RESEARCH ARTICLE

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The Predictive Value of H_2FPEF Score for Contrast Induced Nephropathy in NSTEMI Patients Undergoing Emergency PCI

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Abstract

Background and Aim: Contrast-induced nephropathy (CIN) is acute kidney damage that occurs after recent radiographic contrast media exposure. The aim of our study was to evaluate the association of H_2FPEF score with CIN in patients with non-ST-segment elevation myocardial infarction (NSTEMI) undergoing emergency coronary angiography and percutaneous coronary intervention (PCI).

Materials and Methods: This prospective single center study included 600 patients with NSTEMI scheduled for both emergency coronary angiography and PCI. They were classified into 2 groups according to the incidence of CIN: the first group included 89 patients who developed CIN, and the second group included 511 patients without CIN. All studied cases were clinically evaluated. Echocardiographic assessment, coronary angiography and PCI were done.

Results: Age, hypertension, diabetes mellitus (DM), presence of heart failure and atrial fibrillation, pulmonary artery systolic pressure and H_2FPEF were found to be significant predictors of CIN after emergency PCI. Multivariate logistic regression analysis detected age, DM, and H_2FPEF as the only significant predictors of CIN after emergency PCI. H_2FPEF score can predict CIN with AUC of 0.575 and *P*-value of 0.020, at cutoff >1, with 85.39% sensitivity, 50.49% specificity, 16.1% positive predictive value and 89.8% negative predictive value.

Conclusion: H_2FPEF score shows a statistically significant but limited discriminatory ability in predicting CIN. Its utility as a standalone predictor appears limited and requires further validation.

Keywords: H_2FPEF score, coronary angiography, contrast induced nephropathy

INTRODUCTION

Contrast-induced nephropathy (CIN) refers to impaired renal function following the administration of radiographic contrast media. CIN has several mechanisms. It may occur due to medullary ischemia, vasoconstriction, oxidative stress, or the direct toxic effects of contrast media. It is associated with prolonged hospitalization, increased morbidity, and mortality.[1]

The risk of CIN is lower when less nephrotoxic low osmolar contrast agents are used and when improved prevention strategies are implemented. However, its incidence after coronary angiography is still high and represents an important cause of morbidity and mortality,[2] especially after primary percutaneous coronary intervention (PCI).[3]

Therefore, detecting patients with coronary artery disease (CAD) at increased risk of CIN, as well as using effective prevention strategies, is clinically important. H_2FPEF score can be useful in the etiological differentiation of unexplained dyspnea [preserved- ejection-fraction heart failure (HF) or non-cardiac].[4]

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Thus, we hypothesized that the H_2FPEF score can be used to detect the probability of a kidney function deterioration and progression of CIN in non-ST-elevation myocardial infarction (NSTEMI) patients before commencing the needed invasive treatment. The aim of this study is to evaluate the role of the H_2FPEF score in detecting CIN in NSTEMI patients undergoing emergency PCI.

METHODS

Study Design and Population

This prospective, single center study at Benha University Hospitals, Egypt included 600 patients with NSTEMI scheduled for emergency coronary angiography and PCI throughout the period from February 2023 to September 2024. The exclusion criteria included patients with a history of coronary artery bypass grafting, a history of valve replacement, reduced left ventricular ejection fraction (LVEF) (LVEF <40%), chronic kidney disease [patients with baseline estimated glomerular filtration rate 30 mL/min], and patient refusal. Patients were classified into 2 groups according to the incidence of CIN; the first group included 89 patients who developed CIN and the second group included 511 patients without CIN.

This research was approved by research Ethics Committee of Benha University, Faculty of Medicine, Egypt (approval no: MS 7-8-2023, date: 02.06.2024). All participants provided written informed consent.

