Nigerian Medical Journal
NIGERIA MEDICAL ASSOCIATION
Print ISSN 0300-1652, E-ISSN 2229-774X

Original Article

Atherogenic Indices and Cardiovascular Risk in Post-Menopausal Women: A Comparative Study of Natural Versus Surgical Menopause

Simran Bamniya[1], Ajay Jain[2], Sonal Bhardwaj[3], Arvind Kumar Gupta[4], Vineeta Garg[5], *Sonali Sharma[3]

[1]Department of Biochemistry, JIET Medical College, Jodhpur, Rajasthan, India, [2]Department of Biochemistry, JLN Medical College, Ajmer, Rajasthan, India, [3]Department of Biochemistry, RUHS College of Medical Sciences, Jaipur, Rajasthan, India, [4]Department of Biochemistry, RD Gardi Medical College, Ujjain, Madhya Pradesh, India, [5]Department of Obs. & Gynae. RUHS College of Medical Sciences, Jaipur, Rajasthan, India.

Abstract

Background: Menopause is associated with an increased risk of cardiovascular disease (CVD) due to changes in lipid metabolism. The study objective is to compare lipid profile, atherogenic indices, and cardiovascular risk in women with surgical versus natural menopause, and to assess their correlation with Framingham Risk Score (FRS).

Methodology: This observational study included 120 postmenopausal women aged 40–65 years (natural menopause, n=98; surgical menopause, n=22). Demographic and anthropometric data, as well as blood samples, were collected. Lipid profile, atherogenic indices, and FRS were calculated and compared between groups using appropriate statistical analyses.

Results: Atherogenic indices were elevated in the surgical menopause group(p=0.000) versus those with natural menopause. FRS analysis showed 50% of surgical menopause cases had high cardiovascular risk (>20%) compared to 7.2% in natural menopause. Positive correlations existed between FRS and lipid parameters, including total cholesterol ($r = 0.513$, $p < 0.000$), non-HDL cholesterol ($r = 0.569$, $p < 0.000$), triglycerides ($r = 0.235$, $p = 0.010$), CRI I ($r = 0.661$, $p < 0.001$), CRI II ($r = 0.319$, $p < 0.001$), and AC ($r = 0.381$, $p < 0.001$).

Conclusion: Surgical menopause is linked to higher cardiovascular disease risk compared to natural menopause. The strong correlation of lipid ratios with FRS in the present study reinforces their potential utility as practical adjuncts to established risk prediction tools. These findings highlight the importance of menopause type in CVD risk assessment and the need for monitoring women undergoing surgical menopause.

Keywords: Post-menopause, lipid, atherogenic indices, cardiovascular risk score

***Correspondence:** Dr Sonali Sharma, Department of Biochemistry, RUHS College of Medical Sciences, Jaipur, Facsimile numbers:0141-2795627, E-mail address: sonalisharma14@gmail.com,   Orcid id.0000-0001-5514-1618

How to Cite: Bamniya S, Jain A, Bhardwaj S, Gupta AK, Garg V, Sharma S. Atherogenic indices and cardiovascular risk in post-menopausal women: A comparative study of natural versus surgical menopause. Niger Med J 2025; 67 (1): 2656-2667. https://doi.org/10.71480/nmj.v67i1.1218

Quick Response Code:

Introduction

Menopause, the permanent cessation of menstruation following loss of ovarian activity, impacts women's health[1]. Cardiovascular Disease (CVD) is the leading cause of death in post-menopausal women worldwide, exceeding breast and gynaecologic cancers[2,3]. Females show a higher prevalence of dyslipidemia during midlife, suggesting a role for the menopausal transition [4]. Dyslipidemia is a CVD risk factor. Traditional lipid measurements are linked to CVD onset. Although lowering low-density lipoprotein cholesterol (LDL-C) reduces cardiovascular events, residual risk remains at 50% at recommended levels, indicating a need for new predictors [5]. Various indices provide enhanced CVD risk evaluation by balancing atherogenic and anti-atherogenic lipoproteins [6]. During menopause, declining oestradiol leads to proatherogenic changes, including elevated Total cholesterol(TC), LDL-C, Apolipoprotein B, and higher Lipoprotein (a) levels [7]. Early menopause, whether natural or induced, reduces hormone exposure and predicts CVD. Hysterectomy-related CVD risk stems from premature ovarian failure [8-10]. Women with surgical menopause show greater arterial stiffness than those with natural menopause, potentially increasing CVD risk [11] Research on menopausal transition (MT) and lipid profile shows inconsistent findings. Limited data exist on lipid ratios and CVD risk in natural or surgical menopause. This study examines the correlation between lipid profile and CVD risk and whether lipid ratios better predict risk by menopausal status.

