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RESEARCH ARTICLE

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Monocyte to high-density lipoprotein cholesterol ratio as an independent risk factor for papillary thyroid carcinoma

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Abstract

Background: Papillary thyroid carcinoma (PTC) is considered to be an inflammatory disease. This study aimed to investigate the association of monocyte to high-density lipoprotein cholesterol ratio (MHR) with PTC.

Methods: Clinical parameters from 300 patients with PTC and 552 patients with benign thyroid nodule were compared. Serum renal function and liver enzymes, fasting plasma glucose, lipid profile, and blood cell count were measured.

Results: Patients with PTC had a higher MONO ($p < 0.001$) and MHR ($p < 0.001$). There was a step-wise increase in the prevalence of PTC ($p = 0.003$) with the tertile of MHR. Logistic regression analysis revealed that MHR could be considered an independent risk factor ($p < 0.001$) in the case-control study and the cohort study. Pearson correlation analysis and simple linear regression analysis indicated that MHR was positively associated with neutrophil (NEU) and lymphocyte (LYM) count as well as neutrophil-to-lymphocyte ratio (NLR). Area under the curve (AUC) was 0.711. The optimal cutoff of MHR was 0.33×10^9/mmol.

Conclusion: This study identifies novel evidence that patients with PTC have a higher MHR. MHR is an independent risk factor for PTC. These findings support the application of MHR to predict, diagnose, and evaluate the occurrence of PTC.

KEYWORDS
high-density lipoprotein cholesterol, inflammation, monocyte, monocyte to high-density lipoprotein cholesterol ratio, papillary thyroid carcinoma

1 | INTRODUCTION

There is increasing and consistent evidence that inflammation is closely related to the occurrence and development of cancer.[1-3] Numerous studies have suggested that activation of inflammation is a crucial mechanism that underlies the initiation and progression of thyroid cancer.[4,5] Papillary thyroid carcinoma (PTC) is the most common histological type of differentiated thyroid malignancy. Systemic inflammatory markers, which include systemic inflammation response index,[6] C-reactive protein,[7] neutrophil-(NEU)-to-lymphocyte (LYM) ratio (NLR),[8-10] platelet-lymphocyte ratio (PLR),[11] lymphocyte-to-monocyte ratio (LMR),[12,13] mean platelet volume (MPV), [14] and red cell distribution width (RDW)[15] have recently been shown to be independent prognostic factors in patients with PTC.

Yufeng Pang considered as co-first author.

Monocyte (MONO) to high-density lipoprotein cholesterol (HDL-C) ratio (MHR) is obtained by dividing the MONO count by HDL-C. Monocytes are essential immune system cells that have unique roles during the inflammatory response[16] while HDL-C has several biological activities including inhibition of the proliferation, differentiation, and activation of monocytes, and anti-inflammatory and anti-oxidative roles.[17,18] HDL-C, alone or with the ratio of uric acid (UA), is associated with metabolic syndrome,[19] type 2 diabetes mellitus,[20] thyroiditis,[21] and liver steatosis.[22] MHR is a new biomarker of inflammation and oxidative stress[23,24] and is being increasingly recognized as a novel clinically relevant biomarker of pathological inflammation and a new predictor and prognostic factor in cardiovascular disease,[25-27] peripheral artery disease,[28] metabolic syndrome,[29] diabetic nephropathy,[30] and multiple sclerosis.[31]

Papillary thyroid carcinoma is also associated with increased inflammatory burden. There are no data about the relationship between MHR and PTC. Therefore, our study aimed to investigate this association.

2 | METHODS

2.1 | Study design and population

The study was carried out from January 2018 to December 2020 and involved 372 patients with PTC and 651 people with benign thyroid nodule (BTN) who were recruited from the inpatient departments of Shanghai Fifth People's Hospital, Fudan University. Diagnosis of PTC and BTN was based on pathology. Retrospective analysis of parameters was performed according to the process described in Figure 1. Subjects were excluded from the study if they had any of the following: history of acute infectious disease, abnormal liver or renal function, leukopenia, or any treatment with immunosuppressive agents. Finally, data from 300 patients with PTC and 552 patients with BTN were analyzed.

The study protocol was approved by the medical ethics committee of Shanghai Fifth People's Hospital, Fudan University (NO.2018–114). Informed consent was obtained from all patients and subjects.

2.2 | Data collection

Patient age and medical history, including medication, and body mass index (BMI) were recorded. After a 12-h overnight fast, blood was obtained for assessment of renal function, liver enzymes, fasting plasma glucose (FPG), lipid profile, and blood cell count.

