



Comparison of Clavien-Dindo classification (CDC) and comprehensive complication index (CCI) systems for grading of surgical complications in patients with gastroduodenal perforations-a prospective study

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ABSTRACT

Objective: Gastro-duodenal perforation is a life-threatening surgical emergency associated with high morbidity and mortality, particularly in low- and middle-income countries due to delayed presentation and sepsis. Accurate assessment of postoperative complications is essential for predicting outcomes. While the Clavien-Dindo classification (CDC) is widely used, it records only the highest-grade complication, potentially underestimating overall morbidity. The comprehensive complication index (CCI), a continuous scale incorporating all complications, may provide better prognostic value.

Material and Methods: This prospective observational study was conducted over 18 months in a tertiary care centre in northern India and included 50 adult patients with gastro-duodenal perforation. Postoperative complications were graded using CDC and quantified using CCI. Associations with length of hospital stay (LOS) were analysed using ANOVA, Pearson's correlation, and multivariate linear regression.

Results: The mean age was 42.26 ± 12.92 years, with a predominance of male and rural patients. Most participants had CDC Grade 3A complications (72%), with a mean CCI of 32.94 ± 14.82 . LOS increased significantly with higher CDC grades and CCI categories ($p < 0.01$). CCI showed a significant moderate correlation with LOS ($r = 0.444$, $p = 0.001$), whereas CDC demonstrated a weak, non-significant correlation ($r = 0.149$, $p = 0.303$). On multivariate analysis, CCI independently predicted LOS ($\beta = 0.17$, $p < 0.001$), while CDC was not significant. The CCI-based model showed better predictive performance ($R^2 = 0.35$) compared to the CDC model ($R^2 = 0.21$).

Conclusion: The CCI is a superior predictor of postoperative morbidity and hospital stay compared to CDC, particularly in patients with lower-grade CDC complications, as it more comprehensively reflects the cumulative burden of complications.

Keywords: Gastro-duodenal perforation, Clavien-Dindo classification, comprehensive complication index, postoperative complications, length of hospital stay

INTRODUCTION

Gastro-duodenal perforation is a common surgical emergency associated with significant morbidity and mortality. It may occur secondary to peptic ulcer disease, endoscopic procedures, trauma, or surgery for non-gastroduodenal conditions. Reported mortality in Western countries ranges from 4% to 30%, while data from India remain limited (1). The two major etiological factors implicated are *Helicobacter pylori* infection and the use of non-steroidal anti-inflammatory drugs (2,3). Other contributing factors include smoking, chronic liver disease, chronic renal failure, dialysis or transplantation, and hyperparathyroidism (4).

Duodenal perforation may be either free or contained. Free perforation results in spillage of bowel contents into the peritoneal cavity, causing diffuse peritonitis, whereas contained perforation occurs when leakage is walled off by adjacent organs such as the pancreas (4). Perforation peritonitis is one of the most frequent acute abdominal emergencies encountered by surgeons. In low- and middle-income settings, especially among patients from lower socio-economic groups, delayed presentation is common because of poor awareness and limited access to healthcare. Such delays often lead to septicemia, shock, fluid and electrolyte imbalance, and systemic inflammatory response syndrome, making management particularly difficult (5).

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Sepsis is a major determinant of mortality, accounting for 40-50% of deaths in these patients. At the time of surgery, nearly 30-35% of patients are septic, and over one-fourth may develop septic shock within the first postoperative month, with a mortality rate of 50-60% (6). Postoperative complications occur in up to 30% of cases, with advanced age, preoperative shock, and larger perforation size identified as important risk factors (7,8). Common complications include pneumonia, wound dehiscence, peritonitis, incisional hernia, enterocutaneous fistula, intra-abdominal abscess, ileus, and surgical site infection, the latter being the most common (9).

