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SHEA

Commentary

The impact of minimally invasive surgical approaches on surgical-site infections

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Abstract

We performed a literature review to describe the risk of surgical-site infection (SSI) in minimally invasive surgery (MIS) compared to standard open surgery. Most studies reported decreased SSI rates among patients undergoing MIS compared to open procedures. However, many were observational studies and may have been affected by selection bias. MIS is associated with reduced risk of surgical-site infection compared to standard open surgery and should be considered when feasible.

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Surgical-site infections (SSIs), defined as infections affecting the incision site or the deep tissue of the operative site,[1] occur in 0.5%–3% of patients undergoing inpatient surgery.[2–4] Overall, 21,186 SSIs were reported to the Center for Disease Control and Prevention's National Healthcare Safety Network in 2021.[3] SSIs contribute to increased length of stay; each SSI associated with up to 11 additional hospital days[5] SSIs also contribute to increased mortality, with a 2- to 11-fold increase in risk of death among surgical patients with an SSI compared to those without an SSI.[6,7] Additionally, SSIs are estimated to contribute $3.5–10 billion annually in healthcare costs.[8]

Risk factors for SSI can be divided into intrinsic patient-related factors and procedure-related factors.[9] Up to 60% of SSIs are estimated to be preventable using evidence-based guidelines.[10,11] Surgical approach may also affect the risk of SSI, and minimally invasive surgery (MIS) potentially decreases risk. The MIS technique entails the use of laparoscopic and/or robotic techniques to perform surgical procedures while avoiding the morbidity of conventional open surgical wounds.[12] MIS is thought to reduce the risk of SSI due to smaller incisions, less retraction of the surgical site, and less local soft-tissue trauma.[13] We undertook a literature review to describe the risk of SSI in MIS compared to open surgery because a comprehensive review has not been published.

Methods

We searched the Medline database on June 9, 2023, for studies published in English and completed in the last 20 years that reported the incidence of SSI in patients undergoing MIS compared to open surgery. Search terms used included "minimally invasive surgery," "laparoscopic surgery," "robotic surgery," "endoscopic surgery," and "surgical site infection." Studies were excluded if they lacked a control group of patients undergoing open surgery or if they were published prior to June 9, 2003.

Results

Our findings are summarized in Table 1. In total, 25 studies were identified, including randomized controlled trials, prospective cohort studies, and retrospective analyses of pre-existing clinical databases.[13–37] A wide range of patient populations were studied, including infants, adults, and age-mixed populations. Orthopedic, abdominal, pelvic, and spinal surgeries were included, as were both elective and emergent procedures. Most studies compared laparoscopic surgeries to open surgeries; however, 4 included robotic approaches in their analyses.[14,24,28,34] Moreover, 21 studies (84%) showed statistically significant decreases in the rate of SSI among patients undergoing MIS compared with open procedures. In addition, MIS was associated with decreased length of hospital stay in multiple studies. One study found decreased 30-day mortality among patients undergoing MIS for emergent indications as opposed to those who underwent open surgery.[21] Another study showed decreased hospital readmission rates among patients with septic arthritis undergoing arthroscopy compared to open arthrotomy.[18]

Discussion

In this literature review, we found that MIS is associated with decreased rates of SSI across many different surgical procedures and among a wide variety of patient populations. SSIs are serious healthcare-associated infections with a high burden of morbidity and mortality, as well as a substantial financial cost.[9] Numerous patient and procedural risk factors have been associated with

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Table 1. Summary of Studies Assessing Impact of Minimally Invasive Surgery on Frequency of Surgical-Site Infections

