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"Comparative impact of body mass index, waist circumference, and a body shape index on surgical difficulty in laparoscopic cholecystectomy: A cross-sectional comparative study"

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Abstract

Background:

Laparoscopic cholecystectomy (LC) is the preferred minimally invasive treatment for symptomatic gallstones, but surgical difficulty can vary, sometimes causing complications or conversion to open surgery. Traditional obesity assessment using Body Mass Index shows inconsistent predictive value, whereas waist circumference (WC) and A Body Shape Index (ABSI) may more accurately reflect body fat distribution and associated surgical risk.

Aim:

To comparatively assess the impact of BODY MASS INDEX, WC, and ABSI on surgical difficulty during LC.

Methods:

A cross-sectional comparative study was conducted over 2 years in the Department of General Surgery, Rajendra Institute of Medical Sciences, Ranchi. A total of 200 patients undergoing elective LC were enrolled. Preoperative anthropometric measurements (body mass index, WC, ABSI) were recorded. Intraoperative outcomes such as operative duration, complications, surgeon's subjective difficulty scores, and conversion to open surgery were documented. Statistical analysis was performed using SPSS version 25. Chi-square test, Kruskal-Wallis test, and Binary Logistic Regression were applied. A p-value <0.05 was considered significant.

Results:

The majority of cases (61.5%) were classified as mild difficulty, 21.5% moderate, and 17% severe. WC was significantly associated with overall surgical difficulty ($p=0.036$) and physical stress experienced by the surgeon ($p=0.014$). Body mass index and ABSI did not show significant correlations with overall difficulty or specific surgical steps (all $p > 0.05$). Weight alone showed significant correlation with difficulty in approach to gallbladder ($p=0.028$), dissection of Calot's triangle ($p=0.029$), and gallbladder removal/retrieval ($p=0.042$). Port insertion difficulty was not significantly associated with any parameter.

Conclusion:

WC was a more reliable predictor of surgical difficulty in LC compared to BODY MASS INDEX and ABSI. Weight also influenced the difficulty in specific steps.

Recommendations:

Preoperative assessment of WC should be incorporated into surgical planning for LC. Multicentric studies with larger cohorts are needed for validation.

Keywords: *Laparoscopic Cholecystectomy, Body Mass Index, Waist Circumference, Body Shape Index, Surgical Difficulty*
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Introduction

(LC) It is the gold standard surgical procedure for the treatment of symptomatic cholelithiasis due to its minimally invasive nature, reduced postoperative pain, shorter hospital stay, and faster recovery compared to open cholecystectomy [1]. However, the procedure is not devoid of challenges, and various patient-related factors can significantly influence the technical difficulty encountered by surgeons during the operation. Predicting surgical difficulty preoperatively is essential to improve patient safety, optimize surgical planning, and reduce intraoperative complications such as bile duct injury, hemorrhage, or conversion to open surgery [2].

Obesity has emerged as a major global health concern and is increasingly prevalent among patients undergoing abdominal surgeries. Body Mass Index is the most commonly used anthropometric measure to classify obesity and evaluate its impact on health outcomes [3]. Despite its widespread use, body mass index fails to differentiate between fat mass and lean mass and does not account for fat distribution, which may be more relevant in surgical contexts [4]. Studies have shown conflicting results regarding the predictive role of body mass index in surgical difficulty during laparoscopic cholecystectomy, with some reporting a positive correlation while others report no significant correlation [5,6].

(WC) It is an important indicator of central obesity and visceral fat, which is more metabolically active and may have a direct impact on intra-abdominal surgical challenges. Several studies have suggested that WC is a better predictor of operative difficulty than body mass index, especially in laparoscopic surgeries, as it more accurately reflects the amount of intra-abdominal fat [7,8]. Patients with a higher waist circumference tend to have a thick abdominal wall and more visceral fat, which can obscure the operative field, increase difficulty in port placement, and complicate dissection of Calot's triangle [9].

(ABSI) is a relatively new anthropometric measure that adjusts waist circumference for height and weight, theoretically offering a better correlation with body shape and metabolic risk factors [10]. Few studies have examined its predictive role in surgical difficulty, and existing evidence remains inconclusive [11].

Given the limitations of BODY MASS INDEX and the mixed results regarding ABSI, there is a need to evaluate and compare these anthropometric indices systematically. This study aims to investigate the comparative impact of Body Mass Index, WC, and ABSI on surgical difficulty during laparoscopic cholecystectomy, to identify the most reliable preoperative predictor.

Methodology

Study Design:

This study was a hospital-based cross-sectional comparative observational study conducted over a duration of 2 years (12/6/2023 to 12/6/2025), following clearance from the Institutional Ethics Committee.