Definitions

H_2FPEF score was calculated from clinical and echocardiographic data. The score ranges from 0 to 9 depending on the following data: obesity [body mass index (BMI) >30 kg/m^2] (2 points), use of ≥2 antihypertensive medications (1 point), history of atrial fibrillation (AF) (3 points), pulmonary artery systolic pressure (PASP) >35mmHg (1 point), age >60 years (1 point), E/e' >9 (1 point).[5]

CIN is considered if serum creatinine rises by 25% from baseline or the absolute serum creatinine level rises by 0.5 mg/dL within 48-72 hours following contrast media exposure.[6]

Echocardiographic Measurements

Transthoracic echocardiography measurements were performed using the Vivid 7 ultrasound machine (GE Vingmed Sound, Horten, Norway), with a 2.5-3.5 MHz transducer, in accordance with American Society of Echocardiography guidelines.[7] Modified Simpson's method was used to evaluate LV systolic function.

We measured the ratio of early transmitral flow velocity (E) to early diastolic mitral annular velocity (e') using tissue Doppler imaging (E/e'). PASP was calculated as (4× tricuspid regurgitation pressure gradient) + right atrial pressure.

Coronary Angiography and PCI

We used low-osmolar, nonionic contrast media (Iohexol, omnipaque 350 mg/mL) during PCI procedures. Patients with GFR <60 mL/min./1.73 m^2 received intravenous hydration using normal saline at a rate of 1 mL/kg/hr (or 0.5 mL/kg/hr in HF patients). Aspirin (300 mg) and a P2Y12 antagonist (clopidogrel 600 mg or ticagrelor 180 mg) were given before PCI. During the procedure, unfractionated heparin (70-100 U/kg) was used. Glycoprotein IIb/IIIa inhibitors were used according to the operator's discretion.

Follow-up

The patients were followed up by monitoring plasma creatinine levels and calculating the GFR to determine the development of CIN.

Statistical Analysis

SPSS v26 (IBM Inc., Chicago, IL, USA) was used for statistical analysis. Quantitative variables were expressed as a mean and standard deviation. Comparison between groups was done using unpaired Student's t-test. However, qualitative variables were expressed as frequencies and percentages (%), and Chi-square tests or Fisher's exact tests were used for comparison. We used logistic regression analysis to detect CIN predictors. The receiver operating characteristic (ROC) curve was used to identify the H_2FPEF score cutoff value to predict CIN. *P*-value <0.05 was considered statistically significant.

RESULTS

Baseline characteristics are presented in Table 1. The incidence of CIN was 14.83%. Patients in the CIN group were significantly older ($P = 0.016$). Hypertension (HTN) ($P = 0.022$), smoking ($P = 0.037$), hyperlipidemia ($P = 0.006$), and AF ($P = 0.001$) were significantly more prevalent in the CIN group. The CIN group had significantly higher BMI (28.9±3.19 vs. 27.9±3.11 kg/m^2, $P = 0.005$). However, there was no statistically significant difference between the 2 groups regarding gender, prevalence of stroke, diabetes mellitus (DM), HF, and prior PCI; height, heart rate, weight, systolic, and diastolic blood pressure.

Regarding the renal function tests, no significant statistical differences were detected between the two groups in terms of baseline serum creatinine, GFR, and blood urea nitrogen.

The CIN group had significantly higher H_2FPEF scores. Regarding the individual components of the H_2FPEF score, the number of patients with BMI >30 Kg/m^2, HTN, AF, and aged patients were significantly higher in the CIN group (Table 2).

