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Original Research Article

A study on the prognostic value of red cell distribution width to total serum calcium ratio in acute pancreatitis and comparison with Ranson's and BISAP score - a prospective observational study from a tertiary care center in Chennai

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ABSTRACT

Background: Acute pancreatitis (AP) is a severe inflammatory condition with variable outcomes, and current scoring systems have limitations in predicting its severity. Our study aimed to determine the prognostic value of the red cell distribution width (RDW) -to-total serum calcium ratio in patients with AP.
Methods: This single-center prospective observational study included 100 patients at Madras Medical College, Rajiv Gandhi Government General Hospital between September 2023 and 2024. 16 patients with severe AP were compared to 84 mild AP cases by assessing demographics, aetiology, comorbidities, laboratory results, arterial blood gas, and RDW at 0 and 24 hours. The RDW-to-total serum calcium ratio was evaluated against the established prognostic scores within 24 h of admission.
Results: A total of 100 patients with acute pancreatitis were included in the study, of which 84 (84%) had mild AP, and 16 (16%) had severe AP. The RDW/TSC ratio demonstrated excellent predictive value for mortality, with an area under the receiver operating characteristic curve (AUROC) of 0.909, sensitivity of 95.40%, and specificity of 85.70%. This outperformed RDW at 0 hours (AUROC=0.789), bedside index of severity in acute pancreatitis (BISAP) (AUROC=0.764), and Ranson's score (AUROC=0.711). RDW at 24 hours showed no significant predictive value (AUROC=0.529).
Conclusions: RDW and RDW 0h-to-TSC ratio are cost-effective, non-invasive markers that predict acute pancreatitis (AP) severity and mortality more effectively than Ranson and BISAP scores. An RDW 0 hours >14.15 and RDW 0 hours-to-TSC ratio >1.45 were strong predictors of AP severity.

Keywords: Acute pancreatitis, Red cell distribution width, Total serum calcium, Ranson's score, BISAP score

INTRODUCTION

Acute pancreatitis (AP) is an acute inflammation of the pancreatic parenchyma induced by activated pancreatic enzymes due to multiple causes.[1] It is an acute inflammatory insult to the pancreas, manifesting as severe upper abdominal pain that can radiate to the back. The clinical course exhibits remarkable heterogeneity, ranging from self-limited, self-resolving episodes to fulminant and life-threatening conditions. Severe AP occurs in approximately 25% of pancreatitis cases, and the incidence of AP is on an alarming rise, potentially mirroring the increasing prevalence of established risk factors, such as alcohol abuse and gallstone migration.[2] However, the realm of AP risk factors is still expanding. Several prognostic scoring systems and biological markers have been used to predict the severity and mortality of AP.[3,4] Despite the various scoring systems and methods, there is no reliable instrument to assess the severity of AP at its presentation. Several AP scoring systems and laboratory tests have been proposed and developed to estimate the

prognosis of AP, such as Ranson's score, Balthazar score, BISAP score, SIRS score, C-reactive protein (CRP), serum blood urea nitrogen (BUN), D-dimer, and procalcitonin levels. However, scoring systems have multiple disadvantages, such as the hassle of calculation and the need for ordering specific tests. Red blood cell distribution width (RDW) is an easily obtained, inexpensive, and routinely reported parameter in complete blood count tests. It is commonly performed for the assessment of almost all patients at the time of admission.[5]

RDW and serum calcium levels are inexpensive markers readily available upon admission that can be used to predict the severity of AP.[6] Both RDW and total serum calcium (TSC) are simple routine parameters related to inflammatory status, the results of which are readily available. In our study, we assessed RDW and the RDW-to-TSC ratio to predict the outcome of patients with AP. Although RDW and serum calcium (Ca) alone can be used as predictors of AP severity, they have low sensitivity and specificity.[7]

Aim

Our study aimed to determine the prognostic value of the RDW/TSC in patients with AP.