The Clavien-Dindo classification (CDC) is the most widely used system for grading postoperative complications (10). However, it often underestimates the total morbidity burden by reporting only the highest-grade complication (11). To overcome this limitation, the comprehensive complication index (CCI) was developed as a continuous scale from 0 to 100, integrating all complications according to their severity (11). Since no regional study has compared CDC and CCI in duodenal perforation and has done grade wise comparison of CDC and CCI, the present study aimed to evaluate their utility in predicting postoperative morbidity, length of hospital stay (LOS), and intensive care unit stay in patients undergoing surgery for duodenal ulcer perforation.

MATERIAL and METHODS

Study Design and Setting

This was a prospective observational study conducted over a period of 18 months in the department of general surgery of a tertiary care centre in Northern India. The study included patients presenting with gastro-duodenal perforation and evaluated postoperative morbidity using the CDC and the CCI. The study was conducted after obtaining approval from the Institutional Ethics Committee (IEC), Dr. Ram Manohar Lohia Institute of Medical Sciences. Ethical clearance was granted under IEC no: 122/24, and the proposal was approved in the IEC meeting held on 16.05.2024. Written informed consent was obtained from all participants prior to inclusion in the study.

Study Population

The study included 50 patients aged >18 years who presented to the department of general surgery with gastro-duodenal perforation and fulfilled the eligibility criteria. Patients with an established history of diabetes mellitus or chronic respiratory disease who were on regular treatment for these conditions were not included. In the emergency setting, several such patients presented in a critically ill state or with significant respiratory compromise and were unable or unwilling to provide consent for participation. However, patients in whom hyperglycaemia/diabetes mellitus or a respiratory condition was newly detected

during the index admission, without a previous established diagnosis or history of regular treatment, were not excluded solely on this basis and were included if otherwise eligible and consent could be obtained.

Patients with a history of previous abdominal surgery and those who did not provide consent were excluded. Convenience sampling was adopted because the distribution of postoperative complications across different CDC grades could not be predicted before enrolment. Therefore, all consecutive eligible and consenting patients presenting during the study period were considered for inclusion until the required sample size was achieved. For every patient enrolled in the study, postoperative complications were systematically assessed using the CDC, and the CCI was calculated to quantify the overall postoperative morbidity burden.

Data Collection

All those patients fulfilling the inclusion and exclusion criteria were included in the study. An informed and written consent was taken from the patient. A pretested predesigned proforma especially designed for this study was used to record the information for each individual patient. The socio-demographic characteristics, history of present illness, general and systemic examination and investigation findings of abdominal X-ray or blood investigations were noted.

Diagnosis of perforation was made on the basis of acute attack of abdominal pain with signs and symptoms of generalized peritonitis and radiological evidence of gas in peritoneal cavity. All patients were preoperatively resuscitated with intravenous fluids, and electrolyte imbalance was corrected. Nasogastric aspiration and urethral catheterization were performed in every patient. Preoperatively, antibiotics, ceftriaxone, and metronidazole were given. The patient was taken up for surgery. During the post operative period daily and at discharge CDC and CCI were calculated for the postoperative LOS. The postoperative course was classified prospectively at the time of discharge, according to CDC.

The CCI formula, which integrates every postoperative complication of a patient, was based on methods from operations risk index analysis used in economic science. Each Clavien-Dindo complication grade had an attributed severity weight, which was calculated from the multiplication of the physicians' and patients' perspective of harm. The square root of the sum of all weights amounted to the CCI after dividing by 2 (12).

$$CCI = \sqrt{\sum MRV_{phys} \times MRV_{pat}} / 2,$$

where MRV_{phys} is the median reference value of physicians and MRV_{pat} is the median reference value of patients. The

CCI® scores were calculated from the CDC values for each complication, prospectively reported in the database, and for easier using an online calculator (www.assessurgery.com/about_cci-calculator/). The data were noted down in an excel sheet for further analysis (12).