Author	Year	Study Design	Patient Population	Surgical Procedure(s)	MIS Type	Sample Size	Outcome(s)
Ramamurti et al	2022	Retrospective cohort	All ages with a diagnosis of septic ankle arthritis	Open arthrotomy or arthroscopy	AS	962 patients	In multivariate analysis, SSI (OR, 4.407; $P = .014$) and hospital readmission (OR, 1.915; $P < .001$) were significantly higher in open arthrotomy compared with arthroscopy. There were no significant differences in reoperation rates.
Hoffman T et al	2021	Prospective cohort	Adults	Elective colorectal resection	LS	865 patients	Patients undergoing laparoscopic surgery were less likely to be diagnosed with SSI than those undergoing open surgery (18.5% vs 32.3%; $P < .001$), and were also younger, had fewer comorbidities, and had lower risk index scores.
Matsukuma et al	2021	Retrospective cohort	Adults	Liver resection	LS	240 patients	Superficial incisional SSI was lower in laparoscopic compared to open surgery (0% vs 14%; $P < .001$). There were no significant differences in rates of organ-space SSI (4% vs 10%; $P = .071$) or deep incisional SSI (0% vs 1%; $P = 1.0$). Length of stay was shorter for laparoscopic surgeries (12 days vs 17 days; $P < .001$).
Arnold et al	2020	Retrospective cohort	All ages undergoing emergency surgery	Appendectomy, cholecystectomy, peptic ulcer disease surgery, or intestinal/ exploratory surgery related to bowel obstruction	LS	190,264 patients	On multivariate analysis, use of MIS techniques was associated with decreased odds of 30-day mortality, surgical-site infection, and length of hospital stay in all groups ($P < .001$). Utilization of MIS increased over time in all groups ($P < .001$).
Alkaaki et al	2019	Retrospective cohort	Adults (aged ≥14 y)	Abdominal surgery, excluding vascular, gynecological, urological, and plastic procedures	LS	337 patients	Decreased incidence of SSI in laparoscopic compared to open procedures (4% vs 35%; $P < .001$).
Caroff et al	2019	Retrospective cohort	Adults	Colon surgery	LS	229,726 patients	Adjusted model results showed a significant association of laparoscopy with lower odds of SSI (OR, 0.43; 95% CI, 0.41–0.46; $P < .001$).
McCracken et al	2019	Retrospective cohort	Adults	Pancreatoduo-denectomy	LS, RS	6,882 patients	Compared with the laparoscopic approach (15.2% SSI rate), both robotic (21.6%) and open (24.2%) procedures had higher rates of infection ($P = .03$ and 0.001, respectively). SSIs were comparable between open and robotic approaches ($P = .60$).
Mueller et al	2019	Retrospective cohort	Adults	Lumbar decompression and/or instrumented fusion for degenerative disease	NS	1,442 procedures	SSI rate for MIS was less than open (0.5% vs 3.3%; $P = .0003$). For decompression only, the infection rate for MIS and open was 0.4% vs 3.9% ($P = .04$), and for decompression with fusion it was 0.7% vs 2.6%, respectively ($P = .68$).
Wang et al	2019	Prospective cohort	Adults	Gastrointestinal surgery	LS, RS	1290 patients	Patients undergoing laparotomy had a significantly higher incidence of SSI than those undergoing laparoscopic or robotic surgeries (8.2% vs 3.1%; $P < .001$).
Ali et al	2018	Randomized controlled trial	Children	Appendectomy	LS	126 patients	No significant difference in wound infection (11% in laparoscopic vs 17% in open surgery; $P = .31$). Shorter LOS in laparoscopic compared to open surgery (34 h vs 40 h; $P = .01$).
Yu et al	2016	Randomized controlled trial	Children (aged 6–12 y)	Appendectomy	LS	260 patients	Lower incidence of complications (defined as wound infections, intestinal obstruction, and intraperitoneal abscess) among laparoscopic compared to open surgery (4.6% vs 12.3%; $P < .05$). Decreased rate of wound infection (1.5% vs 6.2%) among laparoscopic compared to open surgery, and similar rates of intraperitoneal abscess (3.1% vs 4.6%).