Table 1: Demographic and clinical data of the studied groups

	Non-CIN group (n=511)	CIN group (n=89)	*P*-value
Age (years)	60.4±9.1	62.9±8.67	0.016*
Male gender	286 (55.97%)	47 (52.81%)	0.580
Smoking	232 (45.4%)	51 (57.3%)	0.037*
Hypertension	237 (46.38%)	53 (59.55%)	0.022*
Diabetes mellitus	1 (34.64%)	26 (29.21%)	0.318
Hyperlipidemia	1 (45.01%)	54 (60.67%)	0.006*
Stroke	2 (3.52%)	6 (6.74%)	0.153
AF	2 (9%)	27 (30.34%)	0.001*
HF	2 (44.23%)	37 (41.57%)	0.641
Previous PCI	2 (7.44%)	5 (5.62%)	0.539
Weight (Kg)	77.5±7.69	77.1±7.18	0.646
Height (m)	1.66±0.04	1.67±0.04	0.309
BMI (kg/m^2)	27.9±3.11	28.9±3.19	0.005*
HR (beats/min)	84.8±8.87	84.8±9.07	0.96
SBP (mmHg)	125.9±9.84	124.8±9.78	0.367
DBP (mmHg)	80.4±7.46	80.1±6.99	0.725
Hb (g/dL)	11.73±0.88	11.67±0.83	0.589
Na+ (mmoL/dL)	141.1±2.59	140.7±2.75	0.300
K+ (mmoL/dL)	4.56±0.57	4.56±0.60	0.966
Total cholesterol (mg/dL)	145.65±19.42	143.87±18.74	0.574
TG (mg/dL)	176.5±25.92	175.8±25.15	0.808
HDL (mg/dL)	43.5±2.91	43.4±3.14	0.645
LDL (mg/dL)	104.98±14.97	105.75±14.4	0.652
eGFR (mL/min/1.73 m^2)			
Baseline	94.8±12.64	93.6±10.87	0.404
After	96.9±13.3	98.2±9.96	0.365
Serum creatinine (mg/dL)			
Baseline	1.21±0.12	1.24±0.12	0.062
After	1.32±0.31	1.87±0.75	**0.001***
BUN (mg/dL)			
Baseline	29.95±3.22	31.09±2.9	0.12
After	30.6±3.79	34.7±3.44	**0.001***
LVEDV (mL)	45.04±2.62	44.7±2.61	0.299
LVESV (mL)	36.1±4.1	37.2±3.7	**0.016***
WMSI	1.50±0.25	1.53±0.26	0.244
E	66.9±7.42	66.7±7.1	0.854
e’	6.6±1.13	6.4±1.08	0.087
E/e’ ratio	10.5±2.23	10.8±2.13	0.232
PASP (mmHg)	29.20±5.88	29.22±5.98	0.97
Contrast volume (cc)	216.75±39.84	218.96±41.5	0.46
H_2FPEF	2.8±1.58	3.2±1.71	**0.012***

*: Statistically significant as *P*-value <0.05.

CIN: Contrast induced nephropathy, AF: Atrial fibrillation, HF: Heart failure, PCI: Percutaneous coronary intervention, BMI: Body mass index, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, Hb: Hemoglobin, TG: Triglycerides, HDL: High density lipoprotein, LDL: Low density lipoprotein, eGFR: Estimated glomerular filtration rate, BUN: Blood urea nitrogen, LVEDV: Left ventricular end-diastole volume, LVESV: Left ventricular end-systolic volume, WMSI: Wall motion score index, E/e’: Early mitral inflow velocity to early diastolic mitral annulus velocity ratio, PASP: Pulmonary artery systolic pressure, H_2FPEF: Obesity “H”, hypertension “H”, atrial fibrillation “F”, pulmonary hypertension “P”, an age >60 years “E”, and E/e’ >9 “F”

Table 2: H_2FPEF score and its components of the studied groups

	Non-CIN group (n=511)	CIN group (n=89)	*P*-value
H_2FPEF (Mean ± SD)	2.8±1.58	3.2±1.71	**0.012***
BMI (>30 kg/m^2)	146 (28.57%)	36 (40.45%)	**0.024***
HTN	237 (46.38%)	53 (59.55%)	**0.022***
AF	2 (9%)	27 (30.34%)	**0.001***
Pulmonary hypertension	29 (5.7%)	6 (6.7%)	0.72
Elderly (age>60 years)	254 (49.71%)	58 (65.17%)	**0.007***
E/e' ratio (>9)	363 (71.04%)	66 (74.16%)	0.547

*: Statistically significant as *P*-value <0.05.

