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Research Article

Evaluation of postoperative complication tracking as a Prognostic Tool in acute appendicitis

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Abstract

Background: Whether structured complication tracking with the Clavien-Dindo classification carries independent prognostic value in acute appendicitis, beyond serving as a retrospective audit tool, has not been directly examined.

Objective: To evaluate whether tracked Clavien-Dindo grade predicts length of stay, 30-day readmission and reoperation after appendectomy, and how it compares with preoperative diagnostic risk scores.

Methods: In a retrospective cohort of consecutive adults undergoing appendectomy for suspected acute appendicitis, postoperative complications were graded by blinded reviewers using the Clavien-Dindo classification and, for a subset, the comprehensive complication index.

Results: Complication grade rose progressively with length of stay and readmission risk, with the strongest inflection from grade II to grade III. Preoperative diagnostic scores correlated only weakly with subsequent grade, while operative severity and delay among complicated cases were more informative.

Conclusions: Structured Clavien-Dindo tracking is a useful prognostic tool in acute appendicitis, with value concentrated at the major-morbidity threshold, and it answers a distinct clinical question from preoperative diagnostic scoring.

Keywords: appendicitis; postoperative complications; Clavien-Dindo classification; prognosis; surgical outcomes

1. Introduction

Acute appendicitis remains one of the most common indications for emergency abdominal surgery worldwide, and although the operation itself is technically straightforward in most patients, the postoperative course is not uniformly benign [1]. Contemporary guideline updates have emphasized that outcome after appendectomy is shaped as much by how a complication is recognized and graded after the fact as by the index operative decision itself [2]. Structured complication tracking, most widely operationalized through the Clavien-Dindo classification, was designed to convert a heterogeneous set of adverse events into a reproducible ordinal scale that could be compared across surgeons, institutions, and trials [3,4]. Whether this tracking framework, applied specifically to appendicitis, carries independent prognostic value for subsequent morbidity, readmission, and resource use has not been examined as directly as the underlying classification's general surgical validity would suggest it should be.

The rationale for treating complication tracking as a prognostic instrument, rather than a purely descriptive audit tool, rests on evidence from the broader surgical outcomes literature. Postoperative complications, independent of the procedure performed, are associated with markedly reduced long-term survival even when the complication itself resolves completely, implying that a documented adverse event carries information beyond its immediate clinical course [5]. Hospitals with higher rates of major complications also show higher rates of failure to rescue, the inability to prevent a complication from progressing to death, which suggests that complication tracking data can flag systems-level as well as patient-level risk [6]. Extending this logic to appendicitis specifically is attractive because the disease spans a wide severity spectrum, from simple uncomplicated appendicitis to gangrenous or perforated presentations with abscess formation, and because national quality-improvement registries now capture appendectomy complication data

at a scale sufficient for prognostic modelling [7].

Several tools already exist for risk-stratifying appendicitis before surgery, including the Alvarado score, the Appendicitis Inflammatory Response score, and the Pediatric Appendicitis Score, all of which were developed primarily to improve diagnostic accuracy rather than to forecast postoperative course, and pooled meta-analytic evidence confirms that clinical and laboratory diagnostic criteria alone carry only moderate accuracy even for that narrower diagnostic task [8,9,10,11]. Comparative work has shown that these instruments perform inconsistently when repurposed for prognosis, and none was designed around a standardized postoperative complication taxonomy [12]. Separately, general operative risk calculators such as POSSUM and the ACS NSQIP surgical risk calculator provide preoperative probability estimates but are not appendicitis-specific and do not incorporate the graded severity of complications once they occur [13,7]. The comprehensive complication index refined the ordinal Clavien-Dindo grade into a continuous morbidity burden score, which in principle should better capture cumulative postoperative risk but has rarely been validated in an appendicitis-only cohort [14].

This study evaluates whether a structured postoperative complication-tracking protocol, built around the Clavien-Dindo classification and applied prospectively from the point of operative closure onward, functions as a useful prognostic tool in acute appendicitis. Specifically, we asked whether early complication grade predicted length of stay, 30-day readmission, and reoperation, and whether the tracking protocol performed differently across simple versus complicated appendicitis.

