Efficacy of the Mannheim Peritonitis Index in Predicting the Prognosis of Small Intestinal Perforation: A Retrospective Study

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Summary

Background: A common emergency faced by surgeons is that of small bowel perforation. Despite advancements in medicine, perforation peritonitis still carries a mortality rate of about 10%. The Mannheim Peritonitis Index (MPI) is a tool developed to help prognosticate patients on arrival and direct timely intervention. Most of the studies done previously included all the causes for peritonitis in general. Our hypothesis was that MPI can help grade patients with small intestinal perforation, and based on this scoring, appropriate intensive care can be given early in the course of admission. This would reduce the morbidity and mortality. **Methods:** In this retrospective, observational study, details regarding 105 patients including their history, examination, and intra-operative findings, laboratory data, and outcomes were collected. Their MPI score was correlated with the outcomes to identify significant prognosticating factors for poor outcomes. **Results:** In our study, an MPI score of 29 could predict mortality with a sensitivity of 63% and a specificity of 65% and morbidity with a sensitivity of 48.57% and a specificity of 77%. **Conclusion:** MPI is a simple and fairly accurate tool in predicting morbidity and mortality among patients with small intestinal perforations.

Keywords: Perforation, Peritonitis, Mannheim Peritonitis Index

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Introduction

A common emergency faced by surgeons is that of bowel perforation, more specifically, that of the small bowel. A perforation of the bowel results in the violation of a closed gastrointestinal system and exposure of the intraperitoneal structures to the intestinal contents. Depending upon the anatomic site of perforation, the time taken for peritonitis to set in, and the extent (whether generalized or localized), the overall prognosis can vary. Biliary or chemical peritonitis secondary to duodenal perforation develops more insidiously, whereas peritonitis secondary to jejunal or ileal perforation is more rapid in its evolution, primarily due to the degree of contamination and the presence of fecal contents in the peritoneum. Some of the most dreaded complications of perforation peritonitis include sepsis and subsequent shock, multiorgan dysfunction syndrome, and death. Despite tremendous evolution seen in the understanding of the pathology, diagnostic modalities, antibiotic availability, treatment options, and resources available, peritonitis that is diffuse in nature is associated with a 10% risk of mortality.

In addition to subjective examination cues, several prognostication tools and scoring systems have been developed in order to make this process more objective. From the outset, by taking heed of patients at risk of having poorer outcomes, a more aggressive line of management and closer monitoring protocol may be initiated, and may lead to better outcomes. The Sequential Organ Failure Assessment (SOFA) score, Acute Physiology and Chronic Health Evaluation (APACHE) II score, Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM), Physiologic Indicators for Prognosis in Abdominal Sepsis (PIPAS) severity score, Calgary Predisposition, Infection, Response, and Organ Dysfunction (CPIRO), World Society of Emergency Surgery Sepsis Severity Score (WSESSSS) are a few scores that are commonly used in prognosticating patients with sepsis. Out of these, SOFA and APACHE II scores are used for sepsis patients in general and do not have variables specific for intra-abdominal sepsis or intraoperative contamination. The POSSUM score is used for predicting morbidity and mortality of patients undergoing general surgery and not specific to peritonitis. Both PIPAS and CPIRO scores are used for peritonitis patients; however, they do not have variables for type of peritonitis and intraoperative contamination. The WSESSSS is used to prognosticate patients with complicated intra-abdominal sepsis. Hence, we chose the Mannheim Peritonitis Index (MPI), which is used specifically for intra-abdominal sepsis and has parameters for organ dysfunction. The MPI was devised by Wacha and Linder in 1987 (Table 1). They assessed factors such as age, gender, organ dysfunction, and intraoperative contamination, among others and devised an index consisting of eight variables to predict mortality in patients with perforation peritonitis. They included cases of small and large intestinal perforations, gastric and duodenal perforations, gall bladder perforations, and even perforations of the female genital tract, while creating the MPI, and measured the outcome in terms of mortality. However, the MPI has not been studied for its utility in predicting mortality along with morbidity, specifically for small bowel perforations. Most of the studies done previously included all the causes for peritonitis in general. In our study, we have focused on only small intestinal perforations. Our hypothesis was that MPI can help grade patients with small intestinal perforations, and based on this scoring, appropriate intensive care can be given early in the course of admission. This would reduce the morbidity and mortality.

Materials and Methods

This was a single-center, retrospective study conducted in the Department of General Surgery and Surgical Oncology at a teaching hospital of a developing country. A total of 105 cases between February 2012 and September 2020 were included retrospectively after obtaining institutional ethics committee approval. Sample size was not calculated and patients were included as per the data collection period (February 2012–September 2020).