METHODS

This single-center prospective observational study included 100 patients with acute pancreatitis in the Department of Institute of Medical Gastroenterology at Madras Medical College, Rajiv Gandhi Government General Hospital, Chennai between September 2023 and September 2024. Our study was approved by the institutional ethics committee before initiation, and informed consent was obtained from all patients.

Inclusion criteria

Patients aged <18 years with a confirmed AP diagnosis of acute pancreatitis were included in our study.

Exclusion criteria

Patients with chronic pancreatitis, malignancy, tumour comorbidity, AP caused by poisoning, surgical operations, trauma, postoperative pancreatic lesions, pregnancy or perinatal period, and blood diseases were excluded from our study.

Methodology

The evaluated variables included demographics, aetiology, comorbidities, laboratory parameters, arterial blood gas analysis, and red cell distribution width at 0 hours and 24 hours. The red cell distribution width to total serum calcium was evaluated and compared with the established and widely adopted prognostic scoring systems within 24 hours of admission (Ranson and BISAP).

Statistical analysis

Descriptive statistics were used for continuous variables, whereas frequency distributions were used for categorical variables. The Kolmogorov-Smirnov test was used to validate the normality assumption. To compare the difference in means between the two groups, an independent sample t-test (Mann-Whitney U-test) was used for parametric and nonparametric data, respectively. The sensitivity, specificity, positive and negative predictive values, and accuracy of each method and its confidence interval (CI) (95% CI) were determined, in addition to the Youden index (sensitivity + specificity – 1) (probability of correct classification) and determining the area under the ROC curve. All statistical calculations were performed using statistical package for the social sciences (SPSS) 21 version (SPSS Inc., Chicago, IL, USA), and statistical significance was set at $p<0.05$.

RESULTS

The mean age was 54.9 years, with no significant difference between the severe and mild acute groups (p=0.163). Aspartate aminotransferase (AST) levels were significantly higher in mild cases (319.11±103.14) than in severe cases (249.25±135.91) (p=0.021). BUN and creatinine levels were significantly elevated in severe cases (BUN: 24.25±9.42, creatinine: 2.092±1.14) compared to mild cases (BUN: 19.74±8.44, creatinine: 1.245±0.676), with p values of 0.043 and 0.01, respectively. Albumin levels were significantly lower in severe cases (3.264±1.107) than in mild cases (3.849±0.847) (p=0.018). CRP levels were notably higher in severe cases at both 0 h (8.219±2.233, p=0.004) and 24 hours (18.731±5.398, p=0.012). Total serum calcium level was significantly lower in severe cases (8.269±1.586) than in mild cases (9.181±1.389), with a p-value of 0.044. The RDW at 0 h was higher in severe cases (14.775±1.142, p=0.026), and the RDW-to-serum calcium ratio was significantly elevated in severe cases (1.85±0.393, p=0.015). Ranson's score was also significantly higher in severe cases (3.25±1.183, p=0.038) (Table 1).

In our study, age did not significantly differ between patients with negative and positive outcomes (58±8.94 versus 54.56±9.06, p=0.273). The prevalence of male gender, alcohol consumption, smoking, and hospital stay duration was similar across both outcome groups, with no significant difference. Significant differences were noted in laboratory parameters: WBC count was lower in patients with negative outcomes (15629.3±1.06) compared to positive outcomes (17727.13±4531.4, p=0.015), and BUN and creatinine levels were higher in negative outcomes (BUN: 26.3±10.54, creatinine: 2.23±1.36) than positive outcomes (BUN: 19.81±8.3, creatinine: 1.29±0.69), with p values of 0.025 and 0.047, respectively. Albumin levels were significantly lower in patients with negative outcomes (2.79±1.01) than in those with positive outcomes (3.86±0.84, p=0.011). Haemoglobin levels were also lower in patients with negative outcomes

(12.15±1.23) than in those with positive outcomes (12.88±0.73, p=0.012). CRP levels at 0 hours (9.2±2.11 versus 6.3±1.88, p=0.023) and 24 hours (20.74±5.67 versus 14.79±3.98, p=0.01) were significantly elevated in the negative outcome group. RDW at 0 hours was higher in patients with negative outcomes (15.28±0.86) compared to those with positive outcomes (13.99±1.46, p=0.001), and the RDW-to-total serum calcium ratio was significantly increased in the negative outcome group (2.06±0.3 versus 1.45±0.34, p=0.025). Ranson's score was higher in patients with negative outcomes (3.6±1.07) versus those with positive outcomes (2.52±1.47, p=0.027) (Table 2).