Material and Methods

Study design and participants

This observational study was conducted among 120 postmenopausal women aged 40 to 65 years who attended the menopause clinic at the Department of Obstetrics and Gynaecology, affiliated with a tertiary care hospital and the constituent medical college of Health University during the period May 2022 to October 2022. Ethical approval for the study was obtained from the institutional ethics committee (reference number: RUHSCMS/Ethics Comm. /2022-23/81 dated 01.07.2022). This study complied with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants. Participants were recruited using a non-probability consecutive sampling technique rather than forced group matching, resulting in a smaller surgical menopause subgroup. Participants were categorized into natural (n =98) and surgical (n = 22) menopause groups based on the causative process for the onset of menopause.

Menopause was diagnosed according to the Stages of Reproductive Ageing Workshop (STRAW) criteria [12]. The study encompassed women who reported either natural or surgical menopause. Post-menopausal women were categorized as having experienced natural menopause or surgical menopause, with the latter defined as having undergone a hysterectomy. Participants were healthy post-menopausal women who were estrogen-deficient (having not used hormone replacement therapy (HRT) for at least six months) and had not experienced menses for at least one year, classified under the natural menopause category. Women with a history of hysterectomy with unilateral or bilateral oophorectomy were included in the surgical menopause category only if the age at surgery was equal to or preceded the age at menopause, and there was no use of HRT for at least six months. The duration of menopause was estimated based on the self-reported onset of natural menopause and the self-reported date of surgery for those who underwent a hysterectomy with bilateral oophorectomy.

The exclusion criteria included women who had undergone hormonal therapy, had significant CVD, active psychological disorders, malignancies within the previous five years, other comorbid diseases, were using beta-blockers and lipid-lowering drugs, and those who did not report their age at menopause. Data for each participant were collected through a comprehensive questionnaire.

Data Collection and measurements

Demographic characteristics were obtained through questionnaire surveys administered by trained researchers. The questionnaire content included sex, age, smoking history, drinking history, and clinical diagnosis. Reproductive history, age at menopause and post-menopausal duration were obtained from the medical history and physical examination. Menopausal status was assigned based on self-reported menstrual cycle histories.

The anthropometric parameters included height, weight, waist circumference (WC) and hip circumference (HC). Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2) [13]. All blood pressure (BP) measurements were obtained using an electronic sphygmomanometer (Omron; Dalian, China). Hypertension was diagnosed according to the Eighth Joint National Committee (JNC 8) blood pressure guidelines [14].

After clinical evaluation and physical examination, blood samples were collected for biochemical analysis.

Laboratory analysis

All tests were performed after overnight fasting and analyzed at the Central Biochemistry Laboratory of the hospital. All laboratory equipments were calibrated prior to use. Serum glucose (fasting) and lipid levels (TC, high-density lipoprotein cholesterol (HDL-C), and triglyceride (TG)) were measured using standard enzymatic methods on a fully automated biochemistry analyzer (Beckman Coulter). The samples were analyzed immediately, and the results were recorded. Furthermore, LDL-C and very-low-density lipoprotein cholesterol (VLDL-C) levels were calculated using the Friedwald formula [15]. Non-HDL-C was defined as total cholesterol minus HDL-C [16]. Dyslipidemia was defined according to the guidelines of the modified AHA/NHLBI ATM III definition[17].

The following non-traditional lipid ratios were computed:

Lipid ratio calculation:[18]

- Castelli's Risk Index (CRI): This index is derived from TC, LDL, and HDL and is divided into two categories:
- Castelli's Risk Index-I (CRI-I) = TC/HDL-C ratio
- Castelli's Risk Index-II (CRI-II) = LDL-C/HDL-C ratio
- Non-HDL cholesterol = TC - HDL-C
- Atherogenic Coefficient (AC) = TG/HDL-C
- Atherogenic Index of Plasma (AIP) = log TG/HDL

Cardiovascular Risk Assessment [19]

The Framingham Risk Score (FRS) was employed to estimate the 10-year risk of cardiovascular disease (CVD) and was calculated electronically by entering the necessary parameters on the following webpage: http://www.cvdrisk-checksecure.com/FraminghamRiskScore.aspx/. The FRS encompasses the entire spectrum of CVD, including coronary heart disease, peripheral vascular disease, stroke, and heart failure. It requires data on the age, sex, systolic blood pressure (SBP), treatment for hypertension, diabetes, total blood cholesterol, and HDL level of each participant.

Absolute 10-year CVD risk was classified as follows:

Low risk <10% , Moderate risk 10-20%, High risk >20%

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 20.0. Continuous variables are presented as mean ± standard deviation (SD), contingent upon the distribution assessed using the Shapiro-

Wilk test. Categorical variables were summarized using frequencies and percentages. Associations between categorical variables were analyzed using the chi-square or Fisher's exact test, as appropriate. For the comparison of continuous variables between groups, the independent t-test or Mann-Whitney U test was employed. Correlations were assessed using Pearson correlation coefficients. Statistical significance was set at $p < 0.05$. Ordinal logistic regression with a logit link function was performed to determine independent predictors of CVD.