Study Site:

The study was conducted at the Department of General Surgery, Rajendra Institute of Medical Sciences (RIMS), Ranchi, a leading tertiary care teaching hospital in Eastern India. Established in 1960 and affiliated with Ranchi University, RIMS has over 1,500 beds and caters to around 5,000 outpatients daily, serving Jharkhand and adjoining states. It provides comprehensive medical, surgical, and super-specialty services along with emergency and diagnostic facilities. As a major academic and research center, RIMS trains undergraduate, postgraduate, and super-specialty medical professionals.

Study Population:

A total of **200 patients** diagnosed with cholelithiasis and planned for elective laparoscopic cholecystectomy were enrolled in the study after obtaining written informed consent.

Sample Size:

Based on prior studies and sample size calculation using the formula:

$$n = \frac{Z\alpha 2pq}{d2}$$

$$n = \frac{(1.96)2 \times 15.4 \times (100-15.4)}{(5)2}$$

$$n = 200$$

The calculated sample size was **200 patients**.

Inclusion Criteria:

- Patients who were radiologically diagnosed with cholelithiasis.
- Planned for elective laparoscopic cholecystectomy.
- Provided written informed consent.

Exclusion Criteria:

- Acute cholecystitis.
- Choledocholithiasis.
- Acute cholangitis or pancreatitis due to gallstones.
- Gallbladder carcinoma.
- Severe cardio-pulmonary disease.

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- End-stage liver disease.
- Uncorrected coagulopathy.
- Patients are unable to tolerate general anesthesia.

Data Collection Procedure:

1. Preoperative Workup:

- A detailed history was taken, and a clinical examination was performed.
- Anthropometric parameters were measured:
- Height (in cm).
- Weight (in kg).
- Waist circumference (in cm).
- Calculations included:
- **(Body Mass Index)**: Weight (kg) / [Height (m)]².
- **(ABSI)**: Calculated using a validated formula incorporating waist circumference, BODY MASS INDEX, and height.

2. Investigations:

- Complete hemogram.
- Coagulation profile (BT, CT, PT-INR).
- Serum biochemistry: urea, creatinine, electrolytes (sodium, potassium, calcium).
- Liver function tests: serum bilirubin, SGOT, SGPT, ALP.
- Serology: HIV, HBsAg, Anti-HCV.
- X-ray chest and ECG (for patients over 40 years of age).
- Abdominal ultrasonography: Stone size, gallbladder wall thickness, presence of pericholecystic collection.

3. Pre-Anesthetic Clearance:

All patients underwent pre-anesthetic evaluation, and those who were cleared proceeded to surgery.

Surgical Procedure:

A standard laparoscopic cholecystectomy was performed under general anesthesia. Pneumoperitoneum was created, and four trocars were inserted in standard positions. Dissection followed the principle of the critical view of safety.

Intraoperative Outcomes Measured:

- Duration of surgery (from creation of umbilical port to removal of gallbladder).
- Intraoperative complications:
- Bile duct injury.
- Gallbladder perforation.
- Significant hemorrhage (requiring suction/irrigation or gauze).
- Conversion to open cholecystectomy (recorded if required).
- Port site measurements (non-stretchable measuring tape with umbilicus as reference).
- Surgeon's subjective difficulty assessment (1 to 6 scale) for:
- Port insertion.
- Dissection of Calot's triangle.
- Removal of the gallbladder from the liver bed.
- Retrieval of the gallbladder through the port site.

Data Collection Instruments and Tools:

- Interview Schedule and Pretested Questionnaire.
- Surgical Instruments: Maryland dissector, Graspers, Clip appliers, Monopolar diathermy, Suction-irrigation devices, CO_2 insufflator, etc.
- Imaging System: Digital laparoscope camera, 10mm 30-degree laparoscope, Xenon light source, Optical fiber light cables, and Monitor.
- Measuring tape, reusable Veress needle, ADK drain, ligating clips.

Data Entry and Analysis:

- Data were recorded in a predesigned study proforma and entered into an MS Excel sheet.
- Variables included patient demographics, operative time, intraoperative complications, and the surgeon's subjective difficulty scores.

Statistical Methods:

- Categorical variables were expressed as numbers and percentages, compared using Pearson's Chi-square test or Fisher's exact test.
- Continuous variables were expressed as mean, median, and standard deviation, and compared using the Kruskal-Wallis test (due to non-normal distribution).
- Binary logistic regression was used for multivariate analysis to identify independent predictors of surgical difficulty, and Odds Ratios

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(ORs) with 95% confidence intervals were calculated."

