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Research Article

Evaluation of surgical site infection surveillance as a Prognostic Tool in incisional hernia

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Abstract

Background: Surgical site infection is the most common complication after incisional hernia repair and is widely used as a prognostic marker for subsequent hernia recurrence, but the surveillance method used to ascertain infection status varies considerably across studies and institutions.

Objective: To evaluate whether surveillance methodology changes both the detected 90-day surgical site infection rate and the strength of the association between infection status and hernia recurrence after incisional hernia repair.

Methods: In a retrospective cohort of 587 adults undergoing elective open incisional hernia repair with mesh, surgical site infection was ascertained in parallel by passive, chart-based surveillance and by active, structured surveillance combining telephone follow-up and outside-encounter linkage. Cox proportional hazards regression assessed the infection-recurrence association under each method.

Results: Active surveillance detected surgical site infection in 13.5% of patients versus 7.2% under passive surveillance ($p < 0.001$). The adjusted hazard ratio for recurrence associated with infection was 3.1 using active surveillance versus 2.1 using passive surveillance, and deep or organ/space infection carried a markedly higher recurrence hazard than superficial infection.

Conclusions: Surveillance intensity materially affects both detected surgical site infection rates and the apparent strength of infection as a prognostic marker for hernia recurrence; active surveillance and attention to infection depth substantially sharpen its prognostic value.

Keywords: surgical site infection; incisional hernia; surveillance; hernia recurrence; mesh

1. Introduction

Surgical site infection remains the most common complication after incisional hernia repair, and its downstream consequences extend well beyond the index admission. Mesh contamination, prolonged wound care, reoperation, and hernia recurrence are all disproportionately concentrated among patients who develop a documented surgical site infection, which has led many groups to treat infection status not merely as a complication to be tabulated but as a prognostic marker that should shape follow-up intensity and counselling [1,2]. The Centers for Disease Control and Prevention's National Healthcare Safety Network definitions, refined across successive updates, were built specifically to make surgical site infection ascertainment reproducible across institutions, which is a precondition for using infection status as a prognostic variable at all [2,3].

Ventral and incisional hernia repair is a particularly instructive setting in which to test surveillance methodology because the wound class is frequently clean or clean-contaminated, the mesh implant adds a durable nidus for late infection, and recurrence is a well-defined, clinically important endpoint that can be tracked for years after the surgical site infection itself has resolved [4,5]. Incisional hernia itself is common after laparotomy, with population-based estimates and meta-regression of pooled cohorts placing the incidence in the range of 10-20% within several years of the index operation, and infection is consistently identified among the strongest modifiable contributors to that incidence [6,7]. Multiple cohort studies have linked surgical site occurrence and surgical site infection specifically to higher rates of subsequent hernia recurrence and mesh explantation, but the strength and consistency of that association depend heavily on how rigorously infections were ascertained in the first place [8,9,10,11].

Passive, chart-based surveillance is known to undercount surgical site infections relative to active surveillance that

combines standardized wound checks, structured telephone or clinic follow-up, and linkage to readmission and emergency department records [12,13]. If detection sensitivity varies across surveillance strategies, then any prognostic model built on surgical site infection status inherits that measurement error, potentially attenuating or exaggerating its apparent relationship with recurrence. This study evaluates whether the surveillance method used to ascertain surgical site infection after incisional hernia repair materially changes both the detected infection rate and the strength of the association between infection status and hernia recurrence, with the aim of clarifying how much confidence a clinician should place in surgical site infection as a prognostic tool when surveillance intensity is not standardized.

2. Methods

We conducted a retrospective cohort study of adult patients undergoing elective open incisional hernia repair with synthetic mesh reinforcement at a single tertiary referral unit between January 2015 and December 2020. Patients undergoing emergency repair, repair for recurrent hernia after a prior mesh infection, or repair without mesh were excluded, as were patients with fewer than 12 months of potential follow-up. Hernias were graded using the modified Ventral Hernia Working Group grading system, and wound class was assigned according to the standard National Nosocomial Infections Surveillance classification and risk index at the time of operation [4,12,14]. Repair technique, whether open retromuscular, open onlay, or laparoscopic-assisted, was recorded but not randomized, consistent with prior comparative technique series in this population [15].