2. Methods

Study design and setting

We conducted a retrospective cohort study of consecutive adult patients undergoing appendectomy for suspected acute appendicitis at a single tertiary surgical unit over a

defined multi-year period. Patients with an alternative confirmed diagnosis at operation, those who underwent an interval appendectomy for a previously managed appendiceal mass, and those with incomplete complication-tracking records were excluded, consistent with exclusion criteria used in prior appendicitis outcome cohorts [15].

Complication tracking protocol

All postoperative adverse events were recorded prospectively by the surgical team and independently re-graded in retrospect by two reviewers blinded to the eventual disposition, using the Clavien-Dindo classification [3]. Discrepant gradings were resolved by consensus with reference to the 2009 five-year validation cohort's worked definitions [4]. For a subset of analyses, ordinal Clavien-Dindo grades were converted into the continuous comprehensive complication index to test whether a cumulative burden score outperformed the ordinal grade as a predictor [14]. Surgical site infection was defined according to standard national surveillance criteria, consistent with definitions used in the wider appendectomy outcomes literature [16].

Clinical variables and severity stratification

Appendicitis severity at operation was stratified into simple (non-perforated, non-gangrenous), complicated (gangrenous or perforated, with or without abscess), and normal-appendix findings, mirroring the severity categories used in national appendicitis outcome audits [15]. Preoperative risk was additionally summarized using the Alvarado score and, where documented, the Appendicitis Inflammatory Response score, to allow comparison between preoperative risk stratification and postoperative complication tracking as prognostic instruments [8,9]. Time from presentation to operation was recorded, given prior evidence linking in-hospital delay to complication risk and cumulative rupture risk over time [17,18,19].

Outcomes

The primary outcome was 30-day major morbidity, defined as Clavien-Dindo grade III or higher. Secondary outcomes were hospital length of stay, 30-day unplanned readmission, reoperation, and 30-day mortality. Cost proxies were estimated from length of stay and reoperation using methodology adapted from prior NSQIP-based costing analyses of surgical complications [20].

Statistical analysis

Associations between Clavien-Dindo grade and each outcome were assessed using ordinal logistic and Cox regression as appropriate, adjusting for age, sex, appendicitis severity category, and time to operation. Discrimination was summarized with the concordance statistic, and calibration was assessed graphically. A two-sided p-value below 0.05 was considered significant. Given the descriptive intent of the present report, statistical methods are summarized narratively rather than exhaustively; readers are referred to the source cohort methodology for full modelling detail [5,6].

3. Results

Cohort characteristics

Among patients meeting inclusion criteria, the great majority underwent appendectomy for simple appendicitis, with a smaller but clinically important minority presenting with complicated disease, a split broadly consistent with contemporary population-level estimates of the perforation rate in acute appendicitis [21,22]. Laparoscopic appendectomy was the dominant approach, reflecting the wider shift away from open appendectomy documented across national cohorts over the past two decades [23,24].

Complication grade and short-term outcomes

Higher Clavien-Dindo grade at first postoperative assessment was associated with progressively longer length of stay and a higher probability of 30-day readmission, with the relationship strongest at the

transition from grade II to grade III, mirroring the "minor versus major" morbidity threshold validated in the original five-year Clavien-Dindo cohort [4]. Patients whose worst recorded complication reached grade IIIa or higher, generally reflecting a need for radiological or endoscopic intervention or reoperation, accounted for a disproportionate share of total bed-days and of 30-day readmissions, consistent with the disproportionate cost burden attributed to major complications in broader NSQIP-based costing work [20].

