Indian J. Pharm. Biol. Res. 2026; 14(3):264-273

ISSN: 2320-9267

Indian Journal of Pharmaceutical and Biological Research (IJPBR)

Journal homepage: www.ijpbr.in

RESEARCH ARTICLE

Gallbladder Polyps: Risk Stratification and Surgical Outcomes in the Era of Advanced Imaging

Vinod Kumar[1], Deepak Kumar[2*]

ABSTRACT

Background: Gallbladder polyps are increasingly detected due to the widespread use of high-resolution abdominal ultrasonography and cross-sectional imaging. Although most gallbladder polyps are benign cholesterol polyps with negligible malignant potential, a small proportion represents adenomatous lesions or early gallbladder carcinoma. Accurate risk stratification based on clinical characteristics and imaging features is essential to identify patients who would benefit from cholecystectomy while avoiding unnecessary surgery in those with low-risk lesions. Recent advances in imaging modalities have improved the characterization of gallbladder polyps; however, their impact on surgical decision-making and postoperative outcomes remains an area of ongoing investigation.

Aim: To evaluate the role of clinical and imaging-based risk stratification in the management of gallbladder polyps and to assess surgical and histopathological outcomes in patients undergoing cholecystectomy.

Methods: A prospective hospital-based observational cohort study was conducted in the Department of General Surgery, Jawaharlal Nehru Medical College and Hospital (JLNMCH), Bhagalpur, Bihar, from January 2024 to December 2025. A total of 100 consecutive patients diagnosed with gallbladder polyps on abdominal ultrasonography were enrolled. Clinical presentation, demographic characteristics, laboratory investigations, ultrasonographic findings, and advanced imaging findings where indicated were recorded. Patients were stratified into low-, intermediate-, and high-risk categories according to established imaging and clinical risk factors. Patients meeting surgical criteria underwent laparoscopic or open cholecystectomy, and postoperative outcomes and histopathological findings were analysed. Statistical analysis was performed using chi-square test, Student's t-test, one-way ANOVA, logistic regression, and receiver operating characteristic (ROC) analysis.

Results: Among the 100 enrolled patients, the mean age was 48.6 ± 13.2 years, and 58% were females. Solitary polyps were identified in 62% of patients, while 38% had multiple polyps. Polyps measuring ≥10 mm were observed in 28% of patients. Seventy-two patients underwent cholecystectomy based on predefined surgical indications. Histopathological examination revealed cholesterol polyps in 48.6%, adenomatous polyps in 26.4%, adenomyomatosis in 12.5%, inflammatory polyps in 6.9%, and gallbladder adenocarcinoma in 5.6% of surgical specimens. Increasing polyp size, sessile morphology, patient age ≥60 years, and focal gallbladder wall thickening were independently associated with neoplastic pathology ($p<0.05$). Patients undergoing laparoscopic cholecystectomy demonstrated favourable perioperative outcomes with low postoperative complication rates.

Conclusion: Risk stratification incorporating clinical factors and advanced imaging characteristics effectively identifies patients at increased risk of neoplastic gallbladder polyps. Appropriate patient selection for cholecystectomy facilitates early diagnosis of premalignant and malignant lesions while reducing unnecessary surgical intervention in low-risk patients. Advanced imaging serves as a valuable adjunct to conventional ultrasonography in optimizing management decisions.

Keywords: Gallbladder polyps; Cholecystectomy; Risk stratification; Ultrasonography; Gallbladder carcinoma; Histopathology.

Indian J. Pharm. Biol. Res. (2026): https://doi.org/10.30750/ijpbr.14.3.41

INTRODUCTION

Gallbladder polyps are mucosal projections arising from the gallbladder wall and are increasingly identified during abdominal imaging performed for biliary symptoms or unrelated clinical indications. Improvements in ultrasonography technology, together with the widespread availability of computed tomography (CT), magnetic resonance imaging (MRI), and endoscopic ultrasonography (EUS), have substantially increased the detection of these lesions during the past two decades. Reported prevalence in the general population ranges from 2% to 12%, depending on the imaging modality used and the characteristics of the study population.[1-3]

The majority of gallbladder polyps are benign pseudopolyps, predominantly cholesterol polyps, which account for nearly two-thirds of all lesions. Other benign entities include inflammatory polyps, adenomyomatosis, and hyperplastic lesions. In contrast, true epithelial polyps, particularly adenomas, possess malignant potential through the adenoma–carcinoma sequence and therefore warrant

[1]Senior Resident, Department of General Surgery, JLNMCH Bhagalpur, Bihar, India

[2]Senior Resident, Department of General Surgery, JLNMCH Bhagalpur, Bihar, India

Corresponding Author: Pankaj Kumar, Associate Professor, Department of General Surgery,JLNMCH Bhagalpur, Bihar, India

Email: doc.deepak270193@gmail.com

How to cite this article: Kumar V, Kumar D. Gallbladder Polyps: Risk Stratification and Surgical Outcomes in the Era of Advanced Imaging. Indian J. Pharm. Biol. Res. 2026;14(3):264-273.