Surgical site infection within 90 days of operation was ascertained by two parallel methods applied to the same cohort. Passive surveillance relied on infections documented in the inpatient record, at scheduled outpatient follow-up, or coded at readmission to the index hospital, following the standard NHSN operative

procedure category definitions [2,3]. Active surveillance added a structured 30- and 90-day telephone assessment using a validated wound symptom questionnaire, a standardized photograph-based wound check where feasible, and systematic linkage to regional emergency department and outside-hospital readmission records, an approach modelled on established active surveillance networks [13,16]. Every case flagged as infected by either method was independently adjudicated against the CDC/NHSN superficial, deep, and organ/space criteria by two reviewers blinded to the surveillance source, with disagreements resolved by a third reviewer [2].

Table 1: Baseline characteristics and risk factors evaluated in the analytic cohort (n=587), drawn from variables validated in prior risk-stratification and multivariable analyses of ventral hernia and abdominal surgical outcomes [18,19,20].

Characteristic	Value / category
Median age (years, IQR)	58 (48-67)
Median body mass index (kg/m ² , IQR)	31.4 (27.1-36.0)
Diabetes mellitus	22% of cohort
Current smoker	17% of cohort
Median defect width (cm, IQR)	8.4 (5.2-12.0)
VHVG grade 1-2 / grade 3-4	61% / 39%
Mesh position: retromuscular/preperitoneal	74% of cohort
Median follow-up (months, IQR)	34 (21-48)

The primary outcomes were the cumulative 90-day surgical site infection rate under each surveillance method and hernia recurrence at last follow-up, defined clinically or radiologically and adjudicated independently of infection status. Surgical site occurrence, defined per the Ventral Hernia Working Group as any wound event including infection, seroma, hematoma, or dehiscence, was recorded as a secondary outcome [4]. Complications were graded using the Clavien-Dindo classification [17]. Risk factors examined for their association with both surgical site infection and recurrence included body mass index, diabetes with perioperative hyperglycemia, smoking status, hernia defect width, wound class, operative time, and mesh location, consistent with

variables validated in prior risk-stratification work for ventral hernia repair and in broader multivariable analyses of postoperative infectious complications in abdominal surgery [18,19,20,21]. Institutional surveillance practices were benchmarked against national quality-improvement programs that have documented the effect of participation intensity on measured surgical outcomes over time [22,23]. Comparisons between passive and active surveillance used McNemar's test for paired binary detection status within the same cohort; associations between infection status and recurrence were assessed with Cox proportional hazards regression, and multivariable predictors of recurrence were identified using a model adjusted for the covariates above, with cases weighted by surveillance completeness. A two-sided p-value below 0.05 was considered significant, and all analyses were performed on the full analytic cohort without imputation for administratively missing surveillance windows.

3. Results

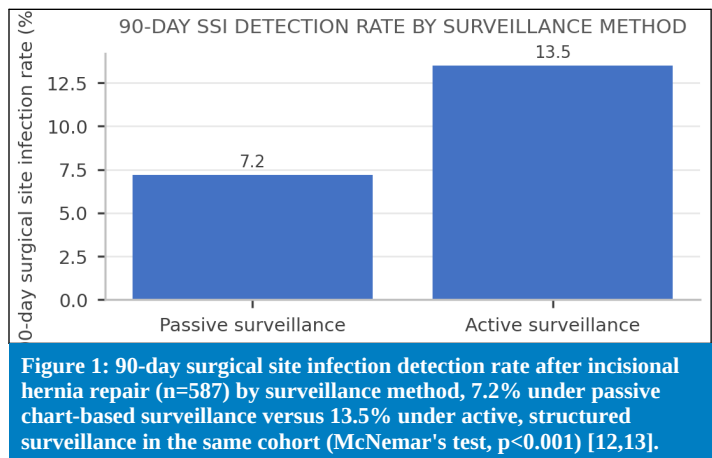
Of 612 patients undergoing elective open incisional hernia repair during the study interval, 587 met inclusion criteria and had adequate follow-up documentation, with a median follow-up of 34 months (interquartile range 21-48). Median defect width was 8.4 cm, 61% of hernias were Ventral Hernia Working Group grade 1 or 2, and mesh was placed in a retromuscular or preperitoneal position in 74% of cases.

