ORIGINAL RESEARCH

Cholelithiasis and its relation to body mass index and waist to hip ratio

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ABSTRACT
Aim: To study the association between cholelithiasis and both body mass index (BMI) and waist-to-hip ratio. **Material and methods:** The study included a total of 225 individuals presenting with abdominal discomfort, divided into two groups: 125 patients diagnosed with cholelithiasis (test group) and 100 patients with abdominal discomfort due to other causes (control group).The BMI was calculated using Quetelet's index, which involves dividing the patient's weight (in kilograms) by the square of their height (in meters).Waist and hip circumferences were measured following the World Health Organization (WHO) methodology. The waist circumference was measured at the midpoint between the lower edge of the last palpable rib and the top of the iliac crest, using a standard measuring tape. The hip circumference was measured at the widest part of the buttocks, with the tape kept parallel to the floor. **Results:** Only 4% of patients with cholelithiasis were underweight, compared to 10% in the control group, indicating a statistically significant difference (p=0.045). In the normal weight category, 24% of the cholelithiasis group fell within this range, compared to 35% of the control group, with a significant p-value of 0.025. Interestingly, both groups had the same percentage (40%) of overweight individuals, indicating no significant difference here (p=0.982). However, obesity was significantly more prevalent in the cholelithiasis group (32%) compared to the control group (15%), with a highly significant p-value (p=0.008). The waist-to-hip ratio (WHR) distribution further supports the link between obesity and cholelithiasis. In the cholelithiasis group, 60% had a WHR above the threshold for abdominal obesity (≥0.9 for men and ≥0.85 for women), compared to 40% in the control group, with a significant p-value of 0.006. Conversely, a lower percentage of patients in the cholelithiasis group (40%) had WHR below the threshold, compared to 60% in the control group, with a matching significant p-value of 0.006. The correlation analysis revealed significant positive correlations between BMI, WHR, and the presence of cholelithiasis, with p-values < 0.001 and 0.002, respectively. **Conclusion:** Overall, these results underscore the significant relationship between obesity, both general (BMI) and central (WHR), and the development of cholelithiasis.

Keywords: Cholelithiasis, Body mass index, Waist to hip ratio

INTRODUCTION

Cholelithiasis, commonly known as gallstone disease, is a prevalent condition characterized by the formation of stones within the gallbladder. These stones can lead to a range of symptoms, from asymptomatic cases to severe abdominal pain and complications such as cholecystitis, pancreatitis, and biliary colic. The formation of gallstones is influenced by various factors, including genetic predisposition, diet, and metabolic conditions. Among these, body mass index (BMI) and waist-to-hip ratio (WHR) have been identified as significant risk factors.[1,2]BMI is a widely used measure to classify individuals based on their body weight relative to their height. It is calculated by dividing a person's weight in kilograms by the square of their height in meters. A BMI of 18.5-24.9 is considered normal, 25-29.9 is overweight, and 30 or above is classified as obese. WHR, on the other hand, is a measure of fat distribution around the torso. It is calculated by dividing the circumference of the waist by that of the hips. A WHR above 0.9 for men and 0.85 for women indicates central obesity, which is closely linked to metabolic syndrome and cardiovascular diseases.[3]The correlation between cholelithiasis and BMI has been extensively studied, revealing a strong association between higher BMI and the risk of gallstone formation. Obesity, as measured by BMI, is a well-documented risk factor for the development of gallstones. This is primarily due to the fact that obesity leads to an increased secretion of cholesterol into bile, which supersaturates the bile and promotes the formation of cholesterol

gallstones. Moreover, obese individuals often exhibit decreased gallbladder motility, which contributes to bile stasis and stone formation.[4]
Several epidemiological studies have demonstrated that individuals with a higher BMI have a significantly increased risk of developing cholelithiasis. For example, data from large cohort studies indicate that the risk of gallstone disease is two to three times higher in obese individuals compared to those with a normal BMI. This association persists even after adjusting for other risk factors such as age, gender, and diet. Additionally, rapid weight loss, often seen in obese individuals undergoing weight reduction surgeries, can paradoxically increase the risk of gallstone formation due to increased bile cholesterol saturation during periods of significant weight loss.[5,6]WHR is another critical factor in the risk assessment for cholelithiasis. Central obesity, as indicated by a high WHR, is associated with an increased risk of gallstone disease. This relationship is attributed to the metabolic effects of visceral fat, which is more metabolically active than subcutaneous fat. Visceral fat is linked to insulin resistance and hyperinsulinemia, conditions that increase the liver's cholesterol output and decrease the bile acid secretion, thus promoting the formation of cholesterol gallstones.[7,8]Studies have shown that individuals with a high WHR have a significantly higher prevalence of gallstones compared to those with a lower WHR. This is particularly evident in postmenopausal women, where central obesity is more pronounced and closely associated with metabolic disturbances. The hormonal changes in postmenopausal women further exacerbate the risk, as decreased estrogen levels contribute to increased cholesterol levels in bile.[9] Furthermore, the combination of high BMI and high WHR poses an even greater risk for cholelithiasis. This combination indicates a higher degree of adiposity and central fat distribution, both of which synergistically increase the likelihood of gallstone formation. Clinically, this necessitates a more vigilant approach in managing patients with high BMI and WHR, emphasizing the importance of lifestyle modifications, weight management, and regular monitoring for gallstone disease.[10,11]Preventive strategies for reducing the risk of cholelithiasis in individuals with high BMI and WHR include maintaining a healthy weight through balanced diet and regular physical activity. Diets low in saturated fats and high in fiber can help reduce cholesterol levels and improve gallbladder motility. Additionally, gradual weight loss is recommended over rapid weight loss to minimize the risk of gallstone formation. For individuals undergoing weight reduction surgeries, prophylactic measures such as ursodeoxycholic acid may be considered to prevent gallstone formation during rapid weight loss phases.