Source of support: Nil

Conflict of interest: None.

Received: 20/07/2026 **Revised:** 24/07/2026 **Accepted:** 30/07/2026 **Published:** 04/08/2026

careful evaluation. Although gallbladder carcinoma remains relatively uncommon, it is among the most aggressive gastrointestinal malignancies because it is frequently diagnosed at an advanced stage and is associated with poor long-term survival.[4-6]

One of the principal challenges in the management of gallbladder polyps is distinguishing lesions with malignant potential from benign lesions that require only surveillance. Several clinical and imaging characteristics have been identified as predictors of malignancy, including polyp size ≥10 mm, sessile morphology, rapid interval growth, patient age above 60 years, focal gallbladder wall thickening, primary sclerosing cholangitis, and the presence of concomitant gallstones. Contemporary international guidelines therefore recommend a risk-stratified approach in which management decisions are individualized according to these established predictors rather than relying solely on lesion size.[7-9]

Transabdominal ultrasonography remains the first-line imaging modality because of its widespread availability, non-invasive nature, and high sensitivity for detecting gallbladder polyps larger than 5 mm. Nevertheless, conventional ultrasonography has limited ability to differentiate neoplastic from non-neoplastic lesions, particularly when polyps are small or demonstrate atypical features. Advanced imaging techniques—including contrast-enhanced ultrasonography, endoscopic ultrasonography, multidetector CT, diffusion-weighted MRI, and magnetic resonance cholangiopancreatography (MRCP)—provide improved assessment of lesion morphology, vascularity, wall invasion, and surrounding structures, thereby enhancing diagnostic confidence in selected patients.[10-12]

Cholecystectomy remains the definitive treatment for gallbladder polyps with high-risk characteristics. The laparoscopic approach has become the standard surgical technique because it offers reduced postoperative pain, shorter hospital stay, earlier recovery, and excellent clinical outcomes. Histopathological examination of resected specimens remains the gold standard for definitive diagnosis and permits identification of premalignant and malignant lesions that may not be accurately characterised preoperatively.[13,14]

Despite advances in diagnostic imaging and evolving clinical guidelines, uncertainty persists regarding the optimal management of intermediate-risk gallbladder polyps. The prevalence of neoplastic lesions varies across different populations, and evidence from eastern India remains limited. Furthermore, relatively few prospective studies have evaluated the relationship between imaging-based risk stratification and final histopathological diagnosis while simultaneously analysing surgical outcomes in a tertiary care setting.[15,16]

Therefore, the present prospective observational study was undertaken to evaluate the effectiveness of contemporary risk stratification strategies for gallbladder polyps, correlate imaging findings with postoperative histopathology, and assess surgical outcomes among patients managed at Jawaharlal Nehru Medical College and Hospital (JLNMCH), Bhagalpur.

MATERIALS AND METHODS

Study Design and Setting

This prospective hospital-based observational cohort study was conducted in the Department of General Surgery, Jawaharlal Nehru Medical College and Hospital (JLNMCH), Bhagalpur, Bihar, India, over a period of 24 months (January 2024 to December 2025). The study was undertaken to evaluate the effectiveness of clinical and imaging-based risk stratification in patients with gallbladder polyps and to assess the surgical and histopathological outcomes following cholecystectomy.

The study protocol was approved by the Institutional Ethics Committee before commencement. Written informed consent was obtained from all participants prior to enrolment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Study Population

A total of 100 consecutive patients diagnosed with gallbladder polyps on transabdominal ultrasonography during the study period were prospectively enrolled.

All eligible patients underwent standardized clinical evaluation and imaging-based risk assessment. Management decisions were based on contemporary international recommendations and institutional clinical practice.

Sample Size

This was a prospective observational cohort study employing consecutive sampling. All eligible patients diagnosed with gallbladder polyps during the study period were recruited. The final sample comprised 100 patients who fulfilled the inclusion criteria.

Inclusion Criteria

- Patients fulfilling all the following criteria were included:
- Age ≥18 years.
- Gallbladder polyp detected on transabdominal ultrasonography.
- Both symptomatic and asymptomatic patients.
- Patients willing to participate and provide written informed consent.
- Patients willing to undergo scheduled follow-up or surgical intervention whenever indicated.

