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Research Article

Association between Insulin Resistance and BARD Fibrosis Risk Score in Women with Metabolic Dysfunction Associated with Steatotic Liver Disease: A Cross-Sectional Study

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Abstract

Background: The prevalence of metabolic dysfunction-associated steatotic liver disease (MASLD) is rising, and its association with insulin resistance (IR) is well established. In many settings, liver biopsy and elastography are not universally available; therefore, simple noninvasive scores are used to estimate fibrosis risk. ***Objectives***: To investigate the relationship between IR and non-invasive fibrosis risk scores in women with ultrasonography-identified MASLD. ***Methods***: In this cross-sectional study, adult women with MASLD underwent fasting glucose and insulin testing to estimate HOMA-IR. Fibrosis risk was evaluated using the BARD score, APRI, and FIB-4. Group comparisons, correlation analyses, receiver operating characteristic (ROC) analysis, and multivariable models were performed. ***Results***: HOMA-IR was significantly higher in women classified as high fibrotic risk by the BARD score (n = 96). HOMA-IR correlated positively with BARD and APRI but showed weak association with FIB-4. In multivariable analysis, higher BARD scores remained independently associated with higher HOMA-IR. ***Conclusions***: Insulin resistance was independently associated with higher noninvasive fibrosis risk in women with MASLD, particularly as assessed by the BARD score. These findings support the clinical utility of simple scores for risk stratification where access to advanced testing is limited.

Keywords: APRI; BARD; FIB-4; HOMA-IR; Insulin resistance; MASLD.

العلاقة بين مقاومة الأنسولين ودرجة خطر تليف BARD لدى النساء المصابات بخلل الأيض المرتبط بمرض الكبد الدهني: دراسة مقطعية

الخلاصة

الخلفية: انتشار مرض الكبد الدهني المرتبط بخلل الأيض (MASLD) في تزايد، وارتباطه بمقاومة الأنسولين (IR) مثبت جيدا. في العديد من الحالات، لا تتوفر خزعة الكبد والتصوير المرن بشكل عام؛ لذلك، تستخدم مؤشرات بسيطة غير جراحية لتقدير خطر التليف. **الأهداف**: دراسة العلاقة بين درجات خطر التليف المقاوم وغير الجراحي لدى النساء المصابات باضطراب الألياف العضلية الحساسة التي تم تحديدها بواسطة الموجات فوق الصوتية. **الطرائق**: في هذه الدراسة المقطعية، خضعت النساء البالغات المصابات بـMASLD المفرط لاختبار الجلوكوز والأنسولين الصائم لتقدير HOMA-IR. تم تقييم خطر التليف باستخدام درجة BARD، وAPRI، وFIB-4. تم إجراء مقارنات جماعية، وتحليلات ارتباط، وتحليل خصائص تشغيل المستقبل (ROC)، ونماذج متعددة المتغيرات. **النتائج**: كان HOMA-IR أعلى بشكل ملحوظ لدى النساء المصنفات كخطر ليفي عالي حسب درجة BARD (n = 96). ارتبط HOMA-IR إيجابيا ب BARD وAPRI لكنه أظهر ارتباطا ضعيفا مع FIB-4. في التحليل متعدد المتغيرات، ظلت درجات BARD الأعلى مرتبطة بشكل مستقل بارتفاع HOMA-IR. **الاستنتاجات**: ارتبطت مقاومة الأنسولين بشكل مستقل بزيادة خطر التليف غير الجراحي لدى النساء المصابات بـMASLD، كما تم تقييمها بنتيجة BARD. تدعم هذه النتائج الفائدة السريرية للدرجات البسيطة لتصنيف المخاطر حيث يكون الوصول إلى الفحوصات المتقدمة محدودا.