Table 1. Mannheim Peritonitis Index

Variable	Score
Age >50 years	5
Female gender	5
Organ failure[a]	7
Malignancy	4
Pre-operative duration of peritonitis >24 hours	4
Origin of sepsis—non-colonic	4
Diffuse generalized peritonitis	6
Exudates	
Clear	0
Purulent	6
Fecal	12

[a]Kidney failure = creatinine level >177 μmol/L or urea level >167 mmol/L or oliguria 20 mL/hour; pulmonary insufficiency = pO_2 <50 mmHg or pCO_2 >50 mmHg; intestinal obstruction/paralysis >24 hours or complete mechanical ileus; shock: systolic blood pressure <90 mmHg or mean arterial pressure <60 mmHg.

All patients aged >18 years who were diagnosed to have small bowel perforation peritonitis and underwent surgery for the same were included in the study. Cases

of perforation involving any site other than the jejunum and ileum and those not undergoing surgical management were excluded. Those with missing data points were excluded.

Pre-operative, intraoperative, and post-operative details were collected from laboratory data, patient files, discharge summaries, and operative notes.

The MPI score was calculated as per the scoring given in Table 1. Other details of history (comorbidities) and routinely done pre-operative investigations (serum sodium, potassium, albumin, C-reactive protein, total leukocyte counts, pH of arterial blood gas) were noted.

The following post-operative complications were assessed: surgical site infections (SSIs), anastomotic leaks, intra-abdominal collections, post-operative fever, sepsis, and those that required re-exploration. Patients who did not develop any of the aforementioned complications were considered as having "uneventful" outcomes. Mortality was defined as a "30-day mortality."

Table 2. Key variables and their association with morbidity and mortality

Variable	Morbidity	No morbidity	*p* value	Mortality	No mortality	*p* value
Age >50 years	25	11	0.788	12	24	**0.052**
Female gender	14	4	0.411	4	14	0.737
Site of perforation—non-colonic	70	35	**0.016**	29	86	0.619
Diffuse peritonitis	56	31	0.411	14	73	0.311
Nature of exudates						
Clear	20	19	**0.018**	14	73	**0.008**
Purulent	13	5	0.785	2	37	0.737
Fecal	37	11	**0.041**	4	14	**0.041**
Mean MPI score	28	23.2	**0.012**	30.3	25.5	**0.037**
Organ failure						
Renal failure	15	5	0.44	6	14	0.192
Pulmonary insufficiency	6	6	0.208	3	9	0.452
Intestinal obstruction	33	13	**0.092**	10	36	0.306
Shock	22	3	**0.014**	10	15	**0.002**

MPI, Mannheim Peritonitis Index.

Foot note : Values in bold denote statistical significance

Data were entered in Microsoft Excel and then analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Data are represented as mean and standard deviation for continuous variables and as percentages for categorical variables. An unpaired t-test was done to compare the means of two groups. A chi-square test or Fisher's exact test was done to find out the association between categorical variables. A receiver operating characteristic analysis along with the Youden Index was used to estimate the cut-off and predictive accuracy.

Predictive accuracy was measured in terms of sensitivity, specificity, positive predictive value, negative predictive value, and accuracy. A *p* value of <0.05 was considered significant.

Ethical considerations

Institutional ethical committee approval was obtained for the study (IEC: 699/2020).

Results

A total of 105 patients were included in the study. Twenty-five patients had uneventful recoveries, and 61 patients had complications. Nineteen patients had mortality outcomes, of which 10 patients suffered from

complications related to the perforation and abdominal sepsis, while 9 died of other causes such as myocardial infarction and pneumonia.

The mean age of the patients was 42.9 years. A majority of the population were in the 21–40-year age group, and the highest mortality rate was seen among those in the age group of 51–70 years. There were 18 (17.1%) female patients and 87 (82.9%) male patients. Both morbidity and mortality were noted to be higher among women. The most common cause of perforation was blunt abdominal trauma. Other causes included idiopathic, typhoid, mesenteric ischemia, tuberculosis, iatrogenic, penetrating trauma, strangulated hernia, and intussusception. All patients underwent a laparotomy. A majority of the patients underwent a resection and anastomosis. The second most common procedure was primary repair. Eight patients underwent resection—anastomosis with covering stoma. In two patients, the procedure was abandoned in view of superior mesenteric artery thrombosis and extensive bowel gangrene. Three patients underwent a lavage and ileostomy, and one patient underwent a primary repair and stoma. The maximum number of perforations involved the ileum.