2.3 | Laboratory data

Serum alanine aminotransferase (ALT), urea nitrogen (UN), UA, creatinine (Crea), total cholesterol (TC), HDL-C, low-density lipoprotein

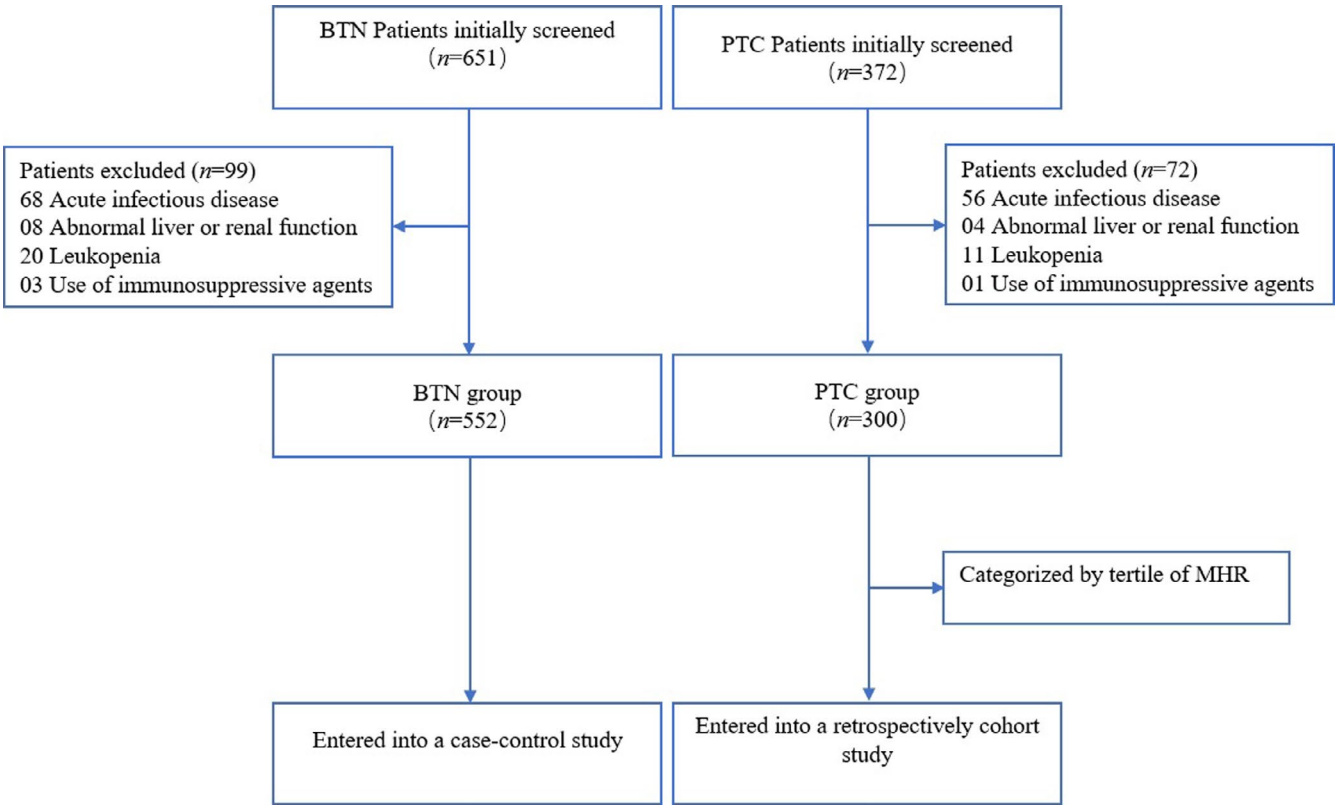

FIGURE 1 Flow chart of the study. BTN, benign thyroid nodule; PTC, papillary thyroid carcinoma; MHR, monocyte to HDL cholesterol ratio

cholesterol (LDL-C), and FPG were analyzed using an automatic analyzer (Cobas702; Roche Corporation). NEU, LYM, MONO, and C-reactive protein (CRP) were analyzed using an automatic blood cell analyzer (Sysmex XN9000). NLR is the ratio of NEU ($\times 10^9$/L) to LYM ($\times 10^9$/L). LMR is the ratio of LYM ($\times 10^9$/L) to MONO ($\times 10^9$/L). MHR ($\times 10^9$/mmol) is the ratio of MONO ($\times 10^9$/L) to HDL-C (mmol/L).

