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RESEARCH ARTICLE

EVALUATION OF MODIFIED SHOCK INDEX AS AN INDICATOR FOR PROGNOSIS AMONG SEPSIS PATIENTS WITH AND WITHOUT COMORBIDITIES PRESENTING TO EMERGENCY DEPARTMENT: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Background and Aim: Despite the established association between sepsis and pre-existing comorbid conditions, limited information is available about the survival impact on sepsis patients.We aimed to assess the predictive ability of modified shock index (MSI) among sepsis patients with and without comorbidities presenting to the emergency department (ED) at our tertiary care centre.

Methodology: This is a prospective, observational study consisting of total 140 patients presented with sepsis. MSI was calculated by dividing the heart rate(HR) by the mean arterial pressure(MAP),and determined at the time of admission. The predictive ability, sensitivity, and specificity of MSI was evaluated.

Results: The mean age of patients was found to be 55.12 years with male predominance(64.29%)as compared to female (35.71%).The top three ranked comorbidities were found to be hypertension (21.43%) followed by Type 2 Diabetes mellitus (20%), and both hypertension & Type 2 Diabetes mellitus (17.86%)with significant association(X^2=185.543;p=0.000)between distribution of comorbidities among patients.Majority of the patientsi.e.,80% were improved from sepsis condition. Whereas, still 20% of patients died because of no recovery from sepsis condition. The area under the curve (AUC) for overall sepsis patients, and patients with and without comorbid condition was 0.483, 0.411, and 0.797 respectively.

Conclusion: MSI had a good predictive ability for sepsis patients without comorbid conditions. While MSI carries suboptimal predictive ability for sepsis patients with comorbid conditions. Owing to MSI, a simple index that can be calculated at the bedside, can be utilized in the emergency department for the management of sepsis patients without comorbidities.

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Introduction:-

Sepsis is a critical immune-mediated reaction to infection that leads to organ injury, with high morbidity and mortality rates, particularly among vulnerable groups. It can progress to septic shock, which carries fatality rates exceeding 60%.[1] According to the Third International Consensus (Sepsis-3), sepsis is defined as "organ dysfunction resulting from dysregulated host responses to infection," where organ dysfunction is signified by an increase in the Sequential Organ Failure Assessment (SOFA) score by 2 or more points in the presence of confirmed or suspected infection. Septic shock represents a subset of sepsis in which circulatory and cellular/metabolic disturbances are severe enough to significantly increase the risk of death.[2]

Prompt recognition and immediate treatment are key in septic shock management. From 1995 to 2015, the global incidence reached 437 cases per 100,000 population, based on a retrospective review of an international database.[3] Current data suggest that incidence continues to rise.[4-6] Mortality in sepsis correlates directly with disease severity.[7] Early detection and timely intervention can curb the progression of sepsis, lower morbidity and mortality, and reduce healthcare costs.[8-10]

Several scoring systems such as SOFA, Rapid Emergency Medicine Score (REMS), Mortality Prediction Model (MPM), and Acute Physiology and Chronic Health Evaluation (APACHE) are used to evaluate sepsis prognosis but require extensive laboratory investigations. The Quick Sequential Organ Failure Assessment (qSOFA) which assesses systolic blood pressure, respiratory rate, and mental status changes, is frequently used in the Emergency Department (ED) but has limited sensitivity in triage.[11]

The Shock Index (SI), calculated as heart rate divided by systolic blood pressure (HR/SBP), and the Modified Shock Index (MSI), derived by dividing heart rate by mean arterial pressure (HR/MAP), provide bedside assessment using simple clinical parameters.[12] MSI is an effective prognostic indicator in sepsis, aiding early diagnosis, guiding fluid resuscitation, and optimizing vasopressor therapy by reflecting vasodilation, low MAP, and impaired organ perfusion.[13]

Additionally, MSI integrates HR, SBP, and DBP thus offering comprehensive insight into cardiovascular and hemodynamic stability.[14] Torabi et al., found that in Emergency Severity Index level 3 patients, age, SI, and SBP were better predictors of mortality than SI or MSI alone.[15] Jayaprakash et al., reported that higher MSI values in early sepsis were linked with myocardial dysfunction and mortality.[13]

