

LEAD FEATURE

Novel Strategies to Prevent Surgical Site Infections

Lisa Croke, Managing Editor

Surgical site infections (SSIs) account for approximately 20% of health care–associated infections. These infections are the most expensive health care–associated infections, costing an estimated \$3.3 billion annually and \$20,000 per admission. Moreover, SSIs can cause substantial morbidity and increased lengths of stay and can result in a 2 to 11 times greater risk of mortality.¹ Thomas Serena, MD, FACS, FACHM, MAPWCA, chief medical officer, Mendota Health, Mendota Heights, Minnesota, indicated that SSIs have always been a major problem in the perioperative period, but the timing and treatment have evolved. “For example, people typically used to still be in the hospital when they developed their SSI, but now they often are at home and, a lot of times, they are not cared for by the surgeon, but by home health or at wound clinics,” he said. “The more we can do to prevent them or, in some cases, detect them at a stage when they are easier to treat, the better.” Modern technologies and novel approaches are increasingly becoming available in health care, some of which may serve as solutions to prevent SSIs.²

Dressings

One study compared a novel color-changing dressing with a standard transparent film dressing to cover surgical incisions in 20 patients, each of whom served as their own control by having one of each dressing used to cover two 1.5-cm incisions (one on each forearm) that were closed with self-adhesive wound approximating strips. The color-changing dressing is waterproof and has a liquid indicator in the perimeter of the dressing that turns blue when moisture is present; the change of color alerts health care personnel and patients to the loss of dressing integrity and the need to change the dressing. Overall, 95% of participants indicated the color-changing dressing

maintained its integrity during showering and other standard activities of daily living compared with 70% of participants who said the same about the standard dressing. In addition, 75% of participants indicated that they preferred the color-changing dressing. The authors concluded that this novel dressing may allow patients to be active postoperatively without concerns about disrupting the dressing.³ According to Serena, one of the authors of this study, one major benefit of the color-changing dressing is that it introduces the patient into the equation of SSI prevention. “The patients liked the dressing, primarily because it provided them with feedback to change it,” he said. Serena added that this dressing is serving as a jumping-off point for more advanced dressings. “It is best to start really simple, which this dressing is, and then build on it to the point where you get to smart dressings,” he said. “I can envision dressings that have all kinds of technology built into them; for example, eventually, I think dressings will be able to tell you how much bacteria is in and around the wound.”



A waterproof color-changing dressing has a liquid indicator in the perimeter of the dressing that turns blue when moisture is present. Photo courtesy of Thomas Serena.

SURGICAL SITE INFECTIONS

Another study evaluated the ability of a novel dressing containing an antimicrobial coating to prevent SSIs in patients undergoing abdominal surgery. The dressing is waterproof; has a hybrid polymer matrix layer, which results in an environment unsuitable for bacteria propagation; and provides prolonged and controlled release of silver ions, which have been shown to have antimicrobial activity. Thirty-two patients who underwent hepatopancreatobiliary, colorectal, or hernia repair surgery, had their surgical incisions covered with the novel dressing and were followed until complete healing of their wounds. The dressing needed to be changed an average of 1.8 times per patient. The first dressing change occurred an average of 3.75 days postoperatively and the second dressing change occurred an average of seven days postoperatively. Only four patients needed a third dressing change; this occurred an average of nine days postoperatively. Only one patient experienced an SSI. The authors indicated that this dressing is appropriate for surgical incisions after abdominal surgery and may increase comfort for patients by decreasing the number of necessary dressing changes.⁴

A third study evaluated the ability of a novel bioresorbable microfilm matrix containing small amounts of ionic and metallic silver to prevent SSIs in 22 patients with diabetes undergoing elective foot or ankle surgery (eg, amputation, exostosis removal, midfoot bone removal, Achilles tendon repair). The microfilm matrix is bioresorbable and antimicrobial. After subcutaneous closure (if applicable), the microfilm matrix is placed at the level of subcutaneous tissue and dermis, the incision is primarily closed, and a cover dressing is applied. Patients were followed for three months. At initial follow-up at three to five days postoperatively, no patients had signs of an SSI, and all the wounds of patients who adhered to postoperative instructions (20 of 22) were completely healed and had no signs of an SSI at the end of three months.⁵

