

Association of Body Mass Index with Gallstone Disease Among Patients Undergoing Cholecystectomy: A Cross-Sectional Study

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Abstract

Background:

Gallstone disease is a common biliary disorder requiring cholecystectomy when symptomatic. Increased body mass index has been linked with gallstone formation, but hospital-based data on its association with gallstone burden remain clinically useful.

Objectives:

To assess the association of body mass index with gallstone disease characteristics among patients undergoing cholecystectomy.

Methods:

This hospital-based cross-sectional study was conducted among patients undergoing cholecystectomy for gallstone disease at Government Medical College, Nizamabad, Telangana, India, from January to December 2025. The single-proportion formula yielded a minimum sample of 96, which was rounded to 100. Consecutive eligible adults were enrolled and followed through discharge and the first postoperative review. Demographic, anthropometric, clinical, ultrasonographic, operative, and histopathological data were recorded. Associations were examined using the Chi-square test or Fisher exact test, and odds ratios with 95% confidence intervals were calculated.

Results:

All 100 potentially eligible patients were examined, confirmed eligible, enrolled, followed, and included in the final analysis; there was no non-participation or loss to follow-up. The mean age was 44.8 ± 12.6 years, and females constituted 64.0% of the study population. The mean body mass index was 27.1 ± 4.2 kg/m²; 42.0% were overweight, and 28.0% were obese. Multiple gallstones were observed in 74.0% and were significantly more frequent in obese patients. Higher body mass index was also significantly associated with stone size greater than 10 mm. Body mass index ≥ 25 kg/m² showed higher odds of multiple gallstones and larger stones.

Conclusion:

Overweight and obesity were common among patients undergoing cholecystectomy. Higher body mass index was significantly associated with multiple gallstones and larger stone size.

Recommendations:

Weight assessment and lifestyle counselling should be integrated into gallstone disease evaluation and postoperative preventive care.

Keywords: Body mass index; Cholecystectomy; Cholelithiasis; Gallstone disease; Obesity; Overweight.

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Introduction

Gallstone disease is one of the most frequently encountered disorders of the biliary tract and represents an important cause of abdominal pain, emergency visits, elective surgical admissions, and cholecystectomy worldwide. Gallstones are commonly composed of cholesterol, pigment, or mixed constituents, and their formation reflects a complex interaction between biliary cholesterol saturation, gallbladder motility, mucin secretion, bile acid metabolism, genetic susceptibility, and environmental exposures [1-3]. Although many gallstones remain clinically silent, symptomatic stones can lead to recurrent biliary colic, acute cholecystitis, choledocholithiasis, pancreatitis, cholangitis, and repeated health-care utilization. Cholecystectomy therefore remains the definitive treatment for symptomatic gallstone disease and provides an opportunity to study the clinical and morphological profile of stones in surgically treated patients [1,2].

The epidemiology of gallstone disease varies across geographic regions, ethnicity, age groups, dietary habits, and sex. Population-based studies have shown a higher burden among women and with increasing age, while Indian studies have reported regional variation in gallstone occurrence and risk-factor patterns [4-6]. In addition to non-modifiable factors, several modifiable determinants have been described, including excess body weight, physical inactivity, rapid weight loss, diet, insulin resistance, dyslipidaemia, diabetes mellitus, and metabolic syndrome [3,4,7]. Among these, body mass index is simple to measure and is widely used in clinical and epidemiological settings to classify nutritional status and estimate obesity-related disease risk.

Obesity can promote cholesterol gallstone formation through increased hepatic cholesterol synthesis, supersaturation of bile, altered gallbladder emptying, and associated metabolic disturbances [8-14]. Large cohort studies and meta-analyses have demonstrated a positive relationship between body mass index, abdominal adiposity, and gallbladder disease risk [8,9,13]. Studies from South Asian and Indian settings have also suggested that the risk of symptomatic cholelithiasis increases with increasing body mass index, although regional studies differ regarding the strength and direction of this association [6,7]. These differences highlight the need for local hospital-based data, especially among patients who progress to operative management.