Despite progress in clinical technology and healthcare delivery, the incidence and mortality of sepsis, especially septic shock, remain substantial. The 2021 international guidelines for sepsis and septic shock emphasize that early recognition and targeted treatment in the initial hours after onset significantly improve outcomes.[16] However, there is still no agreement on the specific role and timing of MSI application in the ED. Moreover, although the association between sepsis and pre-existing comorbidities is well known, evidence on survival outcomes in such patients is limited. Most available studies are retrospective analyses of ED presentations, and prospective studies from India remain scarce.[17]

With this scenario, present study was designed with the main purpose to assess the predictive ability of MSI among sepsis patients with and without comorbidities presenting to the ED at our tertiary care center.

Methodology:-

Study population

This is a prospective, observational study conducted with total of 140patients presented with sepsisat Department of Emergency Medicine, Bapuji hospital attached to J. J. M. Medical College (JJMMC), Davangere, Karnataka. The ethical committee approval and written informed consent were obtained before the conduct of study.

Inclusion criteria

1. Age: ≥18 years
2. Patients who were diagnosed with sepsis on the basis of systemic inflammatory response syndrome (SIRS) criteria and qSOFA score

Exclusion criteria

1. Patients <18 years of age
2. Pregnant women
3. Trauma cases
4. Those with surgical causes of sepsis
5. Patients on immunosuppressive drugs

Sample size

The sample size was calculated assuming the expected mortality of sepsis patients as 19.8% as per Jayaprakash et al., study.[13] The predictive validity was assessed by area under the curve (AUC) value of 0.75 against a null value of 0.5, 95% power, and 5% two-sided alpha error. As per the above-mentioned calculation, the required sample was 107. To account for a loss to follow up of 20%, another 22 subjects were included. The final sample was rounded off to 140.

Data collection

Patients underwent a detailed clinical history, physical examination and necessary blood investigations. The MSI was calculated by dividing the heart rate (HR) by the mean arterial pressure (MAP), were determined at the time of admission.

Study outcomes

The predictive ability, sensitivity, and specificity of MSI was evaluated.

Statistical analysis

Data was entered in Microsoft Excel 2021 and analysis was done using Statistical Software for Social Sciences (SPSS) version 21. Categorical variables were represented in the form of percentages, and frequencies. Continuous variables were presented as descriptive statistics (Mean and Standard deviation). Categorical variables were analysed using the Chi-square test. An received operating curve (ROC) was constructed for MSI to determine the optimal cut-off values. The sensitivity and specificity of the new cut-off value were then evaluated.

Results:-

Demographic and Patient characteristics

The mean age of patients was found to be 55.11 years with male predominance (65%) as compared to female (35.71%).The mean SI and MSI of patients enrolled in the study were found to be 1.14 and 1.56 respectively. The other important patient characteristics were listed in Table 1.

Table 1: Demographicand patient characteristics

Variables	**Mean ± SD**
Age, Years	55.11 ± 17.71
Gender, n (%)	
Male	91 (65.00)
Female	50 (35.71)
HR, bpm	105.51 ± 22.74
SBP, mmHg	96.17 ± 24.94
DBP, mmHg	58.91 ± 15.16
MAP, mmHg	71.36 ± 19.23
RR, breaths/min	28.04 ± 6.39
SpO_2, %	94.19 ± 5.83
Shock Index (SI)	1.14 ± 0.44
Modified Shock Index (MSI)	1.56 ± 0.62

Comorbidities

The distribution of patients based on comorbidities was illustrated in Figure 1. Results depicted that the top three ranked comorbidities were found to be hypertension (21.43%) followed by Type 2 Diabetes mellitus (20%), and both hypertension & Type 2 Diabetes mellitus (17.86%). The Chi-square test revealed significant association (X^2 = 185.543; p=0.000) between distribution of comorbidities among patients.