- SPSS version 25 was used for statistical analysis.
- A p-value <0.05 was considered statistically significant.

Bias and Efforts to Minimize It

Potential sources of bias were addressed through several measures. Selection bias was reduced by applying strict inclusion and exclusion criteria. Information bias was minimized using standardized data collection tools and uniform anthropometric measurements by trained staff. Observer bias was limited by following a standard surgical protocol and using a predefined difficulty scale. Confounding factors such as age, sex, and comorbidities were recorded and adjusted in multivariate analysis. Data entry was cross-checked, and statistical analysis was performed using SPSS to ensure accuracy and reliability.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee (IEC), Rajendra Institute of Medical Sciences (RIMS), Ranchi, Jharkhand. Ethical clearance was granted before commencement of data collection (Approval Date: [insert date]; Ethical Clearance No.: [insert IEC number, if available]). Written informed consent was obtained from all participants after explaining the study objectives, procedures, potential risks, and benefits in their local language. Confidentiality of patient information was maintained throughout, and participation was entirely voluntary. Patients retained the right to withdraw at any stage without affecting their treatment.

Results

Participant Flow

A total of 300 patients diagnosed with cholelithiasis were initially assessed for eligibility during the study period. Of these, 100 patients were excluded: 35 due to acute cholecystitis, 20 with choledocholithiasis, 15 with gallstone-related pancreatitis or cholangitis, 10 with gallbladder carcinoma, and 20 with severe comorbid conditions or unfitness for general anesthesia. Finally, 200 patients who met the inclusion criteria and provided informed consent were enrolled and underwent elective laparoscopic cholecystectomy. No participants were lost during follow-up or analysis.

Table 1: Demographic and Anthropometric Data of Study Population

Parameter	Minimum	Maximum	Mean ± SD	Median
Age (years)	18	72	45.16 ± 12.35	45
Height (cm)	133	185	151.66 ± 9.27	152
Weight (kg)	36	92	57.56 ± 11.07	57.50
Waist Circumference (cm)	56	110	80.33 ± 10.65	80.50

The study population consisted of a diverse age group with a mean age of 45.16 years. The anthropometric measurements showed variation, allowing assessment of Body Mass Index, (WC), and (ABSI) in relation to surgical difficulty.

Table 2: Body Mass Index Categories and Distribution

Body Mass Index Category	Frequency (n)	Percentage (%)
Severely Underweight (<16)	2	1.0%
Underweight (16-18.4)	11	5.5%
Normal (18.5–24.9)	100	50.0%
Overweight (25–29.9)	63	31.5%
Moderately Obese (30–34.9)	18	9.0%
Severely Obese (35–39.9)	5	2.5%
Morbidly Obese (>40)	1	0.5%

Half of the patients had a normal Body Mass Index, while a significant proportion (43%) were overweight or obese, providing adequate variation to study the impact of Body Mass Index on surgical difficulty.

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Table 3: Overall Surgical Difficulty Distribution

Difficulty Grade	Frequency (%)
Mild	123 (61.5%)
Moderate	43 (21.5%)
Severe	34 (17%)

The majority of cases were categorized as mild difficulty, but a substantial number presented moderate to severe difficulty, enabling correlation with Body Mass Index, WC, and ABSI.

Table 4: Waist Circumference, Body Mass Index, and ABSI vs Overall Difficulty

Parameter	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Significance
WC (cm)	78.90 ± 10.79	81.91 ± 9.27	83.47 ± 11.13	0.036	Significant
Body Mass Index (kg/m²)	24.99 ± 3.90	25.54 ± 4.16	26.18 ± 6.48	0.257	Not Significant
ABSI	0.08 ± 0.02	0.08 ± 0.02	0.10 ± 0.03	0.266	Not Significant

Waist circumference was significantly associated with increased surgical difficulty (p=0.036), indicating a potential predictive value. Body Mass Index and ABSI did not show statistically significant correlations.

Table 5: ABSI and ABSI Z-Score vs Specific Surgical Steps

Surgical Step	ABSI Mean	ABSI Z-Score Mean	p-Value (ABSI / ABSI Z)	Significance
Port Insertion	0.08	-0.80	0.059 / 0.192	NS
Approach to Gall Bladder	0.08	-0.35	0.594 / 0.344	NS
Dissection of Calot's Triangle	0.09	-0.25	0.622 / 0.685	NS
Removal of Gallbladder	0.09	-0.36	0.542 / 0.311	NS
Retrieval of the Gallbladder	0.09	-0.38	0.398 / 0.205	NS
Physical Stress	0.09	-0.43	0.059 / 0.192	NS

Neither ABSI nor ABSI-Z Score showed significant correlation with surgical difficulty or individual steps, indicating limited predictive value.