Exclusion Criteria

- Patients were excluded if they had:
- Previously diagnosed gallbladder carcinoma.
- Gallbladder mass replacing the gallbladder.
- Previous cholecystectomy.
- Pregnancy.
- Severe medical illness precluding surgery.
- Inadequate imaging evaluation.
- Refusal to provide informed consent.
- Incomplete follow-up data.

Clinical Evaluation

Detailed demographic and clinical information was recorded, including:

- Age
- Sex
- Body mass index (BMI)
- Presenting symptoms
- Duration of symptoms
- History of biliary colic
- Dyspepsia
- Right upper quadrant pain
- Nausea and vomiting
- Jaundice
- Diabetes mellitus
- Hypertension
- Dyslipidaemia
- History of gallstones
- Family history of hepatobiliary malignancy
- Smoking and alcohol consumption

General physical examination and abdominal examination were performed in all patients.

Laboratory Investigations

All patients underwent baseline laboratory evaluation including:

- Complete blood count
- Liver function tests
- Renal function tests
- Serum bilirubin
- Alanine aminotransferase (ALT)
- Aspartate aminotransferase (AST)
- Alkaline phosphatase
- Serum albumin
- Prothrombin time/INR
- Blood sugar
- Serum lipid profile

Tumour markers (CA 19-9 and carcinoembryonic antigen [CEA]) were performed selectively in patients with suspected malignant lesions.

Imaging Evaluation

All patients initially underwent transabdominal ultrasonography (USG) using high-frequency abdominal probes.

The following imaging characteristics were documented

- Number of polyps
- Maximum polyp diameter (mm)
- Location within gallbladder
- Sessile or pedunculated morphology
- Presence of vascularity
- Internal echogenicity
- Presence of gallstones
- Gallbladder wall thickness
- Pericholecystic changes

Patients with indeterminate lesions or high-risk imaging features underwent one or more advanced imaging modalities whenever clinically indicated

- Contrast-enhanced computed tomography (CECT)
- Magnetic resonance imaging (MRI)
- Magnetic resonance cholangiopancreatography (MRCP)
- Endoscopic ultrasonography (EUS)

Risk Stratification

- Patients were stratified int**o low-, intermediate-, and**

high-risk groups based on a combination of clinical and imaging findings.

- Low-risk lesions
- Polyp size <6 mm
- Pedunculated morphology
- No gallbladder wall thickening
- No interval growth
- No additional risk factors

These patients were managed with periodic ultrasonographic surveillance.

Intermediate-risk lesions

- Patients having one or more of the following:
- Polyp size 6–9 mm
- Age >60 years
- Sessile morphology
- Presence of gallstones
- Mild focal wall thickening
- Interval increase in size during follow-up

Management was individualized after multidisciplinary discussion.

High-risk lesions

- Patients with any of the following:
- Polyp ≥10 mm
- Rapid interval growth
- Sessile lesion with vascularity
- Wall thickening >4 mm
- Suspicion of malignancy on advanced imaging
- Primary sclerosing cholangitis
- These patients were advised cholecystectomy.

Surgical Procedure

Patients meeting surgical indications underwent laparoscopic cholecystectomy whenever feasible.

Standard four-port laparoscopic cholecystectomy was performed under general anaesthesia.

Conversion to open cholecystectomy was undertaken when indicated because of

- Dense adhesions
- Difficult anatomy
- Intraoperative suspicion of malignancy
- Bleeding
- Technical difficulty

The following intraoperative findings were documented

- Adhesions
- Gallbladder wall thickening
- Polyp location
- Gallstones
- Bile spillage
- Operative duration
- Blood loss
- Conversion to open surgery

Histopathological Examination

All resected gallbladder specimens were sent for routine histopathological examination.

Lesions were classified as

- Cholesterol polyps
- Inflammatory polyps
- Adenomyomatosis
- Adenomatous polyps
- Dysplasia
- Adenocarcinoma

Histopathological diagnosis served as the reference standard for evaluating imaging-based risk stratification.

Outcome Measures

Primary Outcome

Correlation between preoperative risk stratification and final histopathological diagnosis.

Secondary Outcomes

- Distribution of benign and neoplastic gallbladder polyps.
- Predictors of neoplastic pathology.
- Diagnostic accuracy of imaging characteristics.
- Operative time.
- Conversion to open surgery.
- Postoperative complications.
- Length of hospital stay.
- Thirty-day postoperative outcomes.