MATERIAL AND METHODS

This study was conducted in the Department of General Surgery at Patna Medical College Hospital, Patna, from August 2023 to March 2024. The research aimed to explore the relationship between cholelithiasis, body mass index (BMI), and waist-to-hip ratio (WHR). The study included a total of 225 individuals presenting with abdominal discomfort, divided into two groups: 125 patients diagnosed with cholelithiasis (test group) and 100 patients with abdominal discomfort due to other causes (control group).

Inclusion criteria

- Age over 20 years
- Presence of abdominal discomfort
- Willingness to participate in the study

Exclusion criteria

- Presence of comorbid conditions such as cardiac disease, renal failure, ascites, and hypoproteinemia
- Pregnant women with gallstones
- Patients with any abdominal mass and gallstones
- History of prior abdominal surgery
- Unwillingness to participate in the study

All participants provided written informed consent after receiving detailed information about the study's purpose and procedures.

Methodology

A comprehensive medical history was obtained for each patient, focusing on the hepato-biliary system and identifying potential risk factors for cholelithiasis. Physical examinations were conducted to assess overall health and gather crucial information at the time of admission. Abdominal examinations followed standard procedures, and findings were meticulously recorded.The following investigations were performed for all participants:

- Complete Blood Count (CBC)
- Liver Function Tests (LFT)
- Renal Function Tests (RFT)
- Abdominal Ultrasound (USG)

The BMI was calculated using Quetelet's index, which involves dividing the patient's weight (in kilograms) by the square of their height (in meters).Waist and hip circumferences were measured following the World Health Organization (WHO) methodology. The waist circumference was measured at the midpoint between the lower edge of the last palpable rib and the top of the iliac crest, using a standard measuring tape. The hip circumference was measured at the widest part of the buttocks, with the tape kept parallel to the floor. Measurements were taken at the end of a normal exhalation.

Criteria for Abdominal Obesity

According to WHO guidelines, abdominal obesity is defined by:

- A waist-to-hip ratio over 0.9 in men and above 0.85 in women
- A BMI greater than 30 kg/m²

Evaluation and Treatment

Patients were evaluated for treatment based on the severity of their symptoms, physical examination findings, and ultrasound results. The collected data were analyzed to determine the correlation between cholelithiasis, BMI, and WHR. Statistical analysis was conducted using appropriate methods to ascertain the significance of the findings.

Statistical analyses

Statistical analyses will be conducted using unpaired t-tests or Mann-Whitney tests for continuous variables, and chi-square tests or Fisher's exact tests for categorical variables. A significance level of $p<0.05$ was used to determine statistical significance. The statistical software SPSS version 25 was used.

RESULTS

Table 1: Demographic Characteristics of Patients

The demographic characteristics of the study participants reveal that the mean age for patients with cholelithiasis was 45.3 years, slightly older than the control group's mean age of 42.8 years. This age distribution suggests that cholelithiasis might be more prevalent among slightly older individuals. Gender distribution was fairly balanced in both groups, with males constituting 52% of the cholelithiasis group and 55% of the control group, while females made up 48% and 45%, respectively. This indicates no significant gender predisposition in this study. Regarding socioeconomic status, a higher percentage of patients in both groups belonged to the middle class, with 56% in the cholelithiasis group and 60% in the control group, suggesting a possible socioeconomic factor influencing healthcare access or disease prevalence.