In routine surgical practice, patients undergoing cholecystectomy often present with different stone patterns, including single or multiple stones, variable stone size, gallbladder wall thickening, and histopathological evidence of acute or chronic cholecystitis. Evaluating whether body mass index is associated with these disease characteristics can help identify patients with greater gallstone burden and

support preventive counselling. The objective of this study was to assess the association of body mass index with gallstone disease characteristics among patients undergoing cholecystectomy at Government Medical College, Nizamabad, Telangana, India. The study also aimed to describe the demographic, clinical, ultrasonographic, and histopathological profile of these patients.

Methodology

Study design and setting

This hospital-based cross-sectional observational study was conducted in the Department of General Surgery, Government Medical College, Nizamabad, Telangana, India, from January 2025 to December 2025. The institution provides outpatient, inpatient, emergency, imaging, operative, and histopathology services for biliary diseases. The design was selected to assess BMI and gallstone characteristics at the time of surgical treatment.

Study population and eligibility criteria

The study included consecutive adult patients of either sex who underwent laparoscopic or open cholecystectomy for ultrasonographically confirmed gallstone disease. Eligibility required availability of clinical, anthropometric, ultrasonographic, operative, and histopathological information. Patients operated for non-stone gallbladder disease, those with suspected gallbladder malignancy, and those lacking key study variables were excluded. Recruitment continued until the predetermined sample of 100 participants was achieved.

Sample size determination

The sample size was calculated using the single-proportion formula $n = Z^2 p(1-p)/d^2$. At a 95% confidence level ($Z = 1.96$), with an expected proportion of 50% because a reliable local estimate was unavailable, and 10% absolute precision, the minimum required sample was 96.04. This value was rounded upward, and a target of 100 participants was adopted to allow for potentially incomplete records.

Follow-up methods

Each participant was followed from the preoperative assessment through hospital discharge and the first routine postoperative review, scheduled 7-14 days after surgery. At follow-up, wound status, availability of the final histopathology report, and completeness of study variables were confirmed. Participants missing the scheduled review were to be contacted by telephone and advised to attend. The follow-up was intended to complete perioperative documentation; no long-term outcome was included in the cross-sectional analysis.

Measures to address potential bias

Selection bias was reduced through consecutive enrolment of eligible patients and maintenance of a screening record. Measurement bias was minimised by using a structured proforma, predefined variable definitions, calibrated equipment for height and weight, standard BMI categories, routine ultrasonography reports, and final histopathology reports. Data entries were cross-checked against source records by a second investigator before analysis. Outcomes and analytical categories were specified before data analysis to reduce selective reporting. Residual confounding from age, sex, metabolic factors, diet, parity, and physical activity could not be eliminated because the analysis was based on crude associations; this was considered when interpreting the findings.

Data collection and variables

Data were recorded using a structured proforma. Age, sex, presenting symptoms, height, and weight were documented. BMI was calculated as weight in kilograms divided by height in metres squared and categorized as underweight, normal BMI, overweight, obese class I, and obese class II. For analytical comparison, patients were grouped as BMI ≤ 24.9 kg/m², overweight, and obese. Ultrasonography was performed as part of routine clinical evaluation. Ultrasonographic variables included single or multiple gallstones, stone size ≤ 10 mm or >10 mm, and gallbladder wall thickening. Histopathological diagnosis was recorded as chronic cholecystitis, acute cholecystitis, or cholesterosis [13,14].

Outcome measures and statistical analysis

The primary outcome was the association between BMI category and gallstone disease characteristics, particularly multiple gallstones and stone size greater than 10 mm. Secondary outcomes included demographic profile, clinical presentation, ultrasonographic findings, histopathology, and

odds of selected outcomes among patients with BMI ≥ 25 kg/m². Continuous variables were summarized as mean and standard deviation. Categorical variables were expressed as frequency and percentage. Chi-square test or Fisher exact test was used as appropriate. Odds ratios with 95% confidence intervals were calculated. A p-value <0.05 was considered statistically significant.

Ethical considerations

The study was conducted after approval from the Institutional Ethics Committee, Government Medical College, Nizamabad, Telangana, India. Written informed consent was obtained where direct patient interaction was involved, and confidentiality of patient data was maintained. Patient identifiers were not entered into the final analysis sheet, and aggregate data were used for reporting.