2.4 | Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 22.0. Normally distributed continuous variables are expressed as mean ± standard deviation and were analyzed by Student t or ANOVA test. Non-normally distributed variables are expressed as median and interquartile range (IQR) and were analyzed by nonparametric test (Mann-Whitney or Kruskal-Wallis). Categorical variables are presented as frequencies and proportions, analyzed by chi-square test. Pearson correlation analysis and simple linear regression analysis were used to evaluate the association of parameters with MHR. Binary logistic regression analysis was performed to evaluate the association of serum MHR with PTC after adjusting for other clinical and biochemical variables. A p value <0.05 was regarded as statistically significant.

3 | RESULTS

3.1 | Demographics of women with PTC and healthy controls in the case-control study

The clinical characteristics of the PTC group (n = 300) and BTN group (n = 552) are shown in Table 1. Compared with the BTN group, ALT (14.0 [11.0, 17.0] vs. 16.0 [11.0, 21.5] U/L, $p = 0.004$), MONO (0.40 ± 0.14 vs. $0.44 \pm 0.16 \times 10^9$/L, $p < 0.001$), and MHR (0.32 ± 0.15 vs. $0.37 \pm 0.18 \times 10^9$/mmol, $p < 0.001$) were significantly increased in the PTC group, while age (54 ± 13 vs. 49 ± 12 years, $p < 0.001$) and HDL-C (1.39 ± 0.38 vs. 1.32 ± 0.36 mmol/L, $p = 0.017$) were significantly decreased (Table 1). There was no significant difference in gender, smoke, BMI, UN, UA, Crea, TC, LDL-C, FPG, NEU, LYM, NLR, LMR, or CRP between the two groups ($p > 0.05$, Table 1).

TABLE 1 Demographics of the study population

Variables	Total	BNT group	PTC group	*p*
n (Male/Female)	852 (211:641)	552 (126:426)	300 (85:215)	0.081
Smoke, n (%)	191 (22.4%)	123 (22.3%)	68 (22.7%)	0.932
Age (years)	52 ± 13	54 ± 13	49 ± 12	**<0.001**
BMI (kg/m^2)	23.6 ± 2.8	23.6 ± 2.9	23.7 ± 2.6	0.685
ALT (U/L)	16.0 (11.0, 23.0)	14.0 (11.0, 17.0)	16.0 (11.0, 21.5)	**0.004**
UN (mmol/L)	4.83 ± 1.32	4.86 ± 1.36	4.76 ± 1.24	0.297
UA (μmol/L)	282 ± 80	281 ± 81	284 ± 78	0.549
Crea (μmol/L)	61.5 ± 13.2	61.6 ± 13.6	61.3 ± 12.5	0.753
TC (mmol/L)	4.59 ± 0.96	4.60 ± 0.92	4.56 ± 1.03	0.588
HDL-C (mmol/L)	1.37 ± 0.37	1.39 ± 0.38	1.32 ± 0.36	**0.017**
LDL-C (mmol/L)	2.96 ± 0.85	2.97 ± 0.82	2.93 ± 0.89	0.567
FPG (mmol/L)	4.87 (4.56, 5.30)	5.06 (4.57, 5.60)	4.72 (4.60, 5.01)	0.530
NEU ($\times 10^9$/L)	4.40 ± 1.37	4.38 ± 1.38	4.43 ± 1.34	0.573
LYM ($\times 10^9$/L)	1.63 ± 0.53	1.61 ± 0.53	1.67 ± 0.55	0.129
MONO ($\times 10^9$/L)	0.42 ± 0.15	0.40 ± 0.14	0.44 ± 0.16	**<0.001**
NLR	3.03 ± 1.59	3.07 ± 1.69	2.95 ± 1.39	0.281
LMR	4.33 ± 1.94	4.43 ± 2.02	4.16 ± 1.79	0.050
MHR($\times 10^9$/mmol)	0.34 ± 0.17	0.32 ± 0.15	0.37 ± 0.18	**<0.001**
CRP (mg/L)	4.0 (2.0, 9.0)	4.0 (2.0, 8.5)	5.0 (2.0, 10.5)	0.058

Note: Data of normal distribution are expressed as mean ± standard deviation and analyzed by student t test. Non-normally distributed variables are expressed as median and interquartile range (IQR), and analyzed by nonparametric test (Mann-Whitney). Categorical variables are expressed as frequencies and proportions, and analyzed by using chi-square test. Bold indicates statistical significance ($p < 0.05$).

Abbreviations: ALT, alanine aminotransferase; BMI, body mass index; BNT, benign thyroid nodule; Crea, creatinine; CRP, C-reactive protei; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LMR, lymphocyte-to-monocyte ratio; LYM, lymphocyte; MHR, monocyte to HDL cholesterol ratio; MONO, monocyte; NEU, neutrophil; NLR, neutrophil-to-lymphocyte ratio; PTC, papillary thyroid carcinoma; TC, total cholesterol; UA, uric acid; UN, urea nitrogen.