Table 2: BMI Distribution in Patients

The BMI distribution shows notable differences between the cholelithiasis and control groups. Only 4% of patients with cholelithiasis were underweight, compared to 10% in the control group, indicating a statistically significant difference (p=0.045). In the normal weight category, 24% of the cholelithiasis group fell within this range, compared to 35% of the control group, with a significant p-value of 0.025. Interestingly, both groups had the same percentage (40%) of overweight individuals, indicating no significant difference here (p=0.982). However, obesity was significantly more prevalent in the cholelithiasis group (32%) compared to the control group (15%), with a highly significant p-value (p=0.008).

Table 3: Waist-to-Hip Ratio Distribution

The waist-to-hip ratio (WHR) distribution further supports the link between obesity and cholelithiasis. In the cholelithiasis group, 60% had a WHR above the threshold for abdominal obesity (≥0.9 for men and ≥0.85 for women), compared to 40% in the control group, with a significant p-value of 0.006. Conversely, a lower percentage of patients in the cholelithiasis group (40%) had WHR below the threshold, compared to 60% in the control group, with a matching significant p-value of 0.006.

Table 4: Clinical Examination Findings

Clinical examination findings reveal that a significant number of cholelithiasis patients (72%) exhibited tenderness in the right upper quadrant (RUQ), compared to only 30% in the control group, indicating a strong association with cholelithiasis. Additionally, 68% of cholelithiasis patients had a positive Murphy's sign, compared to 25% of the control group, highlighting its diagnostic relevance. Jaundice was present in 16% of cholelithiasis patients versus 5% in the control group. These findings underscore the importance of specific clinical signs in diagnosing cholelithiasis.

Table 5: Laboratory Investigation Results

Laboratory results show that elevated liver function tests (LFTs) were significantly more common in cholelithiasis patients (80%) compared to controls (30%), with a p-value of <0.001. Elevated renal function tests (RFTs) were present in 16% of the cholelithiasis group and 10% of the control group, but this difference was not statistically significant (p=0.198). Abnormal complete blood counts (CBCs) were more prevalent in the cholelithiasis group (40%) compared to the control group (20%), with a significant p-value of 0.002.

Table 6: Abdominal Ultrasound Findings

Ultrasound findings, a cornerstone in the diagnosis of cholelithiasis, show that all patients in the cholelithiasis group (100%) had gallstones, as expected. Additionally, gallbladder wall thickening was observed in 64% of cholelithiasis patients compared to 10% in the control group, with a highly significant p-value of <0.001. Dilated bile ducts were noted in 24% of cholelithiasis patients versus 5% in the control group, also highly significant (p<0.001).

Table 7: Correlation between BMI, WHR, and Cholelithiasis

The correlation analysis revealed significant positive correlations between BMI, WHR, and the presence of cholelithiasis, with p-values < 0.001 and 0.002, respectively.

Table 1: Demographic Characteristics of Patients

Characteristic	Cholelithiasis (n=125)	Control (n=100)	Total (n=225)
Age (years), mean ± SD	45.3 ± 12.4	42.8 ± 11.9	44.2 ± 12.2

Gender			
- Male	65 (52%)	55 (55%)	120 (53.33%)
- Female	60 (48%)	45 (45%)	105 (46.67%)
Socioeconomic Status			
- Middle Class	70 (56%)	60 (60%)	130 (57.78%)
- Lower Class	55 (44%)	40 (40%)	95 (42.22%)

Table 2: BMI Distribution in Patients

BMI Category (kg/m²)	Cholelithiasis (n=125)	Control (n=100)	p-value
< 18.5 (Underweight)	5 (4%)	10 (10%)	0.045*
18.5-24.9 (Normal)	30 (24%)	35 (35%)	0.025*
25-29.9 (Overweight)	50 (40%)	40 (40%)	0.982
≥ 30 (Obese)	40 (32%)	15 (15%)	0.008**

Table 3: Waist-to-Hip Ratio Distribution

WHR Category	Cholelithiasis (n=125)	Control (n=100)	p-value
< 0.9 (Men) / < 0.85 (Women)	50 (40%)	60 (60%)	0.006**
≥ 0.9 (Men) / ≥ 0.85 (Women)	75 (60%)	40 (40%)	0.006**

Table 4: Clinical Examination Findings

Parameter	Cholelithiasis (n=125)	Control (n=100)	Total (n=225)
Tenderness in RUQ	90 (72%)	30 (30%)	120 (53.33%)
Positive Murphy's Sign	85 (68%)	25 (25%)	110 (48.89%)
Jaundice	20 (16%)	5 (5%)	25 (11.11%)

Table 5: Laboratory Investigation Results

Test	Cholelithiasis (n=125)	Control (n=100)	Total (n=225)	p-value
Elevated LFT	100 (80%)	30 (30%)	130 (57.78%)	< 0.001**
Elevated RFT	20 (16%)	10 (10%)	30 (13.33%)	0.198
Abnormal CBC	50 (40%)	20 (20%)	70 (31.11%)	0.002**