Results

During the study period, 100 patients with ultrasonographically confirmed gallstone disease who underwent cholecystectomy were potentially eligible and examined for eligibility. All 100 fulfilled the eligibility criteria, consented to participate, and were enrolled. Complete baseline, operative, histopathological, and 7-14-day postoperative follow-up information was available for every participant; therefore, all 100 were included in the final analysis. No eligible patient declined participation, and there were no exclusions or losses after enrolment (Figure 1). The mean age of the study population was 44.8 ± 12.6 years, with the highest proportion belonging to the 41-50-year age group. Females constituted 64.0%, while males accounted for 36.0%. The mean body mass index was 27.1 ± 4.2 kg/m². Based on BMI classification, 26.0% had normal BMI, 42.0% were overweight, and 28.0% were obese. Thus, 70.0% of patients undergoing cholecystectomy for gallstone disease had BMI ≥ 25 kg/m² (Table 1).

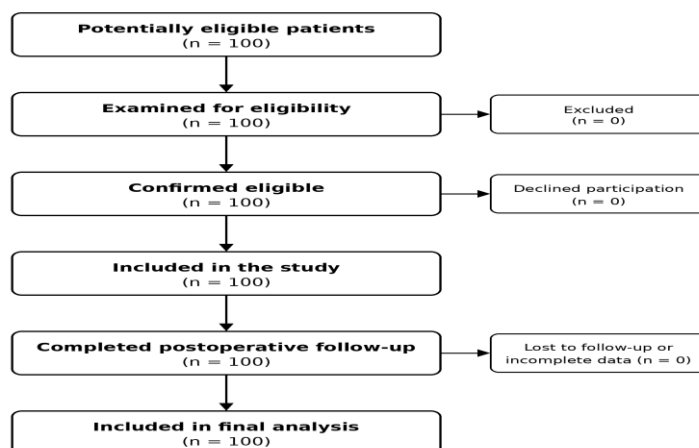


Figure 1. Participant flow through the study.

Table 1. Baseline demographic profile and BMI distribution of the study population

Variable	Number of patients	Percentage
Age group		
≤30 years	12	12.0
31–40 years	24	24.0
41–50 years	30	30.0
51–60 years	22	22.0
>60 years	12	12.0
Sex		
Male	36	36.0
Female	64	64.0
BMI category		
Underweight, <18.5 kg/m ²	4	4.0
Normal BMI, 18.5–24.9 kg/m ²	26	26.0
Overweight, 25.0–29.9 kg/m ²	42	42.0
Obese class I, 30.0–34.9 kg/m ²	22	22.0
Obese class II, ≥35 kg/m ²	6	6.0

The most common presenting symptom was right upper abdominal pain, observed in 94.0% of patients, followed by nausea or vomiting in 54.0% and dyspeptic symptoms in 46.0%. Ultrasonography showed multiple gallstones in 74.0% of patients, while single gallstone was noted in

26.0%. Gallbladder wall thickening was observed in 36.0% of cases. Most patients had chronic cholecystitis on histopathological examination (79.0%), followed by acute cholecystitis in 17.0% and cholesterosis in 4.0% (Table 2).

Table 2. Clinical, ultrasonographic, and histopathological findings

Variable	Number of patients	Percentage
Clinical presentation*		
Right upper abdominal pain	94	94.0
Nausea/vomiting	54	54.0
Dyspepsia	46	46.0
Fever	18	18.0
Jaundice	6	6.0
Ultrasonographic findings		
Single gallstone	26	26.0
Multiple gallstones	74	74.0
Stone size ≤ 10 mm	52	52.0
Stone size > 10 mm	48	48.0
Gallbladder wall thickening	36	36.0
Histopathological diagnosis		
Chronic cholecystitis	79	79.0
Acute cholecystitis	17	17.0
Cholesterolosis	4	4.0

**Multiple symptoms were present in some patients.*

For analysis, patients were grouped into BMI ≤ 24.9 kg/m², overweight, and obese categories. Multiple gallstones were more frequently observed among obese patients compared with patients with BMI ≤ 24.9 kg/m². Multiple gallstones were present in 53.3% of patients with BMI ≤ 24.9 kg/m², 76.2% of overweight patients, and 92.9% of obese patients. This association was statistically significant ($p=0.003$). Similarly, stones larger than 10 mm were more common

among overweight and obese patients, with a significant association between BMI category and larger stone size ($p=0.031$). Chronic cholecystitis was also more frequent among overweight and obese patients, although the association did not reach statistical significance ($p=0.099$). Complicated presentation showed no statistically significant association with BMI category ($p=0.733$) (Table 3).