All complications were assigned a CDC Grade between I and V, with the highest grade for a patient used in the analysis of CDC. The CCI was then calculated for each patient, which assigned a weight to each complication, based on the CDC grade, and combined these to produce a score between 0 (no complications) and 100 (death). For example, a single CDC Grade I complication corresponded to a CCI of 8.7; a single CDC Grade II complication to a CCI of 20.9; and the combination of one CDC Grade I and one CDC Grade II complication to a CCI of 22.6.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS statistical software. Continuous variables were summarized as mean $\pm$ standard deviation (SD) or median [interquartile range (IQR)], while categorical variables were expressed as frequency and percentage. Descriptive statistics were applied to baseline socio-demographic, clinical, hematological, and biochemical parameters. CDC grades were analysed day-wise from postoperative day 1 to day 7 and also as the maximum grade for each participant, whereas the CCI was evaluated as daily mean scores, maximum CCI per participant, and categorized values. The association of CDC grades and CCI categories with LOS was assessed using One-Way ANOVA, and comparison of LOS based on mortality was performed using the independent samples t-test. Pearson's correlation coefficient was used to assess the relationship of LOS with maximum CDC grade and CCI score. Multivariate linear regression analysis was conducted to identify adjusted predictors of hospital stay using two models: one including age, American Society of Anesthesiologists (ASA) grade, duration of surgery, and maximum CDC grade, and the other including age, ASA grade, duration of surgery, and maximum CCI score. Model performance was evaluated using R^2 and adjusted R^2 , and a p-value of <0.05 was considered statistically significant.

RESULTS

Table 1 shows that 50 participants were included, with a mean age of 42.26 ± 12.92 years. The majority were male (96.0%) and from rural areas (62.0%). Educational status was predominantly low, with 44.0% illiterate and only 4.0% graduates. The most common presenting complaint was abdominal pain (86.0%), followed by fever (56.0%), abdominal distension (48.0%), vomiting (36.0%), obstipation (26.0%), and loose stools (12.0%). Comorbidities included hypertension (20.0%), hypothyroidism (4.0%), and tobacco use (38.0%), indicating a predominantly middle-aged, rural, and less-educated population (Table 1).

Guarding was the most frequent abdominal finding (48 participants), followed by abdominal distension (44), diffuse tenderness (10), and rebound tenderness (8), while a tense abdomen was rare (1), reflecting a high prevalence of peritoneal irritation (Figure 1).

The baseline vital parameters showed a mean pulse rate of $107.40 \pm 25.17/\text{min}$ (median 107.40; IQR 33.95), indicating

Table 1. Socio-demographic and clinical characteristics of study participants

Variables		n	%
Mean age (years)		42.26	± 12.920
Sex	Male	48	96.0
	Female	2	4.0
Education level	Illiterate	22	44.0
	Primary	11	22.0
	High school	8	16.0
	Intermediate	7	14.0
	Graduate and above	2	4.0
Residence	Rural	31	62.0
	Urban	19	38.0
Presenting complaint	Abdominal pain	43	86.0
	Fever	28	56.0
	Vomiting	18	36.0
	Abdominal distension	24	48.0
	Not passing stool or flatus	13	26.0
	Loose stools	6	12.0
Hypertension	Yes	10	20.0%
	No	40	80.0%
Hypothyroidism	Yes	2	4.0%
	No	48	96.0%
Smoking/tobacco history	Yes	19	38.0%
	No	31	62.0%

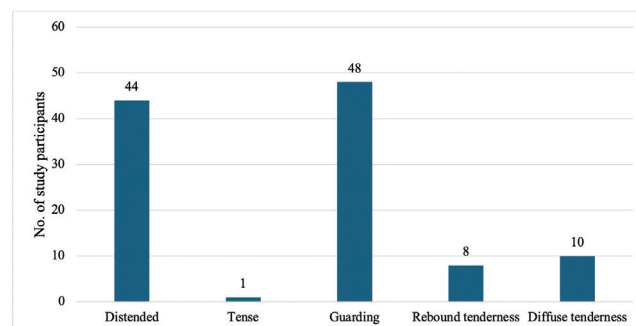


Figure 1. Distribution of abdominal examination findings among the study participants. Guarding was the most common finding (n=48), followed by abdominal distension (n=44), diffuse tenderness (n=10), rebound tenderness (n=8), and tense abdomen (n=1).