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INTRODUCTION

MASLD is the hepatic manifestation of metabolic dysfunction and affects a considerable and growing proportion of adults worldwide [1,2]. Although many patients are asymptomatic, a substantial proportion develop progressive fibrosis and may progress to cirrhosis with hepatic complications [3,4]. Insulin resistance is a central pathogenic mechanism in MASLD and contributes to disease development and progression through dysregulated lipid metabolism, increased oxidative stress, inflammatory activation, and profibrogenic signaling [5–7]. Direct evaluation of fibrosis is not always feasible; therefore, pragmatic estimates of fibrosis risk such as the BARD score, APRI, and FIB-4 are commonly used in clinical practice [8–11]. Furthermore, recent Iraqi studies published in AJMS emphasize fatty liver disease as part of a broader cardiometabolic risk phenotype. Al-Ani et al. reported a significant association between fatty liver stage and increased carotid intima–media thickness (CIMT), a surrogate of subclinical atherosclerosis [12]. Akkila *et al*. reported NAFLD (now MASLD) in 31% of obese adults and observed associations with anthropometric indices and adipose tissue thickness, supporting the relevance of routine clinical measures in NAFLD risk assessment [13]. This study aims to assess the correlation between insulin resistance (HOMA-IR) and non-invasive fibrosis risk scores among women with ultrasound-diagnosed MASLD in Iraq and to evaluate the diagnostic performance of HOMA-IR for predicting high BARD scores.

METHODS

Study design and setting

This analytic cross-sectional study was conducted at a tertiary teaching hospital and outpatient clinics in Iraq. Eligible participants were apparently healthy women diagnosed with hepatic steatosis during routine abdominal ultrasonography.

Inclusion criteria

Adult women aged ≥18 years with ultrasonography-detected fatty liver were eligible.

Exclusion criteria

Included heavy alcohol use, viral hepatitis, other chronic liver diseases, pregnancy, and incomplete laboratory data.

Outcome measurements

Measurements and Definitions: Fasting glucose, fasting insulin, liver enzymes, platelet count, and lipid profile were measured from venous blood after overnight fasting. Insulin resistance was estimated using the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR): fasting insulin (µU/mL) × fasting glucose (mmol/L) / 22.5 [14]. Categorical insulin resistance was defined as HOMA-IR ≥2.5 [15]. Non-invasive fibrosis scores (BARD, APRI, FIB-4) were calculated using standard formulas [9–11].

Ethical considerations

The study was approved by the Research Ethics Committee of the Ministry of Health, Directorate General of Health (approval number: xxxxxxx). All participants provided written informed consent, and no identifiable patient information was collected or disclosed.

Statistical analysis

Continuous variables were summarized as mean±SD (and range when relevant). Associations between HOMA-IR and metabolic/hepatic parameters were assessed using Spearman correlation. Group comparisons used the Mann–Whitney U test (two-group comparisons) or Kruskal–Wallis test (three-group comparisons). Discriminatory performance for high BARD risk was evaluated using ROC analysis. Univariate analyses assessed factors associated with HOMA-IR (age, BMI, waist circumference, triglycerides, HDL-C, and systolic blood pressure). Multivariable linear regression was used to identify independent predictors of HOMA-IR. A two-sided $p < 0.05$ was considered statistically significant.

RESULTS

Table 1 summarizes the baseline anthropometric and metabolic characteristics of the cohort at rest. The participants were predominantly overweight (BMI: 34.54±5.53 kg/m²) and had a mean waist circumference of 98.65±10.83 cm. Insulin resistance was prevalent (HOMA-IR 4.23 ± 3.66, range 1.12–25.00).

Table 1: Baseline anthropometric and metabolic characteristics of the study population (n=96).

Variable	Mean±SD	Range
HOMA-IR	4.23±3.66	1.12-25
BMI (kg/m²)	34.54±5.53	23.63-51.04
Waist circumference (cm)	98.65±10.83	79-130
APRI	0.24±0.08	0.10-0.6
FIB-4	0.73±0.26	0.3-1.48
BARD score	2.55±0.99	0-4.0
Total cholesterol (mg/dL)	178.28±40.92	102-279
HDL (mg/dL)	47.37±13.84	29-110.8
LDL (mg/dL)	103.29±31.53	41.3-188
Triglycerides (mg/dL)	146.67±89.79	36-710

Mean APRI and FIB-4 scores were low (0.24 ± 0.08 and 0.73 ± 0.26, respectively), indicative of an early disease phenotype. Spearman correlations of HOMA-IR with metabolic/liver indexes are presented in Table 2.

