International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Predicting Outcomes of Patients with Perforation Peritonitis Using the Mannheim Peritonitis Index and Acute Physiology and Chronic Health Evaluation II Scoring Systems

Ganesh T A[1], Manik Gedam[2]

[1]Junior Resident, Department of General Surgery, Indira Gandhi Government Medical College & Hospital, Nagpur, India
Corresponding Author Email: *elaganesh98[at]gmail.com*

[2]Associate Professor, Department of General Surgery, Indira Gandhi Government Medical College & Hospital, Nagpur, India

Abstract: ***Introduction: Perforation peritonitis is a severe surgical emergency associated with high morbidity and mortality, particularly in developing countries. Early and accurate risk stratification is essential to guide timely surgical intervention, optimize resource allocation, and improve postoperative care. The Mannheim Peritonitis Index and the Acute Physiology and Chronic Health Evaluation II scoring systems are widely utilized to predict outcomes in these critically ill patients. This study aims to prospectively evaluate and compare the predictive accuracy of these two scoring systems specifically in patients presenting with hollow viscus perforation. Methods: This prospective observational study included 50 patients diagnosed with secondary peritonitis who underwent emergency laparotomy at a tertiary healthcare teaching hospital. Patients with primary peritonitis, trauma-related peritonitis, and acute pancreatitis were excluded. Comprehensive clinical, laboratory, and operative data were recorded to calculate the Mannheim Peritonitis Index and Acute Physiology and Chronic Health Evaluation II scores on admission. The primary outcomes assessed were in-hospital mortality and postoperative morbidity, including wound infection and anastomotic leak. Diagnostic performance was evaluated using receiver operating characteristic curve analysis. Results: The study cohort comprised 38 males (76.0%) and 12 females (24.0%) with a mean age of 43.14 ± 12.83 years. Gastric perforation was the most frequent aetiology, accounting for 18 cases (36.0%). The Mannheim Peritonitis Index, utilizing a cutoff score of 21, demonstrated a sensitivity of 88.89% (8 of 9 non-survivors) and a specificity of 85.37% (35 of 41 survivors) for predicting mortality, yielding an overall diagnostic accuracy of 86.00% (43 of 50 patients). Alternatively, the Acute Physiology and Chronic Health Evaluation II score, at a cutoff of 15, yielded a sensitivity of 77.78% (7 of 9 non-survivors) and a specificity of 97.56% (40 of 41 survivors), achieving a higher overall diagnostic accuracy of 94.00% (47 of 50 patients). Both scoring systems were significantly associated with the incidence of postoperative complications, with higher scores strictly correlating to increased rates of wound infection, wound dehiscence, and the need for re-operation ($p < 0.05$). Conclusion: Both scoring systems serve as highly reliable predictors of mortality and morbidity in perforation peritonitis. The Mannheim Peritonitis Index is a simple, rapid tool highly effective for mortality prediction in resource-limited settings. Conversely, the Acute Physiology and Chronic Health Evaluation II system provides a more comprehensive physiological assessment and slightly superior discriminative accuracy, making it highly valuable for risk stratification in advanced critical care environments.***

Keywords: APACHE II score, Mannheim Peritonitis Index, mortality prediction, perforation peritonitis, postoperative morbidity, surgical emergency.

1. Introduction

Perforation peritonitis, defined as an infection of the peritoneal cavity following gastrointestinal perforation, is a life-threatening surgical emergency associated with significant morbidity and mortality. Peritonitis involves inflammation of the serosal membrane lining the abdominal cavity and is categorized into primary, secondary, and tertiary types. Primary peritonitis, or spontaneous bacterial peritonitis, arises without an identifiable abdominal infection source and is frequently linked to conditions like liver cirrhosis and ascites [1]. Secondary peritonitis is the most prevalent form, predominantly resulting from a hollow viscus perforation caused by conditions such as appendicitis, diverticulitis, or peptic ulcer disease [2,3]. The term perforation originates from the Latin word "perforatus," meaning to bore through, indicating an abnormal opening that allows the lumen of the affected organ to communicate with the normally sterile peritoneal cavity. This leakage of gastrointestinal contents triggers a severe inflammatory reaction that can rapidly advance to systemic inflammation and sepsis [4]. Tertiary peritonitis typically manifests as a recurrent or persistent infection following the treatment of primary or secondary forms, often observed in critically ill or immunocompromised individuals [5]. As a major contributor to secondary peritonitis, hollow viscus perforation accounts for roughly 1.0% of urgent surgical admissions and ranks as the second leading cause of sepsis in intensive care units globally [6]. The overall mortality for secondary peritonitis is reported to be around 6.0%, but this rate can surge to between 30.0% and 35.0% in patients who develop severe sepsis or multi-organ failure [7,8]. Rapid diagnosis and prompt surgical intervention are essential for achieving source control, alongside aggressive resuscitation and appropriate antibiotic therapy [9]. However, patient outcomes vary widely based on individual risk factors, anatomical contamination, and the severity of physiological derangement [10]. Accurate and timely prediction of these outcomes is essential for effective treatment planning, efficient resource utilization, and overall prognostic improvement [11]. Early outcome prediction allows healthcare providers to properly assess disease severity, prioritize high-risk patients for intensive care, and