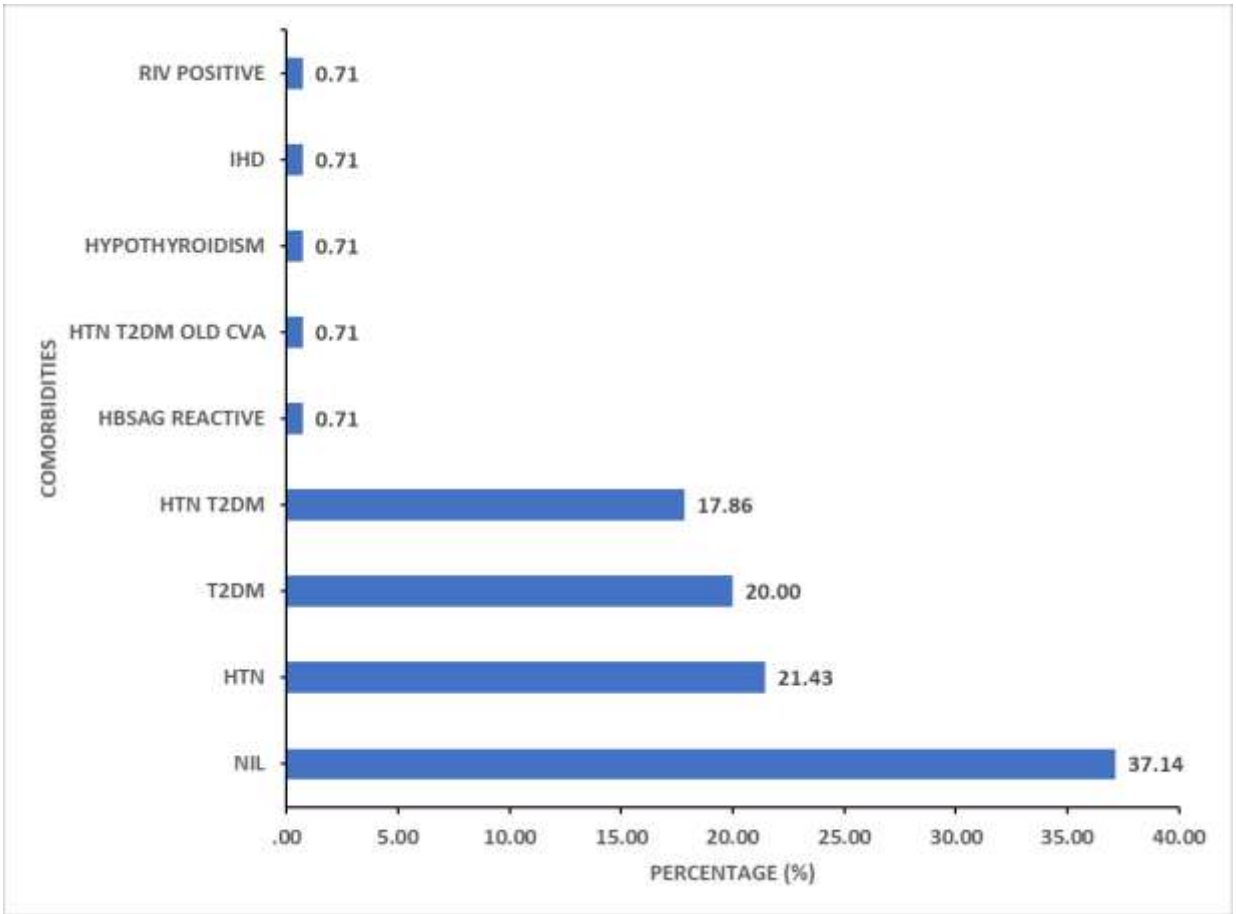

Figure 1. Distribution of patients based on comorbidities

Temperature

The distribution of patients based on temperature was illustrated in Figure 2. Results implied that majority of the patients i.e., 83.6% were afebrile followed by febrile (16.4%). The Chi-square test revealed significant association (X^2 = 63.114; p=0.000) between afebrile and febrile distribution among patients.

