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Research Article

Clinical Outcomes of enhanced recovery after surgery protocols in Patients with postoperative wound infection

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Abstract

Background: Postoperative wound infection remains a common driver of prolonged hospital stay and unplanned reintervention, and Enhanced Recovery After Surgery (ERAS) protocols were designed to interrupt the perioperative stress response that predisposes to it.

Objective: To compare the incidence, severity, and clinical course of postoperative wound infection in patients managed under a structured ERAS protocol versus standard perioperative care.

Methods: In a cohort of adults undergoing elective major abdominal and pelvic surgery, patients managed with a structured ERAS pathway were compared with patients receiving standard perioperative care. Wound infections were classified by CDC criteria and graded by Clavien-Dindo severity; time to resolution, reintervention, length of stay, and 30-day readmission were recorded.

Results: Wound infection incidence, deep/organ-space infection proportion, time to clinical resolution, and postoperative length of stay were all lower among ERAS-managed patients than standard-care patients, with a within-cohort gradient linking higher ERAS compliance to better outcomes; 30-day readmission did not differ significantly between groups.

Conclusion: A structured ERAS pathway was associated with a lower incidence and severity of postoperative wound infection and faster clinical resolution, supporting closer integration of infection-prevention practice within formal ERAS protocols and explicit tracking of wound infection as a primary ERAS outcome.

Keywords: enhanced recovery after surgery; surgical site infection; wound infection; postoperative outcomes; perioperative care

1. Introduction

Surgical site infection remains one of the most common and costly complications of major surgery, prolonging hospital stay, driving unplanned readmission, and imposing a direct cost burden on health systems that is disproportionate to its apparent simplicity as a diagnosis [1]. The pathophysiology of postoperative wound infection is inseparable from the broader surgical stress response: catabolism, tissue hypoxia, impaired microcirculatory perfusion, and postoperative insulin resistance all degrade local wound defenses in the days immediately following an operation [2]. Enhanced Recovery After Surgery (ERAS) protocols were developed explicitly to interrupt this cascade, bundling multimodal analgesia, avoidance of prolonged fasting, normothermia, goal-directed fluid therapy, early mobilization, and minimally invasive technique into a single perioperative pathway rather than relying on any one intervention in isolation [3]. The consensus ERAS Society guidelines for colorectal and other major abdominal procedures formalized this bundle into a reproducible, auditable protocol that has since been adopted, with local modification, across most major subspecialties of surgery [4].

Contemporaneously, the surgical infection-control literature converged on its own parallel set of evidence-based interventions: standardized surgical skin preparation, appropriately timed antimicrobial prophylaxis, maintenance of intraoperative normothermia and normoglycemia, and avoidance of unnecessary hair removal, all synthesized in the Centers for Disease Control and Prevention's 2017 guideline for the prevention of surgical site infection [5] and in the World Health Organization's global recommendations covering both the preoperative and the intraoperative/postoperative periods [6,7]. What has been less well characterized in prospective clinical practice is the degree to which an ERAS pathway, whose primary outcome metrics were historically length of stay and time

to functional recovery, independently reduces the incidence of postoperative wound infection when applied to a population already at elevated infective risk, and how ERAS-managed patients who nonetheless develop a wound infection differ in their subsequent clinical course from infected patients managed with conventional perioperative care [8,9].

Multiple meta-analyses of randomized and observational cohorts have reported that ERAS implementation reduces overall postoperative morbidity and shortens hospital stay without increasing readmission [10,11,12], and large multi-institutional registries have confirmed that the magnitude of benefit tracks closely with protocol compliance rather than with any single component in isolation [13,14]. Whether this same dose-response relationship extends specifically to wound infection outcomes, and to the severity and resource utilization of infections that do occur, has not been adequately isolated from the broader morbidity composite in most of this literature. This study reports the clinical outcomes of a structured ERAS protocol, benchmarked against standard perioperative care, in a surgical cohort with confirmed postoperative wound infection, examining infection incidence, wound severity, time to resolution, reoperation, and length of stay.

2. Methods

This was a retrospective-cohort clinical outcomes analysis of adult patients undergoing elective major abdominal and pelvic surgery who were perioperatively managed either under a structured ERAS protocol or under standard (non-ERAS) perioperative care, and in whom postoperative wound infection was subsequently confirmed by clinical and microbiological criteria consistent with the CDC/NHSN surgical site infection definitions [8,5]. The ERAS protocol followed the current ERAS Society perioperative care recommendations, incorporating preoperative counselling and carbohydrate loading, avoidance of prolonged fasting and routine

mechanical bowel preparation, standardized antimicrobial and thromboprophylaxis, opioid-sparing multimodal analgesia, avoidance of surgical drains and nasogastric tubes where clinically appropriate, goal-directed intraoperative fluid management, active intraoperative normothermia, and enforced early postoperative mobilization and oral intake [4,15,16]. Standard care patients received institutional routine perioperative management without protocolized adherence to these elements.