deliver appropriate supportive measures [12]. Consequently, the use of scoring systems has proven essential in peritonitis management by providing a standardized method to assess severity and predict mortality and morbidity risks. Several scoring systems have been utilized, including the Acute Physiology and Chronic Health Evaluation II (APACHE II) score introduced in 1985 [13], the Mannheim Peritonitis Index (MPI) introduced in 1983 [14], the Peritonitis Index Altona, the Sepsis Severity Score, and the Physiological and Operative Severity Score for the enumeration of Mortality and morbidity (POSSUM) [15]. Among these, the MPI and APACHE II scores are the most commonly used tools for supporting clinical decision-making, guiding the level of monitoring, determining the necessity for surgical intervention, and identifying patients who require admission to an intensive care unit [16]. Despite their widespread application, limited research specifically evaluates the comparative predictive accuracy of these two scoring systems in cases isolated to perforation peritonitis across diverse clinical settings and patient populations. Most existing studies are retrospective, possess limited sample sizes, or focus broadly on general peritonitis rather than specifically on perforation-related cases. Furthermore, there is a notable lack of region-specific or institution-based validation studies that account for variations in healthcare infrastructure, the timeliness of surgical intervention, and patient demographics. This gap hinders the establishment of contextually relevant, evidence-based guidelines for optimizing risk stratification and clinical decision-making in patients suffering from hollow viscus perforation. Therefore, a prospective study comparing the predictive effectiveness of the MPI and the APACHE II score in perforation peritonitis is essential to improve prognostication, guide timely interventions, and ultimately enhance patient outcomes.

2. Materials and Methods

Study Design and Setting

This prospective observational study was conducted at Indira Gandhi Government Medical College, a public tertiary healthcare referral teaching hospital in Nagpur, Maharashtra, India. The study duration was from November 1, 2023, to June 10, 2026.

Participants and Sample Size

The study population comprised patients of all age groups admitted to the emergency department or surgical wards. A total of 50 patients who fulfilled the inclusion and exclusion criteria were enrolled in the study. Informed written consent was obtained from all patients before enrolment.

Inclusion and Exclusion Criteria

Patients were screened and selected based on strict clinical criteria. The complete inclusion and exclusion criteria applied for patient selection are detailed in Table 1.

Table 1: Inclusion and Exclusion Criteria for Patient Selection

Inclusion Criteria	Exclusion Criteria
All patients diagnosed with secondary peritonitis admitted to the emergency department or surgical wards who underwent emergency surgery.	Primary peritonitis
	Peritonitis related to peritoneal dialysis
	Acute pancreatitis
	Peritonitis secondary to trauma

Inclusion and exclusion criteria applied to screen and enrol patients presenting with secondary peritonitis for study participation. No abbreviations are used in this table.

Preoperative Evaluation

A comprehensive clinical history was recorded for all enrolled patients, detailing the duration, location, character, and pattern of abdominal pain, along with previous surgical history and associated symptoms. A general and systemic examination was performed to rule out acute pathology or obvious clinical diagnoses. Routine laboratory investigations included a complete blood count, liver function tests, kidney function tests, random blood sugar, international normalized ratio, human immunodeficiency virus screening, and hepatitis B surface antigen testing. Radiological investigations consisted of erect and supine abdominal X-rays, abdominal and pelvic ultrasonography, and contrast-enhanced computed tomography of the abdomen and pelvis when clinically feasible.

Operative Procedure and Perforation Management

Patients were positioned supine, and the abdomen was prepared and draped under sterile conditions. Adequate preoperative antibiotic prophylaxis was administered. Standard exploratory laparotomy was performed using a midline vertical incision extending from the supraumbilical to the infraumbilical region. Upon entry, the presence of free fluid was assessed for quantity and nature. The site of perforation was identified, and its location and size were documented alongside the degree of peritoneal contamination.

For simple perforations, primary repair was performed by freshening the perforation edges and closing them in two layers using absorbable sutures (such as 2-0 polyglactin 910), with an omental patch placed if applicable. When bowel resection and anastomosis were required for large perforations or gangrenous bowel, the extent of the resected necrotic segment was recorded. In cases of poor bowel condition or high-risk anastomosis, a loop or end ileostomy/colostomy was created. Extensive peritoneal lavage was performed using 3 to 6 liters of warm isotonic saline until clear return was observed. Tube or closed suction drains were placed in the pelvic, subhepatic, or paracolic gutters, and the abdominal wall was closed in layers.

Postoperative Care and Follow-up

Vital signs, drain output, and abdominal girth were monitored every four to six hours. Intravenous ceftriaxone and metronidazole were administered for seven to ten days. Patients were kept nil per os for 48 hours, followed by graded oral intake. Patients were monitored for early complications, including surgical site infection and anastomotic leak, as well as late complications such as intra-abdominal abscess and incisional hernia. Follow-up was conducted at one month and three months post-discharge.

Scoring Systems

The Mannheim Peritonitis Index (MPI) was calculated based on independent risk factors documented during admission and intraoperative assessment. The specific weighting allocated to each clinical and anatomical parameter is detailed in **Table 2**.

Table 2: Mannheim Peritonitis Index (MPI)

Risk Factor	Weighting if Present
Age > 50 years	5
Female sex	5
Organ failure	7
Malignancy	4
Origin of sepsis not colonic	4
Diffuse generalized peritonitis	6
Preoperative duration of peritonitis > 24 hours	4
Intraperitoneal exudate: Clear	0
Intraperitoneal exudate: Cloudy, purulent	6
Intraperitoneal exudate: Fecal	12

Organ failure criteria used in the Mannheim Peritonitis Index (MPI): Kidney failure was defined as serum creatinine > 177 µmol/L (2.0 mg/dL), serum urea > 167 mmol/L, or oliguria < 20 mL/h. Pulmonary insufficiency was defined as PaO2 < 50 mmHg or PaCO2 > 50 mmHg. Intestinal obstruction was defined as paralytic ileus lasting > 24 hours or complete mechanical ileus. Shock was defined as systolic blood pressure < 90 mmHg or mean arterial pressure (MAP) < 60 mmHg. Abbreviations: MPI, Mannheim Peritonitis Index; PaO2, Partial pressure of oxygen; PaCO2, Partial pressure of carbon dioxide; MAP, Mean arterial pressure; h, hour; µmol/L, micromoles per liter; mg/dL, milligrams per deciliter; mmol/L, millimoles per liter; mmHg, millimeters of mercury; mL/h, milliliters per hour. Republished with permission from Springer Nature, from Der Mannheimer Peritonitis-Index. Ein Instrument zur intraoperativen Prognose der Peritonitis, Linder MM, Wacha H, Feldmann U, et al., Der Chirurg, Vol. 58, Issue 2, Copyright 1987 [14].