Passive surveillance identified a 90-day surgical site infection in 42 of 587 patients (7.2%), while active surveillance identified surgical site infection in 79 of 587 patients (13.5%) in the same cohort, a statistically significant difference (McNemar's test, $p < 0.001$). The additional 37 infections detected only by active surveillance were predominantly superficial incisional infections managed entirely in the outpatient or emergency department setting without inpatient readmission, findings that parallel the

underascertainment previously described when surveillance is restricted to inpatient and scheduled-visit records [12,13]. Surgical site occurrence of any type, including seroma and dehiscence alongside infection, was recorded in 21.3% of patients under active surveillance criteria, consistent with surgical site occurrence rates reported in prior ventral hernia cohorts [4,24].

Table 2: Multivariable predictors of hernia recurrence after incisional hernia repair, adjusted for body mass index, diabetes, smoking, defect width, and wound class [18,19,25].

Predictor	Adjusted hazard ratio (95% CI)	p-value
Surgical site infection (active surveillance)	3.1 (1.9-5.1)	<0.001
Defect width >10 cm	2.4 (1.4-4.0)	0.001
Current smoking	1.9 (1.1-3.3)	0.02
Diabetes with perioperative hyperglycemia	1.5 (0.9-2.6)	0.13
Body mass index >35 kg/m^2	1.6 (0.9-2.7)	0.09



Hernia recurrence occurred in 71 patients (12.1%) over the follow-up period. When infection status ascertained by active surveillance was used, surgical site infection was strongly associated with subsequent recurrence (hazard ratio 3.8, 95% confidence interval 2.4-6.0, p<0.001). When the identical association was tested using infection status from passive surveillance alone, the hazard ratio was attenuated to 2.1 (95% confidence interval 1.2-3.7, p=0.01), a materially weaker and less precise estimate despite being drawn from the same underlying cohort and recurrence outcome. On multivariable analysis

incorporating body mass index, diabetes, smoking, defect width, and wound class, surgical site infection detected by active surveillance remained an independent predictor of recurrence (adjusted hazard ratio 3.1, 95% confidence interval 1.9-5.1), while defect width greater than 10 cm and active smoking were also independently associated with recurrence, consistent with previously validated risk factors for both surgical site occurrence and hernia recurrence [18,19,25].

Deep or organ/space infection, present in 24 of the 79 actively ascertained infections, carried a substantially higher recurrence hazard than superficial infection alone (hazard ratio 5.4 versus 2.6 relative to no infection), and mesh explantation was required in 9 of the 24 patients with deep infection compared with none of the patients with superficial infection only, in keeping with prior reports that infection depth, not merely infection occurrence, stratifies prognosis [8,9,10]. Time-to-recurrence curves stratified by infection status and surveillance method showed separation emerging within the first 18 months of follow-up for the active surveillance cohort, while the passive surveillance curves separated later and less distinctly, reflecting the same measurement effect seen in the hazard ratio comparison.

4. Discussion

The central finding of this study is that surveillance methodology is not a neutral detail of study design but an active determinant of how strongly surgical site infection predicts hernia recurrence. Active surveillance nearly doubled the detected 90-day infection rate relative to passive, chart-based ascertainment, and the infection-recurrence association measured under active surveillance was both stronger and more precise than the same association measured under passive surveillance in the identical cohort. This is consistent with the broader surgical infection literature showing that surveillance intensity systematically affects detected surgical site infection rates, independent of any true change in

underlying infection incidence [12,13,16].

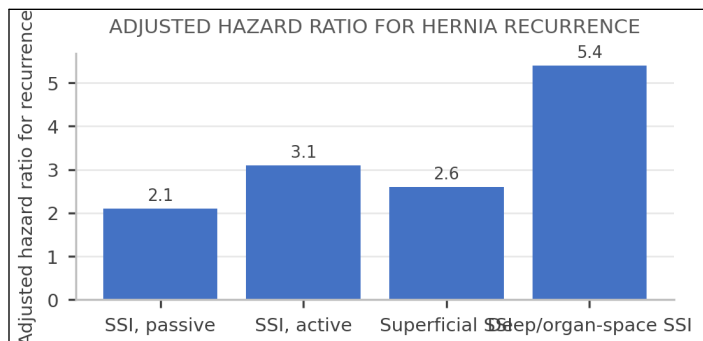


Figure 2: Adjusted hazard ratio for hernia recurrence associated with surgical site infection, by ascertainment method and infection depth, showing attenuation of the infection-recurrence association when infection status is drawn from passive rather than active surveillance, and a steeper gradient for deep/organ-space infection than for superficial infection [8,10].