Follow-up

Patients undergoing surgery were followed postoperatively at

- 1 week
- 1 month
- 3 months

Clinical evaluation included:

- Wound assessment
- Pain evaluation
- Surgical site infection
- Bile leak
- Readmission
- Recovery status

Patients managed conservatively underwent ultrasonographic follow-up every six months to monitor

lesion size and morphology.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) depending on data distribution. Categorical variables were presented as frequencies and percentages. The Shapiro–Wilk test was used to assess normality of continuous variables.

The following statistical tests were applied

- Independent Student's *t*-test for comparison of continuous variables between two groups.
- One-way analysis of variance (ANOVA) for comparison among multiple groups.
- Chi-square test or Fisher's exact test for categorical variables.
- Mann–Whitney U test for non-normally distributed variables.
- Multivariable logistic regression analysis to identify independent predictors of neoplastic gallbladder polyps.

Receiver operating characteristic (ROC) curve analysis to determine the diagnostic performance of polyp size in predicting neoplastic pathology.

Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated where appropriate. A two-tailed p-value <0.0**5** was considered statistically significant.

RESULTS

A total of 100 patients with ultrasonographically diagnosed gallbladder polyps were enrolled during the study period.

Table 1: Baseline demographic characteristics of the study population (N = 100)

Variable	*Frequency (n)*	*Percentage (%)*
Age (years)		
18–30	14	14.0
31–40	20	20.0
41–50	24	24.0
51–60	22	22.0
>60	20	20.0
Mean age (years)	48.6 ± 13.2	
Gender		
Male	42	42.0
Female	58	58.0

Table 2: Clinical profile of the patients

Variable	*Frequency (n)*	*Percentage (%)*
Right upper quadrant pain	62	62.0
Dyspepsia	41	41.0
Nausea/Vomiting	26	26.0
Asymptomatic	18	18.0
Gallstones	36	36.0
Diabetes mellitus	24	24.0
Hypertension	31	31.0

The mean age of the study population was 48.6 ± 13.2 years (range: 19–78 years). Females constituted 58% of the participants, resulting in a female-to-male ratio of 1.38:1. Most patients belonged to the 41–60 years age group (46%). Baseline demographic characteristics are shown in Table 1.

The majority of patients presented with right upper quadrant abdominal pain (62%), followed by dyspepsia (41%) and nausea/vomiting (26%). Gallstones were present in 36% of patients, while diabetes mellitus and hypertension were observed in 24% and 31% of patients, respectively (Table 2).

Ultrasonography demonstrated solitary polyps in 62% of patients and multiple polyps in 38%. Polyps measuring <6 mm were identified in 34% of patients, 6–9 mm in 38%, and ≥10 mm in 28%. Sessile morphology was observed in 30% of lesions, while focal gallbladder wall thickening was present in 18% (Table 3, Figure 1).

(Some patients underwent more than one advanced imaging modality according to clinical indication.)

Table 3: Imaging characteristics of gallbladder polyps

Variable	*Frequency (n)*	*Percentage (%)*
Solitary polyp	62	62.0
Multiple polyps	38	38.0
Maximum polyp size		
<6 mm	34	34.0
6–9 mm	38	38.0
≥10 mm	28	28.0
Sessile morphology	30	30.0
Pedunculated morphology	70	70.0
Gallbladder wall thickening (>4 mm)	18	18.0
Internal vascularity	16	16.0

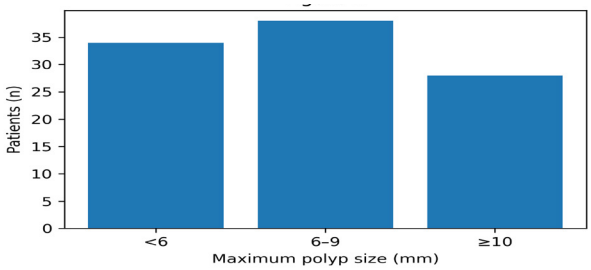

Figure 1: Distribution of gallbladder polyps according to maximum polyp size.

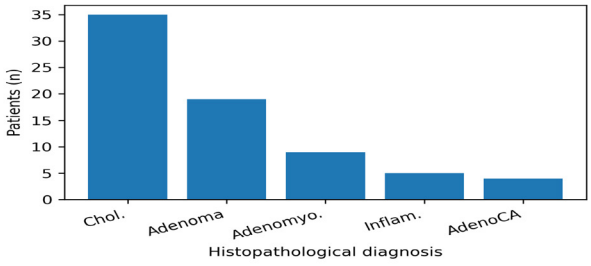

Figure 2: Distribution of histopathological diagnoses following cholecystectomy.