tachycardia, while mean systolic and diastolic blood pressures were 116.61 ± 17.46 mmHg (IQR 23.56) and 73.73 ± 10.88 mmHg (IQR 14.68), respectively, suggesting largely stable hemodynamics. The mean respiratory rate was 20.60 ± 3.19 /min (IQR 4.31), reflecting mild tachypnea. Systemic examination revealed no abnormalities, with 100% participants having normal CVS and CNS findings. Perioperatively, PRBC transfusion was minimal, with 94.0% requiring 0-1 unit and 6.0% requiring 2 units, whereas FFP requirement was higher (0-1 unit: 20.0%, 2-3 units: 42.0%, ≥ 4 units: 38.0%).

Most participants were ASA Grade II (64.0%), followed by Grade I (30.0%) and Grade III (6.0%), indicating predominantly ASA I-II status (94.0%). Hematological parameters showed mean hemoglobin of 10.21 ± 1.78 g/dL (7.67-14.00), TLC $12199.77 \pm 4840.04/\text{mm}^3$ (5.55-23650.00), and platelet count 2.13 ± 0.99 lakhs/ mm^3 (0.87-4.52). Biochemical parameters revealed elevated liver enzymes (aspartate aminotransferase 79.64 ± 31.29 U/L; alanine aminotransferase 77.08 ± 30.30 U/L; alkaline phosphatase 148.07 ± 38.53 U/L), mildly raised total bilirubin (1.27 ± 0.62 mg/dL), deranged renal function (urea 1.67 ± 0.77 mg/dL; creatinine 2.35 ± 0.96 mg/dL), and low serum albumin (2.82 ± 0.52 g/dL), indicating hepatobiliary dysfunction with associated renal impairment and hypoalbuminemia in the study population.

Most participants had CDC Grade 3A complications (72.0%) with a mean CCI of 32.94 ± 14.82 , and hospital stay increased significantly with higher CDC grades and CCI categories ($p=0.001$ and $p=0.004$), indicating that greater complication severity was associated with longer hospitalization (Table 2). CCI showed a moderate and significant positive correlation with hospital stay ($r=0.444$, $p=0.001$), whereas maximum CDC had a weak and non-significant correlation ($r=0.149$, $p=0.303$), suggesting CCI is a better predictor of LOS (Table 3). On multivariate analysis, only CCI independently predicted hospital stay ($\beta=0.17$, $p<0.001$), while age and duration of surgery showed borderline significance and CDC was not significant after adjustment (Table 4).

The day-wise distribution of Clavien-Dindo complication grades shows that in the early postoperative period (POD1-POD2), lower-grade complications predominated, with Grade 2 being most common (70.0% on POD1 and 82.0% on POD2), while no higher-grade complications were observed initially. By POD3, Grade 3A (16.0%) and occasional Grade 4 (2.0%) complications began to appear. From POD4 onwards, there was a clear shift toward higher-grade complications, with Grade 3A becoming prominent (34.0% on POD4 and peaking at 40.0% on POD7), along with the emergence of severe complications such as Grade 3B, Grade 4, and Grade 5. Although lower-grade complications (Grade 1 and 2) persisted throughout, their proportion fluctuated and declined relative to higher grades in later days. Overall, the trend indicates an early predominance of mild complications

followed by progression to more severe complications in a subset of patients during the later postoperative period (Figure 2).

The day-wise analysis of CCI scores shows that the mean complication burden increased from POD1 (18.00 ± 6.18) to POD2 (22.24 ± 4.33), followed by a slight decline on POD3 (21.99 ± 6.51) and POD4 (20.99 ± 13.81). Thereafter, a gradual rise was observed, reaching 22.38 ± 15.03 on POD5 and peaking at 24.24 ± 15.15 on POD6, with a marginal decrease on POD7 (24.07 ± 18.72). The range and SD increased notably from POD4 onwards (range up to 93), indicating greater variability and occurrence of severe complications in later postoperative days (Figure 3).