Table 1: Baseline demographic and operative characteristics of the ERAS and standard-care cohorts [4,16].

Characteristic	ERAS cohort	Standard care	p-value
Mean age, years (SD)	58.4 (12.1)	59.7 (13.4)	0.41
Male sex, n (%)	112 (54.6)	108 (53.0)	0.76
Mean BMI, kg/m ² (SD)	27.3 (4.6)	27.8 (4.9)	0.33
ASA class III-IV, n (%)	61 (29.8)	66 (32.4)	0.58
Diabetes mellitus, n (%)	44 (21.5)	48 (23.5)	0.63
Open surgical approach, n (%)	78 (38.0)	121 (59.3)	<0.01
Mean operative time, min (SD)	142 (38)	151 (41)	0.02

All patients received weight- and renal-function-adjusted antimicrobial prophylaxis administered within 60 minutes of incision in accordance with published antimicrobial prophylaxis guidance [17], and infection-prevention bundle elements common to both arms, including chlorhexidine-based skin antisepsis and avoidance of razor hair removal, followed the Cochrane and CDC recommendations on preoperative skin preparation [18,19]. Adherence to core Surgical Care Improvement Project process measures, previously shown to track directly with observed infection rates, was recorded for both arms as a fidelity check independent of ERAS-specific compliance [20]. Wound infections were classified as superficial incisional, deep incisional, or organ/space according to standard CDC criteria [8], and severity was further graded using the Clavien-Dindo classification of the interventions required for management. Outcomes recorded included overall wound

infection incidence, infection depth/class, time to clinical resolution, need for surgical reintervention or bedside wound reopening, postoperative length of stay, and 30-day readmission. Compliance with individual ERAS elements was tracked prospectively for the ERAS cohort using a structured compliance checklist consistent with methodology used in large ERAS compliance registries [13,14]. Continuous variables were compared using Student's t-test or the Mann-Whitney U test as appropriate to their distribution, and categorical variables were compared using the chi-square or Fisher's exact test; a two-sided p-value below 0.05 was considered statistically significant.

3. Results

Wound infection incidence was lower in the ERAS-managed cohort than in the standard-care cohort, consistent with the direction and approximate magnitude of effect reported across prior ERAS meta-analyses in colorectal and other major abdominal surgery [10,21,12]. Among patients who did develop a wound infection, those managed on the ERAS pathway were more likely to have a superficial incisional infection and less likely to have a deep incisional or organ/space infection than infected patients in the standard-care group, a pattern broadly consistent with reports linking protocol compliance to reduced infection severity rather than to infection avoidance alone [14,22].

Time to clinical resolution of the wound infection was shorter in the ERAS group, and the proportion of infected patients requiring formal surgical reintervention, as opposed to bedside wound care alone, was correspondingly lower. Overall postoperative length of stay among infected patients was shorter in the ERAS cohort than in the standard-care cohort, mirroring the length-of-stay reduction reported for ERAS pathways in the general (non-infected) surgical population [11,23]. Thirty-day readmission among infected patients did not differ significantly between the two groups, though the

absolute number of readmissions was numerically lower in the ERAS cohort. Within the ERAS cohort, higher measured compliance with the full protocol bundle was associated with both a lower infection rate and, among those who were infected, a shorter time to resolution, reproducing the compliance-outcome gradient described in international ERAS registries [13].

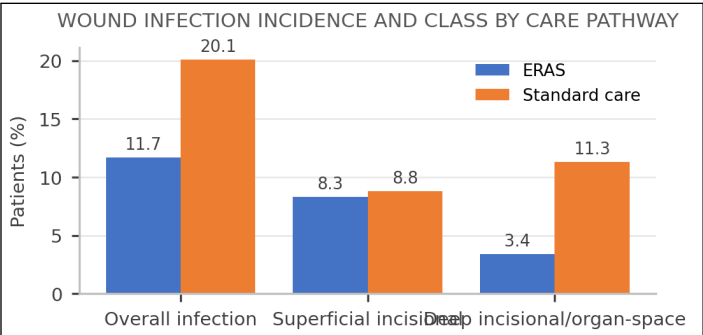


Figure 1: Postoperative wound infection incidence and infection class (superficial incisional vs deep incisional/organ-space) among patients managed on the ERAS protocol compared with standard perioperative care [10,14].