Patients were stratified into positive and negative outcome groups, and The AUCs of RDW at admission and RDW/TSC for predicting mortality were 0.789 and 0.909, respectively.

The RDW to total serum calcium ratio exhibited the best diagnostic performance with an AUROC of 0.909, indicating excellent discrimination, along with high sensitivity (95.40%) and specificity (85.70%), making it a strong predictor. RDW at 0 hours (AUROC=0.789) and the BISAP score (AUROC=0.764) also showed good discriminatory power, with statistically significant results and a reasonable balance between sensitivity and specificity. The Ranson score (AUROC=0.711) performed well, whereas serum glucose and BUN showed moderate to fair discrimination, although the serum glucose level was not statistically significant. The RDW at 24 hours performed poorly, with an AUROC of 0.529 and no significant predictive value. Overall, the RDW-to-total serum calcium level ratio was the most effective variable (Table 3).

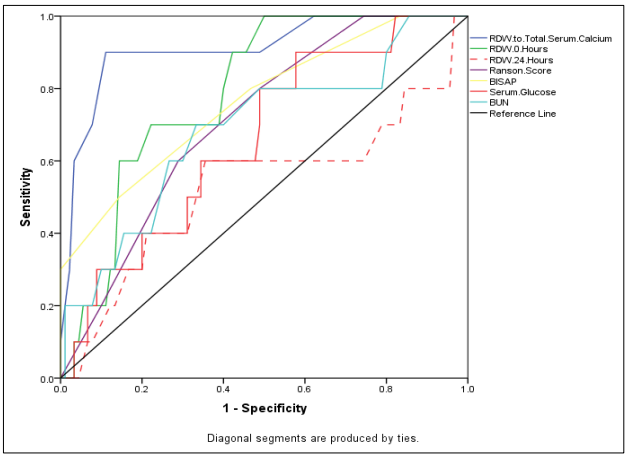

Figure 1: Area under the receiver operating characteristic curve (AURO) of prognostic scores and independent risk factors for acute pancreatitis mortality.

Table 1: Demographic details, lab parameters, and scores of the population according to acute pancreatitis severity.

Parameters	Total cohort	Severe	Mild	P value
Demographic details				
Age	54.9±9.067	57.688±8.284	54.369±9.158	0.163
Gender (male)	64 (64%)	11 (68.8%)	53 (63.1%)	0.666
Alcohol (yes)	24 (24%)	4 (25%)	20 (23.8%)	0.919
Smoking (yes)	27 (27%)	5 (31.2%)	22 (26.2%)	0.676
Hospital stays	14.38±6.612	14.875±7.136	14.286±6.548	0.762
Comorbidities (yes)	91 (91%)	14 (87.5%)	77 (91.7%)	0.594
Laboratory parameters				
WBC count	17517.35±4342.765	16645.188±3285.139	17683.476±4513.34	0.288
AST	307.93±111.261	249.25±135.906	319.107±103.136	0.021
ALT	267.34±70.925	267.063±86.554	267.393±68.163	0.986
Total bilirubin	2.303±1.148	2.759±1.164	2.216±1.132	0.083
Platelet count	221.75±67.541	231.563±60.163	219.881±69.028	0.484
BUN	20.46±8.714	24.25±9.42	19.738±8.44	0.043
Creatinine	1.381±0.823	2.092±1.14	1.245±0.676	0.01
Albumin	3.755±0.913	3.264±1.107	3.849±0.847	0.018
LDH	445.02±330.105	478±149.246	438.738±354.542	0.468
Serum glucose	155.34±61.519	161.75±65.046	154.119±61.157	0.669
Haemoglobin	12.811±0.813	12.306±1.057	12.907±0.726	0.043
Hematocrit	41.412±7.96	41.069±8.194	41.477±7.963	0.856
Serum amylase	999.344±261.041	997.138±294.894	999.764±256.048	0.974
CRP 0 hours	6.591±2.087	8.219±2.233	6.281±1.92	0.004
CRP 24 hours	15.387±4.517	18.731±5.398	14.75±4.063	0.012
Total serum calcium	9.035±1.453	8.269±1.586	9.181±1.389	0.044
RDW 0 hours	14.123±1.458	14.775±1.142	13.999±1.484	0.026
RDW 24 hours	13.885±1.375	13.919±1.43	13.879±1.373	0.918