Antibiotic Matrix

One study evaluated the effectiveness of a novel broad-spectrum antibiotic (doxycycline)-eluting polymer-lipid encapsulation matrix in preventing superficial and deep SSIs in patients undergoing elective colorectal surgery. The matrix forms a protected reservoir and allows a localized, continuous release of doxycycline for 30 days. After fascia closure and before skin closure, it is applied to the

soft-tissue wound surfaces. There were 179 patients who were randomized to receive either standard of care (SOC) SSI prophylaxis (n = 91), such as IV antibiotics and mechanical bowel preparation, or the matrix combined with SOC (n = 88). The incisions were evaluated at one, five, 14, 30, and 60 days after surgery. Those receiving the matrix plus SOC had a 64% relative risk reduction in SSIs compared with those receiving only SOC (SSI rate of 8% versus 22%). No significant differences in adverse events occurred between the two groups. The authors concluded that this novel matrix could be a promising addition to current SSI prevention bundles.⁶

Wound Retractor

One study evaluated the effectiveness of a novel wound retractor that combines barrier protection with continuous antibiotic wound irrigation for preventing SSIs in patients undergoing an elective colorectal resection. Forty-one patients received the novel wound protector and 82 patients received a standard wound protector. Thirty-day SSI rates were significantly lower (0% versus 12.2%) and lengths of stay were significantly shorter (four versus five days) in the patients who received the novel wound protector versus the standard wound protector. The number needed to treat for the novel wound protector to prevent one SSI was 8.2 patients.⁷ Another study evaluated the same type of wound retractor for preventing SSIs in 108 patients undergoing elective colorectal surgery. Patients' characteristics were input into the American College of Surgeons National Surgical Quality Improvement Program Risk Calculator to identify the predicted rate versus observed rate of SSIs. The observed rate was 3.7% (four SSIs) and the mean predicted rate was estimated to be 9.5%, which was a 61% difference.⁸

Possible Future Options

A new antimicrobial suture material that glows in medical imaging, which is currently being evaluated in a laboratory setting, has potential to support wound monitoring postoperatively and prevent SSIs for mesh implants and internal sutures. The suture is composed of polymers with iodine and nanoparticles (ie, carbon dots) added. The carbon dots are fluorescent, and the iodine provides antimicrobial properties. In one study, the suture, which was threaded through chicken meat, was visible on computed tomography (even more than 22 days later) and eliminated 99% of drug-

SURGICAL SITE INFECTIONS

resistant bacteria after six hours at body temperature. Being able to identify suture integrity and anatomical location can help decrease the risk of SSIs.^{9,10} Shadi Houshyar, PhD, senior lecturer, RMIT University, Melbourne, Australia, and lead author of this study said that this suture has advantages over some existing antimicrobial sutures. “This special thread can be easily seen using noninvasive imaging techniques, such as computed tomography, which means that doctors can monitor the thread in real time, even if it has been inside the body for a long time,” she said. “The thread also can be used as a marker to keep track of the surgical site during and after surgery, which can help reduce the risk of infection after the procedure is complete.” Houshyar noted that although the suture material is made of polymers approved by the US Food and Drug Administration, before it can be implemented in practice, the contrast agent used to make the thread visible in medical imaging needs to undergo testing for its effect on human health and interactions with cells. “The next phase of the project will involve conducting preclinical and small clinical studies to verify the thread’s visibility and toxicity in a large animal group, followed by testing on human subjects,” she said. “This process is likely to take around seven years, after which the suture may become available for widespread use. Our promising initial results suggest that it may become a valuable tool for surgeons in the future.”