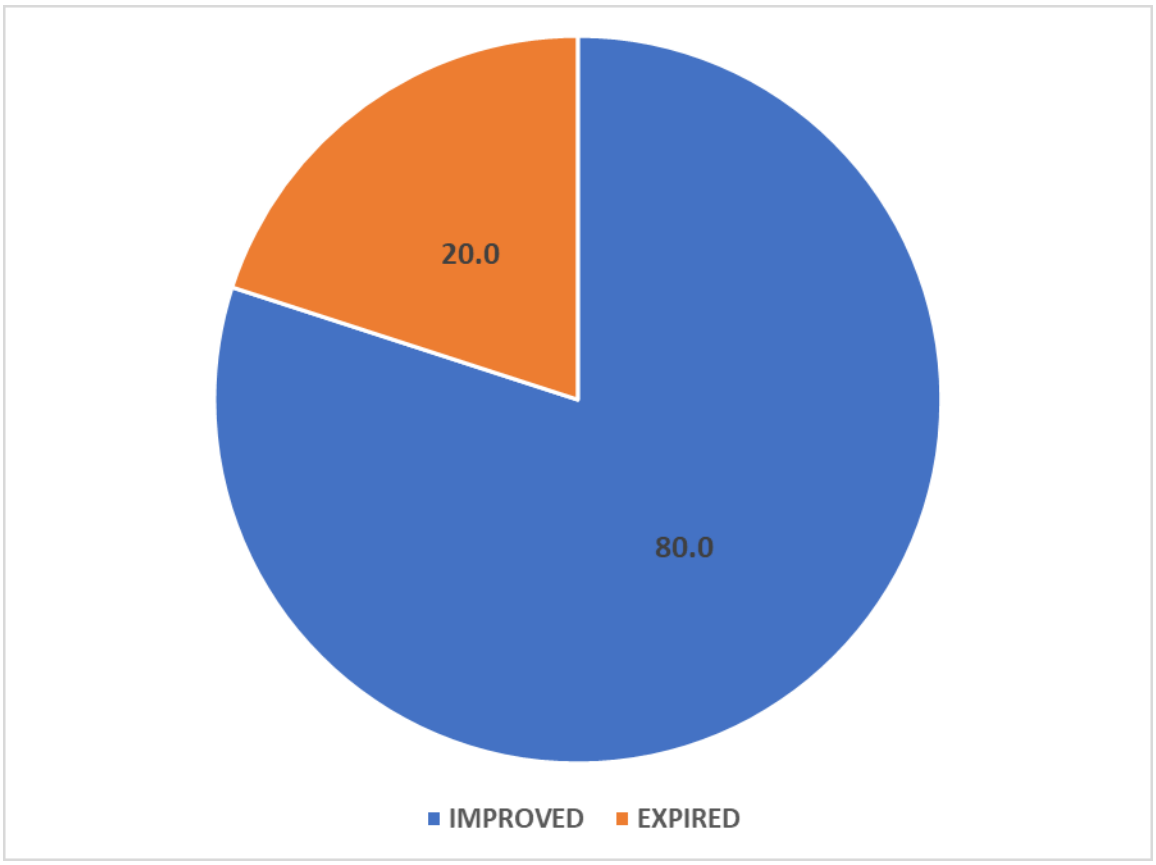

Figure 2. Distribution of patients based on temperature

Inotropes requirements

The distribution of patients based on requirements of inotropes was illustrated in Figure 3. Results inferred that majority of the patients i.e., 87.9% required inotropes. Whereas, still 12.1% of patients doesn't required inotropes. The Chi-square test revealed significant association (X^2 = 80.257; p=0.000) between requirements of inotropes among patients.