Continued.

Parameters	Total cohort	Severe	Mild	P value
RDW to total serum calcium	1.509±0.384	1.85±0.393	1.444±0.348	0.015
Scores				
Ranson	2.63±1.468	3.25±1.183	2.512±1.493	0.038
BISAP	1.48±0.937	1.625±0.957	1.452±0.937	0.514

Table 2: Demographic details, lab parameters, and scores of the population according to acute pancreatitis mortality.

Parameters	Total cohort	Negative outcomes	Positive outcomes	P value
Demographic details				
Age	54.9±9.07	58±8.94	54.56±9.06	0.273
Gender (male)	64 (64%)	7 (70%)	57 (63%)	0.677
Alcohol (yes)	24 (24%)	4 (40%)	20 (22%)	0.212
Smoking (yes)	27 (27%)	3 (30%)	24 (27%)	0.822
Hospital stays	14.38±6.61	16±6.6	14.2±6.63	0.431
Comorbidities (yes)	91 (91%)	8 (80%)	83 (92%)	0.2
Laboratory parameters				
WBC count	17517.35±4342.76	15629.3±1.06	17727.13±4531.4	0.015
AST	307.93±111.26	171.4±108.62	323.1±101.24	0.32
ALT	267.34±70.93	261.7±99.6	267.97±67.74	0.85
Total bilirubin	2.3±1.15	2.9±1.2	2.24±1.13	0.124
Platelet count	221.75±67.54	235.1±67.64	220.27±67.75	0.524
BUN	20.46±8.71	26.3±10.54	19.81±8.3	0.025
Creatinine	1.38±0.82	2.23±1.36	1.29±0.69	0.047
Albumin	3.76±0.91	2.79±1.01	3.86±0.84	0.011
LDH	445.02±330.1	507.7±150.19	438.06±344.15	0.256
Serum glucose	155.34±61.52	185±54.38	152.04±61.65	0.091
Haemoglobin	12.81±0.81	12.15±1.23	12.88±0.73	0.012
Hematocrit	41.41±7.96	42.58±8.32	41.28±7.96	0.648
Serum amylase	999.34±261.04	965.24±323.25	1003.13±255.12	0.727
CRP 0 hours	6.59±2.09	9.2±2.11	6.3±1.88	0.023
CRP 24 hours	15.39±4.52	20.74±5.67	14.79±3.98	0.01
Total serum calcium	9.04±1.45	7.6±1.53	9.19±1.36	0.022
RDW 0 hours	14.12±1.46	15.28±0.86	13.99±1.46	0.001
RDW 24 hours	13.89±1.38	13.95±1.61	13.88±1.36	0.894
RDW to total serum calcium	1.51±0.38	2.06±0.3	1.45±0.34	0.025
Scores				
Ranson	2.63±1.47	3.6±1.07	2.52±1.47	0.027
BISAP	1.48±0.94	1.8±0.92	1.44±0.94	0.271

Table 3: Diagnostic performance of RDW, calcium, and clinical scores for predicting outcomes.