H_2FPEF: Obesity "H", hypertension "H", atrial fibrillation "F", pulmonary hypertension "P", an age >60 years "E", and E/e' > 9 "F", BMI: Body mass index, HTN: Hypertension, AF: Atrial fibrillation, E/e': Early mitral inflow velocity to early diastolic mitral annulus velocity ratio

Using the univariate logistic regression analysis, older age, HTN, DM, AF, HF, PASP, and H_2FPEF score were significant predictors of the incidence of CIN. However, multivariate regression analysis revealed that age, DM, and H_2FPEF score were the only significant predictors for the incidence of CIN (Table 3). An ROC curve was performed to detect the diagnostic accuracy of H_2FPEF score to predict the incidence of CIN. The H_2FPEF score can predict CIN with an AUC of 0.575 and a *P*-value of 0.020 at a cutoff of >1 demonstrating 85.39% sensitivity, 50.49% specificity, 16.1% positive predictive value (PPV), and 89.8% negative predictive value (NPV) (Figure 1).

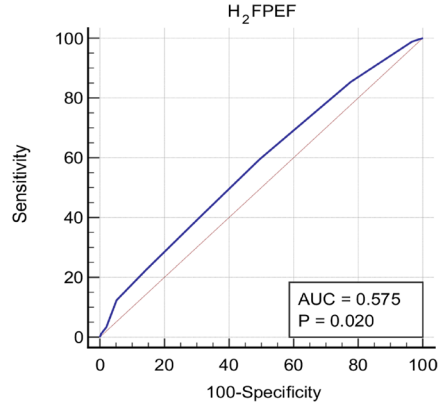

Figure 1: ROC curve analysis of H_2FPEF for prediction of the incidence of CIN

ROC: Receiver operating characteristic, CIN: Contrast-induced nephropathy

DISCUSSION

PCI remains the gold standard for management of acute coronary syndrome (ACS). Even if successful revascularization was achieved, CIN is associated with increased mortality, morbidity, and prolonged hospital stay.[8]

H_2FPEF is a simple score based on clinical and echocardiographic data. It was previously used in several studies to detect the severity and complexity of CAD.[9] Our study was done to determine whether this score can predict CIN in ACS patients undergoing PCI.

Our study revealed that the incidence of CIN was 14.83%. Similarly, Wang et al.[10] reported an incidence of CIN of 15.33% in ACS patients undergoing PCI. Also, Imadoğlu et al.[11] found that CIN occurred in 18.5% of ACS patients.

CIN development has several well-established risk factors such as renal impairment, older age (> 65 years), presence of HF, DM, non-steroidal anti-inflammatory and other nephrotoxic drugs, long-standing hypotension, dehydration, and high doses of contrast medium. Contrast-medium osmolality has, also, a major role in CIN development.[12]

Our study revealed that patients with CIN were significantly older and with a higher prevalence of HTN, dyslipidemia, smoking, and AF. A finding consistent with Imadoğlu et al.[11] who reported that ACS patients who had CIN were older, diabetics, and smokers.

The present study reported that the CIN group had a significantly higher H_2FPEF score. Regarding the individual components of the H_2FPEF score, the CIN group had a significantly higher number of patients with BMI >30 kg/m^2, HTN, AF, and elderly patients. Based on univariate logistic regression analysis, we found that age, HTN, DM, AF, HF, PASP, and H_2FPEF score are significant predictors for the incidence of CIN. Multivariate regression analysis revealed that age, DM, and H_2FPEF were the only significant independent predictors for CIN after emergency PCI. Similarly, Ozbeyaz et al.[13] found that significantly higher H_2FPEF scores were present in the CIN patients (4.10±1.92 vs. 2.28±1.56, $P < 0.001$). Also, they found that H_2FPEF score is an independent predictor of CIN development [odds ratio 1.633 95% confidence interval (1.473-1.811), $P < 0.001$] together with age, DM, PASP, and left anterior descending as an infarct-related artery. In addition, they supported our results by concluding that H_2FPEF score is a predictor of CIN in ACS patients undergoing PCI.