Table 3. ROC analysis of MPI with a cut-off value of >29

	AUC	Sensitivity	Specificity	Accuracy
MPI and morbidity	0.653	48.57	77.14	58.1
MPI and mortality	0.651	63.19	65.12	64.76

AUC, area under the curve; MPI, Mannheim Peritonitis Index; ROC, receiver operating characteristic.

The mean MPI score among the study population was 26.371. Those with morbidity had a mean MPI score of 28, and those without morbidity had a mean MPI score of 23.2. This was found to be statistically significant with a *p* value of 0.012 (Table 2). Similarly, the mean MPI scores were 30.3 and 25.5, among those who had mortal outcomes and those who did not, respectively, which was found to be significant with a *p* value of 0.037. Thus, the MPI score at a cut-off of 29 could predict morbidity with a sensitivity of 48.57% and a specificity of 77.14% and mortality with a sensitivity of 63.16% and a specificity of 65.12% (Table 3). The area under the curve (AUC) of MPI in predicting morbidity was 0.653 (Figure 1).

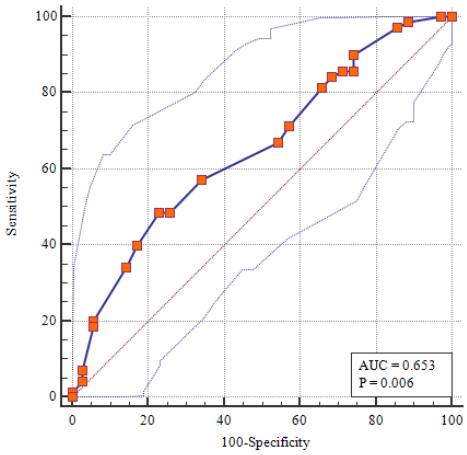

Figure 1. ROC curve of MPI in predicting morbidity. AUC, area under the curve; MPI, Mannheim Peritonitis Index; ROC, receiver operating characteristic.

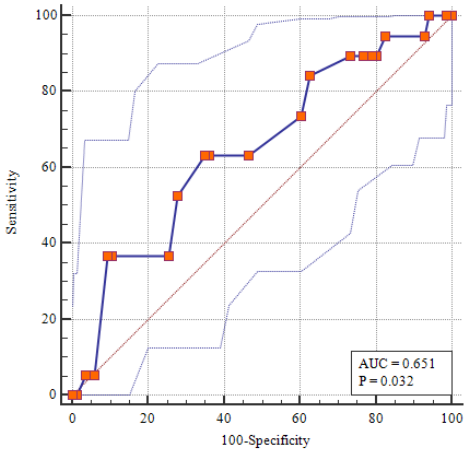

Figure 2. ROC curve of MPI in predicting mortality. AUC, area under the curve; MPI, Mannheim Peritonitis Index; ROC, receiver operating characteristic.

Similarly, the AUC of MPI in predicting mortality was 0.651 (Figure 2). A statistically significant higher morbidity and mortality rate was noted in patients who were in hemodynamic shock at the time of presentation, with *p* values of 0.014 and 0.002, respectively (Table 2). Ninety patients had a duration of >24 hours between the

onset of symptoms and surgery, and 87 patients had features of diffuse peritonitis. Malignancy was noted in five patients. Based on intraoperative findings regarding the nature of exudate found in the peritoneal cavity, clear exudates were noted to be predictors of lower morbidity and mortality, whereas fecal exudates were noted to be significant risk factors for poorer outcomes. The most common post-operative complication was SSI followed by sepsis (44%). Of the 19 mortalities that we had, 12 had an MPI score of >29. Of the 19 patients who died, 9 had *Escherichia coli* sepsis and 5 had blood or peritoneal fluid cultures positive for *Klebsiella*. Other organisms that were implicated in sepsis were Enterobacteriaceae, *Proteus*, and *Candida*. Ten patients had anastomotic leaks, of which nine underwent re-exploration, and one had an ultrasound-guided pigtail catheter placed. Other complications included post-operative fever, pneumonia, and intra-abdominal collections.