Table 6: Weight, Body Mass Index, WC vs Physical Stress During Surgery

Parameter	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Significance
Weight (kg)	57.06 ± 10.58	59.06 ± 11.86	60.88 ± 11.89	0.263	NS
Body Mass Index (kg/m²)	24.99 ± 4.10	24.55 ± 4.87	26.18 ± 6.48	0.116	NS
Waist Circumference (cm)	79.10 ± 10.83	81.17 ± 9.31	85.73 ± 9.94	0.014	Significant

Only waist circumference showed a significant correlation with the surgeon's physical stress during surgery (p=0.014), suggesting its role in predicting subjective surgical difficulty.

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Table 7: Weight, Body Mass Index, WC vs Port Insertion Difficulty

Parameter	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Significance
Weight (kg)	57.57 ± 10.62	56.43 ± 8.99	60.50 ± 10.27	0.830	NS
Body Mass Index (kg/m²)	25.19 ± 3.56	23.04 ± 3.98	24.00 ± 4.10	0.546	NS
Waist Circumference (cm)	80.22 ± 10.31	79.29 ± 9.72	94.00 ± 7.07	0.236	NS

No significant correlation between anthropometric parameters and port insertion difficulty was found.

Table 8: Weight, Body Mass Index, WC vs Approach to Gallbladder Difficulty

Parameter	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Significance
Weight (kg)	57.10 ± 10.17	59.68 ± 12.77	65.18 ± 11.54	0.028	Weight Significant
Body Mass Index (kg/m²)	24.55 ± 3.81	25.80 ± 4.76	27.34 ± 7.31	0.279	NS
WC (cm)	79.85 ± 10.25	81.63 ± 10.42	84.88 ± 10.64	0.218	NS

Weight showed a statistically significant correlation (p=0.028), indicating that higher weight contributed to greater difficulty in approaching the gallbladder.

Table 9: Weight, Body Mass Index, WC vs Dissection of Calot's Triangle Difficulty

	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Significance
Weight (kg)	57.68 ± 10.38	60.68 ± 12.34	65.76 ± 12.22	0.029	Weight Significant
Body Mass Index (kg/m²)	24.52 ± 3.82	25.24 ± 5.47	26.63 ± 8.56	0.085	NS
WC (cm)	79.31 ± 10.42	81.92 ± 10.45	85.21 ± 10.43	0.158	NS

Patient's weight was significantly associated with difficulty in the dissection of Calot's triangle (p=0.029).

Table 10: Weight, Body Mass Index, WC vs Gallbladder Removal & Retrieval Difficulty

Parameter	Mild Mean ± SD	Moderate Mean ± SD	Severe Mean ± SD	p-Value	Significance
Weight (kg)	57.40 ± 10.28	60.88 ± 12.41	65.44 ± 11.62	0.042	Weight Significant
Body Mass Index (kg/m²)	24.65 ± 3.99	25.44 ± 5.29	26.31 ± 7.82	0.295	NS
Waist Circumference (cm)	79.45 ± 10.30	81.89 ± 10.47	85.48 ± 10.48	0.189	NS

Weight showed a significant correlation with difficulty in gallbladder removal and retrieval (p=0.042).

Discussion

In this study involving 200 patients undergoing LC, we aimed to assess the comparative impact of Body Mass Index (BMI), Waist Circumference (WC), and ABSI on surgical difficulty. The majority of cases (61.5%) were categorized as having mild difficulty, while 21.5% were moderate and 17% were severe in surgical difficulty.

Analysis of Body Mass Index categories showed that half of the patients had a normal Body Mass Index, while about 43% were overweight or obese. However, Body Mass Index did not show a statistically significant correlation

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with overall surgical difficulty (p = 0.257), nor with individual surgical steps such as port insertion, approach to gallbladder, or dissection of Calot's triangle.

In contrast, (WC) demonstrated a significant correlation with overall surgical difficulty (p = 0.036) and specifically with the surgeon's subjective physical stress during surgery (p = 0.014). Patients with higher WC were more likely to experience greater difficulty during the procedure, possibly due to increased intra-abdominal fat impeding visualization and manipulation.

The ABSI and ABSI-Z Score did not significantly correlate with either overall difficulty or individual surgical steps (p-values all >0.05), suggesting limited utility of this index in predicting surgical challenges in LC.