Results

Table 1: Baseline characteristics of the study participants

Variables	**Natural Menopause (n=98)**	**Surgical Menopause (n=22)**	**Total Menopause (n=120)**	**p-value (t-test or chi-square test)**
Age (years) (Mean ± SD)	56.4±4.0	55.9±4.6	56.3±4.1	0.649
Age group (n%)				
<50 years	10 (10.2)	3 (13.6)	13 (10.8)	0.139
50-59 Years	59 (60.2)	17 (77.3)	76 (63.3)	
60-65 Years	29 (29.6)	2 (9.1)	31 (25.8)	
Age at menarche (years) (Mean ± SD)	13.9±1.3	14.4±1.4	14.01±1.4	0.089
Age at menopause (years) (Mean ± SD)	49.7±2.1	47.6±1.8	49.3±2.2	0.000**
Age of mother at menopause (years) (Mean ± SD)	50.1±0.7	50.2±0.7	50.1±0.7	0.682
Marital status (n%)				
Married	87 (88.8)	19 (86.4)	106 (88.3)	0.233
Divorced	0 (0.0)	1 (4.5)	1 (0.8)	
Widow	11 (11.2)	2 (9.1)	13 (10.9)	
Alcohol user (n%)	1 (1.0)	1 (4.5)	2 (1.7)	0.455
Smoking (n%)	3 (3.1)	1 (4.5)	4 (3.3)	0.842
Comorbid Condition(n%)				
Thyroid	2 (2.0)	4 (18.2)	6 (5.0)	0.0017*
Diabetes	7 (7.1)	9 (40.9)	16 (13.3)	0.000**

Family history of cardiac disease(n%)	17 (17.3)	9 (40.9)	26 (21.7)	0.050
Reproductive life span(n%)				
25-34	17 (23.0)	7 (46.7)	24 (27.0)	0.059
35-44	57 (77.0)	8 (53.3)	65 (73.0)	

*Significant p<0.05 , ** Highly significant p< 0.001

Table 1 provides details of baseline characteristics of study participants. Mean age was comparable between groups: 56.4±4.0 years for natural menopause and 55.9±4.6 years for surgical menopause (P=0.649). Most women in both groups were aged 50-59 years. Mean age at menarche was higher in the surgical group (14.4±1.4) versus the natural group (13.9±1.3; p=0.089). Age at menopause was lower in the surgical group (47.6±1.8) than the natural group (49.7±2.1; p=0.000). No differences were found in marital status, alcohol use, or smoking. Thyroid disorders (p=0.0017) and diabetes (p=0.000) were more prevalent in the surgical group. Family history of cardiac disease was higher in the surgical group (40.9% vs. 17.3%; p=0.050). Reproductive life span was shorter in the surgical group, though not significantly (p=0.059).

Table 2: Anthropometric and biochemical parameters in study participants.

Variables	**Natural menopause (n=98) (Mean ± SD)**	**Surgical menopause (n=22) (Mean ± SD)**	**Total menopause (n=120) (Mean ± SD)**	**p-value**
Height(meters)	1.6±0.1	1.6±0.1	1.6±0.1	0.741
Weight(kg)	65.4±7.7	73.4±8.2	66.9±8.3	0.000**
Body mass index (Kg/m^2)	26.6±3.9	29.6±4.1	27.1±4.1	0.002*
Waist circumference (Centimetres)	85.7±7.4	91.7±4.3	86.8±7.3	0.000**
Hip circumference (centimetres)	101.2±4.9	103.4±7.4	101.6±5.5	0.094
Waist to hip ratio	0.9±0.1	0.9±0.1	0.9±0.1	0.028*
Systolic blood pressure (mmHg)	128.7±7.0	133.9±12.5	129.7±8.5	0.008*
Diastolic blood pressure (mmHg)	83.4±9.9	86.8±12.5	83.9±10.4	0.167
Glucose(Fasting)(mg/dL)	99.9±17.0	109.7±12.5	101.7±16.7	0.012*
Total Cholesterol(mg/dL)	204.5±38.9	219.1±43.3	207.2±40.0	0.122
Triglycerides (mg/dL)	158.6±46.3	189.2±63.5	164.2±51.0	0.010*
HDL-C(mg/dL)	43.9±9.7	33.2±2.3	41.9±9.7	0.000**
LDL-C(mg/dL)	131.9±35.2	139.8±37.9	133.3±35.7	0.352
VLDL-C(mg/dL)	37.3±15.8	38.9±8.9	37.6±14.8	0.650
Non-HDL-C(mg/dL)	160.6±40.6	185.9±42.8	165.3±41.9	0.010*
CRI I	4.8±1.2	6.6±1.3	5.1±1.4	0.000**