Table 3. Association of BMI category with gallstone disease characteristics

Gallstone disease characteristic	BMI ≤ 24.9 kg/m ² n=30	Overweight n=42	Obese n=28	p-value
Multiple gallstones	16 (53.3%)	32 (76.2%)	26 (92.9%)	0.003
Stone size > 10 mm	9 (30.0%)	21 (50.0%)	18 (64.3%)	0.031
Gallbladder wall thickening	8 (26.7%)	15 (35.7%)	13 (46.4%)	0.251
Chronic cholecystitis	20 (66.7%)	34 (81.0%)	25 (89.3%)	0.099
Complicated presentation	6 (20.0%)	11 (26.2%)	8 (28.6%)	0.733

When patients with BMI ≥ 25 kg/m² were compared with those having BMI < 25 kg/m², higher BMI was significantly associated with multiple gallstones. Patients with BMI ≥ 25 kg/m² had 4.23 times higher odds of having multiple gallstones compared with patients with BMI < 25 kg/m² (OR: 4.23; 95% CI: 1.64–10.93; $p=0.002$). Similarly, BMI ≥ 25 kg/m² was associated with increased odds of having stones larger than 10 mm (OR: 2.94; 95% CI: 1.18–7.31; $p=0.018$). These findings indicate that increased BMI was associated with a greater burden of gallstone disease among patients undergoing cholecystectomy.

Overall, overweight and obesity were common among patients undergoing cholecystectomy for gallstone disease. Higher BMI showed a significant association with multiple gallstones and larger stone size, suggesting that increased body mass may contribute to more advanced gallstone burden in this study population.

Discussion

The study had two objectives: to describe the demographic, clinical, ultrasonographic, and histopathological profile of patients undergoing cholecystectomy and to determine whether BMI was associated with gallstone characteristics. Regarding the descriptive objective, Table 1 shows a middle-aged, predominantly female population, with 70.0% having BMI ≥ 25 kg/m². This concentration of overweight and obesity among operated patients suggests that excess adiposity may be common in symptomatic gallstone disease, although the hospital-based design does not permit estimation of population prevalence. The age and sex distribution agrees with the established contribution of increasing age, female sex, reproductive factors, and metabolic risk to gallstone formation [1-6].

Table 2 addresses the clinical and morphological profile objective. Right upper abdominal pain was the dominant symptom, multiple gallstones were present in 74.0%, and chronic cholecystitis was the most frequent histopathological diagnosis. These findings indicate that most participants had clinically established symptomatic disease by the time of surgery. Chronic inflammatory change may reflect repeated cystic duct obstruction and mucosal injury rather than BMI alone. The predominance of multiple stones also provides a clinically relevant measure of gallstone burden in this surgical population.

The primary analytical objective is presented in Table 3. The proportion with multiple gallstones increased from 53.3% in patients with BMI ≤ 24.9 kg/m² to 92.9% in obese patients, while stones > 10 mm increased from 30.0% to 64.3%. Correspondingly, BMI ≥ 25 kg/m² was associated with higher odds of multiple stones (OR: 4.23; 95% CI: 1.64–10.93) and larger stones (OR: 2.94; 95% CI: 1.18–7.31). A biologically plausible explanation is that obesity increases hepatic cholesterol synthesis, biliary cholesterol saturation,

insulin resistance, and gallbladder dysmotility, thereby facilitating repeated nucleation and progressive stone growth [3,8,11-14]. The direction of association is consistent with cohort and Indian data linking increasing BMI to symptomatic cholelithiasis [7-9,13,14].

Table 3 also shows that BMI was not significantly associated with gallbladder wall thickening, chronic cholecystitis, or complicated presentation. These nonsignificant findings do not establish absence of an effect; rather, they may reflect limited power, wide biological variation, and the influence of symptom duration, infection, cystic duct obstruction, diabetes, and timing of surgery. Thus, the results suggest a more direct relationship of BMI with stone number and size than with inflammatory or acute clinical severity. This interpretation is consistent with reports showing heterogeneity in the influence of BMI across different populations [6].