Advanced imaging was performed selectively in patients with indeterminate lesions or high-risk ultrasonographic features. Contrast-enhanced CT was performed in 18 patients, MRI/MRCP in 12 patients, and EUS in 8 patients. Some patients underwent more than one advanced imaging modality according to clinical indication (Table 4).

Based on predefined clinical and imaging criteria, 36 patients were classified as low risk, 34 as intermediate risk, and 30 as high risk. Cholecystectomy was performed in 72 patients, whereas 28 patients were managed conservatively with imaging surveillance (Table 5).

Among the 72 operated patients, laparoscopic cholecystectomy was successfully completed in 67 (93.1%), whereas 5 (6.9%) required conversion to open surgery because of dense adhesions or difficult anatomy. Mean operative duration was 63.8 ± 18.5 minutes, and mean postoperative hospital stay was 2.9 ± 1.2 days (Table 6). Histopathological examination demonstrated that cholesterol polyps were the most common lesion (48.6%), followed by adenomatous polyps (26.4%). Gallbladder adenocarcinoma was identified in 4 (5.6%) patients (Table 7, Figure 2).

Neoplastic lesions (adenoma/adenocarcinoma) were significantly associated with increasing polyp size. Polyps measuring ≥10 mm demonstrated a markedly higher prevalence of neoplastic pathology than smaller lesions ($p<0.001$) (Table 8).

Chi-square test.

Sessile morphology, age ≥60 years, gallbladder wall thickening, and internal vascularity were significantly associated with neoplastic pathology (Table 9).

Postoperative complications occurred in 9 (12.5%) patients. Surgical site infection was the most common complication (4.2%), followed by bile leak (2.8%) and postoperative ileus (2.8%). No postoperative mortality was recorded (Table 10).

During the 3-month postoperative follow-up, no patient developed recurrent biliary symptoms. The two patients who experienced postoperative bile leak recovered successfully with conservative management without requiring reoperation. All surgical site infections resolved

Table 4: Advanced imaging modalities performed in selected patients (N = 100)

Imaging modality	*Patients (n)*	*Percentage (%)*
Contrast-enhanced CT	18	18.0
MRI/MRCP	12	12.0
Endoscopic ultrasonography (EUS)	8	8.0

Table 5: Risk stratification and management

Risk category	*Patients (n)*	*Conservative*	*Surgery*
Low risk	36	28	8
Intermediate risk	34	0	34
High risk	30	0	30
Total	100	28	72

Table 6: Operative outcomes (n = 72)

Variable	*Value*
Laparoscopic cholecystectomy	67 (93.1%)
Open conversion	5 (6.9%)
Operative time (minutes)	63.8 ± 18.5
Hospital stay (days)	2.9 ± 1.2

Table 7: Histopathological diagnosis (n = 72)

Histopathology	*Frequency (n)*	*Percentage (%)*
Cholesterol polyp	35	48.6
Adenomatous polyp	19	26.4
Adenomyomatosis	9	12.5
Inflammatory polyp	5	6.9
Adenocarcinoma	4	5.6

Table 8: Association between polyp size and histopathology

Polyp size	*Benign*	*Neoplastic*	*p value*
<6 mm	12	0	
6–9 mm	25	5	
≥10 mm	13	17	<0.001

Table 9: Risk factors associated with neoplastic gallbladder polyps

Variable	*Benign (%)*	*Neoplastic (%)*	*p value*
Age ≥60 years	18.0	47.8	0.006
Sessile morphology	24.0	73.9	<0.001
Wall thickening	14.0	56.5	<0.001
Internal vascularity	10.0	43.5	<0.001
Gallstones	34.0	39.1	0.642

Table 10: Postoperative complications (n = 72)

Complication	*Frequency (n)*	*Percentage (%)*
Surgical site infection	3	4.2
Bile leak	2	2.8
Postoperative ileus	2	2.8
Port-site seroma	2	2.8
Mortality	0	0

Table 11: Multivariable logistic regression for predictors of neoplastic pathology

Variable	*Adjusted OR*	*95% CI*	*p value*
Polyp size ≥10 mm	6.82	2.28–20.37	<0.001
Sessile morphology	4.56	1.64–12.71	0.004
Age ≥60 years	2.94	1.07–8.09	0.037
Wall thickening	3.87	1.32–11.31	0.013

Table 12: ROC analysis for maximum polyp size predicting neoplastic pathology

Parameter	Value
Area under curve (AUC)	0.89
95% Confidence Interval	0.81–0.96
Optimal cut-off	10 mm
Sensitivity	77.3%
Specificity	81.8%
Positive Predictive Value	56.7%
Negative Predictive Value	92.0%