Niger Med J 2025;67(1): 171 - 182, **ISSN**: 0300-1652, **E-ISSN**: 2229-774X, **Publisher**: Nigerian Medical Association. Jan. – Feb. **2026**

CRI II	3.1±0.9	4.2±1.2	3.3±1.1	0.000**
AC	3.7±1.3	5.7±1.9	4.1±1.6	0.000**
AIP	0.6±0.1	0.7±0.2	0.6±0.2	0.000**

*Significant p<0.05 , ** Highly significant p< 0.001

HDL-C- high-density lipoprotein cholesterol, **LDL-C-** low-density lipoprotein cholesterol, **VLDL-C** very-low-density lipoprotein cholesterol, **Non HDL-C-**Non high-density lipoprotein cholesterol, **CRI-I-** Castelli's Risk Index-I, **CRI-II-** Castelli's Risk Index-II, **AC**- Atherogenic Coefficient, **AIP**- Atherogenic index of plasma

In this study, women who underwent surgical menopause exhibited significantly higher weight, BMI, and waist circumference compared to those who experienced natural menopause (p< 0.05). Additionally, the waist-to-hip ratio and systolic blood pressure were notably elevated in the surgical group (p=0.028 and p=0.008, respectively). Fasting glucose and triglyceride levels were significantly increased (p=0.012 and p=0.010), whereas HDL-C levels were markedly lower (33.2±2.3 vs. 43.9±9.7 mg/dL; p=0.000). Atherogenic indices, including CRI I, CRI II, AC, and AIP, were significantly elevated in the surgical menopause group (all p=0.000), indicating a heightened cardiovascular risk. No significant differences were observed in height, hip circumference, diastolic blood pressure, LDL-C, or VLDL-C levels. (Table 2)

Table 3. Ordinal logistic regression analysis showing predictors of cardiovascular risk category in postmenopausal women

Variable	**β**	**SE**	**Wald χ^2**	**p value**	**Odds Ratio (Expβ)**	**95% CI for OR**
Age (years)	0.51	0.15	11.46	0.001*	1.66	1.24-2.23
Age at menopause (years)	-0.13	0.24	0.29	0.590	0.88	0.56-1.40
Body mass index (Kg/m^2)	0.00	0.11	0.00	0.969	1.00	0.81-1.24
Waist to hip ratio	-4.95	8.41	0.35	0.556	0.007	0.0000005-101
Waist Circumference (Centimetres)	0.11	0.10	1.29	0.256	1.12	0.92-1.35
Triglycerides (mg/dL)	0.02	0.05	0.16	0.690	1.02	0.93-1.12
Serum glucose (fasting) (mg/dL)	-0.03	0.03	0.93	0.335	0.97	0.92-1.03
Systolic blood pressure(mmHg)	0.15	0.05	8.72	0.003*	1.16	1.05-1.27

Non-HDL-C (mg/dL)	0.30	0.11	7.67	0.006*	1.35	1.09-1.67
HDL-C (mg/dL)	-1.18	0.47	6.36	0.012*	0.31	0.12-0.77
CRI-I	-10.08	4.05	6.18	0.013	<0.001	<0.001-0.12
CRI-II	-0.11	0.43	0.06	0.802	0.89	0.39-2.08
AC	-1.92	1.71	1.26	0.261	0.15	0.005-4.17
AIP	15.59	14.37	1.18	0.278	5.9×10^{6}	0.000003 – 1.4×10^{14}
Surgical menopause vs natural menopause	3.81	1.70	5.00	0.025*	45.1	1.60-1268
Diabetes mellitus (yes vs. no)	-	-	9.46	0.002*	-	-
Thyroid dysfunction	4.42	2.59	2.91	0.088	82.8	0.52-13345

*Significant p<0.05, **β-** Regression Coefficient (β Coefficient), **SE-**Standard error (of the regression coefficient, **Wald χ^2-** Wald Chi-square Statistic, **Exp β-** Exponentiation of β

HDL-C- high-density lipoprotein cholesterol, **Non HDL-C-**Non high-density lipoprotein cholesterol, **CRI-I-** Castelli's Risk Index-I, **CRI-II-** Castelli's Risk Index-II, **AC**- Atherogenic Coefficient, **AIP**- Atherogenic index of plasma

Ordinal logistic regression with a logit link function was performed to determine independent predictors of cardiovascular risk category among menopausal women. The final model demonstrated a statistically significant improvement over the intercept-only model (Likelihood ratio $\chi^2 = 225.033$, df = 17, $p < 0.001$). Goodness-of-fit statistics indicated adequate model calibration (Pearson $\chi^2 = 148.329$, p = 1.000; Deviance $\chi^2 = 60.242$, p = 1.000). The model showed excellent explanatory power, with pseudo R-square values of 0.847 (Cox & Snell), 1.000 (Nagelkerke), and 1.000 (McFadden).