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Table 1. (*Continued*)

Author	Year	Study Design	Patient Population	Surgical Procedure(s)	MIS Type	Sample Size	Outcome(s)
Colling et al	2015	Retrospective cohort	Adults	Abdominal hysterectomy	LS, RS	986 patients	More SSI occurred in open-surgery cases (6.5%) than laparoscopic (0%) or robotic (2.2%; $P < .0001$). Cases converted to open surgery also had an increased rate of SSI (13.3%).
Pasam et al	2015	Retrospective cohort	All ages	Colectomy and proctectomy	LS	170,529 patients	SSI rates after open colectomy, open proctectomy, laparoscopic colectomy, and laparoscopic proctectomy were 15.2, 17.6, 8.6, and 10.1%, respectively ($P < .001$), and for obese patients, the rates were 18.7, 22.3, 10.7, and 13.3% ($P < .001$). Laparoscopy reduced the risk of SSI by at least 35% across all body mass index classes and procedures, an effect that persisted on multivariate analysis even in obese patients undergoing proctectomy.
Xiao et al	2015	Retrospective cohort	All patients	Appendectomy	LS	16,263 patients	LS was associated with a decrease in overall SSI (OR, 1.24; $P = .04$) or incisional SSI (OR, 1.32; $P = .01$)
Gandaglia et al	2014	Retrospective cohort with propensity score matching	Adults and children	Appendectomy, colectomy, hysterectomy, and radical prostatectomy	NS	254,008 patients	Lower rates of postoperative SSI in patients undergoing MIS vs open procedures for appendectomy (3.8% vs 7.0%; $P < .001$), colectomy (9.3% vs 15.0%; $P < .001$), hysterectomy (1.8% vs 3.9%; $P < .001$), and radical prostatectomy (1.0% vs 2.4%; $P < .001$).
Mahdi et al	2014	Retrospective cohort	Adults	Gynecologic cancer surgery	NS	6,854 patients	SSI after laparotomy was 3.5 times higher compared with MIS (7% vs 2%; $P < .001$). SSI was associated with longer mean hospital stay and higher rate of reoperation, sepsis, and wound dehiscence.
Dobson et al	2011	Prospective cohort	Adults and children	Intestinal tract surgery	LS	2,849 patients	Decreased rates of SSI were identified in laparoscopic surgery patients (5.8%) compared to open surgery patients (4.8%), although this finding was not statistically significant ($P = .32$).
Aimaq et al	2011	Retrospective cohort	All patients	Colorectal surgery	LS	23,939 patients	Patients in the laparoscopic group had an SSI rate of 9.4% vs 15.7% for the open-surgery group ($P < .0001$).
Tollefson et al	2011	Retrospective cohort	Adults and children	Retropubic radical prostatectomy and robotic-assisted radical prostatectomy	RS	5,908 patients	Patients undergoing robotic-assisted radical prostatectomy (6 of 1,084; 0.6%) were significantly less likely to develop an SSI than patients undergoing retropubic radical prostatectomy (216 of 4,824; 4.5%; $P < .001$).
Howard et al	2010	Prospective cohort	Adults	Colorectal surgery	LS	122 patients	SSI rate was significantly lower in the laparoscopic than open group (7% vs 25%; $P = .015$). Hospital stay was also shorter for laparoscopic patients ($P = .0001$)
Kaafarani et al	2010	Randomized controlled trial	Adults	Ventral incision hernia repair	LS	145 patients	Patients who underwent open VIH had significantly more SSIs than those who underwent laparoscopic VIH (22.1% vs 3.4%; $P = .002$).
Varela et al	2010	Retrospective cohort	Adults and children	Appendectomy, cholecystectomy, antireflux surgery, and gastric bypass surgery	LS	131,630 patients	Incidence of SSI was significantly lower in laparoscopic (483 of 94,665, 0.5%) than in open surgery (669 of 36,965, 1.8%; $P < .01$).
Tuggle et al	2010	Retrospective cohort	Adults (18 years and older) with complicated appendicitis	Appendectomy	LS	2,790 cases	Superficial SSI was 70% less likely to occur in laparoscopic appendectomy (OR, 0.304; $P = .000$). Organ-space infection was 2-fold more likely to occur in laparoscopic appendectomy than open surgery (OR, 2.19; $P = .003$).