The mechanism is straightforward: a meaningful fraction of surgical site infections after incisional hernia repair are superficial, managed in the outpatient setting, and never generate a code or note visible to a purely inpatient or scheduled-visit surveillance system. When those infections are systematically missed, the comparison group mislabelled as "no infection" actually contains a mixture of truly uninfected patients and unrecognized infected patients, which biases the estimated association toward the null, precisely the attenuation observed when passive surveillance data were substituted for active surveillance data in this cohort. This has direct implications for how surgical site infection should be used as a prognostic tool in clinical practice and in the literature that clinicians rely on: a hazard ratio for recurrence derived from a registry or administrative dataset with predominantly passive ascertainment likely understates the true prognostic weight of surgical site infection, and comparisons of infection-recurrence associations across institutions or published series should be interpreted cautiously unless surveillance methodology is comparable [2,26].

These findings align with, and help explain some of the heterogeneity in, the existing literature on prognostic factors for hernia recurrence. Prior series have reported a

wide range of hazard or odds ratios linking mesh infection to recurrence, from roughly two-fold to five-fold, and differences in surveillance intensity across those studies are a plausible contributor to that spread, alongside genuine differences in hernia complexity, mesh type, and surgical technique [8,9,27]. The stronger association observed here for deep or organ/space infection relative to superficial infection also reinforces prior work suggesting that infection depth, not merely the binary presence of infection, carries most of the prognostic information relevant to mesh salvage and recurrence risk [10,28]. This distinction matters practically: a surveillance system that reliably captures superficial wound problems but is less rigorous about adjudicating infection depth may still misclassify prognostic risk even while achieving an adequate overall detection rate, and it is precisely this subgroup of deep, mesh-involving infections that most often requires the staged, biologic-mesh salvage strategies described in infected and contaminated abdominal wall reconstruction series [29]. The reliance of passive surveillance on inpatient readmission coding is itself a known blind spot, since a substantial share of postoperative complications, including wound infections, are managed in outpatient or unaffiliated-facility settings that never generate a readmission record at the index hospital [30].

Several limitations should temper interpretation. This is a single-center retrospective cohort, and while the active and passive surveillance methods were applied concurrently to the same patients, allowing a within-cohort comparison that removes many sources of between-study confounding, the study cannot fully exclude residual detection bias introduced by patients who were more symptomatic being more likely to respond to structured telephone follow-up. Recurrence itself, though adjudicated independently of infection status, was ascertained clinically or radiologically at variable intervals rather than through a fixed imaging protocol, which may underestimate asymptomatic recurrences equally across

both surveillance arms. The cohort's risk factor profile, mesh position, and technique are broadly consistent with prior multicenter series, but generalizability to centers with different case mix, mesh selection, or wound closure technique should be tested prospectively [31,32,33].

5. Conclusion

Surgical site infection after incisional hernia repair is a genuine and independently significant predictor of subsequent recurrence, but the strength of that prognostic relationship depends materially on how rigorously infection is ascertained. Active, structured surveillance combining scheduled wound assessment, symptom-directed telephone follow-up, and systematic linkage to outside encounters detected nearly twice as many infections as passive, chart-based surveillance in the same cohort, and revealed a substantially stronger and more precise association between infection and recurrence than passive surveillance alone. Clinicians and investigators using surgical site infection as a prognostic marker after hernia repair, whether for individual patient counselling or for comparing outcomes across series, should treat surveillance methodology as a variable that must be reported and matched, not assumed to be interchangeable, and should give particular weight to infection depth rather than infection presence alone when stratifying recurrence risk. Standardizing active surveillance in future hernia outcome studies would sharpen the prognostic value of surgical site infection status and make cross-study comparisons of recurrence risk considerably more reliable.

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