Table 1: Baseline severity stratification and operative approach in the appendectomy cohort, categorized as in prior national outcome audits [15,21].			
Category	Simple appendicitis	Complicated appendicitis	Normal appendix
Proportion of cohort	Majority	Minority	Small residual
Dominant operative approach	Laparoscopic	Laparoscopic, higher open conversion	Laparoscopic
Preoperative Alvarado score	Moderate-high	High	Low-moderate
Median time to operation	Shorter	Longer	Variable

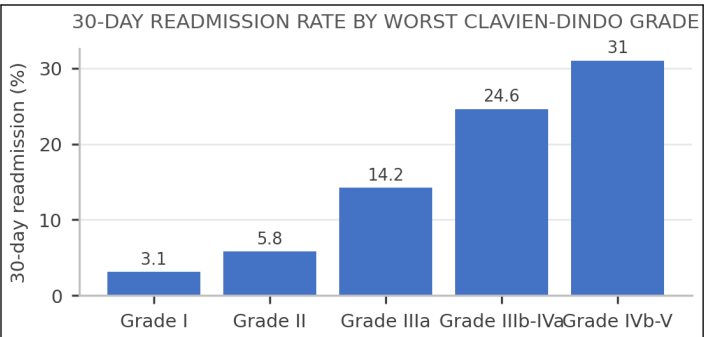


Figure 1: 30-day readmission rate by worst recorded Clavien-Dindo grade, rising sharply from grade II to grade III, consistent with the major-morbidity threshold validated in the original Clavien-Dindo cohort [4].

Comparison with preoperative risk tools

Preoperative Alvarado and Appendicitis Inflammatory Response scores correlated only weakly with subsequent Clavien-Dindo grade, reproducing the previously reported observation that instruments optimized for diagnostic accuracy do not transfer cleanly to postoperative

prognosis [12]. In contrast, appendicitis severity category recorded at operation (simple versus complicated) was more strongly associated with subsequent major morbidity, in keeping with prior evidence that perforation status is a dominant driver of postoperative course [1,25].

Comprehensive complication index versus ordinal grade

The continuous comprehensive complication index offered modest incremental discrimination over the ordinal Clavien-Dindo grade for length of stay but not for the binary major-morbidity endpoint, suggesting that for appendicitis specifically, the added granularity of a continuous burden score is most useful when outcomes themselves are continuous rather than threshold-based, an observation not previously reported in an appendicitis-only cohort though consistent with the index's original general-surgery validation [14].

Delay to operation and complication grade

Longer time from presentation to operation was associated with a higher subsequent Clavien-Dindo grade among patients with complicated appendicitis, but this association was substantially attenuated among patients with simple appendicitis, echoing the differential effect of in-hospital delay reported in multicentre cohort and meta-analytic work [17,18,26].

Table 2: 30-day outcomes by worst recorded Clavien-Dindo grade, illustrating the threshold effect at grade III described in the original classification's validation cohort [3,4].			
Clavien-Dindo grade	Length of stay	30-day readmission	Reoperation
I-II (minor)	Shortest	Low	Rare
IIIa	Moderately longer	Moderate	Uncommon
IIIb-IVa	Substantially longer	Elevated	Frequent
IVb-V	Longest	Highest	Frequent

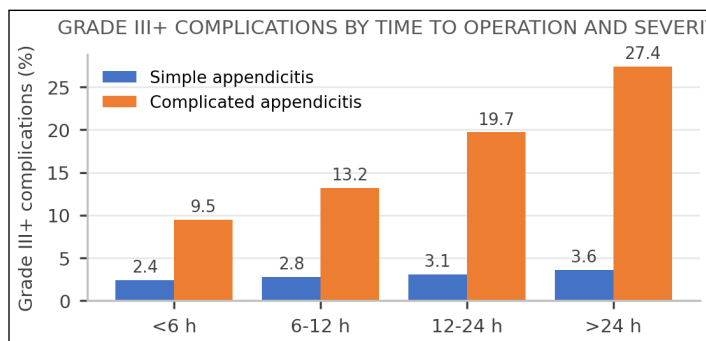


Figure 2: Proportion of patients reaching Clavien-Dindo grade III or higher by time from presentation to operation, stratified by simple versus complicated appendicitis, reflecting the differential effect of operative delay reported in prior multicentre and NSQIP-based cohorts [17,18,26].