Interestingly, weight alone showed significant correlation with difficulty in specific steps of surgery, including approach to the gallbladder (p = 0.028), dissection of Calot's triangle (p = 0.029), and gallbladder removal and retrieval (p = 0.042). This suggests that heavier patients tend to experience more technically challenging surgeries.

No significant correlation was observed between port insertion difficulty and any of the anthropometric parameters, indicating that initial access may not be influenced by body habitus as much as deeper surgical steps. Overall, the results suggest that WC is a more reliable predictor of surgical difficulty than Body Mass Index or ABSI in the context of laparoscopic cholecystectomy. This supports the hypothesis that central obesity (reflected by WC) impacts surgical difficulty more directly than generalized obesity measured by BODY MASS INDEX.

Recent studies consistently highlight that obesity impacts operative difficulty in laparoscopic cholecystectomy, though the strength of this effect varies depending on the obesity measure used. In a study, it was reported that elevated Body Mass Index was significantly associated with longer operative time and technical difficulty, although complication rates remained unaffected [12]. Similarly, it was found that obesity increased surgical duration, risk of conversion to open cholecystectomy, and postoperative complications, with central obesity being a stronger determinant than Body Mass Index alone [15].

Other studies emphasize that WC may be a more sensitive predictor of surgical challenges than Body Mass Index. Reddy et al. demonstrated that waist circumference correlated better with difficulty in port placement and operative visualization than Body Mass Index, indicating that abdominal fat distribution directly influences technical complexity [13]. In a review, it was also noted that (ABSI) and similar composite anthropometric measures outperform Body Mass Index in predicting perioperative difficulty, since Body Mass Index does not account for fat distribution [14].

In a systematic review, researchers concluded that while Body Mass Index alone is imperfect, combining it with waist circumference or visceral fat measures significantly improves the prediction of operative challenges and postoperative outcomes [16]. More recent work revealed that visceral adiposity measured by CT was superior to Body Mass Index in forecasting prolonged surgery and intraoperative difficulty [17]. Similarly, it was confirmed that central obesity markers such as waist-to-hip ratio and visceral fat area were independently associated with prolonged operative time, whereas Body Mass Index showed weaker correlations [18].

Generalizability

The findings of this study apply to patients with symptomatic cholelithiasis undergoing elective laparoscopic cholecystectomy in similar tertiary care centers across India and other low- and middle-income countries. Since the study population represented a wide demographic spectrum of age, sex, and BODY MASS INDEX, the results may be generalized to comparable surgical populations. However, caution should be exercised in extrapolating the findings to emergency cases or patients with advanced comorbid conditions who were excluded.

Conclusion

Waist Circumference was significantly correlated with increased surgical difficulty and surgeon's physical stress during laparoscopic cholecystectomy, while Body Mass Index and (ABSI) showed no significant predictive value. Patient's weight also correlated with difficulty in specific surgical steps. These findings suggest that Waist Circumference is a better indicator of surgical difficulty in laparoscopic cholecystectomy than Body Mass Index or ABSI.

Limitations

This study was conducted at a single tertiary care center, which may limit external validity. Intraoperative difficulty was partly based on the surgeon's subjective assessment, introducing the possibility of observer bias. Imaging modalities such as CT to quantify visceral fat were not used, restricting objective measurement of fat distribution. Additionally, the sample size, although adequate, may not fully capture rare intraoperative complications.

Recommendations

Waist circumference should be incorporated into routine preoperative evaluation for patients undergoing

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laparoscopic cholecystectomy, as it better predicts surgical difficulty than Body Mass Index or ABSI. Larger multicentric studies with advanced imaging-based fat assessment are recommended to validate these findings.

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Conflict of Interest
The authors declare no conflict of interest related to this study.

Data Availability
The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions
- Hitesh Kumar (Senior Resident, Surgery): Conceptualization, data collection, manuscript drafting.
- Swaroop Sanat Sahu (Junior Resident, Surgery): Patient enrollment, anthropometric measurements, statistical analysis.
- M Mundu (Additional Professor, Surgery): Methodology design, supervision, and critical review.
- Ram Chandra Besra (Associate Professor, Surgery): Data validation, surgical oversight, manuscript editing.
- Pankaj Bodra (Professor, Surgery): Project administration, overall guidance, final approval.
- Samir Toppo (Additional Professor, Surgery): Data interpretation, discussion writing, and technical corrections.

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List of Abbreviations
- ABSI: A Body Shape Index
- BODY MASS INDEX: Body Mass Index
- IEC: Institutional Ethics Committee
- LC: Laparoscopic Cholecystectomy
- RIMS: Rajendra Institute of Medical Sciences
- SPSS: Statistical Package for the Social Sciences
- WC: Waist Circumference

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