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# Modified APACHE II scoring and Mannheims peritonitis Index (MPI) in predicting the outcome of patients with peritonitis secondary to hollow viscous perforation

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**Abstract**
The prognosis and outcome of peritonitis depend upon the interaction of several factors, which includes` patient-related factors, disease-specific factors, diagnostic and therapeutic interventions. Categorizing patients into different risk groups would help prognosticate the outcome, select patients for intensive care and determine operative risk, thereby helping to choose the nature of the operative procedure, e.g. damage control vs. definitive procedure. Study population consisted of 80 consecutive patients with peritonitis secondary to hollow viscus perforation which were confirmed on emergency laparotomy. APACHE II score was assigned to all patients. Mean apache II scores in survivors were 7.5±5.3 and in non survivors 19.7±4.7. Of the 72 survivors, with mean of 7.5, 8 patients who died had a mean of 19.5, and again the difference between groups were significant ($p< 0.0001$).
Based on APACHE II scores patients were divided into 3 groups with scores of <10, 11-20 and >20. The number of patients scoring less than 10 was 71(88.8%) of the study group. One patient with less than a score of 10 expired. 5 patients had scores in range of 11-20, 2 survived and 3 expired. 4 patients had scores more than 20 and all 4 patients expired.

**Keywords:** Modified APACHE II scoring, Mannheims peritonitis Index (MPI), peritonitis secondary to hollow viscous perforation

## Introduction
Peritonitis presents most commonly due to the localized or generalized infection caused from various factors. Secondary peritonitis is the most common form that follows an intraperitoneal source usually from perforation of hollow viscera. Acute generalized peritonitis due to underlying hollow viscus perforation is a critical & life-threatening condition. It is a common surgical emergency in most of the general surgical units across the world. It is often associated with significant morbidity and mortality [1].
The multifaceted nature of abdominal surgical infections makes it difficult to precisely define the disease and to assess its severity and therapeutic progress. Both the anatomic source of infection and to a greater degree, the physiologic compromise it inflicts affects the outcome.
High-risk patients require timely and aggressive treatment especially in severe peritonitis. To select them reasonably well, evaluation through a prognostic scoring system is the approach of choice. Early prognostic evaluation is desirable so as to be able to select high-risk patients for more aggressive treatment especially in severe peritonitis [1].
The prognosis and outcome of peritonitis depend upon the interaction of several factors, which includes` patient-related factors, disease-specific factors, diagnostic and therapeutic interventions. Categorizing patients into different risk groups would help prognosticate the outcome, select patients for intensive care and determine operative risk, thereby helping to choose the nature of the operative procedure, e.g. damage control vs. definitive procedure [2].
Various scoring systems have been used to assess the prognosis and outcome of patients with peritonitis. Those used include the Acute Physiological and Chronic Health Evaluation score (APACHE II) (1985), the Mannheim Peritonitis Index (MPI) (1983), the Peritonitis Index Altona (PIA), The Sepsis Severity Score (1983), and the Physiological and Operative Severity Score for Enumeration of Mortality and Morbidity (POSSUM) [3].

The mortality of intra-abdominal infection is related mainly to the severity of the patient's systemic response and his premorbid physiologic reserves, estimated best using the Acute Physiology and Chronic Health Evaluation II (APACHE-II) scoring system [4].
The Mannheim peritonitis index (MPI) emerged as a reliable marker for assessing the severity and prognosis of intra-abdominal infection with sensitivity and specificity comparable to APACHE II score which has been adopted as the gold standard by Surgical Infection Society. This score was designed specifically for peritonitis and it combines preoperative and operative data and is easy to apply [3, 5].
Various authors have reported APACHE II to be a better system for prognostication of the outcome of patients with peritonitis, while others concluded that MPI provides a more reliable means of risk evaluation [2, 6].