Table 2: Spearman correlations between HOMA-IR and metabolic/hepatic variables

Variable	Spearman r	*p*-value
BMI	0.205	0.045
Waist circumference	0.221	0.030
APRI	0.265	0.009
FIB-4	0.060	0.564
BARD score	0.426	<0.001
Total cholesterol	0.006	0.950
HDL	0.009	0.931
LDL	-0.074	0.476
Triglycerides	0.004	0.973

HOMA-IR was positively correlated with BARD score ($r = 0.426$, $p< 0.001$), APRI ($r = 0.265$, $p= 0.009$), BMI ($r = 0.205$, $p= 0.045$), and waist circumference ($r = 0.221$, $p= 0.030$). HOMA-IR showed no significant correlations with FIB-4 or lipid fractions. Scatter plots showing associations between HOMA-IR and BARD score (Figure 1) and waist circumference are provided (Figure 2). HOMA-IR levels did not differ significantly across FIB-4 fibrosis categories ($p= 0.250$). BMI, waist circumference, total cholesterol, and triglycerides also did not differ by FIB-4 category (Table 3).

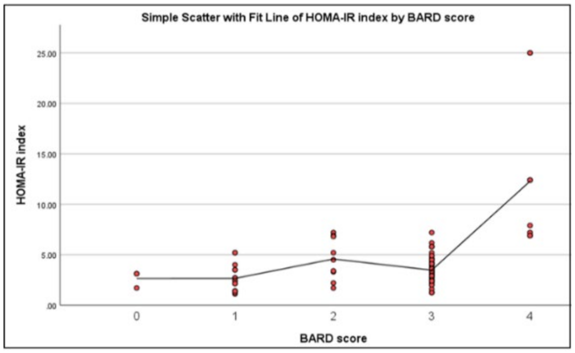

Figure 1: Scatter plot showing the relationship between HOMA-IR and BARD score.

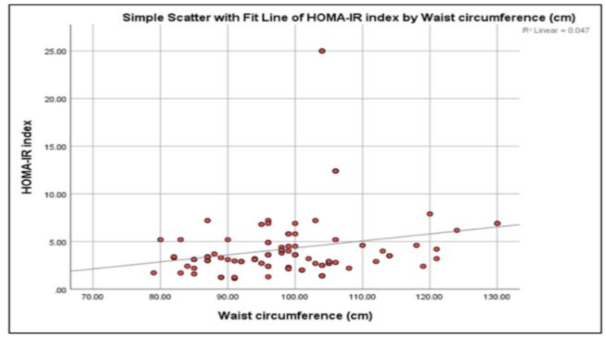

Figure 2: Scatter plot showing the relationship between HOMA-IR and waist circumference.

Table 3: Mann–Whitney U test comparing variables between low and high BARD fibrosis risk groups

Variable	Low BARD risk Mean rank (n=20)	High BARD risk Mean rank (n=76)	U statistic	*p*-value
HOMA-IR	29.68	53.45	383.5	<0.001
BMI	52.80	47.37	674.0	0.438
Waist circumference	51.55	47.70	699.0	0.582

Categorical insulin resistance (HOMA-IR ≥2.5) was significantly associated with high BARD fibrosis risk (χ^2= 8.421, *p*= 0.004) (Table 4).

Table 4: Crosstabulation of HOMA-IR category and BARD fibrosis risk (χ^2=8.421, *p*=0.004)

HOMA-IR category	Low BARD risk (n=20)	High BARD risk (n=76)	*p*-value
Normal (<2.5)	10(50)	14(18.4)	0.004
Insulin resistant (≥2.5)	10(50)	62(81.6)	0.006

Values were expressed as frequency and percentage.

Insulin resistance was more frequent in the high-BARD group than the low-BARD group (81.6% *vs*. 50.0%), and this distribution is shown in Figure 3.