TABLE 2 Comparison of parameters among three groups categorized by tertile of MHR in the cohort study

Variables	Lowest group	Middle group	Highest group	*p*
MHR ($\times10^9$/mmol)	below 0.24	0.24–0.37	above 0.37	
n (Male/Female)	270 (21:249)	294 (74:220)	288 (116:172)	**<0.001**
Smoke, n (%)	70 (25.9%)	61(20.7%)	60 (20.8%)	0.247
Age (years)	52 ± 13	53 ± 12	51 ± 13	1.000
BMI (kg/m^2)	23.3 ± 2.8	23.7 ± 2.7	24.0 ± 2.7	0.152
ALT (U/L)	14.0 (11.0, 16.0)	11.0 (10.0, 16.0)	16.5 (12.0, 23.8)	**<0.001**
UN (mmol/L)	4.78 ± 1.19	4.84 ± 1.36	4.87 ± 1.39	1.000
UA (μmol/L)	258 ± 68	281 ± 83	306 ± 79	**<0.001**
Crea (μmol/L)	57.2 ± 10.5	62.2 ± 13.9	61.5 ± 13.2	**<0.001**
TC (mmol/L)	4.75 ± 0.92	4.60 ± 0.95	4.42 ± 0.98	**<0.001**
HDL-C (mmol/L)	1.65 ± 0.36	1.37 ± 0.28	1.09 ± 0.25	**<0.001**
LDL-C (mmol/L)	2.97 ± 0.84	3.00 ± 0.81	2.90 ± 0.89	1.000
FPG (mmol/L)	4.83 (4.40, 5.27)	5.04 (4.70, 5.65)	4.81 (4.48, 5.41)	0.854
NEU ($\times10^9$/L)	3.72 ± 1.30	4.39 ± 1.29	5.04 ± 1.18	**<0.001**
LYM ($\times10^9$/L)	1.51 ± 0.50	1.63 ± 0.51	1.75 ± 0.57	**<0.001**
MONO ($\times10^9$/L)	0.29 ± 0.08	0.40 ± 0.08	0.56 ± 0.13	**<0.001**
NLR	2.83 ± 1.73	3.02 ± 1.56	3.22 ± 1.48	**0.010**
LMR	5.58 ± 2.20	4.21 ± 1.53	3.29 ± 1.30	**<0.001**
CRP (mg/L)	4.0 (2.0, 8.0)	4.0 (2.0, 7.0)	4.0 (1.4, 11.0)	**0.042**

Note: Data of normal distribution are expressed as means ± standard deviation and analyzed by student t test. Non-normally distributed variables are expressed as median and interquartile range (IQR), and analyzed by nonparametric test (Kruskal-Wallis H). Categorical variables are expressed as frequencies and proportions, and analyzed by chi-squaretest. Bold indicates statistical significance ($p < 0.05$).

Abbreviations: ALT, alanine aminotransferase; BMI, body mass index; Crea, creatinine; CRP, c-reactive protein; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LMR, lymphocyte-to-monocyte ratio; LYM, lymphocyte; MHR, monocyte to HDL cholesterol ratio; MHR, monocyte to HDL cholesterol ratio; MONO, monocyte; NEU, neutrophil; NLR, neutrophil-to-lymphocyte ratio; TC, total cholesterol; UA, uric acid; UN, urea nitrogen.

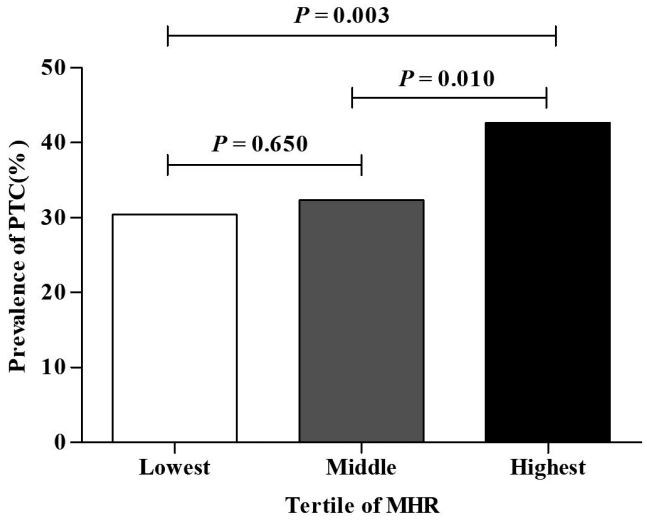

FIGURE 2 Prevalence of PTC among three groups categorized by tertile of MHR. PTC, papillary thyroid carcinoma; MHR, monocyte to HDL cholesterol ratio