Table 5 compares the predictive accuracy of two multivariate linear regression models for LOS, one based on the CDC and the other on the CCI. The CDC model demonstrated an R^2 value of 0.21, indicating that it explained 21% of the variability in LOS, with an adjusted R^2 of 0.14 after accounting for the number of predictors, reflecting modest predictive ability and limited contribution beyond confounding variables. In contrast, the CCI model showed a higher R^2 of 0.35, meaning it explained 35% of the variability in LOS, with an adjusted R^2 of 0.30, indicating

Table 2. Distribution of maximum postoperative complication severity and association with length of hospital stay

Parameters		n	%
Max CDC	Grade 2	8	16.0
	Grade 3A	36	72.0
	Grade 4	5	10.0
	Grade 5	1	2.0
CCI	20-29.9	25	50.0
	30-39.9	18	36.0
	>40	7	14.0
Max CCI		32.94 ± 14.82	
Length of hospital stay in CDC grade	CDC Grade 2	12.88 ± 1.25	f- 6.39, p- 0.001
	CDC Grade 3A	15.53 ± 3.49	
	CDC Grade 4	19.40 ± 6.84	
	CDC Grade 5	4.00	
Length of hospital stay (days) in CCI score category	CCI 20-29.9	13.36 ± 2.34	f- 6.30 p- 0.004
	CCI 30-39.9	16.83 ± 2.71	
	CCI >40	18.00 ± 8.58	

SD cannot be calculated as n=1. SD: Standard deviation, CDC: Clavien-Dindo classification, CCI: Comprehensive complication index.

Table 3. Correlation of maximum CDC and CCI with length of hospital stay

Parameters		r	p-value
MAX CDC	Length of hospital stay (days)	0.149	0.303
CCI	Length of hospital stay (days)	0.444	0.001

CDC: Clavien-Dindo classification, CCI: Comprehensive complication index.

Table 4. multivariate linear regression for LOS

Variable	β coefficient (Model A: CDC)	p-value	β coefficient (Model B: CCI)	p-value
Age (years)	0.07	0.053	0.058	0.088
ASA grade	-1.27	0.118	-0.89	0.214
Duration of surgery (minutes)	0.023	0.081	0.017	0.141
Maximum CDC	0.61	0.092	NA	NA
Maximum CCI	NA	NA	0.17	<0.001

LOS: Length of hospital, CDC: Clavien-Dindo classification, CCI: Comprehensive complication index, NA: Not applicable, ASA: American Society of Anesthesiologists.