**Methodology**
Study population consisted of 80 consecutive patients with peritonitis secondary to hollow viscus perforation which were confirmed on emergency laparotomy.
Diagnosis of peritonitis due to hollow viscus perforation was made by:

- History:
  Symptoms, onset of presenting illness and duration of illness noted.
- Patient details suggestive of chronic health disorders such as cardiac, respiratory, renal, liver failure and immunodeficiency disorders noted.

**Clinical examination**
Presence of guarding, rigidity, tenderness on palpation and obliteration of liver dullness of the abdomen were noted.

- Radiologically: air under diaphragm.
- At the time of admission:

1. Vital parameters noted:
   Heart rate, Blood pressure, Mean arterial pressure, Respirator rate, Temperature
2. Investigations

- Hematocrit
- Total WBC count
- Blood - urea
- Serum creatinine
- Serum Na+
- Serum K+
- $PaO_2$
- Arterial pH
- Chest x-ray
- Plain x-ray abdomen - erect
- Abdominal paracentesis
- Proforma filled.
- Intra operative findings noted

**Mannheim Peritonitis index (1983)**
The MPI analyzes 8 prognostically significant factors.

**APACHE II**
APACHE II scores were calculated as per the method of Knaus. Acute physiological and chronic health evaluation includes The Acute Physiological Score (APS), age points and chronic health score. APS is based upon 12 physiological variables.
Chronic Health Points: If the patient has a history of severe organ system insufficiency or is immunocompromised as defined below, assign points as follows:

a. for non-operative or emergency postoperative patients - 5 points
b. for elective postoperative patients - 2 points

**Statistical analysis**
APACHE II and MPI scores were tested by quantitative methods based on statistical criteria.
The following statistical tests were done to know the ability to predict outcome.

**Results**
APACHE II score was assigned to all patients. Mean apache II scores in survivors were 7.5±5.3 and in non survivors 19.7±4.7. Of the 72 survivors, with mean of 7.5, 8 patients who died had a mean of 19.5, and again the difference between groups were significant ($p< 0.0001$).
Based on APACHE II scores patients were divided into 3 groups with scores of <10, 11-20 and >20. The number of patients scoring less than 10 was 71(88.8%) of the study group. One patient with less than a score of 10 expired. 5 patients had scores in range of 11-20, 2 survived and 3 expired. 4 patients had scores more than 20 and all 4 patients expired.

**Table 1:** Apache Ii Distribution in Relation to Outcome of Patients Studied

| Apacheii | Outcome | | Total |
|---|---|---|---|
| | Survived | Expired | |
| <10 | 70(97.2%) | 1(12.5%) | 71(88.8%) |
| 11-15 | 2(2.8%) | 3(37.5%) | 5(6.3%) |
| >20 | 0(0%) | 4(50%) | 4(4.9%) |
| Total | 72(100%) | 8(100%) | 80(100%) |

$P<0.001$**

Based upon their MPI score, the patients were divided into three groups, MPI scores of less than 21, 21-29 and more than 29. None of the 52 patients with score <21 had mortality. 22 patients scored in range of 21-29 with mortality rate of 13.63%. 5 of 6 patients (MR=83.72) died who scored >29 as shown in table. Mean MPI score among survivors was 15.86±6.57 and in non-survivors was 32.13±4.67.

**Table 2:** Mannheims Peritonitis Index (MPI) in Relation to Outcome of Patients Studied

| Mannheims peritonitis index | Outcome | | Total |
|---|---|---|---|
| | Survived | Expired | |
| <21 | 52(72.2%) | 0(0%) | 52(65%) |
| 21-29 | 19(26.4%) | 3(37.5%) | 22(27.5%) |
| >29 | 1(1.4%) | 5(62.5%) | 6(7.5%) |
| Total | 72(100%) | 8(100%) | 80(100%) |

$P< 0.001$**, significant, Fisher Exact test

**Table 3:** Distribution of Apache Ii and MPI among Survivors and Non-Survivors

| Score | Survivors n=72 | Non survivors n=8 | P value |
|---|---|---|---|
| Apacheii | 4.78±2.63 | 15.38±4.65 | <0.0001 |
| MPI | 15.86±6.57 | 32.13±4.67 | <0.0001 |

Distribution of APACHE II and MPI among survivors showed mean apache score of 4.78±2.63 and mean MPI score of 15.86±6.57 which was found statistically significant($P<0.0001$), and non survivors had mean APACHE II score of 15.38±4.65and mean MPI score of 32.13±4.67 and was statistically significant ($P>0.0001$).