The Acute Physiology and Chronic Health Evaluation II (APACHE II) score was calculated within the first 24 hours of admission by combining points assigned to 12 acute physiological variables, age points, and chronic health points. The scoring matrix for APACHE II physiological variables is presented in **Table 3**.

Table 3: APACHE II - Physiological Variables and Point Allocations

Physiologic Variable	+4 (High)	+3 (High)	+2 (High)	+1 (High)	0 (Normal)	+1 (Low)	+2 (Low)	+3 (Low)	+4 (Low)
Temperature rectal (°C)	≥ 41.0	39.0 to 40.9	—	38.5 to 38.9	36.0 to 38.4	34.0 to 35.9	32.0 to 33.9	30.0 to 31.9	≤ 29.9
Mean arterial pressure (mmHg)	≥ 160	130 to 159	110 to 129	—	70 to 109	—	50 to 69	—	≤ 49
Heart rate (ventricular response)	≥ 180	140 to 179	110 to 139	—	70 to 109	—	55 to 69	40 to 54	≤ 39
Respiratory rate (breaths/min)	≥ 50	35 to 49	—	25 to 34	12 to 24	10 to 11	6 to 9	—	≤ 5
Oxygenation: A-aDO2 or PaO2 (mmHg)	≥ 500	350 to 499	200 to 349	—	< 200 (PaO2 > 70)	PaO2 61 to 70	—	PaO2 55 to 60	PaO2 < 55
Arterial pH (preferred)	≥ 7.70	7.60 to 7.69	—	7.50 to 7.59	7.33 to 7.49	—	7.25 to 7.32	7.15 to 7.24	< 7.15
Serum HCO3 (venous mEq/L)	≥ 52.0	41.0 to 51.9	—	32.0 to 40.9	22.0 to 31.9	—	18.0 to 21.9	15.0 to 17.9	< 15.0
Serum sodium (mEq/L)	≥ 180	160 to 179	155 to 159	150 to 154	130 to 149	—	120 to 129	111 to 119	≤ 110
Serum potassium (mEq/L)	≥ 7.0	6.0 to 6.9	—	5.5 to 5.9	3.5 to 5.4	3.0 to 3.4	2.5 to 2.9	—	< 2.5
Serum creatinine (mg/dL)	≥ 3.5	2.0 to 3.4	1.5 to 1.9	—	0.6 to 1.4	—	< 0.6	—	—
Hematocrit (%)	≥ 60.0	—	50.0 to 59.9	46.0 to 49.9	30.0 to 45.9	—	20.0 to 29.9	—	< 20.0
White blood count (total/mm³ in 1000s)	≥ 40.0	—	20.0 to 39.9	—	3.0 to 14.9	—	1.0 to 2.9	—	< 1.0
Glasgow Coma Scale (GCS)	—	—	—	—	Score = 15 minus actual GCS	—	—	—	—

Total APACHE II Score Calculation = A + B + C. (A) Total Acute Physiology Score (APS): The sum of points assigned to the 12 physiological variables above (worst values recorded during the first 24 hours of admission). (B) Age Points: ≤ 44 years = 0 points; 45 to 54 years = 2 points; 55 to 64 years = 3 points; 65 to 74 years = 5 points; ≥ 75 years = 6 points. (C) Chronic Health Points: For patients with a history of severe organ system insufficiency or immunocompromise: Non-operative or emergency postoperative admission = 5 points; Elective postoperative admission = 2 points. Abbreviations: APACHE II, Acute Physiology and Chronic Health Evaluation II; ABG, Arterial blood gas; A-aDO2, Alveolar-arterial oxygen gradient; FiO2, Fraction of inspired oxygen; GCS, Glasgow Coma Scale; HCO3, Bicarbonate; PaO2, Partial pressure of oxygen; °C, Degrees Celsius; mmHg, Millimeters of mercury; mEq/L, Milliequivalents per liter; mg/dL, Milligrams per deciliter; %, Percentage; mm³, Cubic millimeters. Republished with permission from Wolters Kluwer Health, Inc., from APACHE II: A severity of disease classification system, Knaus WA, Draper EA, Wagner DP, Zimmerman JE, Critical Care Medicine, Vol. 13, Issue 10, Copyright 1985 [13].

Statistical Analysis

Data collection was conducted using a pretested and predesigned clinical proforma, and the compiled data were systematically entered into a Microsoft Excel spreadsheet for initial processing. All formal statistical analyses were

performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics were utilized to summarize baseline demographic and clinical characteristics. Continuous variables were expressed as mean and standard deviation (SD). Categorical variables were presented as absolute frequencies (n) and percentages (%).

To evaluate and compare the predictive accuracy of the MPI and APACHE II scoring systems for mortality, Receiver Operating Characteristic (ROC) curve analysis was employed. The Area Under the Curve (AUC) was calculated to assess the overall discriminative ability of each scoring system. Optimal cut-off values were identified using the Youden index to maximize diagnostic accuracy. At these predefined thresholds, predictive performance was quantified by calculating Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and overall Diagnostic Accuracy. Comparative analyses to determine associations between scoring system risk categories and categorical morbidity outcomes were evaluated using Pearson's Chi-square test or Fisher's exact test as appropriate, with a two-tailed p-value of less than 0.05 considered statistically significant.