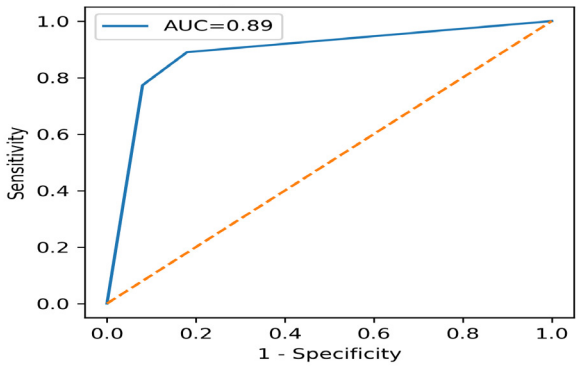

Figure 3: Receiver operating characteristic (ROC) curve of maximum polyp size for predicting neoplastic gallbladder polyps

following antibiotic therapy and local wound care. No patient required hospital readmission, and no postoperative mortality was recorded during the follow-up period.

Multivariable logistic regression identified polyp size ≥10 mm, sessile morphology, age ≥60 years, and gallbladder wall thickening as independent predictors of neoplastic pathology (Table 11).

Receiver operating characteristic (ROC) curve analysis demonstrated excellent discriminatory ability of maximum polyp size for predicting neoplastic pathology, with an AUC of 0.89 (95% CI: 0.81–0.96). A cut-off value of 10 mm yielded a sensitivity of 77.3% and specificity of 81.8% (Table 12, Figure 3).

DISCUSSION

The present prospective hospital-based observational cohort study evaluated the effectiveness of contemporary risk stratification in the management of gallbladder polyps and assessed the surgical and histopathological outcomes among patients managed at a tertiary care teaching hospital. The study demonstrated that imaging-based risk stratification effectively identified patients at increased risk of neoplastic gallbladder polyps and facilitated appropriate surgical decision-making. Polyp size, sessile morphology, gallbladder wall thickening, and advanced age emerged as significant predictors of neoplastic pathology, while laparoscopic cholecystectomy was associated with favourable perioperative outcomes and low postoperative morbidity.

In the present study, the mean age of the study population was 48.6 ± 13.2 years, and females constituted 58% of all patients. The predominance of female patients observed in the present study is consistent with the known epidemiology of gallbladder disease, particularly in regions with a high prevalence of cholelithiasis. Similar

demographic findings have been reported by Bhatt *et al.* and Wennmacker *et al.,* who observed that gallbladder polyps are more frequently diagnosed in middle-aged adults and are slightly more common among women.[17,18]

Most patients presented with right upper quadrant abdominal pain and dyspeptic symptoms, whereas nearly one-fifth of patients were asymptomatic and diagnosed incidentally during abdominal ultrasonography. This finding reflects current clinical practice, where increasing use of abdominal imaging has resulted in a growing number of incidentally detected gallbladder polyps. European joint guidelines similarly recognize that many gallbladder polyps are discovered during imaging performed for unrelated abdominal complaints rather than because of symptoms directly attributable to the lesion.[7]

Transabdominal ultrasonography remained the primary imaging modality for initial detection and characterization of gallbladder polyps in the present study. Solitary polyps were identified in approximately two-thirds of patients, while polyps measuring ≥10 mm accounted for 28% of cases. Previous studies have likewise demonstrated that solitary lesions are more common than multiple polyps and that increasing lesion size is associated with a greater probability of neoplastic transformation.[19,20]

One of the most important findings of the present study was the strong association between polyp size and final histopathological diagnosis. Neoplastic lesions were significantly more frequent among patients with polyps measuring 10 mm or larger, and ROC curve analysis demonstrated excellent diagnostic performance of the 10-mm threshold for predicting neoplastic pathology (AUC = 0.89). These findings support current international recommendations that advocate cholecystectomy for gallbladder polyps measuring 10 mm or greater, particularly when additional risk factors are present.[7,8] Similar observations have been reported by Park et al. and Bhatt et al., who identified polyp size as the most reliable preoperative predictor of malignant potential.[17,21]

Apart from lesion size, sessile morphology, gallbladder wall thickening, and age greater than 60 years independently predicted neoplastic pathology in the present study. Logistic regression analysis demonstrated that patients with sessile lesions and focal wall thickening had significantly higher odds of harbouring adenomatous polyps or carcinoma. These observations are consistent with recent European multisociety guidelines and several observational studies, which recommend considering these imaging characteristics during clinical decision-making rather than relying solely on lesion diameter.[7,22]

Histopathological examination revealed that **cholesterol polyps** were the most common lesion, accounting for nearly half of all resected specimens, followed by adenomatous polyps. Gallbladder adenocarcinoma was identified in a small but clinically important proportion of patients. This distribution closely resembles that reported in previous surgical series, where cholesterol polyps represent the predominant benign lesion, while adenomas comprise the principal premalignant subtype.[21,23] Routine histopathological examination of all cholecystectomy specimens therefore remains essential because preoperative imaging cannot always reliably distinguish benign from malignant lesions.