3.2 | Comparison of clinical parameters among three groups categorized by tertile of MHR in the cohort study

Subjects were divided into three groups according to tertile of MHR: lowest (below 0.24), middle (0.24–0.37), or highest (above 0.37). There was a step-wise increase in the prevalence of PTC (30.4% vs. 32.3% vs. 42.7%, $p = 0.003$; Figure 2), and increased level of ALT (14.0 [11.0, 16.0] vs. 11.0 [10.0, 16.0] vs. 16.5 [12.0, 23.8] U/L, $p < 0.001$], UA (258 ± 68 vs. 281 ± 83 vs. 306 ± 79 μmol/L, $p < 0.001$), Crea (57.2 ± 10.5 vs. 62.2 ± 13.9 vs. 61.5 ± 13.2 μmol/L, $p < 0.001$), NEU (3.72 ± 1.30 vs. 4.39 ± 1.29 vs. 5.04 ± 1.18 × 10^9/L, $p < 0.001$), LYM (1.51 ± 0.50 vs. 1.63 ± 0.51 vs. 1.75 ± 0.57 × 10^9/L, $p < 0.001$), MONO (0.29 ± 0.08 vs. 0.40 ± 0.08 vs. 0.56 ± 0.13 × 10^9/L, $p < 0.001$), NLR(2.83 ± 1.73 vs. 3.02 ± 1.56 vs. 3.22 ± 1.48, $p = 0.010$), and CRP (4.0 [2.0, 8.0] vs. 4.0 [2.0, 7.0] vs. 4.0 [1.4, 11.0] mg/L, $p = 0.042$) with MHR tertile and a step-wise decrease in TC (4.75 ± 0.92 vs. 4.60 ± 0.95 vs. 4.42 ± 0.98 mmol/L, $p < 0.001$), HDL-C (1.65 ± 0.36 vs. 1.37 ± 0.28

TABLE 3 Logistic regression analysis (enter method) to determine the risk factors for development of PTC in case-control study

Variables	β (SE)	OR (95% CI)	*p*
Age (years)	−0.027 (0.006)	0.973 (0.962, 0.985)	**<0.001**
ALT (U/L)	0.011 (0.006)	1.011 (1.000, 1.023)	**0.049**
MHR ($\times10^9$/mmol)	0.036 (0.360)	4.882 (2.037, 11.700)	**<0.001**
Age (years)	−0.028 (0.006)	0.973 (0.961,0.984)	**<0.001**
ALT (U/L)	0.011 (0.006)	1.011 (1.000,1.023)	0.050
HDL-C (mmol/L)	−0.340 (0.206)	0.712 (0.475,1.066)	0.099
MONO ($\times10^9$/L)	1.511 (0.497)	4.531 (1.711,12.001)	**0.002**

Note: Data are presented as regression coefficient (standard error), odds ratio (95% confidence interval) and *p* value. Logistic regression analysis (enter method) was used determine the risk factors for development of PTC in the case-control study. Bold indicates statistical significance ($p < 0.05$).

Abbreviations: ALT, alanine aminotransferase; HDL-C, high-density lipoprotein cholesterol; MHR, monocyte to HDL cholesterol ratio; MONO, monocyte; PTC, papillary thyroid carcinoma.

TABLE 4 Logistic regression analysis (enter method) to determine the risk factors for development of PTC in the cohort study

Variables	β (SE)	OR (95% CI)	*p*
Gender	0.195 (0.041)	1.216 (0.554, 2.670)	0.626
ALT (U/L)	−0.010 (0.011)	0.990 (0.968, 1.013)	0.394
Crea (μmol/L)	−0.024 (0.014)	0.976 (0.949, 1.004)	0.095
TC (mmol/L)	0.026 (0.149)	1.026 (0.766, 1.375)	0.861
NEU ($\times10^9$/L)	−0.079 (0.109)	0.924 (0.746, 1.144)	0.468
LYM ($\times10^9$/L)	−0.396 (0.303)	0.673 (0.371, 1.219)	0.191
CRP (mg/L)	−0.001(0.013)	0.999 (0.973, 1.025)	0.916
MHR ($\times10^9$/mmol)	3.740 (0.892)	41.102 (7.335, 241.672)	**<0.001**
Gender	0.253 (0.228)	1.288 (0.824, 2.014)	0.268
ALT (U/L)	−0.011 (0.006)	1.011 (1.000, 1.023)	0.058
Crea (μmol/L)	−0.012 (0.007)	0.988 (0.974, 1.002)	0.096
TC (mmol/L)	−0.002 (0.081)	0.998 (0.851, 1.171)	0.983
NEU ($\times10^9$/L)	−0.084 (0.064)	0.919 (0.810, 1.043)	0.190
LYM ($\times10^9$/L)	0.029 (0.142)	1.030 (0.780, 1.360)	0.835
HDL-C (mmol/L)	−0.311 (0.220)	0.733 (0.476, 1.129)	0.159
MONO ($\times10^9$/L)	1.912 (0.592)	6.766 (2.120, 21.590)	**0.001**