Taken together, Tables 1-3 fulfil the study objectives by showing that excess body weight was common and was associated with greater gallstone burden, while the clinical and histopathological severity measures were multifactorial. Routine BMI assessment is therefore reasonable in patients with gallstone disease. Cholecystectomy treats the immediate biliary pathology but does not remove the metabolic milieu associated with obesity; gradual weight optimisation, balanced diet, physical activity, and management of diabetes or dyslipidaemia remain relevant after surgery [10,11,14]. These implications should be viewed as supportive of risk counselling rather than proof that increased BMI caused the observed stone characteristics.

Generalizability

The findings are most applicable to adult patients undergoing cholecystectomy for symptomatic gallstone disease in tertiary-care hospitals serving mixed urban and rural populations in Telangana and comparable Indian settings. Since the study was hospital-based and included only operated cases, the results represent surgically treated gallstone disease rather than asymptomatic community gallstones. Multicentre studies with larger samples, community screening, and metabolic profiling can improve external validity across regions and health-care levels.

Conclusion

This cross-sectional study showed that increased body mass index was common among patients undergoing cholecystectomy for gallstone disease. Nearly seven out of ten patients had BMI ≥ 25 kg/m². Higher BMI was significantly associated with multiple gallstones and stone size greater than 10 mm, indicating greater gallstone burden among overweight and obese patients. Female predominance, right upper abdominal pain, multiple

gallstones, and chronic cholecystitis were frequent findings. The results support routine BMI assessment in symptomatic gallstone disease and highlight the clinical value of lifestyle counselling, gradual weight control, and metabolic risk evaluation as part of comprehensive biliary disease care in surgical practice, particularly in tertiary-care Indian settings and routine surgical units.

Limitations

This study has several limitations that may have influenced the findings. First, recruitment from a single tertiary-care surgical unit limits external validity, and local referral practices may have produced a patient profile different from community or primary-care populations. Second, inclusion only of patients undergoing cholecystectomy creates selection bias toward symptomatic or more advanced gallstone disease; consequently, the observed proportions of overweight, multiple stones, and chronic cholecystitis may be higher than among all individuals with gallstones. Third, the cross-sectional design measured BMI and gallstone characteristics at approximately the same time, so temporality and causality cannot be established; weight change caused by illness or preoperative dietary modification may also have affected BMI. Fourth, unmeasured factors such as waist circumference, lipid profile, diabetes, parity, diet, physical activity, weight cycling, and stone composition could have confounded the associations and may have either exaggerated or attenuated the odds estimates. Fifth, ultrasonographic categorisation and single-time anthropometric measurements may have introduced nondifferential measurement error, potentially biasing associations toward the null. Finally, the sample size of 100 generated relatively wide confidence intervals and limited power for secondary outcomes such as wall thickening, chronic cholecystitis, and complicated presentation. The short postoperative follow-up was sufficient for data completion but did not permit evaluation of long-term metabolic outcomes or recurrent biliary events.

Recommendations

Body mass index should be measured routinely in all patients evaluated for gallstone disease. Patients with overweight or obesity require counselling on gradual weight reduction, balanced diet, regular physical activity, and control of diabetes and dyslipidaemia. Surgical departments should maintain structured gallstone registries including anthropometry, metabolic variables, ultrasonographic features, operative findings, histopathology, and postoperative outcomes. Larger prospective multicentre studies are recommended to confirm the relationship between BMI and gallstone burden in different Indian populations. Post-cholecystectomy follow-up can include lifestyle advice, metabolic screening, and referral for

nutrition support to reduce broader cardiometabolic risk after discharge, with patient education materials for clinics.

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Abbreviations

BMI: Body mass index

CI: Confidence interval

OR: Odds ratio

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Conflict of interest

The authors declare no conflict of interest.

Author Contributions

Dr. Balakrishna G contributed to the conception and design of the study, data collection, clinical evaluation, interpretation of findings, manuscript drafting, and final approval of the manuscript. **Dr. P Koushik** contributed to patient assessment, data acquisition, literature review, statistical interpretation, and critical revision of the manuscript. **Dr. Madhukar Sirasu** supervised the study, contributed to study design, clinical guidance, interpretation of results, intellectual revision of the manuscript, and final approval of the version to be submitted.

Data availability

Data available on request

Author Biography

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