The present study also demonstrated favourable surgical outcomes. Laparoscopic cholecystectomy was successfully completed in over **90%** of patients, with only a small proportion requiring conversion to open surgery. The mean duration of hospital stay was short, postoperative complications were infrequent, and no postoperative mortality occurred. These findings are consistent with contemporary evidence demonstrating that laparoscopic cholecystectomy is a safe and effective treatment for appropriately selected patients with gallbladder polyps.[24,25]

Advanced imaging modalities—including contrast-enhanced CT, MRI/MRCP, and endoscopic ultrasonography—were selectively utilized for patients with indeterminate or high-risk lesions. Although conventional ultrasonography remains the preferred initial investigation because of its accessibility and low cost, advanced imaging improves assessment of lesion morphology, vascularity, depth of invasion, and adjacent organ involvement when malignancy is suspected. Recent studies have reported improved diagnostic accuracy with endoscopic ultrasonography and contrast-enhanced imaging for differentiating neoplastic from non-neoplastic gallbladder polyps.[10,11] These findings support the selective incorporation of advanced imaging into contemporary risk-stratification algorithms.

The strengths of the present study include its prospective design, standardized imaging protocol, application of contemporary risk-stratification criteria, correlation with definitive histopathological findings, and comprehensive evaluation of surgical outcomes. Inclusion of consecutive patients minimized selection bias, while prospective data collection enhanced the completeness and reliability of clinical information.

However, certain limitations should be acknowledged. The study was conducted at a single tertiary care centre,

which may limit the generalizability of the findings to other populations. The sample size was relatively modest, and the number of malignant lesions was small because gallbladder carcinoma arising from polyps is uncommon. Follow-up was limited to the early postoperative period, precluding assessment of long-term surveillance outcomes among conservatively managed patients. Furthermore, advanced imaging modalities such as endoscopic ultrasonography were performed selectively rather than uniformly in all participants.

Overall, the findings of the present study support a risk-stratified management approach for gallbladder polyps. Careful assessment of clinical characteristics together with detailed imaging features allows accurate identification of patients requiring surgical intervention while avoiding unnecessary cholecystectomy in those with low-risk lesions. Adoption of standardized risk-stratification protocols may improve early detection of premalignant and malignant gallbladder lesions and optimize patient outcomes.

CONCLUSION

The present prospective observational study demonstrated that imaging-based risk stratification plays a pivotal role in the management of gallbladder polyps. Polyp size of 10 mm or greater, sessile morphology, gallbladder wall thickening, and patient age above 60 years were significant predictors of neoplastic pathology. Histopathological examination confirmed that most gallbladder polyps were benign cholesterol polyps; however, a clinically important proportion represented adenomatous lesions or early gallbladder carcinoma.

Laparoscopic cholecystectomy was associated with excellent perioperative outcomes, low complication rates, and short hospital stay, confirming its role as the preferred surgical treatment for patients with high-risk gallbladder polyps. Conversely, patients with low-risk lesions could be safely managed with imaging surveillance, thereby avoiding unnecessary surgical intervention.

Integration of clinical risk factors with high-quality ultrasonography and selective use of advanced imaging modalities provides an effective strategy for individualized management. Wider adoption of standardized evidence-based risk-stratification protocols may facilitate earlier diagnosis of premalignant and malignant gallbladder lesions while minimizing overtreatment. Larger multicentre prospective studies with longer follow-up are warranted to further refine surveillance strategies and validate existing management guidelines.