3. Results

The study cohort included 50 patients, comprising 38 males (76.0%) and 12 females (24.0%), with a male-to-female ratio of 3.17:1. Patient ages ranged from 18 to 72 years, with a mean age of 43.14 ± 12.83 years. The majority of patients belonged to the 46–55 years age group (18 patients, 36.0%), followed by the 36–45 years group (12 patients, 24.0%). Regarding the anatomical origin of peritoneal sepsis, gastric perforation was the most frequent aetiology, observed in 18 patients (36.0%). Appendicular perforations were noted in 11 patients (22.0%), duodenal perforations in 8 patients (16.0%), ileal perforations in 7 patients (14.0%), and colonic perforations in 4 patients (8.0%). Rare sites included gallbladder perforation (1 patient, 2.0%, female) and jejunal perforation (1 patient, 2.0%, male).

More than half of the study population (26 patients, 52.0%) presented with an MPI score of ≤ 15. Seventeen patients (34.0%) had scores between 16 and 27, while 7 patients (14.0%) recorded severe MPI scores of ≥ 27. All patients with appendicular perforations (11 patients, 100.0% within that subgroup) presented with an MPI score of ≤ 15. Conversely, all patients with colonic perforations (4 patients, 100.0% within that subgroup) presented with an MPI score of ≥ 27. For the APACHE II system, 17 patients (34.0%) had an initial score of ≤ 5, 26 patients (52.0%) recorded scores between 6 and 15, and 7 patients (14.0%) presented with scores of ≥ 16. Colonic perforations were predominantly associated with higher APACHE II scores, with 3 of 4 patients (75.0%) recording a score of ≥ 16. The distribution of anatomical perforation sites categorized by MPI and APACHE II severity strata is presented in **Table 4**.

Table 4: Distribution of Cases by Site of Perforation Across Mannheim Peritonitis Index (MPI) and APACHE II Risk Categories

Site of Perforation	MPI ≤ 15 (n, %)	MPI 16–26 (n, %)	MPI ≥ 27 (n, %)	APACHE II ≤ 5 (n, %)	APACHE II 6–15 (n, %)	APACHE II ≥ 16 (n, %)
Gastric	8 (44.4%)	9 (50.0%)	1 (5.6%)	5 (27.8%)	11 (61.1%)	2 (11.1%)
Appendicular	11 (100.0%)	0 (0.0%)	0 (0.0%)	7 (63.6%)	4 (36.4%)	0 (0.0%)
Duodenal	5 (62.5%)	3 (37.5%)	0 (0.0%)	2 (25.0%)	5 (62.5%)	1 (12.5%)
Ileal	1 (14.3%)	4 (57.1%)	2 (28.6%)	1 (14.3%)	5 (71.4%)	1 (14.3%)
Colonic	0 (0.0%)	0 (0.0%)	4 (100.0%)	0 (0.0%)	1 (25.0%)	3 (75.0%)
Gallbladder	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)
Jejunal	0 (0.0%)	1 (100.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)
Total Cohort	26 (52.0%)	17 (34.0%)	7 (14.0%)	17 (34.0%)	26 (52.0%)	7 (14.0%)

Data are presented as absolute frequencies (n) and row percentages (%). Abbreviations: MPI, Mannheim Peritonitis Index; APACHE II, Acute Physiology and Chronic Health Evaluation II; n, number of cases; %, percentage.

The overall in-hospital mortality rate for the entire study cohort was 18.0% (9 deaths out of 50 patients). Based on the MPI scoring system, no deaths occurred in patients with a score of ≤ 15 (0 deaths out of 26 patients, 0.0% mortality in this category). Among patients with an MPI score between 16 and 26, mortality occurred in 3 of 17 patients (17.6% category mortality), comprising 1 duodenal perforation (1 death out of 3 patients, 33.3%), 1 gastric perforation (1 death out of 9 patients, 11.1%), and 1 ileal perforation (1 death out of 4 patients, 25.0%). In the high-risk MPI ≥ 27 group, 6 of 7 patients died (85.7% category mortality), including 4 colonic perforations (4 deaths out of 4 patients, 100.0%), 1 gastric perforation (1 death out of 1 patient, 100.0%), and 1 ileal perforation (1 death out of 2 patients, 50.0%).

When analysed by the APACHE II scoring system, no deaths occurred in patients with a score of ≤ 5 (0 deaths out of 17 patients, 0.0% mortality in this category). In the APACHE II 6–15 score group, 2 deaths occurred among 26 patients (7.7% category mortality), consisting of 1 ileal perforation (1 death out of 5 patients, 20.0%) and 1 colonic perforation (1 death out of 1 patient, 100.0%). In patients with an APACHE II score of ≥ 16, mortality was 100.0% (7 deaths out of 7 patients), accounting for 2 gastric perforations (2 of 2 patients, 100.0%), 1 ileal perforation (1 of 1 patient, 100.0%), and 3 colonic perforations (3 of 3 patients, 100.0%). The site-specific distribution of non-survivors across both scoring systems is detailed in **Table 5**.

Table 5: Distribution of Non-Survivors Based on Site of Perforation Across MPI and APACHE II Risk Categories

Site of Perforation	MPI ≤ 15 Deaths (n, %)	MPI 16–26 Deaths (n, %)	MPI ≥ 27 Deaths (n, %)	APACHE II ≤ 5 Deaths (n, %)	APACHE II 6–15 Deaths (n, %)	APACHE II ≥ 16 Deaths (n, %)
Gastric	0 (0.0%)	1 (11.1%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
Duodenal	0 (0.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Ileal	0 (0.0%)	1 (25.0%)	1 (50.0%)	0 (0.0%)	1 (20.0%)	1 (100.0%)
Colonic	0 (0.0%)	0 (0.0%)	4 (100.0%)	0 (0.0%)	1 (100.0%)	3 (100.0%)
Appendicular	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Gallbladder	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Jejunal	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total non-survivors	0 (0.0%)	3 (17.6%)	6 (85.7%)	0 (0.0%)	2 (7.7%)	6 (85.7%)

Data are presented as number of deaths (n) and percentage mortality within each specific subgroup (%). Abbreviations: MPI, Mannheim Peritonitis Index; APACHE II, Acute Physiology and Chronic Health Evaluation II; n, number of deaths; %, percentage.