**Table 4:** Sharpness of Apache Ii and MPI

| | <0.1 (sharp) | 0.1-0.9 (Not sharp) | >0.9 (sharp) |
|---|---|---|---|
| APACHE II | 72 | 7 | 1 |
| MPI | 72 | 5 | 3 |

The distribution of scores, a measure for sharpness of the predictions, is shown in table. The distribution of APACHE II scores with low score values had low probabilities of death (< 0.1) for 72 of the 80 patients, (90%). In addition, APACHE II assigned a high risk of death (p> 0.9) to 1 of 80 patients (1.2%) of patients. But 7 patients (8.8%) were assigned a moderate risk (>0.1 and < 0.9) of death indicating that its predictions were "not sharp" in these cases.

The distribution of MPI scores with low score values had low probabilities of death (< 0.1) for 72 of the 80 patients, (90%). MPI assigned a high risk of death (p> 0.9) to 3 of 80patients (3.75%) of patients. But 5 patients (6.25%) were assigned a moderate risk (>0.1 and < 0.9) of death indicating that its predictions were "not sharp" in these cases.

MPI and APACHE II both were sharp in prediction. But MPI is sharper than APACHE II.

**Table 5:** Association between Apache Ii total Score and Probability of Death

| APACHE II total score | Actual no of deaths | Cumulative no of deaths | Proportion of deaths | Probability of death |
|---|---|---|---|---|
| 1-5 | 0 | 0 | 0.00 | 0.00 |
| 6-10 | 1 | 1 | 0.125 | 0.125 |
| 11-15 | 3 | 4 | 0.375 | 0.50 |
| 16-20 | 3 | 7 | 0.375 | 0.875 |
| 21-25 | 1 | 8 | 0.125 | 1.00 |
| Total | 8 | | 1.00 | |

APACHE II scores for 1 to 15 there were no deaths and expected number of deaths was also zero, and for 6-10, actual number of death was equal to expected number of deaths. With scores of 16 to 20 actual number of death was 3 as expected number of death was 7 with probability of 0.875 indicating it is reliable. For scores 21-25 actual number of death was 1 where as expected number of deaths was 8 with probability of 1.00.

**Table 6:** Association between MPI total Score and Probability of Death

| MPI total score | No of deaths | cumulative no of deaths | Proportion of deaths | Cumulative proportion of deaths |
|---|---|---|---|---|
| 12-19 | 0 | 0 | 0.00 | 0.00 |
| 20-24 | 0 | 0 | 0.00 | 0.00 |
| 25-29 | 3 | 3 | 0.375 | 0.375 |
| 30-34 | 2 | 5 | 0.25 | 0.625 |
| 35-39 | 3 | 8 | 0.375 | 1.00 |
| Total | 8 | | 1.00 | |

MPI scores from 12 to 24, there were no deaths and expected number of deaths was also 0. With scores of 25 to 29 actual number of death was 3 and was equal to expected number of death. For scores 30-34 actual number of death was 2 where as expected number of deaths was 5 with probability of 0.65. For scores 35-39 actual no of deaths was 3 and expected number of deaths was 8 with probability of 1.00.

## Discussion

All the patients were assigned APACHE II score. APACHE II score in our study was from 0 to 30, with the average of 5.84 (SD 4.291) points. None of the patients (n-14) with scores more than 20 survived (MR-100%). This finding was consistent with all the other studies. There was 100% mortality in patients whose score was >20 in Ajaz *et al.*, Horiuchi *et al.* and Ashish Ahuja studies. In other studies, different values of scores were reported for the dead patients.