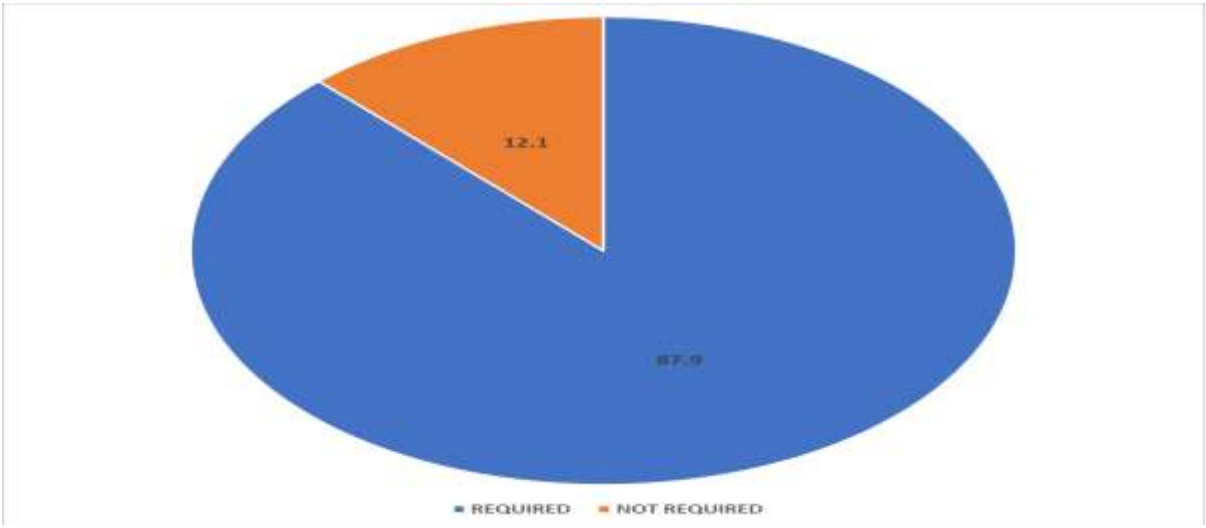

Figure 3. Distribution of patients based on requirements of inotropes

Outcomes

The distribution of patients based on outcomes was illustrated in Figure 4. Results depicted that majority of the patients i.e., 80% were improved from sepsis condition. Whereas, still 20% of patients died because of no recovery from sepsis condition. The Chi-square test revealed significant association (X^2 = 80.257; p=0.000) between outcomes of patients.

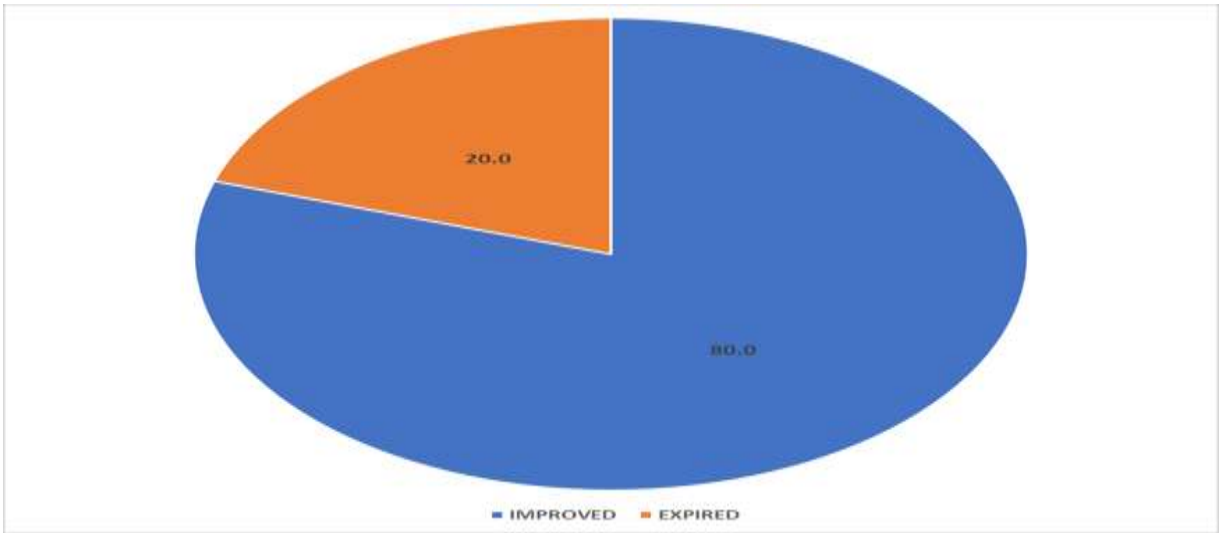

Figure 4. Distribution of patients based on outcomes of patient

Predictive ability of MSI:

The ROC curve of the MSI in sepsis patients overall, and sepsis patients with and without comorbid conditions with a cut-off of 1.25, illustrates the test's accuracy by plotting sensitivity against 1-specificity (Figure 5a, 5b, and 5c). The area under the curve (AUC) for overall sepsis patients, and sepsis patients with and without comorbid condition was found to be 0.483, 0.411, and 0.797 respectively. These findings indicated about the suboptimal predictive ability of MSI for overall sepsis patients and sepsis patients with comorbid conditions. Whereas, MSI has good predictive ability for sepsis patients without comorbid conditions. The sensitivity and specificity of MSI in predicting sepsis for sepsis patients overall, and sepsis patients with and without comorbid conditions were listed in Table 2.