After adjustment for all covariates, advancing age (β = 0.51, p = 0.001), systolic blood pressure (β = 0.15, p = 0.003), and non-HDL cholesterol (β = 0.30, p = 0.006) were significantly associated with increased odds of belonging to a higher cardiovascular risk category. In contrast, higher HDL cholesterol levels (β = −1.18, p = 0.012) were associated with a protective effect. CRI-I also showed a significant independent relationship with cardiovascular risk (β = −10.08, p = 0.013) (Table 3).

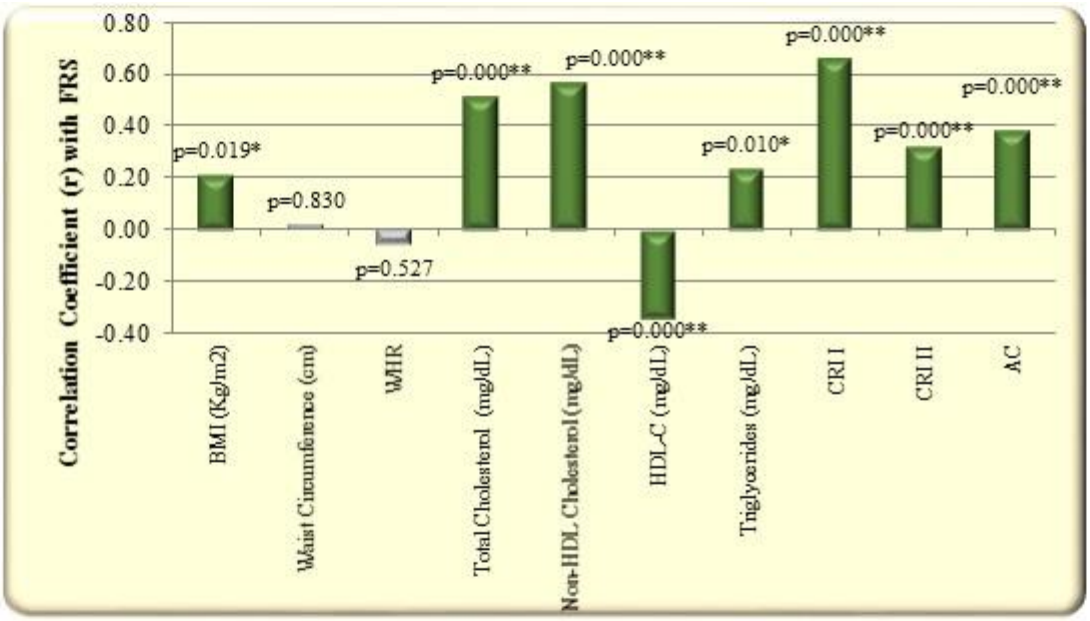
Table 4: Framingham risk score of study participants according to the type of menopause

FRS	Natural Menopause n=98 (n%)	Surgical Menopause n=22 (n%)	Total (n%)	p-value
Low (<10%)	69 (70.4)	3 (13.6)	72 (60.00)	**0.000****
Moderate (10-20%)	22 (22.4)	8 (36.4)	30 (25.0)	
High (>20%)	7 (7.2)	11 (50.0)	18 (15.0)	

** Highly significant p< 0.001

The analysis of Framingham risk scores indicated that a significantly greater proportion of women who underwent surgical menopause (50%) exhibited a high cardiovascular risk (>20%) compared to those who experienced natural menopause (7.2%) (p = 0.000). Conversely, the majority of women with natural menopause (70.4%) were categorized as low-risk (<10%). (Table 4)

Figure: Pearson Correlation between anthropometric, biochemical parameters and lipid ratios with Framingham Risk Score



The figure shows a correlation analysis between lipid parameters and FRS. A significant positive correlation was identified between FRS and various lipid parameters, including total cholesterol (r = 0.513, p < 0.000), non-HDL cholesterol (r = 0.569, p < 0.000), triglycerides (r = 0.235, p = 0.010), CRI I (r = 0.661, p < 0.001), CRI II (r = 0.319, p < 0.001), and AC (r = 0.381, p < 0.001). Additionally, BMI showed a weak yet significant correlation with FRS (r = 0.214, p = 0.019), whereas waist circumference and WHR were not significantly correlated with FRS. Notably, HDL was significantly negatively correlated with FRS (r = -0.344, p < 0.001).