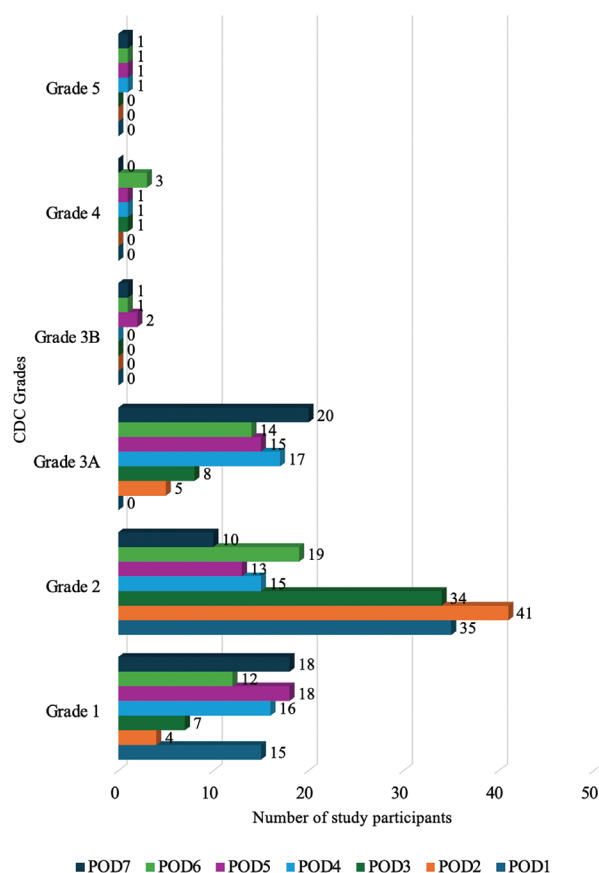


Figure 2. Day-wise distribution of Clavien-Dindo classification (CDC) grades during the postoperative period. The figure demonstrates the distribution of daily CDC grades from postoperative day (POD) 1 to POD7, with lower-grade complications predominating during the early postoperative period and higher-grade complications appearing during subsequent postoperative days. These are daily CDC grades and should be distinguished from the maximum CDC grade attained by each patient during the entire hospitalization.

Table 5. Predictive accuracy comparison of CDC and CCI		
Model	R ²	Adjusted R ²
CDC model	0.21	0.14
CCI model	0.35	0.3

CDC: Clavien-Dindo classification, CCI: Comprehensive complication index.

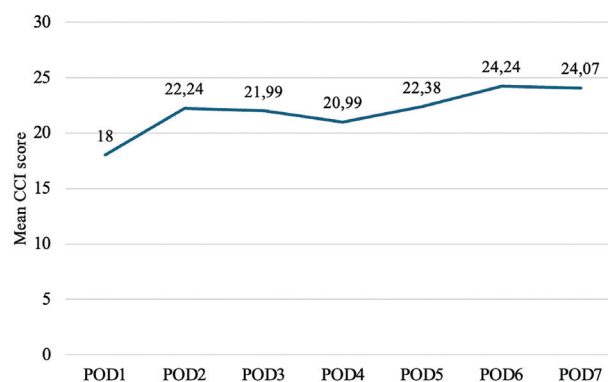


Figure 3. Day-wise distribution of comprehensive complication index (CCI) scores during the postoperative period. The figure demonstrates changes in mean CCI scores from postoperative day (POD)1 to POD7, representing the cumulative postoperative complication burden over time.

better model stability and minimal overfitting. The higher explanatory power of the CCI model (an absolute increase of 14% in R^2) highlights its superior predictive performance over the CDC model. This suggests that CCI, being a continuous and cumulative measure of postoperative complications, more effectively captures the overall morbidity burden and is a more reliable predictor of hospital stay compared to the categorical CDC system (Table 5).

Multivariable linear regression analysis demonstrated that the CCI was an independent predictor of LOS after adjustment for age, ASA grade, and duration of surgery ($\beta=0.17$, $p<0.001$). In contrast, the maximum CDC grade was not independently associated with LOS after adjustment ($\beta=0.61$, $p=0.092$). Furthermore, the predictive model incorporating CCI demonstrated superior explanatory performance ($R^2=0.35$; adjusted $R^2=0.30$) compared with the model based on CDC ($R^2=0.21$; adjusted $R^2=0.14$), indicating that CCI accounted for a greater proportion of the variability in postoperative hospital stay.

DISCUSSION

Our study showed that duodenal perforation mainly affected middle-aged adults with a marked male predominance and a predominantly rural background. The male proportion in our

cohort was higher than that reported by Parray et al. (13) and Chowdhary et al. (14), but was broadly similar to Bose et al. (15). The mean age in our study was slightly lower than that reported by Bojanapu et al. (1) and Bose et al. (15) supporting that this condition commonly affects adults in the fourth to fifth decade.

Abdominal pain was the most common presenting symptom, followed by fever, distension, vomiting, and obstructive symptoms, which is broadly consistent with previous perforation peritonitis studies. Chowdhary et al. (14) and Bose et al. (15) also reported abdominal pain as the dominant complaint, although they observed higher rates of distension and vomiting, suggesting relatively more advanced presentation in their patients.

