should be safe, easy to use, rapid, esthetic, cost-effective, and should not require device removal. However, the evidence does not clearly state the best skin closure technique that satisfies all of these conditions. In obese patients undergoing midline vertical incisions in gynecologic oncology procedures, a randomized clinical trial did not demonstrate a difference in surgical site infection with subcuticular sutures compared with staples (32% vs 33%; RR 1.05; 95% CI 0.68 to 1.64).[61] One retrospective study in patients undergoing abdominal hysterectomy was done to compare skin closure procedures and surgical site infection. The rates were 0.33% in patients with skin adhesives, 0.61% in sutures, 0.90% in staples, and 1.02% in staples plus skin adhesives (p=0.002). Therefore, skin adhesives appear to be a safe alternative to maintain the integrity of the closure and minimize the risk of infection.[62]

Recommendation

- Routine use of skin adhesives (such as Dermabond Prineo (Dermabond, Ethicon, Inc., Somerville, NJ, USA) on all abdominal incisions.
- Avoid the use of staples whenever possible (limited data in support).

POINTS OF CONTROVERSIES

Wound Dressing

Wound dressings applied after wound closure may provide temporary physical barriers until the continuity of the skin is restored (within about 48 hours) and can help absorb exudate. There are basic wound dressings (gauze) and advanced wound dressings such as films, foams, hydrocolloids, hydrogels, and silver-containing dressings. A Cochrane review investigated the use of dressings in clean and potentially contaminated surgery to decrease surgical site infections. They found no evidence to suggest that covering surgical wounds or any type of wound dressing is more effective than others in reducing the risk of surgical site infection.[63] Another Cochrane review evaluated the risks of removing a wound dressing within or beyond 48 hours after clean or clean-contaminated surgery. The authors concluded that early removal of wound dressings appears to have no detrimental effect on surgical site infections.[64] It should be noted that this statement is based on very low-quality evidence. Nonetheless, four surgical site infection bundles in gynecology oncology surgery recommend dressing removal on the second post-operative day (24–48 hours post-operatively).[9–12]

A safe and effective wound dressing option that may reduce surgical site infections, especially in patients with obesity or gynecological malignancies after laparotomy, is closed-incisional negative pressure therapy. Leitao et al conducted a randomized clinical trial to evaluate wound complications (infection, separation, seroma, or hematoma) by comparing standard gauze with negative pressure wound therapy in 505 patients undergoing laparotomy for confirmed or presumed gynecologic malignancy, including morbidly obese patients. The authors did not support the routine use of prophylactic negative pressure wound therapy at the time of laparotomy incision closure in patients undergoing gynecologic malignancy surgery or morbidly obese patients for benign indications. However, they highlight that negative pressure wound therapy systems may be useful in certain settings, such as in the management of wounds left open primarily or complex disrupted post-operative wounds.[65]

Skin tissue adhesives (such as Dermabond Prineo) can be used on an already closed wound as a dressing without an additional covering.[62] The selection of wound dressing should be chosen based on wound closure type and cost, as it is unlikely to affect surgical site infection rates.

Universal MRSA Testing

Decolonization refers to the practice of treating patients with an antimicrobial and/or antiseptic agent to suppress *S. aureus* colonization, including both methicillin-susceptible *S. aureus* (MSSA) and methicillin-resistant *S. aureus* (MRSA).[66] A prospective cohort study that included eight surgical categories (abdominal, orthopedic, urological, neurological, cardiovascular, thoracic, and plastic surgery and solid organ transplant) found that decolonization strategies (nasal mupirocin ointment and chlorhexidine body washing) did not reduce MRSA surgical site infections (p=0.29).[67] As a result, decolonization is typically focused on high-risk procedures such as orthopedic, cardiothoracic, spine, and brain surgeries.[15 68] In the context of gynecologic oncology surgery, there is no specific evidence that directly addresses the recommendation for nasal screening and decolonization.

Surgical Attire

The development of perioperative surgical attire policies, as part of an intervention in a surgical bundle, could achieve a reduction in surgical site infection rates. However, no strong evidence exists that surgical attire directly affects surgical site infection. To reduce the potential for transporting pathogenic organisms, AORN guidelines recommend that personnel remove surgical attire before leaving the healthcare facilities and that this be laundered in the healthcare organization (accredited laundry) to ensure effective laundering standards.[69] Markel et al conducted a study on operating room headgear and found that disposable bouffant hats produced greater permeability, particle contamination, and passive microbial shed compared with cloth caps.[70] Despite this, no association is demonstrated between headgear patency and surgical site infection rates.

Conclusions

Surgical site infections carry significant complications, including increased patient morbidity and mortality, higher rates of readmission and reinterventions, and increased health-related costs. Different levels of evidence support the application of individual interventions to reduce infections. However, the most impactful and cost-effective changes are seen when multiple standardized interventions are applied simultaneously.

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