Note: Data are presented as regression coefficient (standard error), odds ratio (95% confidence interval) and *p* value. Logistic regression analysis (enter method) was used to determine the risk factors for development of PTC in the cohort study. Bold indicates statistical significance ($p < 0.05$).

Abbreviations: ALT, alanine aminotransferase; Crea, creatinine; CRP, C-reactive protein; HDL-C, high-density lipoprotein cholesterol; LYM, lymphocyte; MONO, monocyte; NEU, neutrophil; PTC, papillary thyroid carcinoma; TC, total cholesterol; UA, uric acid.

vs. 1.09 ± 0.25 mmol/L, $p < 0.001$), and LMR (5.58 ± 2.20 vs. 4.21 ± 1.53 vs. 3.29 ± 1.30, $p < 0.001$; Table 2).

3.3 | Monocyte to high-density lipoprotein cholesterol ratio was an independent risk factor for PTC

To determine independent risk factors for PTC in the case-control study, age, ALT, and MHR, were entered into a binary logistic regression model (enter method). Age (β [SE] = −0.027 [0.006], OR [95% CI] = 0.973 [0.962, 0.985], $p < 0.001$), ALT (β [SE] = 0.011[0.006], OR [95% CI] = 1.011[1.000, 1.023], $p < 0.049$), and MHR (β [SE] = 0.036 [0.360], OR [95% CI] = 4.882 [2.037, 11.700], $p < 0.001$) were independently associated with PTC (Table 3). Then, age, ALT, HDL-C, and MONO were entered into a binary logistic regression model (enter method). Age (β [SE] = −0.028 [0.006], OR [95% CI] = 0.973[0.961, 0.984], $p < 0.001$), and MONO (β [SE] = 1.511[0.497], OR [95% CI] = 4.531 [1.711, 12.001], $p = 0.002$) were independently associated with PTC (Table 3).

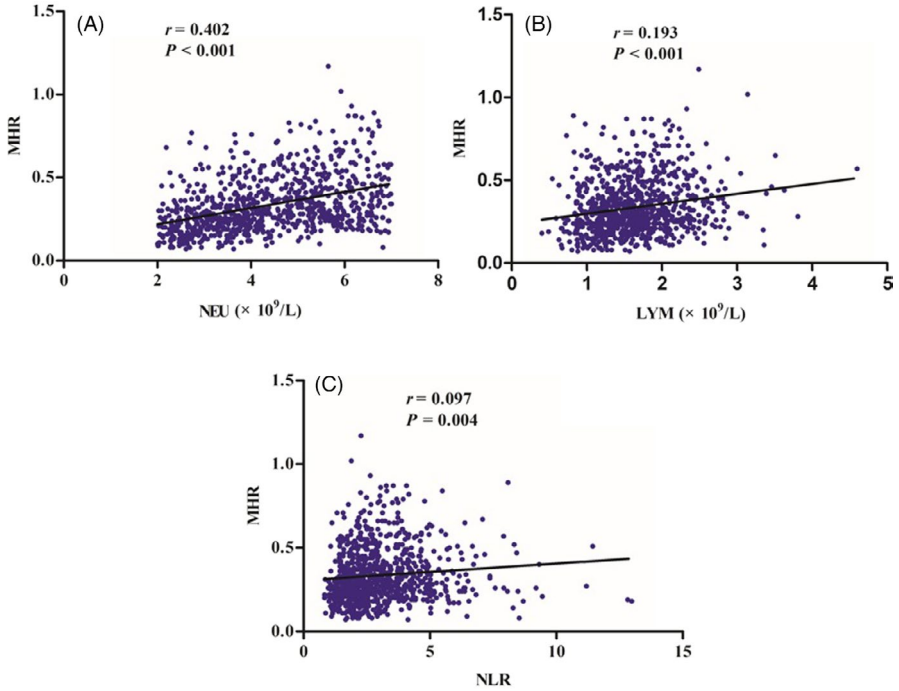

FIGURE 3 (A) Pearson correlation between MHR and NEU; (B) Pearson correlation between MHR and LYM; (C) Pearson correlation between MHR and NLR. MHR, monocyte to HDL cholesterol ratio; NEU, neutrophil; LYM, lymphocyte; NLR, neutrophil-to-lymphocyte ratio