Baseline investigations in our study suggested anemia, hypoalbuminemia, renal impairment, and hepatobiliary dysfunction, reflecting significant systemic stress. Similar studies have shown that greater physiological derangement, higher ASA grade, and older age are associated with worse postoperative outcomes, particularly when assessed using CCI (16,17). Although most of our patients were ASA II, the laboratory abnormalities and transfusion requirements indicate that important organ dysfunction was still present. This finding supports the observation by Bojanapu et al. (1) that preoperative organ dysfunction is a major determinant of adverse outcomes in perforation patients.

Early postoperative complications in present study were predominantly low-grade on POD1, but intervention-requiring complications increased progressively over the first week, with Grade 3A becoming most common by POD7 and a gradual rise in cumulative morbidity on CCI. Mean CCI increased from 18.00 ± 6.18 on POD1 to 24.07 ± 18.72 on POD7, with increasing variability and severe morbidity in a subset of patients. This trend is consistent with Kawakatsu et al. (18), who showed that serial postoperative CCI strongly predicts severe outcomes, with important cut-off values identified on Day 1, Day 4, and Day 7. Our findings similarly suggest that CCI is useful for capturing the evolving cumulative burden of postoperative morbidity better than isolated complication grades, particularly from POD4 onward.

In our study, overall postoperative morbidity during the first week was substantial, with most patients reaching a maximum CDC grade of 3A and a low mortality of 2.0%. The mean maximum CCI was 32.94 ± 14.82 , indicating a considerable cumulative complication burden. Compared with Singh et al. (19), who reported higher mortality in gastrointestinal perforation patients, our mortality was lower despite a high frequency of intervention-requiring complications. Our mean CCI was close to the severe-event burden reported by Metzemaekers et al. (20) but lower than the heavier morbidity load described by Smeyers

et al. (21). Similar validation studies have also shown that while CDC reflects the highest complication grade, CCI better captures the total postoperative morbidity burden, supporting the usefulness of both measures in our cohort (22,23).

In our study, LOS increased with increasing postoperative morbidity by both CDC grade and CCI category, but CCI showed a stronger and statistically significant correlation with LOS, unlike CDC. This suggests that CCI better reflects the cumulative complication burden responsible for prolonged hospitalization. Our findings are consistent with previous studies showing a stronger association of CCI with LOS than CDC, including Llàcer-Millán et al. (16), Mathes et al. (17), Huang et al. (24), and Ricci et al. (25). Prediction studies by Giani et al. (26) also demonstrated superior discrimination of CCI for excessive LOS, while similar results have been reported by Tirota et al. (23).

Studies have shown that mortality is more strongly related to overall complication severity, organ dysfunction, and delayed treatment rather than LOS alone. However we had a low mortality rate so comparing survivor with non-survivor is not statistically valid. Higher mortality has been reported by Singh et al. (19) and Bojanapu et al. (1), while Kawakatsu et al. (18) demonstrated that severe postoperative morbidity trajectories are strongly associated with death. Thus, our findings support that mortality is better explained by complication burden and baseline severity than by hospital stay duration alone.

In our study, CCI was the only significant independent predictor of length of stay, whereas maximum CDC, age, ASA grade, and duration of surgery were not independently significant. This supports the view that CCI better reflects cumulative postoperative morbidity and is therefore more useful for predicting prolonged hospitalization. Similar findings have been reported by Llàcer-Millán et al. (16), Geiger et al. (22), and Huang et al. (24), who also found CCI to be more sensitive than CDC in identifying clinically relevant morbidity and hospital-resource outcomes. Bojanapu et al. (1) further support this by showing that greater physiological insult and more complicated postoperative courses are associated with worse outcomes and longer care needs.

CCI showed better predictive performance for length of stay than CDC, with higher R^2 and adjusted R^2 values, indicating that cumulative morbidity explains hospital stay more accurately than the single highest complication grade. This is consistent with previous studies showing stronger LOS association and better discrimination with CCI than CDC, including Llàcer-Millán et al. (16), Mathes et al. (17), Huang et al. (24), Ricci et al. (25), Giani et al. (26), Geiger et al. (22), and Tirota et al. (23). Overall, these findings support CCI as a more sensitive and clinically useful predictor of postoperative recovery and resource utilization than CDC.