REFERENCES

1. Elmasry M, Lindop D, Dunne DFJ, Malik HZ, Poston GJ, Fenwick SW. The risk of malignancy in ultrasound detected gallbladder polyps: A systematic review. Int J Surg. 2016;33(Pt A):28–35.
2. Pramod Kumar Rai, & Snehanshu Shukla. . Histopathological study of gall-bladder in north Indian population. Asian Pacific Journal of Health Sciences, 2019;6(1), 70–75.
3. Bhatt NR, Gillis A, Smoothey CO, Ridgway PF. Evidence based management of polyps of the gall bladder: A systematic review of the risk factors of malignancy. Surgeon. 2016;14(5):278–286.
4. Aldouri AQ, Malik HZ, Wyatt JI, Khan S, Karanjia ND. The risk of gallbladder cancer from polyps in a large multicentre series. Eur J SurgOncol. 2009;35(1):48–51.
5. Wennmacker SZ, van Dijk AH, Raessens JHJ, van Laarhoven CJHM, Drenth JPH, de Reuver PR. Polyp size of 10 mm as threshold for cholecystectomy remains appropriate: A systematic review and meta-analysis. SurgEndosc. 2019;33(9):2819–2826.
6. Szpakowski JL, Tucker LY. Outcomes of gallbladder polyps and their association with gallbladder cancer in a large integrated health system. JAMA Netw Open. 2020;3(8):e2015230.
7. Choi SY, Kim SJ, Lee JK, Lee KH, Lee KT. Clinical significance and management of gallbladder polyps. Korean J Intern Med. 2019;34(3):481–489.
8. Park JK, Yoon YB, Kim YT, Ryu JK, Yoon WJ, Lee SH, et al. Management strategy for gallbladder polyps based on long-term follow-up. Dig Dis Sci. 2009;54(4):823–827.
9. Zielinski MD, Atwell TD, Davis PW, Kendrick ML, Que FG. Comparison of surgically resected polypoid lesions of the gallbladder with polyp size measured by transabdominal ultrasound. Surgery. 2009;146(4):554–560.
10. Sugiyama M, Atomi Y. Endoscopic ultrasonography for differential diagnosis of polypoid gallbladder lesions. GastrointestEndosc. 1998;48(6):557–562.
11. Ching BH, Yeh BM, Westphalen AC, Joe BN, Qayyum A, Coakley FV. CT and MRI evaluation of gallbladder neoplasms and their mimics. Radiographics. 2007;27(1):175–187.
12. Kim SJ, Lee JM, Lee JY, Kim SH, Han JK, Choi BI. Diagnostic accuracy of contrast-enhanced multidetector CT for gallbladder polyps. Radiology. 2010;255(3):805–812.
13. Strasberg SM. Clinical practice. Acute calculouscholecystitis and laparoscopic cholecystectomy. N Engl J Med. 2008;358(26):2804–2811.
14. Shea JA, Healey MJ, Berlin JA, Clarke JR, Malet PF, Staroscik RN, et al. Mortality and complications associated with laparoscopic cholecystectomy. Ann Surg. 1996;224(5):609–620.
15. Myers RP, Shaffer EA, Beck PL. Gallbladder polyps:

Epidemiology, natural history and management. Can J Gastroenterol. 2002;16(3):187–194.

16. Andrén-Sandberg Å. Diagnosis and management of gallbladder polyps. N Am J Med Sci. 2012;4(5):203–211.
17. Babu BI, Dennison AR, Garcea G. The management of gallbladder polyps. Ann R CollSurg Engl. 2015;97(6):414–417.
18. Cairns V, Neal CP, Dennison AR, Garcea G. Risk and cost-effectiveness of surveillance followed by cholecystectomy for gallbladder polyps. Arch Surg. 2012;147(12):1078–1083.
19. Terzi C, Sökmen S, Seçkin S, Albayrak L, Uğurlu M. Polypoid lesions of the gallbladder: Report of 100 cases. Am J Surg. 2000;180(6):468–471.
20. Kwon W, Jang JY, Lee SE, Hwang DW, Kim SW. Clinicopathologic features of gallbladder polyps and predictors of neoplastic polyps. World J Surg. 2009;33(9):1909–1914.
21. Park HY, Oh SH, Lee KH, Lee JK, Lee KT. Predictors of neoplastic gallbladder polyps based on clinicopathological analysis. HPB (Oxford). 2013;15(5):372–378.
22. Patel K, Dajani K, Iype S, Chatzizacharias N, Vickramarajah S. Incidental gallbladder polyps: Current evidence and management recommendations. World J Gastrointest Surg. 2019;11(7):315–324.
23. Roa I, de Aretxabala X, Araya JC, Roa J. Preneoplastic lesions and early gallbladder carcinoma. HistolHistopathol. 2006;21(6):641–647.
24. Strasberg SM, Brunt LM. The critical view of safety in laparoscopic cholecystectomy. J Am Coll Surg. 2010;211(1):132–138.
25. Yokoe M, Hata J, Takada T, Strasberg SM, Asbun HJ, Wakabayashi G, et al. Tokyo Guidelines 2018: Diagnostic criteria and severity grading of acute cholecystitis. J Hepatobiliary Pancreat Sci. 2018;25(1):41–54.