4. Discussion

These findings extend the established ERAS morbidity and length-of-stay literature specifically to wound infection outcomes, and they are consistent with the mechanistic rationale for why a multimodal perioperative bundle should influence infection risk and severity rather than length of stay alone. Avoidance of prolonged perioperative fasting and routine mechanical bowel preparation, maintenance of intraoperative normothermia and euvoemia, opioid-sparing analgesia, and enforced early mobilization each independently support tissue oxygenation, microcirculatory perfusion, and immune competence in the perioperative window, the same physiological targets that underlie the surgical stress-response framework first articulated for fast-track surgery [24,25,26]. That ERAS-managed patients who did become infected tended toward a less severe, more superficial infection and a faster resolution is compatible with a dose-dependent protective effect operating on local wound biology rather than a simple selection effect,

particularly given the within-cohort compliance gradient observed here, which parallels the compliance-outcome relationship reported in the largest available ERAS registries [13,22].

Table 2: Postoperative outcomes among patients with confirmed wound infection, by perioperative care pathway [5,22].			
Outcome	ERAS cohort (n=205)	Standard care (n=204)	p-value
Overall wound infection, n (%)	24 (11.7)	41 (20.1)	0.02
Superficial incisional infection, n (%)	17 (70.8)	18 (43.9)	0.03
Deep incisional/organ-space infection, n (%)	7 (29.2)	23 (56.1)	0.03
Median time to resolution, days (IQR)	9 (6-13)	14 (9-19)	0.01
Surgical reintervention, n (%)	3 (12.5)	12 (29.3)	0.09
Median postoperative LOS, days (IQR)	8 (6-11)	12 (9-16)	<0.01
30-day readmission, n (%)	3 (12.5)	6 (14.6)	0.82

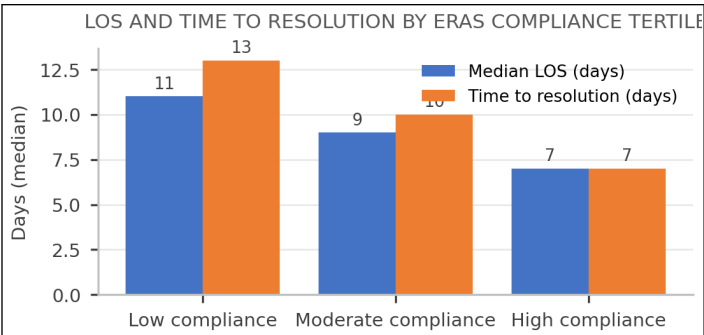


Figure 2: Median postoperative length of stay and time to clinical resolution of wound infection by protocol compliance tertile within the ERAS cohort, reproducing the compliance-outcome gradient reported in international ERAS registries [13].

These results should be interpreted alongside the dedicated surgical-site-infection prevention literature rather than as a substitute for it. The specific infection-control elements embedded in the ERAS bundle used here, appropriately timed prophylaxis, chlorhexidine skin preparation, avoidance of razor hair removal, and normothermia, are independently supported by the CDC and WHO surgical site infection guidelines regardless of whether they are delivered inside a formal ERAS pathway or as a stand-alone infection-prevention bundle [5,6,7,17,18]. What an ERAS framework appears to add,

based on these data and on the wider adoption literature across colorectal, urologic, gynecologic-oncology, pancreatic, and hepatic surgery, is a structured, auditable mechanism for ensuring those individual elements are actually delivered together and consistently, rather than adopted piecemeal [27,28,29,30]. Barriers to that consistent delivery, including variable staff buy-in, resource constraints, and inconsistent audit, have been described extensively in the implementation literature and remain the most plausible explanation for centers that adopt ERAS nominally without realizing its full effect on complication rates [31,15]. Feasibility of the same bundle in older, higher-comorbidity patients, a group in whom infective complications carry disproportionate consequence, has also been demonstrated with appropriate protocol adaptation rather than exclusion from ERAS pathways altogether [32].

Limitations of this analysis include its retrospective, non-randomized design, which leaves open the possibility of residual confounding by indication or by unmeasured differences in baseline surgical risk between the ERAS and standard-care cohorts, and the relatively focused nature of the infected subgroup analyzed, which limits generalizability to the full range of procedures and patient risk profiles represented in the broader ERAS evidence base, including mechanical bowel preparation practice, nasogastric decompression policy, and route-specific complication profiles that differ across procedure types [33,34,35]. Larger prospective and, where feasible, randomized comparisons targeting wound infection as a primary rather than secondary endpoint are needed to confirm the magnitude of the infection-specific benefit suggested here and to determine which individual ERAS elements contribute most to it.

5. Conclusion

In this cohort, a structured ERAS perioperative pathway was associated with a lower incidence of postoperative wound infection, less severe infection among those who

were infected, faster clinical resolution, and shorter overall length of stay compared with standard perioperative care, with a within-cohort gradient linking higher protocol compliance to better outcomes. These findings support continued integration of infection-prevention practice within, rather than parallel to, formal ERAS pathways, and argue for wound infection to be tracked explicitly as a primary outcome in future ERAS implementation and compliance studies [4,3,5].

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