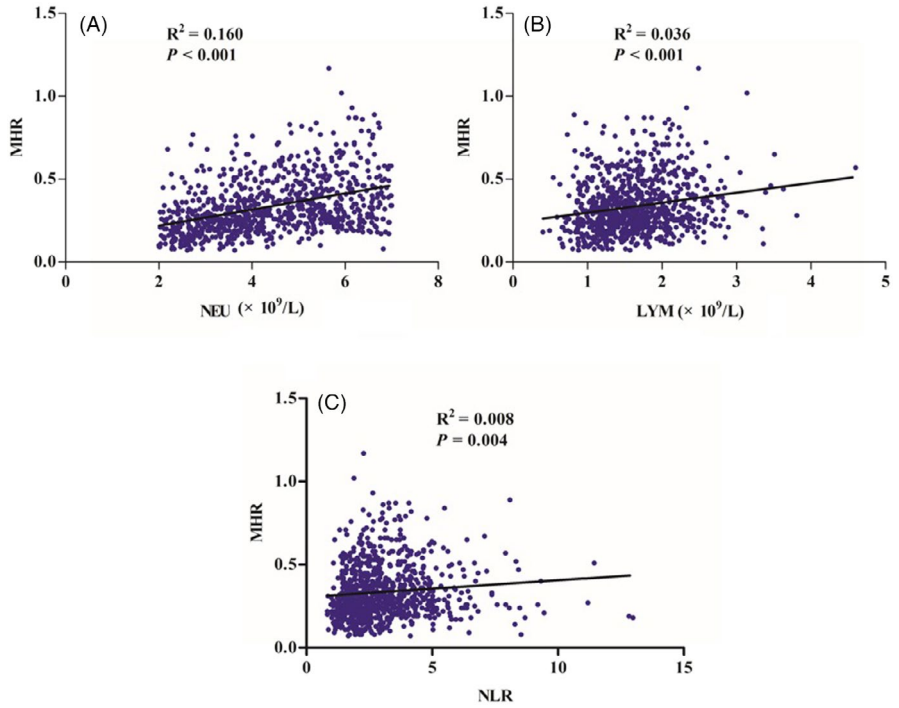

FIGURE 4 (A) Simple linear regression analysis between MHR and NEU; (B) Linear regression analysis between MHR and LYM; (C) Linear regression analysis between MHR and NLR. MHR, monocyte to HDL cholesterol ratio; NEU, neutrophil; LYM, lymphocyte; NLR, neutrophil-to-lymphocyte ratio

To determine independent risk factors for development of PTC in the cohort study, gender, ALT, Crea, TC, NEU, LYM, CRP, and MHR were entered into a binary logistic regression model (enter method). MHR (β [SE] = 3.740 [0.892], OR [95% CI] = 41.102 [7.335, 241.672], $p < 0.001$) was independently associated with PTC (Table 4). Then, gender, ALT, Crea, TC, NEU, LYM, HDL-C, and MOHO were entered into a binary logistic regression model (enter method). MONO (β [SE] = 1.912 [0.592], OR [95% CI] = 6.766 [2.120, 21.590], $p < 0.001$) was independently associated with PTC (Table 4).

3.4 | Correlation of MHR with other inflammatory parameters

Pearson correlation analysis revealed that MHR was positively correlated with NEU ($r = 0.402$, $p < 0.001$, Figure 3A), LYM ($r = 0.193$, $p < 0.001$, Figure 3B), and NLR ($r = 0.097$, $p = 0.004$, Figure 3C).

Simple linear regression analysis revealed that MHR was also positively associated with NEU ($R^2 = 0.160$, $p < 0.001$, Figure 4A), LYM ($R^2 = 0.036$, $p < 0.001$, Figure 4B), and NLR ($R^2 = 0.008$, $p = 0.004$, Figure 4C).