Discussion

This study investigates lipid irregularities and ratios in women with surgical menopause, compared to those with natural menopause, as an indicator of CVD risk. In this research, surgical menopause was associated with a significantly increased risk of CVD, with persistent associations between lipid ratios and the FRS. These findings add to growing evidence that the type of menopause has important clinical implications for cardiovascular risk.

In this study, BMI was significantly higher in post-menopausal women who underwent surgical intervention compared to those who experienced natural menopause. This finding is consistent with previous studies [20]. A study reported 26.5% prevalence of obesity among women with natural menopause and 34.0% among those with surgical menopause [21]. In our study, fasting glucose levels and SBP were significantly elevated in women with surgical menopause. Lower adjusted SBP levels across age ranges compared to pre-, peri-, or surgically postmenopausal women in women with natural menopause have been reported [20]. Our findings support prior evidence that surgical menopause is associated with a less favourable cardio-metabolic profile.

A key contribution of this work is the consistent elevation of multiple atherogenic indices—CRI I and II, AC, and AIP—in women with surgical menopause, along with their strong positive correlations with FRS. These composite indices reflect the balance between atherogenic and anti-atherogenic lipoproteins and therefore offer a more integrated assessment of lipid-related cardiovascular risk than individual lipid measurements alone. The observed associations with FRS suggest that lipid ratios may enhance the identification of high-risk women, particularly in those who undergo abrupt estrogen deprivation following surgical menopause.

Importantly, although traditional lipid parameters, such as total cholesterol and LDL-C, did not differ consistently between groups, atherogenic indices were uniformly higher in the surgical menopause group. This finding supports the growing recognition that reliance on isolated lipid values may underestimate cardiovascular risk in post-menopausal women. Paul J et al reported higher TG and lower HDL-C in women with surgical menopause[22]. A positive correlation between menopausal status and elevated TC, LDL, apolipoprotein B (apo-B), and high AC ratio has been reported earlier [23,24]. Women who have gone through menopause face a higher likelihood of developing CVD.

The relationship between HDL-C levels and menopausal status might be more complex than suggested by measuring plasma total HDL-C alone. Research has shown that AIP could serve as a strong and independent indicator of coronary artery disease among Chinese Han post-menopausal women, potentially offering more predictive power than conventional lipid measures [25].

Composite lipid indices have emerged as promising indicators of coronary artery disease risk, demonstrating superior predictive capability compared to traditional single lipid measures [26]. AIP accounts for approximately 30% of the risk associated with developing CVD [27].

Both natural and surgical premature menopause are linked to a heightened risk of developing various cardiovascular diseases[28]. The main mechanism behind estrogen's anti-atherosclerotic effect is its influence on blood lipid levels. Surgical menopause is associated with a higher degree of coronary atherosclerosis, calcified plaque, and an increase in CVD events. Postmenopausal women, whether they have experienced surgical or natural menopause, have stiffer, larger elastic arteries compared to premenopausal women[11].

In the present study, women with surgical menopause exhibited significantly greater cardiovascular risk compared with those experiencing natural menopause (β = 3.808, p = 0.025), indicating that surgical menopause independently predicted higher risk category status. Overall, the model identified age, diabetes mellitus, systolic blood pressure, non-HDL cholesterol, HDL cholesterol, CRI-I, and surgical menopause as key determinants of the cardiovascular risk category.

The higher proportion of women classified as having high cardiovascular risk following surgical menopause is consistent with longitudinal and population-based studies reporting increased cardiovascular morbidity and mortality in this group [21]. However, the present study extends these observations by demonstrating a clear link between elevated cardiovascular risk scores and unfavorable lipid ratios, underscoring the role of dyslipidemia as a key mediator of excess cardiovascular risk after surgical menopause.

When analysing the data based on the age at which menopause occurs, a progressive relationship was found between the onset of CVD and younger age at menopause for both natural and surgical types [29,30]. A study conducted by Honigberg et al [28] indicated that both natural and surgical premature menopause (occurring before the age of 40 years) were linked to a modest yet statistically significant increase in the risk of a composite of cardiovascular diseases among post-menopausal women. The extent to which menopausal characteristics and CHD are related through these factors remains uncertain [30].

To the best of our knowledge, limited research has evaluated dyslipidemia using lipid ratios in postmenopausal women. Incorporating these indices into routine clinical practice may enable earlier identification of women at high cardiovascular risk after surgical menopause, allowing timely lifestyle and preventive interventions. Understanding menopause-related alterations in lipid metabolism is essential to addressing the rising burden of CVD in women, and the timing of menopause should be considered an important factor in cardiovascular risk assessment. Clinically, this study highlights the value of atherogenic indices for cardiovascular risk stratification in postmenopausal women, as they are inexpensive, easily derived from routine lipid profiles, and particularly useful in resource-limited settings.