**Table 7:** Apache Ii Score With 100% Mortality in Various Studies

| | Various World-wide Studies | Apache II scores with 100% mortality |
|---|---|---|
| 1 | our study | >20 |
| 2 | Ajaz *et al.* [2] | >20 |
| 3 | Horiuchi *et al.* [7] | >20 |
| 4 | Ashish Ahuja [1] | >20 |
| 5 | Samir Delibegovic *et al.* [8] | >28 |
| 6 | Chen *et al.* [9] | >40 |
| 7 | Edward *et al.* [10] | >22 |

Our study had MPI score ranging from 10 to 38, the overall mean was 17.49(SD 8.052). None of the patients (n-22) with scores >31 survived. Similarly various studies showed 100% mortality with varied scores as shown in table.

**Table 8:** MPI Score with 100% Mortality in Various Studies

| | Studies | MPI scores with 100% mortality |
|---|---|---|
| 1 | our study | >31 |
| 2 | Ajaz *et al.* [2] | >29 |
| 3 | Notash *et al.* [11] | >21 |
| 4 | C Ohmann *et al.* [12] | >30 |

## Accuracy or discriminative ability

The area under ROC curve measures discrimination, that is, the ability of the scoring system to correctly classify survivors and non survivors. The area below the curve was 0.982 for APACHE II in our study and was consistant with Samir Delibegovic *et al.* study (0.96) implying that it has an excellent discriminative ability where as Mishra *et al.* (0.82) and C Ohmann *et al.* (0.87) showed good accuracy. AUC for MPI in our analysis was 0.979 which was consistant with Notash *et al.* (0.97) and Samir Delibegovic *et al.* (0.90) implying excellent discriminative ability but Mishra *et al.* with AUC of 0.85 showed good accuracy where as C Ohmann *et al.* (AUC-0.79) had fair accuracy. Our analysis resulted in APACHE II being more accurate than MPI as with C Ohmann *et al.* and Samir Delibegovic *et al.* where as MPI had better discriminative ability than APACHE IIin Mishra *et al.* study.

**Table 9:** Comparison of Area under Roc Curve in Various Studies

| | Study | Area under ROC curve in APACHE II | Area under ROC curve in MPI |
|---|---|---|---|
| 1 | our study | 0.982 | 0.979 |
| 2 | Mishra *et al.* [13] | 0.82 | 0.85 |
| 3 | Notash *et al.* [11] | | 0.97 |
| 4 | C Ohmann *et al.* [12] | 0.87 | 0.79 |
| 5 | Samir Delibegovic *et al.* [14] | 0.96 | 0.90 |

Distribution of APACHE II and MPI among survivors showed mean apache score of 4.78±2.63 and mean MPI score of 15.86±6.57 which was found statistically significant ($P<$ 0.0001), and non survivors had mean APACHE II score of 15.38±4.65 and mean MPI score of 32.13±4.67 and was statistically significant ($P>0.0001$).

Thus APACHE II scores were consistent with survivors having lower scores and non-survivors high scores. Similarly MPI scores were also consistent with low scores among survivors and higher scores among non survivors.

**Table 10:** Distribution of Apache Ii and MPI as in Other Studies

| Studies | Score | Survivors n=72 | Non survivors n=08 | P value |
|---|---|---|---|---|
| Our study | APACHE II | 4.78±2.63 | 15.38±4.65 | <0.0001 |
| | MPI | 15.86±6.57 | 32.13±4.67 | <0.0001 |
| Notash *et al.* [11] | MPI | 19.4(6.7) | 33.1(4.8) | <0.0001 |
| A Horiuchi *et al.* [15] | APACHE II | 10.4(3.84) | 19.3(2.87) | 0.00003 |
| | MPI | 25.1(4.68) | 28.6(5.95) | 0.141 |

N: no of patients

Scoring systems as cited in various other studies are compared in Table.