The diagnostic performance of the MPI and APACHE II systems in predicting 30-day mortality was evaluated using Receiver Operating Characteristic (ROC) curve analysis, as illustrated in **Figure 1**. At an optimal cutoff score of 21, the MPI yielded a sensitivity of 88.89% (8 of 9 non-survivors correctly identified), a specificity of 85.37% (35 of 41 survivors correctly identified), a positive predictive value (PPV) of 57.14% (8 deaths among 14 high-risk patients), a negative predictive value (NPV) of 97.22% (35 survivors among 36 low-risk patients), and an overall diagnostic accuracy of 86.00% (43 of 50 patients correctly classified). The Area Under the Curve (AUC) for the MPI was 0.946 (95% CI: 0.865–0.988; $p < 0.001$). Using an optimal cutoff score of 15, the APACHE II score demonstrated a sensitivity of 77.78% (7 of 9 non-survivors), a specificity of 97.56% (40 of 41 survivors), a PPV of 87.50% (7 deaths among 8 high-risk patients), an NPV of 95.24% (40 survivors among 42 low-risk patients), and an overall diagnostic accuracy of 94.00% (47 of 50 patients correctly classified). The AUC for the APACHE II system was 0.955 (95% CI: 0.880–0.991; $p < 0.001$).

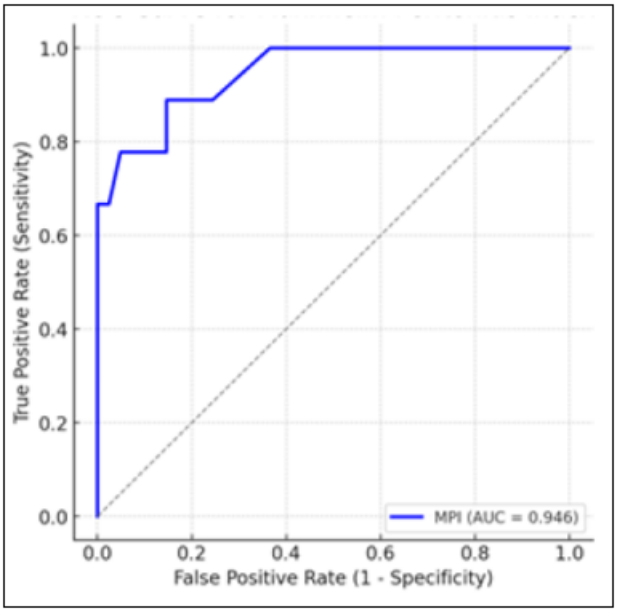

Figure 1: Receiver Operating Characteristic (ROC) Curves for Mortality Prediction Using the Mannheim Peritonitis Index (MPI) and APACHE II Scoring Systems

ROC, Receiver Operating Characteristic; MPI, Mannheim Peritonitis Index; APACHE II, Acute Physiology and Chronic Health Evaluation II; AUC, Area Under the Curve; CI, Confidence Interval. The ROC curve for APACHE II (AUC = 0.955) and MPI (AUC = 0.946) demonstrates excellent discriminative ability for predicting in-hospital mortality compared to the diagonal reference chance line (AUC = 0.500).

Postoperative morbidity was analysed using the established optimal ROC cutoff thresholds for both the MPI (≥ 21) and APACHE II (≥ 15) scoring systems. Overall postoperative complications occurred in 13 of the 50 study patients (26.0%). Patients with an MPI score of ≥ 21 experienced significantly higher rates of wound infection compared to those with an MPI of < 21 (9 of 14 patients, 64.3% vs. 1 of 36 patients, 2.8%; $p < 0.001$). Wound dehiscence occurred in 6 of 14 patients (42.9%) in the MPI ≥ 21 group compared to 1 of 36 patients (2.8%) in the < 21 group ($p = 0.001$). Re-operation was required in 3 of 14 patients (21.4%) with an MPI ≥ 21, whereas no re-operations (0 of 36 patients, 0.0%) were recorded in the < 21 group ($p = 0.019$). Anastomotic leak was noted in 2 of 14 patients (14.3%) in the ≥ 21 group and 0 of 36 patients (0.0%) in the < 21 group ($p = 0.074$).

When evaluated by APACHE II risk categories, wound infection was present in 7 of 8 patients (87.5%) with a score of ≥ 15, compared to 3 of 42 patients (7.1%) scoring < 15 ($p < 0.001$). Wound dehiscence occurred in 7 of 8 patients (87.5%) in the APACHE II ≥ 15 group and was absent (0 of 42 patients, 0.0%) in the < 15 group ($p < 0.001$). Re-operation rates were 1 of 8 patients (12.5%) in the ≥ 15 group and 2 of 42 patients (4.8%) in the < 15 group ($p = 0.414$). Anastomotic leak occurred in 1 of 8 patients (12.5%) in the ≥ 15 group and 1 of 42 patients (2.4%) in the < 15 group ($p = 0.297$). The comparative diagnostic performance of both scoring systems in predicting major postoperative complications is summarized in **Table 6**.