Test result variable(s)	AUROC	P value	95% CI	Cut-off	Sensitivity	Specificity
RDW to total serum calcium	0.909	0.001	(0.806, 1.000)	1.45	95.40%	85.70%
RDW 0 hours	0.789	0.003	(0.677, 0.902)	14.15	87.30%	75.40%
RDW 24 hours	0.529	0.761	(0.306, 0.752)	11.75	63.20%	85.80%
Ranson score	0.711	0.029	(0.569, 0.853)	2.5	73.40%	65.80%
BISAP	0.764	0.021	(0.602, 0.906)	1.5	79.80%	67.30%
Serum glucose	0.659	0.1	(0.496, 0.821)	123	79.00%	65.30%
BUN	0.687	0.053	(0.505, 0.869)	16.5	63.10%	72.20%

DISCUSSION

Our study provides insight into the prognostic value of the RDW to TSC ratio in predicting the severity and mortality of AP. The findings indicate that RDW and the RDW-to-TSC ratio are effective, low-cost, and non-invasive markers that outperform traditional scoring systems like Ranson's and BISAP in predicting severe AP outcomes.

The RDW, which reflects the variability in the size of circulating red blood cells, is a commonly included metric in routine blood counts and has been found to be a useful marker of systemic inflammation and disease severity.[8] Previous studies have highlighted RDW as a significant prognostic factor not only in haematological conditions but also in other diseases, including cardiovascular and inflammatory diseases. This aligns with the observation in our study that elevated RDW was correlated with higher severity in AP. The positive association between RDW and inflammation, which is characteristic of AP, makes RDW a plausible marker for predicting AP outcomes.[9]

Specifically, our results revealed that patients with severe AP had significantly higher RDW at 0 hours (RDW 0 hours) and a higher RDW 0 hours-to-TSC ratio compared to those with mild AP. These findings are consistent with those from other investigations that demonstrated the value of RDW in predicting both severity and mortality in AP. For example, a study by Goyal et al performed a systematic review that supported RDW's role as a prognostic biomarker, identifying high admission RDW as indicative of increased mortality risk in AP patients.[5]

The mechanistic connection between RDW and acute pancreatitis may be explained by the role of systemic inflammation in erythropoiesis. Inflammation associated with AP can inhibit erythropoietin production and increase oxidative stress, leading to elevated RDW values.[10] This theory is supported by studies that have shown a correlation between increased RDW and elevated levels of inflammatory markers, such as C-reactive protein, which are often elevated in AP.[11]

Moreover, hypocalcemia is a well-known indicator of severe AP and has been linked to worse outcomes, as it often indicates pancreatic necrosis. Our study showed that the RDW 0 hours-to-TSC ratio had a superior predictive value compared to RDW alone, suggesting that combining RDW with TSC provides better prognostic information. This was also observed in the study by Wang et al, which found that RDW values were significantly correlated with serum calcium levels, and this combination served as a strong predictor for AP mortality.[12]

Another notable observation from our study is the association of higher RDW/TSC ratios with increased rates of ICU admission, surgical intervention, and mortality. This association highlights the clinical potential of RDW/TSC as a valuable early predictor of severe disease, allowing for more timely and aggressive interventions in patients at higher risk. This is consistent with the findings of Senol et al, who demonstrated that RDW on admission had high sensitivity and specificity for predicting mortality in AP patients.[13]

Limitations

Despite these promising findings, our study's limitations include the relatively small sample size and the single-center nature of the data, which may limit the generalizability of the results. Future studies should aim to validate these findings in larger, multi-center cohorts and explore the integration of RDW and TSC measurements into existing prognostic models for AP.

CONCLUSION

RDW and TSC are uncomplicated, inexpensive, non-invasive, and quantitative serum markers readily accessible as components of a complete blood count test. Our study highlights the substantial predictive capability of RDW, evaluated at admission and within the initial 24 hours, as well as the RDW 0 hours-to-TSC ratio for both severity and mortality in AP, outperforming the predictive performance of the Ranson and BISAP scores. An RDW 0-hour value exceeding 14.15 and an RDW 0 hour-to-TSC ratio greater than 1.45 were identified as strong predictors of AP severity.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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