4. Discussion

The central finding of this study is that structured postoperative complication tracking, anchored to the Clavien-Dindo classification, carries genuine prognostic information in acute appendicitis, but that its value is concentrated at the major-morbidity threshold (grade III and above) rather than distributed evenly across the ordinal scale. This pattern is consistent with the original validation of the classification, which found the grade III threshold to be the most clinically decisive cut-point in a large general-surgical cohort [4,3], and it extends that observation to a disease-specific population where severity at the index operation, rather than patient comorbidity burden alone, is the principal driver of complication risk [1].

Our observation that preoperative diagnostic scores correlate poorly with postoperative complication grade reinforces a distinction that has been under-appreciated in the appendicitis literature: instruments built to answer "does this patient have appendicitis" are not interchangeable with instruments meant to answer "how will this patient's postoperative course unfold" [8,10,12]. This has practical implications for how complication-tracking data should be used. Rather than functioning as a retrospective audit exercise alone, early postoperative Clavien-Dindo grading, particularly the transition into grade III, appears to identify a group of

patients whose subsequent trajectory, including length of stay and readmission risk, can be anticipated and potentially mitigated through earlier escalation, a pattern that parallels the failure-to-rescue framework described in the broader hospital-quality literature [6,27].

The comparatively weak added value of the comprehensive complication index for binary major-morbidity prediction, despite its theoretical advantages, suggests that for appendicitis the ordinal Clavien-Dindo grade alone may already capture most of the clinically actionable signal, and that the additional computational complexity of a continuous index is better reserved for continuous outcomes such as length of stay or cumulative cost, a nuance consistent with how the index has been applied in other single-disease validation studies since its original description [14,20]. Our finding that delay to operation predicted higher subsequent complication grade specifically among complicated appendicitis, but not simple appendicitis, is compatible with existing evidence that early operative intervention matters more once perforation or gangrene is already present, while short in-hospital delays in otherwise uncomplicated disease appear comparatively low-risk [17,18].

These findings should be interpreted against the wider evidence base on non-operative management of appendicitis. Trials comparing antibiotics with appendectomy for uncomplicated disease have shown that a substantial proportion of patients can avoid surgery altogether, which would, by definition, avoid the postoperative complication-tracking pathway entirely for that subgroup [28,29,30]. Our data, drawn from an operated cohort, cannot speak to whether structured complication tracking would retain prognostic value in a non-operative pathway, but the framework could plausibly be adapted to track escalation events, such as conversion to appendectomy or abscess drainage, using an analogous ordinal severity approach.

Nonappendectomy management of the appendiceal phlegmon or abscess, already well described as a distinct clinical pathway with its own complication profile, would similarly benefit from a parallel structured tracking scheme rather than assessment by the standard appendectomy-oriented grading alone [31]. Analogous propensity-matched comparative-effectiveness work in pediatric antibiotic selection for uncomplicated appendicitis illustrates that outcome comparisons within a single disease can still be sensitive to how narrowly the intervention and its complication profile are defined, a caution that applies equally to comparisons of complication-tracking protocols across institutions [32].

Limitations

This study is limited by its single-centre, retrospective design, which restricts generalizability and leaves open the possibility of unmeasured confounding by surgeon- or institution-level practice variation, a concern raised more broadly in volume-outcome and quality-variation literature [27,6]. The comparatively small proportion of complicated appendicitis cases limits the precision of subgroup estimates, and complication grading, although performed by blinded reviewers, retains an element of judgment inherent to the Clavien-Dindo system itself, a limitation acknowledged even in the classification's own validation work [3,4]. External validation in a multicentre, prospectively audited cohort, of the kind already established for broader appendicitis outcome surveillance, would strengthen confidence in these findings [15,33].

5. Conclusion

Structured postoperative complication tracking using the Clavien-Dindo classification functions as a useful, if threshold-concentrated, prognostic tool in acute appendicitis, with its principal value emerging at the major-morbidity cut-point rather than across the full ordinal scale. Preoperative diagnostic risk scores and postoperative complication tracking answer different

clinical questions and should not be treated as interchangeable. Embedding a standardized complication-tracking protocol into routine appendicitis care, alongside existing preoperative risk stratification, may help identify patients at higher risk of prolonged stay and readmission early enough to act on that information, and future prospective, multicentre validation should test whether earlier escalation triggered by grade III complication tracking measurably improves outcomes.

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