Table 3: Logistic regression analysis for prediction of CIN

	Univariate		Multivariate	
	OR (95% CI)	***P*-value**	**OR (95% CI)**	***P*-value**
Age (years)	1.032 (1.0058 to 1.0589)	**0.016***	1.035 (1.0085 to 1.0623)	**0.009***
Sex	0.587 (0.3664 to 0.9431)	0.28	1.355 (0.7058 to 2.602)	0.361
BMI (kg/m^2)	1.069 (0.9972 to 1.1476)	0.060	1.067 (0.9940 to 1.1472)	0.072
Smoking	1.114 (0.7062 to 1.7588)	0.641	0.662 (0.3217 to 1.3644)	0.264
Hypertension	0.587 (0.3718 to 0.9285)	**0.023***	0.658 (0.3501 to 1.2383)	0.195
Diabetes mellitus	0.619 (0.3932 to 0.9763)	**0.039***	0.565 (0.3507 to 0.9115)	**0.019***
Hyperlipidemia	1.123 (0.7097 to 1.7779)	0.619	0.930 (0.7122 to 1.2150)	0.595
Stroke	0.505 (0.1948 to 1.3096)	0.160	0.465 (0.1731 to 1.2528)	0.130
AF	0.227 (0.1318 to 0.3914)	**<0.001***	0.931 (0.7130 to 1.2158)	0.600
HF	0.530 (0.3350 to 0.8401)	**0.007***	1.032 (0.6354 to 1.6766)	0.898
Previous PCI	1.349 (0.5163 to 3.5280)	0.541	1.364 (0.4969 to 3.7464)	0.546
HR (beats/min)	0.999 (0.9743 to 1.0250)	0.960	1.00 (0.9750 to 1.0257)	0.998
SBP (mmHg)	0.989 (0.9670 to 1.0125)	0.366	0.989 (0.9669 to 1.0124)	0.364
DBP (mmHg)	0.994 (0.9647 to 1.0253)	0.725	0.994 (0.9644 to 1.0251)	0.715
Hb (g/dL)	1.120 (1.0417 to 1.2046)	0.42	0.942 (0.7266 to 1.2202)	0.649
Na+ (mmoL/dL)	0.931 (0.7194 to 1.2054)	0.588	0.954 (0.8748 to 1.0408)	0.290
K+ (mmoL/dL)	0.996 (0.9917 to 1.0021)	0.248	1.005 (0.6760 to 1.4935)	0.981
TG (mg/dL)	0.955 (0.8759 to 1.0416)	0.299	0.999 (0.9898 to 1.0073)	0.736
HDL (mg/dL)	0.982 (0.9097 to 1.0603)	0.644	0.983 (0.9102 to 1.0612)	0.658
LDL (mg/dL)	1.003 (0.9884 to 1.0188)	0.652	1.004 (0.9886 to 1.0191)	0.632
eGFR (mL/min/1.73 m^2)	0.992 (0.9743 to 1.0105)	0.403	0.989 (0.9701 to 1.0082)	0.258
Serum creatinine (mg/dL)	6.492 (0.9783 to 43.0791)	0.053	1.077 (0.9719 to 1.1946)	0.156
BUN (mg/dL)	0.991 (0.6685 to 1.4707)	0.966	1.465 (0.5822 to 3.6896)	0.417
LVEDV (mL)	0.957 (0.8762 to 1.0414)	0.289	0.957 (0.8763 to 1.0461)	0.335
LVESV (mL)	0.954 (0.8754 to 1.0412)	0.294	0.967 (0.8851 to 1.0577)	0.468
WMSI	1.690 (0.6983 to 4.0932)	0.244	1.815 (0.7233 to 4.5559)	0.204
E/e' ratio	1.062 (0.9618 to 1.1743)	0.232	1.059 (0.9565 to 1.1721)	0.270
PASP (mmHg)	1.005 (1.0001 to 1.0115)	**0.046***	2.101 (1.1353 to 3.8881)	0.18
Contrast volume (cc)	1.001 (0.9632 to 1.0397)	0.970	1.005 (0.9996 to 1.0113)	0.069
H_2FPEF	1.188 (1.0378 to 1.3604)	**0.012***	0.218 (0.1198 to 0.3982)	**<0.001***