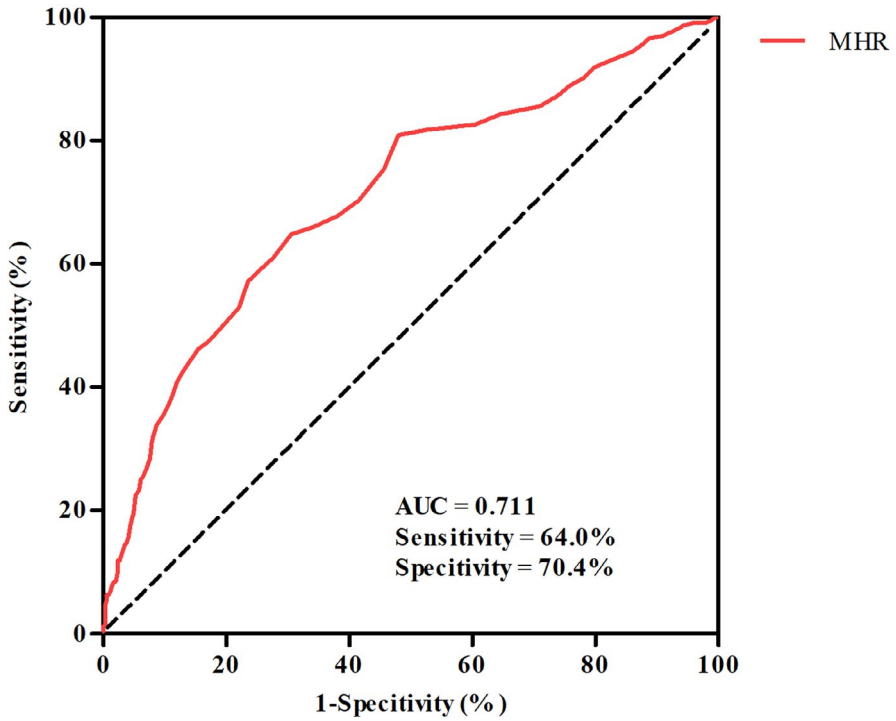

FIGURE 5 ROC curve of MHR for diagnosing PTC. AUC = 0.711 (95% CI: 0.668–0.754, $p < 0.001$). PTC, papillary thyroid carcinoma; MHR, monocyte to HDL cholesterol ratio; AUC, area under the ROC curve

3.5 | The accuracy of MHR for the diagnosis of PTC

The area under the ROC curve (AUC) of MHR was 0.711 (95% CI: 0.668–0.754, $p < 0.001$). The sensitivity, specificity, and cutoff values of PFR were evaluated. The cutoff value with the highest Youden index (0.346) was defined as the optimization. The optimal value of MHR as an indicator for monitoring the development of PTC was 0.33 × 10^9/mmol, which yielded a sensitivity of 64.0% and a specificity of 70.4% (Figure 5).

4 | DISCUSSION

Papillary thyroid carcinoma is related to inflammatory factors, but its pathogenesis has not been fully elucidated. We innovatively analyzed the relationship between MHR and PTC. The present study revealed novel evidence that MHR is closely related to PTC and an independent risk factor for PTC.

Monocyte is involved in the occurrence of PTC. Park et al.[32] found that thyroid tumors had a high infiltration with inflammatory MONO, while blood and bone marrow were unaffected in a mouse model. In human PTC, the abundance and proportion of MONO were significantly increased, and MONO appeared to play a tumor-promoting role.[33] The present study revealed that the level of MONO in the peripheral blood of PTC patients was significantly increased and MONO was an independent risk factor for PTC.

Monocyte to high-density lipoprotein cholesterol ratio is a new biomarker of inflammation and oxidative stress.[23,24] Combining two indicators of opposite changes, MHR is a valuable marker in systemic inflammatory diseases. It is being increasingly recognized as a novel clinically relevant biomarker of pathological inflammation and a new predictor and prognostic factor in cardiovascular disease, cerebrovascular disease, peripheral artery disease, metabolic syndrome, diabetic nephropathy, and multiple sclerosis.[23-31] Nonetheless rarely has MHR been studied in thyroid disease. One large-scale study reported that MHR level was significantly increased in patients with thyroid nodules; MHR was significantly associated with the presence of thyroid nodule and strongly associated with the presence and size of thyroid nodule irrespective of gender.[34] There has been no report of a correlation between MHR and PTC. Our study confirmed our hypothesis that MHR was significantly increased in and closely related to PTC and an independent risk factor for PTC.

Although NEU, LYM, and NLR are classic inflammatory indicators, studies have suggested that they are associated with the incidence of PTC.[8-11] In our study, NEU, LYM, and NLR were significantly higher in the lowest tertile of MHR group compared with the highest. MHR was positively correlated with NEU, LYM, and NLR. We speculated that MHR might participate in the pathogenesis of PTC by affecting inflammation.

This study has some limitations. The cross-sectional method prevented exploration of a causal relationship between MHR and PTC. Future longitudinal studies may provide clarification.

In summary, this study identifies novel evidence that patients with PTC have a higher MHR. MHR is an independent risk factor for PTC. These findings support the application of MHR to predict, diagnose, and evaluate the occurrence of PTC.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no datasets were generated or analyzed during the study.

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