Discussion

The mean age of our study population was 42.9 years, which was similar to the study done by Arif et al. (1). There was a male preponderance in our study (82.9%), which was similar to a study conducted by Karki et al. (2). The most common cause for peritonitis in our study was blunt abdominal trauma. This is in contrast to the study done by Tobome et al. where idiopathic ileal perforation was the commonest cause (3). The reason could be that as ours is a tertiary care referral hospital, most of the uncomplicated peritonitis cases would be managed at primary or secondary care hospitals and only complicated cases such as those with trauma might be referred. The most common post-operative complication noted in our study was SSI (44%). This percentage was more than the SSI rate (22.9%) in a study conducted by Sreedath and Rajesh (4). The difference in the outcome is probably due to the fact that in our study only small bowel perforations were studied compared to the study done by Sreedath and Rajesh, where all causes were included. In their study, perforated appendicitis and stomach and duodenal perforations were the most common causes. The mortality rate in our study was 18.5%, which is similar to the mortality rate (16%) reported in the study conducted by Urval and Desai and the mortality rate (14%) in the study conducted by Sharma et al. (5, 6). Eighty-five percent of our patients presented after 24 hours of the onset of symptoms, which is similar to the articles published by Yadav et al., Rongpi et al., and Singh et al. who reported 87%, 90%, and 91% of their patients presenting after 24 hours (7-9). In the studies conducted by Sharma et al. and Neri et al., 68% and 14% of their patients presented after 24 hours (10, 11). This difference could be as these studies were conducted in populations where socioeconomic development was higher and these populations had better access to health care services. Most of our patients presented late as patients are referred from secondary and primary care hospitals. Though in other similar studies, when >24 hours had elapsed between the time of onset of symptoms and surgical intervention, the outcome was noted to be worse; in our study, owing to the fact that a vast majority of the patients presented late, such a conclusion could not be drawn. Organ failure was present in 50% of our patients, which was comparable to the studies done by Pathak et al. and Gueiros et al. (12, 13). However, a study done by Nachiappan and Litake had 22% of patients with organ failure. This could be explained by the fact that most of their cases had gastroduodenal perforations and presented early in the course of the disease (14). Malignancy was found in 5% of our study population, which was comparable to the studies done by Maheshwari et al., Ramteke et al., and Budzyński et al. (15-17). All of the perforations were non-colonic in nature as we included only small bowel perforations. However, this was comparable to a study conducted by Salamone et al., where approximately 75% of their cases were non-colonic perforations (18). In other studies conducted by Patil et al. and Pattanaik et al., most of their cases were non-colonic in origin (19, 20). Diffuse peritonitis was present in 83% of our patients comparable to the study done by Muralidhar et al. who reported a diffuse peritonitis rate of 90% (21). Forty-six percent of our patients had feculent exudate at laparotomy, which is higher as compared to the study done by Mohan et al., Chaudhari et al., and Bamrah et al., who reported that between 10% and 20% of their patients had feculent exudate (22-24). This can be explained by the fact that most of their cases had

gastroduodenal and appendicular perforations. In our study, the optimal cut-off value of MPI was found to be 29. This value could predict morbidity with a sensitivity of 48.57% and a specificity of 77.14%. For the same cut-off, mortality can be predicted with a sensitivity of 63.16% and a specificity of 65.12%. The AUC at this cut-off value was found to be 0.65 for both morbidity and mortality. This value indicates that MPI is a fairly good score at predicting morbidity and mortality. In the original study conducted by Linder et al., they reported a sensitivity and a specificity of 84% and 79%, respectively, with an accuracy of 81% for predicting mortality, at a cut-off of 26 (25). In another study conducted by Neri et al., the cut-off of MPI was found to be 21 with a sensitivity of 86% and a specificity of 59%. The discrepancy in these findings could be because of the fact that there were differences in the type of perforations commonly seen in their study, as these studies had more cases of appendicitis and gastroduodenal perforations. Discrepancy can also be because of differences in socioeconomic and geographical characteristics of the population. The cut-off value of MPI was found to be 29 in another study conducted by Karki et al., with a sensitivity of 95.6% and a specificity of 50%.

Conclusion

Based on the sensitivity and specificity values of MPI derived from our study, we can draw conclusion that MPI is a simple and fairly accurate tool in predicting morbidity and mortality among patients with small intestinal perforations. However, this conclusion can only be extrapolated to hospitals who have patients with similar characteristics as our patients. Further prospective studies are needed to evaluate these results.

Limitations of the study

As this was a retrospective study with a small sample size, further prospective studies are needed to evaluate the results. Most of our patients presented after 24 hours of symptoms compared to other studies.

Author Contributions

KRS, MU, and VK were involved in conceptualization of the study. SS was involved in collecting data and writing the manuscript. All authors contributed equally to reviewing and editing the original draft.

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