Table 2: Performance metrics of MSI for sepsis screening

Metrics	MSI		
	Overall	With Comorbidities	Without Comorbidities
Area under curve (AUC)	0.483	0.411	0.797
Sensitivity (Sn)	72.2%	78.3%	63.0%
Specificity (Sp)	56.0%	68.4%	16.7%

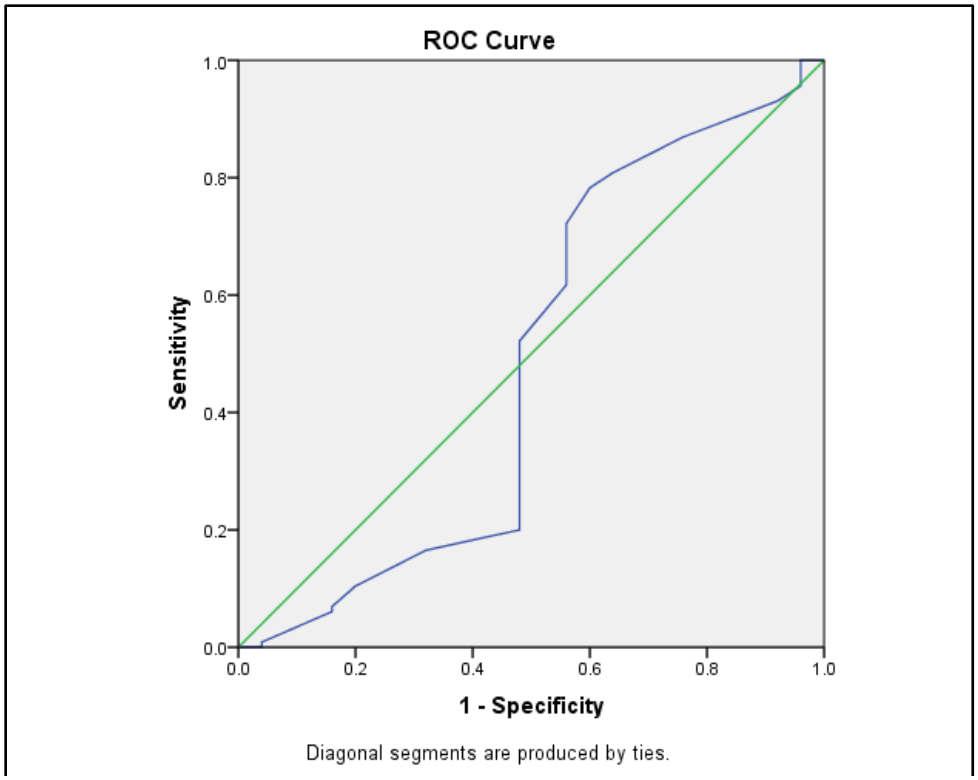