So, the present study demonstrated that the CCI was superior to the CDC in predicting postoperative outcomes in patients with gastroduodenal perforations. Although the maximum CDC grade was not independently associated with LOS after adjustment ($\beta=0.61$, $p=0.092$), the CCI remained a significant independent predictor ($\beta=0.17$, $p<0.001$). Furthermore, the CCI model showed better explanatory ability than the CDC model ($R^2=0.35$ vs. 0.21). This may be attributed to the CCI incorporating the cumulative burden of all postoperative complications, whereas the CDC considers only the highest-grade complication.

The present study has several important strengths, including the use of both the CDC and the CCI for standardized assessment of postoperative morbidity, which allowed comparison between a categorical and a cumulative complication scoring system. In addition, day-wise recording of CDC grades and CCI scores from POD1 to POD7 provided a detailed picture of early postoperative morbidity progression, and the evaluation of their association with LOS through multivariable regression helped identify CCI as an independent predictor of hospital stay.

Study Limitations

This study has several limitations. First, it was conducted at a single center with a relatively small sample size ($n=50$), which may limit the generalizability of the findings and reduce the statistical power to detect associations for less frequent outcomes. Moreover, the modest sample size in relation to the four variables included in each multivariable regression model may have resulted in less precise or unstable regression estimates and an increased risk of model overfitting. Therefore, the multivariable findings, including the observed predictive advantage of CCI over CDC, should be interpreted cautiously and require validation in larger, adequately powered, multicenter studies. Second, postoperative follow-up was restricted to the first 7 days, thereby capturing only early postoperative complications. Consequently, late postoperative events such as delayed surgical site infections, intra-abdominal collections, anastomotic complications, readmissions, and other complications occurring after hospital discharge could not be evaluated. As both the CDC Classification and the CCI are cumulative measures of postoperative morbidity, the absence of long-term follow-up may have resulted in an underestimation of the overall complication burden, particularly for the CCI. Finally, the possibility of minor data recording inconsistencies, particularly for variables with uniform or near-uniform prevalence, cannot be completely excluded and may have influenced the interpretation of some findings.

CONCLUSION

In conclusion, patients with gastro-duodenal perforation in our study were mainly middle-aged rural males presenting with abdominal pain, fever, distension, and vomiting, with evidence of

significant baseline physiological stress and organ dysfunction in some cases. Postoperative morbidity increased over the first week, with most patients reaching CDC Grade 3A and a moderate-to-high mean maximum CCI. Although both CDC and CCI were associated with longer hospital stay, CCI showed a stronger correlation and emerged as the best independent predictor of prolonged hospitalization, particularly by better capturing cumulative morbidity even among patients with lower CDC grades. Overall, CCI appears to be a more sensitive and clinically useful tool than CDC for assessing postoperative outcomes in gastro-duodenal perforation. Larger multi-center studies with longer follow-up are needed to validate these findings and to assess the value of routine serial CCI-based monitoring.

Ethics

Ethics Committee Approval: The study was conducted after obtaining approval from the Institutional Ethics Committee (IEC), Dr. Ram Manohar Lohia Institute of Medical Sciences. Ethical clearance was granted under IEC no: 122/24, and the proposal was approved in the IEC meeting held on 16.05.2024.

Informed Consent: Written informed consent was obtained from all participants prior to inclusion in the study.

Footnotes

Author Contributions

Surgical and Medical Practices - P.R., A.S., R.S., S.K.S.; Concept - P.R.; Design - P.R.; Data Collection or Processing - M.F., P.R., A.S., R.S., S.K.S.; Analysis or Interpretation - M.F., P.R.; Literature Search - M.F., R.S.; Writing - M.F., P.R., A.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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