Mean APACHE was lower in survivors than in non-survivors in our analysis and in study by A Horiuchi *et al.* [60] which was statistically significant with P value <0.0001 in both the studies.

Mean MPI was lower in survivors than in non-survivors in our analysis and Notash *et al.* [55] and had statistically significant difference with P value <0.0001 in both the studies. Whereas in Horiuchi *et al.* [60] analyses mean MPI scores among survivors did not vary much from non survivors and was not statistically significant. Thus APACHE II score distribution was significantly better among survivors and non survivors than MPI score distribution.

Sharpness is the degree of confidence associated with the predictions- for example, do most of the predictions for survival or death exceed a certain value (> 0.9).

We can conclude from our study that both APACHE II and MPI are sharp in predicting outcome, but MPI is sharper in prediction than APACHE II.

Prediction of sharpness as cited in other studies are listed in table.

**Table 11:** Sharpness Showing Comparison with Other Studies

| | | <0.1 (sharp) | 0.1-0.9 (Not sharp) | >0.9 (sharp) |
|---|---|---|---|---|
| Apache II | Our study | 72 (90%) | 7(8.8%) | 1(1.2%) |
| | Samir Delibegovic *et al.* [14] | 71(48.9%) | 64(44%) | 10 |
| | C. Ohmann *et al.* [12] | 68(25%) | 201(74.1%) | 2 |
| MPI | Our study | 72 (90%) | 5(6.25%) | 3 (3.75%) |
| | Samir Delibegovic *et al.* [14] | 0 | 145(100%) | 0 |
| | C. Ohmann *et al.* [12] | 164(60.5%) | 101(37.2%) | 6 |

Most of the patients in our study (90%) and Samir Delibegovic *et al.* found APACHE II as sharp predictor of outcome as most of low score values had low probabilities of death in both the studies. In addition, APACHE II assigned a high risk of death ($p$ > 0.9) to only 1 of 80 patients but in C. Ohmann *et al.* study APACHE II predictions were "not sharp"(74.1%).

MPI was also found to be sharp in predicting outcome in our study which is concurrent with C Ohmann *et al.* In Samir Delibegovic *et al.* study MPI was not at all sharp as all 145 patients were in moderate risk category (0.1-0.9).

Thus there is varying opinion regarding sharpness of scoring systems in literature.

**Reliability of scoring systems**

We analysed Reliability (calibration) of probabilities by comparing observed and predicted death rates (Fig. both APACHE II and MPI scoring systems observed and predicted death rates showed no significant difference). Thus in our analyses both APACHE II and MPI were reliable in predicting prognosis in perforative peritonitis patients.

C Ohmann *et al.* cited that only for APACHE I1 there were no significant differences between observed and predicted death rates, which indicates reliable predictions (goodness of fit). In the middle range (probability of death0.2 and < 0.8) the reliability was good. At the extreme end, probabilities indicated a higher expected death rate than was actually observed. The MPI was not reliable (with differences between expected and observed death rates for small and high probabilities), with higher expected than observed death rates for all probabilities greater than 0.2. In summary, only the APACHE II produced reliable predictions, and the probabilities derived from the MPI score cannot be relied on.

Samir Delibegovic *et al.* have found that the highest rate of correlation between the observed and the expected mortality rate was in APACHE II system thus APACHE II exhibited the best predictive power.

**Conclusion**

Modified APACHE II and MPI scoring predicts mortality which was significant irrespective of the etiology. As per our analyses APACHE II and MPI both had good sensitivity and specificity. Both scoring systems were accurate, sharp and reliable in predicting outcome. But in all these aspects APACHE II was found to be better than MPI in prediction.

Modified APACHE II score considers physiological adversities of the disease which can be used easily and effectively to

identify high risk patients for intensive care. Whereas MPI score has the advantage of being easier to calculate with very minimum basic investigations and was specifically designed as a scoring system for peritonitis. The draw back with MPI is that it needs operative findings to complete the scoring.

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