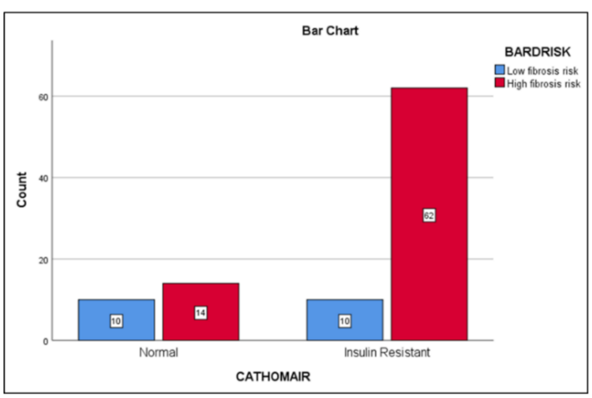

Figure 3: Distribution of BARD fibrosis risk groups by categorical HOMA-IR status (HOMA-IR ≥2.5).

In ROC analysis for high BARD risk, HOMA-IR showed acceptable discriminatory performance (AUC 0.743), followed by BMI, waist circumference, APRI, and FIB-4 (Table 5). The multivariable regression model (R^2= 0.172; *p*= 0.050) explained 17.2% of the variance in HOMA-IR (Table 6). Age was independently associated with HOMA-IR (standardized β= -0.341; Table 7).

Table 5: ROC analysis: discriminatory ability of markers for high BARD risk

Test variable	AUC	Interpretation
HOMA-IR	0.743	Acceptable
BMI	0.658	Modest
Waist circumference	0.639	Modest
APRI	0.632	Modest
FIB-4	0.670	Modest

Table 6: Multiple linear regression model summary for predictors of HOMA-IR

Model	R	R^2	Adjusted R^2	*p*-value
1	0.415	0.172	0.086	0.050

Table 7: Regression coefficients for predictors of HOMA-IR

Predictor	B	SE	Standardized β	t
Age (year)	-0.131	0.056	-0.341	-2.315*
BMI (kg/m²)	0.062	0.104	0.094	0.597
WC (cm)	0.057	0.054	0.169	1.058
APRI	3.016	5.804	0.068	0.520
FIB-4	2.150	2.499	0.150	0.861
Total cholesterol (mg/dL)	-0.016	0.020	-0.183	-0.807
HDL (mg/dL)	-0.005	0.030	-0.021	-0.184
LDL (mg/dL)	0.004	0.023	0.038	0.195
Triglycerides (mg/dL)	0.000	0.005	-0.011	-0.088

WC: Waist circumference; IR, insulin resistance (>2.5 as HOMA-IR). High BARD risk is defined as a BARD score ≥2. **p*<0.05.

DISCUSSION

Our study demonstrates a strong association between insulin resistance and high-risk non-invasive fibrosis (BARD) among apparently healthy women with ultrasound-detected MASLD in Iraq. The BARD score correlated positively with HOMA-IR and was also associated with APRI, BMI, and waist circumference. These findings support the established role of insulin resistance in MASLD progression through altered lipid metabolism, oxidative stress, inflammation, and profibrogenic signaling [5–7]. Importantly, HOMA-IR showed acceptable predictive performance for high BARD fibrosis risk among the evaluated markers in our cohort. This suggests that integrating metabolic parameters (fasting insulin and fasting glucose) may improve risk stratification in MASLD, particularly in settings where advanced fibrosis assessment techniques are not readily available. Regional Iraqi studies—including recent work published in AJMS—have emphasized the cardiometabolic context of fatty liver disease, supporting the relevance of metabolic risk assessment in local practice [12,13]. In the literature, HOMA-IR thresholds to define insulin resistance vary by population and study design [15]. In contrast, we observed no significant differences in HOMA-IR across FIB-4 categories. Such findings may reflect generally low FIB-4 values and an early disease profile in our cohort, limiting the discriminative ability of FIB-4 in this setting.

Study limitations

This study has limitations. Its cross-sectional design precludes causal inference. Steatosis was diagnosed by ultrasonography. There was no liver biopsy or elastography for direct fibrosis staging. In addition, only women were enrolled, and the study was conducted at a single center, which may limit generalizability but defines risk assessment needs.

Conclusion

In women with MASLD detected by ultrasonography in Iraq, insulin resistance was associated with an increased risk of non-invasive fibrosis according to the BARD score. HOMA-IR, which stands for Homeostasis Model Assessment of Insulin Resistance, had good predictive performance for high BARD risk and may help in selecting patients to undergo additional evaluation where elastography resources are limited.

Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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