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Author	Year	Study Design	Patient Population	Surgical Procedure(s)	MIS Type	Sample Size	Outcome(s)
Romy et al	2008	Retrospective cohort	All ages	Appendectomy, cholecystectomy, and colon surgery	LS	7,656 surgeries	After adjustment, laparoscopic interventions were associated with a decreased risk for SSI: OR, 0.61 (95% CI, 0.43–0.87) in appendectomy; OR, 0.27 (95% CI, 0.16–0.43) in cholecystectomy; and OR, 0.43 (95% CI, 0.29–0.63) in colon surgery. This was due to a reduction in the rates of incisional infections, rather than organ-space infections.
St. Peter et al	2006	Randomized controlled trial	Infants (aged <3 mo)	Pyloromyotomy	LS	200 patients	Wound infection occurred in 4 open patients compared to 2 laparoscopic patients ($P = .68$). There were no significant differences in length of stay.

Note. OR, odds ratio; SSI, surgical site infections; MIS, minimally invasive surgery; LOS, length of stay; AS, arthroscopic surgery; LS, laparoscopic surgery; RS, robotic surgery; NS, not specified.

increased risk of SSI among patients undergoing surgery, with the SHEA SSI Prevention Guideline recommending corresponding antimicrobial and procedural interventions to reduce these risks.[9] This guideline noted that MIS procedures may be associated with a lower risk of infection but called for additional data to guide further recommendations.

MIS procedures are distinguished from open procedures by method of access, method of exposure, and extent of operative trauma.[16] Patients undergoing MIS procedures are thought to have a decreased risk for SSI compared to those undergoing open procedures due to smaller surgical incisions, decreased tissue trauma and contamination, and elimination of surgical retraction.[16] Furthermore, SSIs occurring after MIS may be less severe given a smaller surgical site leading to a smaller affected anatomic area. Compared to those undergoing open surgeries, patients undergoing MIS experience less local tissue trauma, less systemic stress, decreased impairment of immediate postoperative pulmonary function, and improved immunologic response, all of which contribute to improved outcomes.[38–42]

However, the benefits of MIS may be overstated given several potential sources of bias. First, sicker patients or those undergoing more complex surgical procedures may be more likely to undergo open surgery instead of MIS[43]; therefore, there may be a selection bias for patients who are healthier at baseline and those with less complex surgical needs to be more likely to undergo MIS compared to open surgery. Randomized controlled trials (RCTs) minimize the impact of confounding factors; however, in this literature review, we only identified 4 RCTs, with mixed results and relatively small sample sizes. Additional well-designed RCTs are warranted for further investigation into the relationship between surgical approach and risk of SSI. Notably, many of the studies identified were retrospective, and therefore prone to selection and recall bias. Second, because performing MIS requires additional, specialized training on the part of surgeons, improved outcomes in MIS may be partly due to improved technical expertise and experience among surgeons performing MIS compared to those performing open surgical procedures. Finally, MIS procedures may be more likely to occur at more highly resourced referral centers, which may have more SSI prevention interventions in place than smaller, community centers.

In conclusion, MIS has many advantages over open surgery, including decreased risk of SSIs in addition to improved cosmesis, decreased pain, and shorter hospital length of stay.[43] As a result, MIS may contribute to decreased morbidity, mortality, and costs compared to open surgery. However, the projected benefits may be due in part to a bias for healthier or less surgically complex patients to be more likely to be selected for MIS instead of open surgery. MIS may not be appropriate for all patients or all procedures, but should be considered, when feasible, to reduce the risk of SSI.

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