Table 6: Abdominal Ultrasound Findings

Finding	Cholelithiasis (n=125)	Control (n=100)	Total (n=225)	p-value
Gallstones Present	125 (100%)	0 (0%)	125 (55.55%)	< 0.001**
Gallbladder Wall Thickening	80 (64%)	10 (10%)	90 (40%)	< 0.001**
Dilated Bile Ducts	30 (24%)	5 (5%)	35 (15.55%)	< 0.001**

Table 7: Correlation between BMI, WHR, and Cholelithiasis

Parameter	Correlation Coefficient (r)	p-value
BMI and Cholelithiasis	0.45	<0.001**
WHR and Cholelithiasis	0.38	0.002**

DISCUSSION

The demographic data indicates that patients with cholelithiasis tend to be slightly older, with a mean age of 45.3 years compared to 42.8 years in the control group. This trend aligns with previous studies, such as those by Shaffer (2018)[12] and Everhart et al. (2020)[13], which also observed higher incidences of gallstones in older populations. The gender distribution in this study shows a slight male predominance in both groups. However, many other studies, such as the one by Méndez-Sánchez et al. (2019)[14], have reported a higher prevalence of cholelithiasis in females. This discrepancy might be attributed to regional variations or differences in sample size and demographics.The socioeconomic status analysis revealed a majority of middle-class patients in both groups, which may reflect the hospital's patient demographic or access to healthcare. Studies by Park et al. (2021)[15] have shown that socioeconomic status can influence the prevalence and management of cholelithiasis, with lower socioeconomic status being associated with higher risks and delayed treatment.The BMI distribution highlights a significant correlation between obesity and cholelithiasis. A notably higher percentage of patients with cholelithiasis were classified as obese (32%) compared to the control group (15%). This finding is consistent with studies by Stender et al. (2017)[16] and Di Ciaula et al. (2019), which found obesity to be a significant risk factor for gallstone disease.[17] The statistical significance (p=0.008) underscores the strong link between higher BMI and cholelithiasis, suggesting that weight management might be a crucial preventive measure.The underweight category had fewer cholelithiasis patients compared to controls, which could indicate that lower body weight is not a major risk factor for gallstone formation. The normal and overweight categories showed balanced distributions, but the critical observation remains the high prevalence of obesity among cholelithiasis patients, aligning with the broader understanding that obesity contributes to the pathogenesis of gallstones.The WHR data further supports the association between central obesity and cholelithiasis. A significant portion of cholelithiasis patients had a WHR above the threshold for abdominal obesity (60% compared to 40% in the control group), with a p-value of 0.006. This correlation aligns with findings from Chang et al. (2019)[18] and Lammert et al. (2020), who also identified central obesity as a critical risk factor for gallstones.[19] The study's results highlight that central obesity, as indicated by a high WHR, may be more predictive of cholelithiasis risk than BMI alone. This is significant because it emphasizes the need for measuring WHR in clinical settings to better assess the risk of gallstone disease.

The clinical examination findings demonstrate strong diagnostic indicators for cholelithiasis. A significant number of cholelithiasis patients exhibited RUQ tenderness (72%) and a positive Murphy's sign (68%), compared to lower percentages in the control group. These clinical signs are well-supported by literature, including a study by Afdhal (2020), which emphasized the diagnostic importance of RUQ tenderness and Murphy's sign in cholelithiasis.[20] The presence of jaundice in 16% of cholelithiasis patients versus 5% in controls further indicates complications such as choledocholithiasis or cholangitis, which are critical considerations in patient management.Laboratory findings revealed that elevated LFTs were significantly more common in cholelithiasis patients (80%) compared to controls (30%), with a p-value of <0.001. This is consistent with research by Portincasa et al. (2018), which associates elevated liver enzymes with biliary obstruction and inflammation due to gallstones.[21] Abnormal CBCs were also more prevalent in the cholelithiasis group (40%) compared to controls (20%), which is statistically significant (p=0.002). This might reflect an inflammatory response or secondary infection, aligning with findings by McPhee and Papadakis (2019).[22] Ultrasound findings, a key diagnostic tool for cholelithiasis, confirmed the presence of gallstones in all patients diagnosed with the condition (100%). Gallbladder wall thickening and dilated bile ducts were also significantly more common in cholelithiasis patients. These ultrasound findings are crucial for confirming the diagnosis and assessing complications, as supported by studies from Ko et al. (2019) and Bortoff et al. (2020), which emphasize the accuracy and importance of ultrasound in diagnosing gallstone disease and related complications.[23,24]

CONCLUSION

Overall, these results underscore the significant relationship between obesity, both general (BMI) and central (WHR), and the development of cholelithiasis.

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