Figure 5a. ROC analysis of predictive validity of MSI in overall sepsis patients

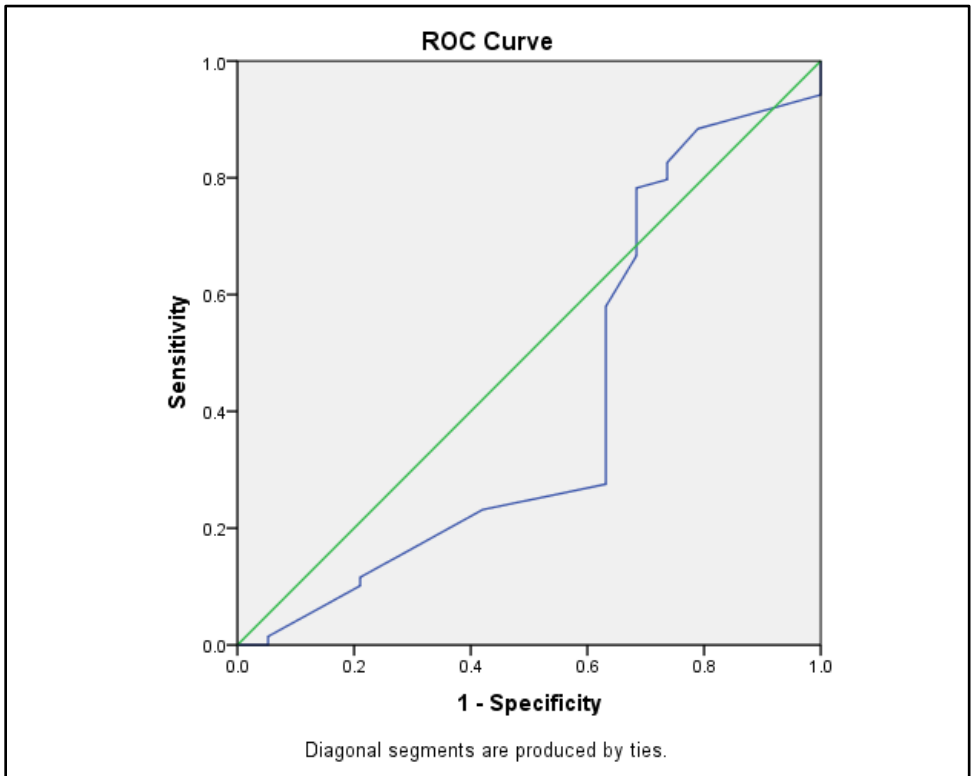

Figure 5b. ROC analysis of predictive validity of MSI in sepsis patients with comorbidities

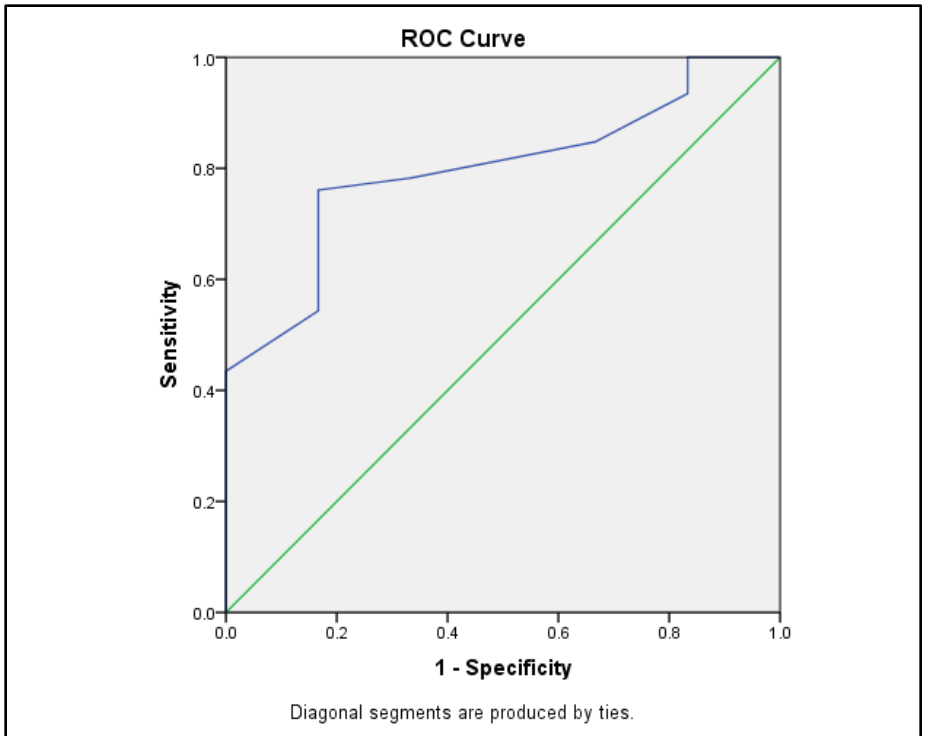

Figure 5c. ROC analysis of predictive validity of MSI in sepsis patients without comorbidities