Table 6: Comparative Diagnostic Performance of Mannheim Peritonitis Index (MPI) and APACHE II in Predicting Postoperative Morbidity

Morbidity Parameter	MPI ≥ 21 (n, %)	MPI < 21 (n, %)	MPI p-value	APACHE II ≥ 15 (n, %)	APACHE II < 15 (n, %)	APACHE II p-value
Wound infection	9 (64.3%)	1 (2.8%)	< 0.001	7 (87.5%)	3 (7.1%)	< 0.001
Wound dehiscence	6 (42.9%)	1 (2.8%)	0.001	7 (87.5%)	0 (0.0%)	< 0.001
Re-operation	3 (21.4%)	0 (0.0%)	0.019	1 (12.5%)	2 (4.8%)	0.414
Anastomotic leak	2 (14.3%)	0 (0.0%)	0.074	1 (12.5%)	1 (2.4%)	0.297

Data are presented as absolute number of patients (n) and percentage incidence within each scoring tier (%). Abbreviations: MPI, Mannheim Peritonitis Index; APACHE II, Acute Physiology and Chronic Health Evaluation II; n, number of cases; %, percentage; p-value, probability value evaluating statistical significance using Pearson's Chi-square or Fisher's exact test (p < 0.05 considered significant).

4. Discussion

This prospective observational study evaluated the prognostic and diagnostic utility of the Mannheim Peritonitis Index (MPI) and APACHE II scoring systems in 50 patients presenting with perforation peritonitis. The study population demonstrated a clear male predominance (38 males, 76.0%; 12 females, 24.0%) and a mean age of 43.14 ± 12.83 years, with the 46–55 years bracket representing the largest demographic subgroup (18 patients, 36.0%). Gastric perforation was the most frequent anatomical site (18 patients, 36.0%), followed by appendicular (11 patients, 22.0%), duodenal (8 patients, 16.0%), and ileal perforations (7 patients, 14.0%). Both scoring systems proved highly effective in prognosticating 30-day mortality and major postoperative morbidity. While the APACHE II score (at an optimal ROC cutoff of 15) achieved a slightly higher overall diagnostic accuracy (47 of 50 patients, 94.00% vs. 43 of 50 patients, 86.00%), positive predictive value (7 of 8 patients, 87.50% vs. 8 of 14 patients, 57.14%), and Area Under the Curve (0.955 vs. 0.946), the MPI (at a cutoff of 21) demonstrated superior sensitivity (8 of 9 non-survivors, 88.89% vs. 7 of 9 non-survivors, 77.78%) and an exceptional negative predictive value (35 of 36 survivors, 97.22%). Crucially, both scores exhibited a 0.0% mortality rate within their low-risk strata (0 deaths among 26 patients with MPI ≤ 15, and 0 deaths among 17 patients with APACHE II ≤ 5), confirming their reliability as clinical exclusion tools for fatal outcomes.

Mannheim Peritonitis Index (MPI)

Our study confirms the high discriminative capacity of the Mannheim Peritonitis Index (AUC = 0.946; accuracy = 86.00%, 43 of 50 patients correctly classified). The observed 0.0% mortality in patients with an MPI < 15 (0 of 26 patients) mirrors the landmark findings of Billing et al. (mortality 2.3% for MPI < 21) [17], Malik et al. (mortality 0.0% for MPI < 15) [18], and Bosscha et al. [19]. A structured comparison of our MPI results against published literature is presented in **Table 7**.

Table 7: Comparison of Mannheim Peritonitis Index (MPI) Predictive Performance with Published Literature

Study / Author	Sample Size (N)	Cutoff	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy / AUC
Billing et al. [17]	2,003	26	86.00%	74.00%	—	—	Accuracy: 83.0%
Wacha & Linder [14]	1,253	26	88.00%	87.00%	90.00%	90.00%	—
Kumar et al. [16]	50	25	100.00%	91.00%	69.00%	100.00%	Accuracy: 69.0%
Madake et al. [20]	65	21	—	—	—	—	Accuracy: 89.2%; AUC: 0.989
Singh & Naniwadekar [21]	300	Tiered	—	—	—	—	AUC: 0.840
Malik et al. [18]	101	25	—	—	—	—	< 15 mortality 0.0%; > 25 mortality 82.3%
Present Study	50	21	88.89%	85.37%	57.14%	97.22%	Accuracy: 86.00%; AUC: 0.946

Abbreviations: N, Total sample size; PPV, Positive Predictive Value; NPV, Negative Predictive Value; AUC, Area Under the Curve; %, percentage; —, data not explicitly reported in original publication.

Furthermore, our optimal ROC cutoff of 21 achieved a sensitivity of 88.89% (8 of 9 non-survivors) and an NPV of 97.22% (35 of 36 survivors), reinforcing MPI as a highly dependable screening tool to rule out fatal perioperative outcomes. The lower PPV (57.14%, 8 deaths among 14 patients) observed in our cohort compared to early European series (such as Wacha & Linder, PPV 90.0%) is a well-documented statistical consequence of disease prevalence and modern resuscitation protocols: while high-risk patients (MPI ≥ 21) suffer intense intra-abdominal sepsis, advances in broad-spectrum antimicrobial therapy, damage-control surgery, and intensive care allow a significant fraction of high-score patients to survive, thereby diluting the PPV without compromising overall accuracy (86.00%) [14,22]. Moreover, our findings demonstrate that MPI is a powerful predictor of postoperative morbidity: patients scoring ≥ 21 had a 71.4% (10 of 14 patients) major morbidity rate—exhibiting statistically significant increases in wound infection (9 of 14 patients, 64.3%; p < 0.001), wound dehiscence (6 of 14 patients, 42.9%; p = 0.001), and re-operation rates (3 of 14 patients, 21.4%; p = 0.019). This is biologically explained by MPI's direct incorporation of peritoneal exudate character (purulent or fecal) and diffuse sepsis, which directly dictate incision line contamination and fascial failure [23,24].

APACHE II Scoring System

The APACHE II scoring system demonstrated outstanding diagnostic precision in our study, achieving an AUC of 0.955, an overall accuracy of 94.00% (47 of 50 patients), and a high specificity of 97.56% (40 of 41 survivors) at an optimal cutoff of 15. These figures closely mirror the prospective Indian cohorts of Kumar et al. (specificity 100.0%, accuracy 83.33%) [16], Madake et al. (AUC = 0.955, accuracy 89.10%)

[20], and Jhobta et al. [3]. A comparative summary of APACHE II performance across studies is shown in **Table 8**.