*: Statistically significant as *P*-value <0.05.

BMI: Body mass index, AF: Atrial fibrillation, HF: Heart failure, PCI: Percutaneous coronary intervention, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, Hb: Hemoglobin, TG: Triglycerides, HDL: High density lipoprotein, LDL: Low density lipoprotein, eGFR: Estimated glomerular filtration rate, BUN: Blood urea nitrogen, LVEDV: Left ventricular end-diastole volume, LVESV: Left ventricular end-systolic volume, WMSI: Wall motion score index, E/e': Early mitral inflow velocity to early diastolic mitral annulus velocity ratio, PASP: Pulmonary artery systolic pressure, OR: Odds ratio, CI: Confidence interval

We further investigated the diagnostic accuracy of H_2FPEF for predicting the incidence of CIN, and we found that H_2FPEF can significantly predict the incidence of CIN ($P = 0.020$) with AUC of 0.575, at cut-off >1, with 85.39% sensitivity, 50.49% specificity, 16.1% PPV, and 89.8% NPV. Despite being statistically significant, the low AUC implies limited diagnostic accuracy. Therefore, it can be used to identify patients at increased risk of developing CIN. The NPV (89.8%) is good, suggesting that if the score is ≤ 1, it's highly likely the patient will not develop CIN. This high NPV might be a more practical takeaway for the score than its low PPV (16.1%). Similarly, Ozbeyaz et al.[13] evaluated the relationship between the H_2FPEF score and CIN in ACS patients undergoing PCI. The ROC curve identified an H_2FPEF score of 2.5 as an optimal cut-off value to predict CIN development with a sensitivity of 79.8% and a specificity of 64.1%. The difference in optimal cut-off values could be due to differences in the patient populations, as they studied patients with ACS; however, we assessed only patients with STEMI.

Study Limitations

This study had some limitations. Firstly, the modest AUC of the ROC indicates weak predictive capacity. Additionally, there was no external validation cohort. Also, it was a single center research, evaluating only patients with NSTEMI with a small sample size. The small number of patients developing CIN might influence the generalizability of findings. Finally, intraobserver and interobserver variability could not be excluded.

CONCLUSION

H_2FPEF score shows a statistically significant, but limited discriminatory ability in predicting CIN after emergency PCI in NSTEMI patients. Its utility as a standalone predictor appears limited and requires further validation. However it can be used to identify patients at increased risk of CIN.

Ethics

Ethics Committee Approval: This research was approved by research Ethics Committee of Benha University, Faculty of Medicine, Egypt (approval no: MS 7-8-2023, date: 02.06.2024).

Informed Consent: All participants provided written informed consent.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.S.M.S., M.A.E., M.S.A.A.N., Concept: A.S.M.S., E.S.A.E.K.E.D., M.S.A.A.N., Design: A.S.M.S., E.S.A.E.K.E.D., M.S.A.A.N., Data Collection or Processing: A.S.M.S., M.A.E., M.S.A.A.N., Analysis or Interpretation: A.S.M.S., E.S.A.E.K.E.D., M.A.E., M.S.A.A.N., Literature Search: A.S.M.S., M.A.E., M.S.A.A.N., Writing: A.S.M.S., M.A.E., M.S.A.A.N.

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