Discussion:-

Despite advancements in emergency care in recent years, evidence consistently indicates that sepsis remains a significant global health concern.[18] It accounts for more than 6 million deaths each year and is among the costliest conditions treated in hospitals.[19] The burden of sepsis is particularly high in older adults, those with multiple comorbidities, and individuals with diminished functional status.[20] The SI is frequently applied in the early assessment of hypovolemic shock; however, using only SBP in its calculation may neglect the role of DBP. From a clinical perspective, mean arterial pressure is regarded as a more reliable measure of tissue perfusion.[17] Therefore, this prospective observational study aims to assess the predictive value of the MSI in sepsis patients, both with and without comorbid conditions, who present to the emergency department of our tertiary care hospital.

In our study the mean age of patients was found to be 55.12 years with male predominance. These findings were comparable with the literature reports published by various other research investigators. In another prospective observational study carried out by Uppal et al., reported the mean age of 57.84 years with male predominance.[21] These findings were similar to our findings on demographic characteristics. Furthermore, Prasad et al., also reported the mean age of patients 56.12 years with male predominance in their prospective observational study.[4]

The mean SI and MSI of patients enrolled in our study were found to be 1.14 and 1.56 respectively. These findings were in constituent with previous studies reported by various other researchers. Prasad et al., in their prospective observational study found SI and MSI values of 1.02 and 1.47 respectively.[4]Uppal et al., also found MSI value of 1.41 in their prospective observation study to determine the prognostic value of MSI in patients diagnosed with sepsis.[21] Furthermore, Devendra Prasad et al., in another prospective observational study to assess the predictive validity of MSI in predicting the prognosis of sepsis patients with and without co-morbidities reported the mean MSI of 1.47 on arrival to ED.[17]

The top two ranked comorbid conditions were found to be hypertension (21.43%) and Type 2 Diabetes mellitus (T2DM)of 20% in our study. In concurrence withour study findings Devendra Prasad et al., in their prospective observational study enrolled sepsis patients with T2DM comorbid conditions of 53.5% proportion.[17] In another

prospective observational study carried out by Prasad et al., enrolled 27.7% of sepsis patients with T2DM comorbid condition.[4]

Majority of the patients in our study i.e., 80% were improved from sepsis condition. Whereas, still 20% of patients died because of no recovery from sepsis condition. The findings of ROC analysis in our study indicated about the suboptimal predictive ability of MSI for overall sepsis patients and sepsis patients with comorbid conditions with AUC values of 0.483 and 0.411 respectively. However, MSI has shown good predictive ability for sepsis patients without comorbid conditions in our study with AUC value of 0.797.

Contradictorily, Devendra Prasad et al., in their prospective observational study to assess the predictive validity of MSI in predicting the prognosis of sepsis patients with and without co-morbidities demonstrated that among people with co-morbidities, the MSI value on arrival to the emergency room had good predictive validity in predicting the need for mechanical ventilation after 24 hours. Predictive validity for patients stepping down from ICU after 24 hours was good.[17]

Additionally, Althunayyan et al. reported that the MSI was an effective tool for triaging febrile patients.[12] Liu et al. demonstrated that MSI was a more accurate predictor of mortality in emergency cases compared to the SI, heart rate, or blood pressure when used individually.[22] In a prospective study, Singh et al. observed that MSI values below 0.7 and above 1.3 were strongly linked to higher mortality rates.[14] Existing research indicates that between 54% and 65% of sepsis patients have underlying comorbidities, which significantly affect their clinical outcomes.[23]

Conclusion:-

In conclusion, our study showed that the MSI had good predictive accuracy for sepsis patients without comorbidities, but its performance was weaker in those with existing comorbid conditions. As a straightforward tool that can be calculated at the bedside, MSI can be a practical aid in the emergency department for managing sepsis cases without comorbidities. Incorporating MSI into ED practice may support timely identification and intervention in high-risk sepsis patients, thereby enhancing outcomes and lowering mortality.

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