Table 8: Comparison of APACHE II Predictive Performance with Published Literature

Study / Author	Sample Size (N)	Cutoff Evaluated	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy / AUC
Knaus et al. [13]	5,815	Varied	—	—	—	—	High calibration across ICU admissions
Kumar et al. [16]	50	10–20	85.00%	100.00%	100.00%	96.00%	Accuracy: 83.33%
Madake et al. [20]	65	11	—	—	—	—	Accuracy: 89.10%; AUC: 0.955
Singh & Naniwadekar [21]	300	Tiered	—	—	—	—	AUC: 0.870; High-risk mortality 55.0%
Malik et al. [18]	101	> 20	—	—	—	—	< 10 mortality 0.0%; > 20 mortality 91.7%
Present Study	50	15	77.78%	97.56%	87.50%	95.24%	Accuracy: 94.00%; AUC: 0.955

Abbreviations: N, Total sample size; PPV, Positive Predictive Value; NPV, Negative Predictive Value; AUC, Area Under the Curve; ICU, Intensive Care Unit; %, percentage; —, data not explicitly reported in original publication.

The high PPV (87.50%, 7 deaths among 8 high-risk patients) and specificity (97.56%) of APACHE II confirm that severe physiological derangement—as measured by vital signs, arterial oxygenation, electrolyte imbalances, and renal function—is the primary driver of mortality in peritonitis [25]. Patients with an APACHE II score ≥ 16 experienced 100.0% mortality across gastric (2 of 2 patients), ileal (1 of 1 patient), and colonic (3 of 3 patients) perforation subsets, reinforcing that multi-organ dysfunction syndrome (MODS) overcomes even aggressive surgical source control [26,27]. Additionally, patients scoring ≥ 15 had an 87.5% (7 of 8 patients) major morbidity rate, with wound infection and dehiscence occurring in 87.5% (7 of 8 patients) of cases ($p < 0.001$). This reflects the profound tissue hypoperfusion, catabolism, and immune paralysis accompanying high APACHE II physiological distress [28].

5. Study Limitations

This study has several important limitations that warrant consideration when interpreting the findings. First, as a single-center study conducted at a tertiary care public teaching hospital with a relatively modest sample size of 50 patients, the external generalizability of the results to lower-tier healthcare facilities and larger regional populations may be limited. This is particularly relevant within smaller anatomical sub-cohorts, such as colonic (4 patients, 8.0%) or hepatobiliary perforations (1 patient, 2.0%), where statistical power for subgroup comparison is constrained.

Second, the strictly defined inclusion criteria evaluated only secondary peritonitis resulting from hollow viscus perforations—excluding traumatic, primary, and tertiary etiologies—thereby restricting the direct extrapolation of these prognostic thresholds across all intra-abdominal sepsis presentations.

Third, outcome assessment was confined to the immediate 30-day post-operative hospital stay, leaving long-term survival, delayed adhesive bowel obstruction, and late incisional hernia rates unassessed.

Fourth, while the APACHE II scoring system demonstrated superior overall diagnostic accuracy (94.00%), its dependency on comprehensive laboratory parameters and arterial blood gas analyses may constrain its immediate feasibility in resource-limited emergency settings compared to the simpler, intraoperatively derived MPI.

Finally, the inherent subjective grading of intraoperative MPI components, such as the exact physical quality of peritoneal exudate and the anatomical extent of peritonitis, introduces a potential risk of inter-observer variability among surgical teams. Multicenter prospective cohorts with larger sample sizes are necessary to externally validate these cutoff thresholds.

6. Conclusions

Both the Mannheim Peritonitis Index (MPI) and the Acute Physiology and Chronic Health Evaluation II (APACHE II) scoring systems demonstrate excellent predictive accuracy for 30-day mortality and major postoperative morbidity in patients presenting with secondary peritonitis due to hollow viscus perforation. The MPI serves as a simple, rapid, and highly sensitive intraoperative risk-stratification tool, making it exceptionally effective for mortality exclusion and clinical decision-making in emergency and resource-constrained settings. Conversely, the APACHE II scoring system provides a comprehensive evaluation of acute systemic physiological derangement, offering superior overall accuracy, specificity, and positive predictive value for fatal outcomes and postoperative complications. The clinical selection between these two tools should be guided by institutional infrastructure: MPI is recommended for rapid intraoperative triage, whereas APACHE II is highly valuable in critical care environments where intensive physiological monitoring and laboratory resources are readily available.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

- **Acquisition, analysis, or interpretation of data:** Ganesh T A, Manik Gedam
- **Drafting of the manuscript:** Ganesh T A
- **Critical review of the manuscript for important intellectual content:** Manik Gedam
- **Supervision:** Manik Gedam.

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. The study protocol and synopsis were reviewed and approved by the Board of Research Studies (BORS) and the Institutional Ethics Committee at Indira Gandhi

Government Medical College, Nagpur, and the Maharashtra University of Health Sciences (MUHS/Medical/MUHS-060603/2019, dated May 21, 2024).

Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work.

Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

[1] Runyon BA: Management of adult patients with ascites due to cirrhosis: an update. Hepatology. 2009, 49:2087-2107. 10.1002/hep.22853
[2] Sartelli M, Chichom-Mefire A, Labricciosa FM, et al.: The management of intra-abdominal infections from a global perspective: 2017 WSES guidelines for management of intra-abdominal infections. World J Emerg Surg. 2017, 12:29. 10.1186/s13017-017-0141-6
[3] Jhobta RS, Attri AK, Kaushik R, Sharma R, Jhobta A: Spectrum of perforation peritonitis in India--review of 504 consecutive cases. World J Surg. 2006, 30:2253-2258. 10.1186/1749-7922-1-26
[4] Marshall JC: Intra-abdominal infections. Microbes Infect. 2004, 6:1015-1025. 10.1016/j.micinf.2004.05.017
[5] Nathens AB, Rotstein OD, Marshall JC: Tertiary peritonitis: clinical features of a complex nosocomial infection. World J Surg. 1998, 22:158-163. 10.1007/s002689900364
[6] Weiser TG, Haynes AB, Molina G, et al.: Estimate of the global volume of surgery in 2012: an assessment supporting improved health outcomes. Lancet. 2015, 385:11. 10.1016/S0140-6736(15)60806-6
[7] Bohnen JM, Mustard RA, Oxley AB, Schouten BD: APACHE II score and abdominal infection. A prospective study. Arch Surg. 1988, 123:225-229. 10.1001/archsurg.1988.01400260113014
[8] Gauzit R, Pean Y, Barth X, et al.: Epidemiology, management, and prognosis of secondary non-postoperative peritonitis: a French prospective observational multicenter study. Surg Infect (Larchmt. 2009, 10:119-127. 10.1089/sur.2007.092
[9] Evans L, Rhodes A, Alhazzani W, et al.: Surviving sepsis campaign: international guidelines for management of sepsis and septic shock. 20212021, 49:1063-1143. 10.1097/CCM.0000000000005337.
[10] Schein M: Surgical management of intra-abdominal infection: is there any evidence?. Langenbecks Arch Surg. 2002, 387:1-7. 10.1007/s00423-002-0276-z
[11] Anaya DA, Nathens AB: Risk factors for severe sepsis in secondary peritonitis. Surg Infect (Larchmt. 2003, 4:355-362. 10.1089/109629603322761418
[12] Qureshi AM, Zafar A, Saeed K, Quddus SC: Predictive power of Mannheim Peritonitis Index. J Coll Physicians Surg Pak. 2005, 15:693-696.
[13] Knaus WA, Draper EA, Wagner DP, Zimmerman JE: APACHE II: a severity of disease classification system. Crit Care Med. 1985, 13:818-829. 10.1097/00003246-198510000-00009
[14] Linder MM, Wacha H, Feldmann U, Wesch G, Streifensand RA, Gundlach E: Der Mannheimer Peritonitis-Index: Ein Instrument zur intraoperativen Prognose der Peritonitis (The Mannheim peritonitis index. An instrument for the intraoperative prognosis of peritonitis). Chirurg. 1987, 58:84-92.
[15] Copeland GP, Jones D, Walters M: POSSUM: a scoring system for surgical audit. Br J Surg. 1991, 78:355-360. 10.1002/bjs.1800780327
[16] Kumar P, Singh K, Kumar: A: A comparative study between Mannheim peritonitis index and APACHE II inpredicting the outcome in patients of peritonitis due to hollow viscous perforation. Int Surg J. 2017, 4:690-696. 10.18203/2349-2902.isj20170215
[17] Billing A, Fröhlich D, Schildberg FW: Prediction of outcome using the Mannheim peritonitis index in 2003 patients. Peritonitis Study Group. Br J Surg. 1994, 81:209-213. 10.1002/bjs.1800810217
[18] Malik AA, Wani KA, Dar LA, et al.: Mannheim Peritonitis Index and APACHE II: prediction of outcome in. patients with peritonitis. Ulus Travma Acil Cerrahi Derg. 2010, 16:27-32.
[19] Bosscha K, Reijnders K, Hulstaert PF, Algra A, van der Werken C: Prognostic scoring systems to predict outcome in peritonitis and intra-abdominal sepsis. Br J Surg. 1997, 84:1532-1534. 10.1111/j.1365-2168.1997.02809.x
[20] Madake PM, Barnwal AA, Gangadhar AC, Sankpal S, Sankpal T: A comparative observational study between APACHE II scoring system and Mannheim Peritonitis Index in perforation peritonitis. Int J Sci Res. 2024, 13:1204-1208.
[21] Singh SR, Naniwadekar RG: Evaluation of Mannheim Peritonitis Index and APACHE II score in predicting mortality and morbidity in patients with peritonitis from hollow viscus perforation. Front Health Inform. 2024, 13:6225-6238.
[22] Notash AY, Salimi J, Rahimian H, Fesharaki MH, Abbasi A: Evaluation of Mannheim peritonitis index and multiple organ failure score in patients with peritonitis. Indian J Gastroenterol. 2005, 24:197-200.
[23] Demmel N, Maag K, Osterholzer G: The value of clinical parameters for determining the prognosis of peritonitis--validation of the Mannheim Peritonitis Index. Langenbecks Arch Chir. 1994, 379:152-158.
[24] Biondo S, Ramos E, Fraccalvieri D: Circle J, Ragué JM, Jaurrieta E: Comparative study of left colonic Peritonitis Severity Score and Mannheim Peritonitis Index. Br J Surg. 2006, 93:616-622. 10.1002/bjs.5326

[25] Ohmann C, Wittmann DH, Wacha H: Prospective evaluation of prognostic scoring systems in peritonitis. Peritonitis Study Group. Eur J Surg. 1993, 159:267-274.
[26] Dellinger RP, Levy MM, Rhodes A, et al.: Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock, 2012. Intensive Care Med. 2013, 39:165-228. 10.1007/s00134-012-2769-8
[27] Ramesh, A. G., & Ramesh, K. S. (2018: A prospective study of Mannheim peritonitis index as a prognostic scale in analysis of outcome in hollow viscus perforation. International Surgery Journal. 5:1306-1309. 10.18203/2349-2902.isj20180991
[28] Sartelli M, Abu-Zidan FM, Catena F, et al.: Global validation of the WSES Sepsis Severity Score for patients with complicated intra-abdominal infections: a prospective multicentre study (WISS Study). World J EmergSurg. 2015, 10:33. 10.1186/s13017-015-0055-0