Limitations

The present study is subject to several limitations. Firstly, the sample size in the surgical menopause group is notably smaller than in the natural menopause group. Secondly, the age at menopause was self-reported and determined retrospectively, several years after the event. Furthermore, the study lacks information regarding the reasons for prior bilateral oophorectomy, which could have elucidated potential risk mechanisms. As this is a cross-sectional study, the findings indicate associations rather than causality. Lastly, physical activity, a significant predictor of metabolic changes in menopausal women, was not evaluated.

Conclusion

Women with surgical menopause demonstrated a significantly higher cardiovascular disease risk compared to those with natural menopause, as evidenced by markedly elevated Framingham Risk Scores. This increased risk was closely associated with adverse lipid alterations and consistently higher atherogenic indices, including CRI I, CRI II, AC, and AIP, which showed strong correlations with cardiovascular risk. The strong correlation of lipid ratios with FRS in the present study reinforces their potential utility as practical adjuncts to established risk prediction tools.

While menopause is widely recognized as a period of increased cardiometabolic vulnerability, these findings underscore the clinical value of incorporating atherogenic indices alongside conventional lipid parameters for improved cardiovascular risk stratification, particularly in women undergoing surgical menopause, enabling earlier identification and targeted preventive interventions.

References

1. Dosi R, Bhatt N, Shah P, Patell R. Cardiovascular disease and menopause. J of Clin Diagn Res. 2014;8(2):62–64. doi:10.7860/JCDR/2014/6457.4009
2. Mosca L, Hammond G, Mochari-Greenberger H, Towfighi A, Albert MA; American Heart Association Cardiovascular Disease and Stroke in Women and Special Populations Committee of the Council on Clinical Cardiology, Council on Epidemiology and Prevention, Council on Cardiovascular Nursing, Council on High Blood Pressure. Fifteen-year trends in awareness of heart disease in women: results of a 2012 American Heart Association national survey. Circulation.2013;127(11):1254-e29.doi:10.1161/CIR.0b013e318287cf2f
3. Lerner D J, Kannel WB. Patterns of coronary heart disease morbidity and mortality in the sexes: a 26-year follow-up of the Framingham population. Am Heart J.1986;111(2):383–390. doi:10.1016/0002-8703(86)90155-9
4. El Khoudary SR, Aggarwal B, Beckie TM, Hodis HN, Johnson AE, Langer RD et al. Menopause transition and cardiovascular disease risk: implications for timing of early prevention: a scientific statement from the American Heart Association.Circulation.2020;142(25):e506–e532. doi:10.1161/CIR.0000000000000912
5. Matsuura Y, Kanter JE, Bornfeldt KE. Highlighting residual atherosclerotic cardiovascular disease risk. Arterioscler Thromb Vasc Biol. 2019;39(1):e1–e9. doi:10.1161/ATVBAHA.118.311999
6. Sheng G, Kuang M, Yang R, Zhong Y, Zhang S, Zou Y. Evaluation of the value of conventional and unconventional lipid parameters for predicting the risk of diabetes in a non-diabetic population. J Transl Med.2022;20(1):266.doi: 10.1186/s12967-022-03470-z
7. EUGenMed Cardiovascular Clinical Study Group; Regitz-Zagrosek V, Oertelt-Prigione S, Prescott E, Franconi F, Gerdts E, Foryst-Ludwig A et al. Gender in cardiovascular diseases: impact on clinical manifestations, management, and outcomes. Eur Heart J. 2016;37(1):24-34. doi:10.1093/eurheartj/ehv598
8. Ingelsson E, Lundholm C, Johansson AL, Altman D. Hysterectomy and risk of cardiovascular disease: A population-based cohort study. European Heart Journal 2011;32(6):745–750. doi:10.1093/eurheartj/ehq477
9. Howard BV, Kuller L, Langer R, Manson JE, Allen C, Assaf A et al. Risk of cardiovascular disease by hysterectomy status, with and without oophorectomy: the women's health initiative observational study. Circulation. 2005;111 (12):1462–1470. doi:10.1161/01.CIR.0000159344.21672.FD
10. Siddle N, Sarrel P, Whitehead M. The effect of hysterectomy on the age at ovarian failure: Identification of a subgroup of women with premature loss of ovarian function and literature review. Fertil Steril.1987;47(1):94–100. doi:10.1016/s0015-0282(16)49942-5
11. Abbas SZ, Sangawan V, Das A, Pandey AK. Assessment of cardiovascular risk in natural and surgical menopause. Indian J of Endocrinol and Metab. 2018 ;22(2):223-228. doi:10.4103/ijem.IJEM_620_17
12. Harlow SD, Gass M, Hall JE, Lobo R, Maki P, Rebar RW et al. Executive summary of the stages of reproductive aging workshop +10: addressing the unfinished agenda of staging reproductive aging. J Clin Endocrinol Metab. 2012;97:1159-68. doi:10.1210/jc.2011-3362
13. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual.Champaign Illionois,Human Kinetics books.1988;55-70.
14. Hernandez-Vila E. A review of the JNC 8 blood pressure guideline.Tex Heart Inst J.2015;42(3):226-8. doi:10.14503/THIJ-15-5067
15. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972;18(6):499–502.
16. Virani SS. Non-HDL cholesterol as a metric of good quality of care: opportunities and challenges. Tex Heart Inst J.2011;38(2):160-162.