One study evaluated the effectiveness of using fluorescence imaging to identify bacterial burden of a surgical wound to potentially decrease SSIs. There were 58 wounds that were visually inspected for clinical signs and symptoms of infection and underwent fluorescence imaging and microbiological assessment to identify bacterial burden. Although 44 of the wounds (75.8%) had bacterial loads of concern (ie, greater than 10^4 colony-forming units/g) as identified by microbiological analysis, only three had clinical signs or symptoms of infection. Fluorescence imaging detected 18 wounds with bacterial loads of concern and was more than 5.5 times as sensitive for identifying infection as clinical signs and symptoms. The authors concluded that such advanced imaging could allow for early identification of high bacterial loads and help

enhance SSI monitoring and decrease SSIs by allowing for earlier intervention.¹¹ According to Serena, who is also an author on this study, the next steps are to look at how to use fluorescence imaging to guide therapy at the point-of-care in the OR and in the postoperative period. “If you see fluorescence in the OR, maybe you can leave the wound open or debride or irrigate it further; right now, we do not know what to do because it has not been studied yet, but we do know we will do something to eliminate that fluorescence,” he said. “Fluorescence imaging also has the potential to change the way we manage closed wounds in the postoperative period, particularly high-risk ones like perforated diverticulitis; because of its ability to detect bacteria long before there are signs or symptoms of infection, we will be able to intervene at a very early stage.”

Conclusion

Surgical site infections can cause substantial morbidity and increase mortality, making it essential that novel prevention strategies continue to be identified. In recent years, many technologies have been assessed, and new options continue to emerge. Serena indicated that he believes the era of diagnostics in wound care has arrived. “It is in its infancy, but I would expect great things in the next few years with resonance imaging, improved fluorescence imaging, and other types of imaging and biomarkers,” he concluded.



A suture composed of polymers with iodine and nanoparticles (ie, carbon dots) added is currently being studied. Photo courtesy of Shadi Houshyar.

SURGICAL SITE INFECTIONS

References

1. *Surgical Site Infection Event*. Atlanta, GA: Centers for Disease Control and Prevention; January 2023. Accessed July 28, 2023. <https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscscscurrent.pdf>
2. Greer B. New Technologies in Post-surgical Wound Dressings. Onco'Zine. Published January 16, 2023. Accessed July 28, 2023. <https://www.oncozine.com/new-technologies-in-post-surgical-wound-dressings/>
3. Breisinger K, Harrell K, Serena L, Serena TS. A prospective clinical pilot study comparing two post-operative dressings in the treatment of surgical incisions in volunteers. *J Wound Care*. 2022;31(suppl 9).
4. Oliverius M, Drozd J, Bratka P, Whitley A, Duchonova BM, Gürlich R. A new silver dressing, StopBac, used in the prevention of surgical site infections. *Int Wound J*. 2021;19(1):29-35.
5. Chatelain R. The efficacy of a novel silver-containing bioresorbable microfilm matrix in at-risk surgical wounds: a clinical case series. *Wounds*. 2021;33(10):245-252.
6. Zmora O, Stark Y, Belotserkovsky O, et al. A prospective, randomized assessment of a novel, local antibiotic releasing platform for the prevention of superficial and deep surgical site infections. *Tech Coloproctology*. 2023;27:209-215.
7. Malek AJ, Stafford SV, Papaconstaninou HT, Thomas JS. Initial outcomes of a novel irrigating wound protector for reducing the risk of surgical site infection in elective colectomies. *J Surg Res*. 2021;265:64-70.
8. Papaconstaninou HT, Bimbaum EH, Ricciardi R, et al. Impact of a novel surgical wound protection device on observed versus expected surgical site infection rates after colectomy using the National Surgical Quality Improvement Program Risk Calculator. *Surg Infect*. 2019;20(1):35-38.
9. Houshyar S, Yin H, Pope L. Smart suture with iodine contrasting nanoparticles for computed tomography. *Open Nano*. 2023;9:100120.
10. Smart stitches could reduce infection and simplify post op monitoring. Science Daily. February 1, 2023. Accessed July 28, 2023. <https://www.sciencedaily.com/releases/2023/02/230201084352.htm>
11. Sandy-Hodgetts K, Anderson CA, Al-Jalodi O, Serena L, Teimouri C, Serena TE. Uncovering the high prevalence of bacterial burden in surgical site wounds with point-of-care fluorescence imaging. *Int Wound J*. 2022;19(6):1438-1448.