17. Lepor NE, Vogel RE; National Cholesterol Education Program Adult Treatment Panel III. Summary of the third report of the National Cholesterol Education Program Adult Treatment Panel III. Rev Cardiovasc Med. 2001;2(3):160-165.
18. Sasikala T, Goswami K. Castelli risk index-1 and atherogenic coefficient are better predictors of cardiometabolic risk in patients with hypothyroidism. Int J Clin Biochem Res. 2020;7(2):254-259. doi:10.18231/j.ijcbr.2020.055
19. Zhou H, Zhang C, Ni J, Han X. Prevalence of cardiovascular risk factors in non-menopausal and postmenopausal inpatients with type 2 diabetes mellitus in China. BMC Endocr Disord.2019;19(1):98. doi:10.1186/s12902-019-0427-7
20. de Kat AC, Dam V, Onland-Moret NC, Eijkemans MJ, Broekmans FJ, Van der Schouw YT. Erratum to: Unraveling the associations of age and menopause with cardiovascular risk factors in a large population-based study. BMC Med. 2017;15(1):74. doi: 10.1186/s12916-017-0841-5
21. Price MA, Alvarado BE, Rosendaal NTA, Câmara SMA, Pirkle CM, Velez MP. Early and surgical menopause associated with higher Framingham Risk Scores for cardiovascular disease in the Canadian Longitudinal Study on Aging. Menopause. 2021 ;28(5):484-490.doi: 10.1097/GME.0000000000001729
22. Paul J, Khanam RA, Mirza TT, Saha MK, Halim MA, Basher MS et al. Lipid profile status in natural and surgical menopausal women: a comparative study. Mymensingh Med J.2020;29(2):254-262.
23. Derby CA, Crawford SL, Pasternak RC, Sowers M, Sternfeld B, Matthews KA. Lipid changes during the menopause transition in relation to age and weight: The study of women's health across the nation. Am J Epidemiol.2009;169 (11):1352–1361. doi: 10.1093/aje/kwp043
24. Zago V, Sanguinetti S, Brites F, Berg G, Verona J, Basilio F et al. Impaired high-density lipoprotein antioxidant activity in healthy postmenopausal women. Atherosclerosis.2004;177(1):203-210.doi:10.1016/j.atherosclerosis.2004.07.011
25. Guo Q, Zhou S, Feng X, Yang J, Qiao J, Zhao Y et al. The sensibility of the new blood lipid indicator--atherogenic index of plasma (AIP) in menopausal women with coronary artery disease. Lipids Health Dis. 2020;19(1):27. doi:10.1186/s12944-020-01208-8.
26. Zhou K, Qin Z, Tian J, Cui K, Yan Y, Lvu S. The atherogenic index of plasma: a powerful and reliable predictor for coronary artery disease in patients with type 2 diabetes. Angiology. 2021; 72(10):934–941.doi:10.1177/00033197211012129.
27. Bhardwaj S, Bhattacharjee J, Bhatnagar MK, Tyagi S. Atherogenic index of plasma ,Castelli risk index and atherogenic coefficient-new parameters in assessing cardiovascular risk. Int J of Pharm Bio Sci. 2013;3:359-364.
28. Honigberg MC, Zekavat SM, Aragam K, Finneran P, Klarin D, Bhatt DL et al. Association of premature natural and surgical menopause with incident cardiovascular disease.JAMA.2019;322(24):2411-2421. doi:10.1001/jama.2019.19191.
29. Zhu D, Chung HF, Dobson AJ, Pandeya N, Brunner EJ, Kuh D et al. Type of menopause, age of menopause and variations in the risk of incident cardiovascular disease: pooled analysis of individual data from 10 international studies.HumReprod.2020;35(8):1933-1943. doi: 10.1093/humrep/deaa124
30. Dam V, van der Schouw YT, Onland-Moret NC, Groenwold RHH, Peters SAE, Burgess S et al. Association of menopausal characteristics and risk of coronary heart disease: a pan-European case-cohort analysis. Int J Epidemiol. 2019;48(4):1275-1285. doi: 10.1093/ije/dyz016