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Efficacy and Safety of Ultrasound-guided Radiofrequency Ablation versus Laparoscopic Cholecystectomy in Gallbladder Polyps: A bicentric study

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Abstract

The long-term efficacy of ultrasound-guided radiofrequency ablation (RFA) and laparoscopic cholecystectomy (LC) for patients with gallbladder polyps remains uncertain. This study aimed to compare the efficacy and safety of RFA and LC in patients with gallbladder polyps. In this retrospective study, we included 160 patients who underwent treatment for gallbladder polyps at two Chinese medical centres from May 2021 to May 2023, with 79 cases in the RFA group and 81 cases in the laparoscopic cholecystectomy (LC) group. The lesion disappearance rates of RFA group were 83.5%, 89.9%, 94.9%, 97.5% and 100.0% at 1 week, 1 month, 3 months, 6 months and 1-year after ablation, respectively. In the RFA group, no statistically significant difference was observed in the diameter of non-target lesions between the preoperative measurements and those taken at any postoperative follow-up (all $P>0.05$). There was no statistically significant difference in gallbladder contraction rate and gallbladder wall thickness before and after ablation ($P>0.05$). Postoperative ALT and AST levels were significantly higher, while TP levels were lower, in the LC group compared to the RFA group (all $P<0.05$). The differences in hospital stay, operative time, postoperative anal

exhaust time, postoperative eating time, and NRS scores on the first postoperative day were also statistically significant (all $P<0.05$). The incidence of complications and treatment costs between the two groups did not show statistically significant differences ($P>0.05$). Compared with the RFA group, the LC group showed a higher incidence of abdominal pain, abdominal distension, diarrhea, bile reflux gastritis, and malabsorption at 1-year postoperatively (all $P<0.05$). Sessile polyps were at higher risk for bile leakage than pedunculated polyps in the RFA group ($P=0.038$). In conclusion, ultrasound-guided RFA of gallbladder polyps can effectively inactivate the polyps while preserving the gallbladder, representing a safe, effective, and feasible alternative to LC.

Keywords: gallbladder polyp; radiofrequency ablation; lesion disappearance rate; laparoscopic cholecystectomy; gallbladder preservation.

1. Introduction

Gallbladder polyps are locally raised mucosal growth in the gallbladder cavity, and the vast majority are asymptomatic[1]. Gallbladder polyps are usually divided into the neoplastic gallbladder polyps (NGPs) and the nonneoplastic gallbladder polyps, the latter accounts for approximately 60%-70% of the gallbladder

polyps [2,3]. NGPs of adenoma phenotype can transform into malignant tumours, which can be regarded as gallbladder adenocarcinoma in the early stage of the proliferation and development[2]. In addition, accumulating studies have shown that 3% to 8% of adenomas are prone to have the malignant potential[4,5].

Gallbladder cancer is an aggressive malignancy with a poor prognosis and low survival rate[6], which can be developed from gallbladder adenomas. In clinic, laparoscopic cholecystectomy (LC) is the preferred treatment for the gallbladder adenomas. However, the accompanying complications included bile duct injury, vascular injury and metabolic disorders are prone to occur after LC [7,8]. And the rate of malignancy in the resected specimens is relatively low[2,4].Furthermore, studies have shown that removing the gallbladder may increase the risk of gastrointestinal tumours[9,10]. The regular active surveillance is recommended for gallbladder polyps <10 mm in size, while it is well-known that the size ≥10 mm of the gallbladder polyps is one of the risk factors related to malignancy and LC[11,12]. Therefore, gallbladder polyps should be treated with the gallbladder-preserving as much as possible.

Abdominal ultrasound is considered the imaging test of choice for evaluating gallbladder disease and conventional ultrasound (CUS) combined with contrast-enhanced ultrasound (CEUS) is helpful for

distinguishing the benign and malignant gallbladder polyps[13,14]. The diagnostic accuracy for distinguishing the benign and malignant polyps is 91.17% and 92.47%, respectively[14,15].Currently, ultrasound-guided radiofrequency ablation (RFA) has a wide range of in the treatment of solid tumors, with the advantages of minimal invasiveness, safety and repeatability[16,17].

In this retrospective study, we not only compared the efficacy and safety of ultrasound-guided RFA with LC for the treatment of gallbladder polyps, but also assessed the symptoms within 1-year postoperatively and cost-effectiveness between the RFA group and the LC group. Additionally, we analyzed factors associated with bile leak occurrence in the RFA group. Finally, the standardized ablation protocol and post-ablation guidance were mentioned in our study.

2. Materials and methods

This retrospective bicentric study included patients who underwent treatment for gallbladder polyps at two Chinese hospitals, which was approved by the Institutional Review Board of the Affiliated Hospital of Jiangsu University and the Institutional Review Board of the First Affiliated Hospital of Zhengzhou University (Approval No: KY2023H0621-05, 2023-KY-0714-002), and the requirement for written informed consent was waived because of the retrospective nature of the study. This study was carried out in

accordance with the Declaration of Helsinki. All equipment, consumables and calculation formulas used for ablation are specified in the *Supplemental Material 1*.

2.1 Patients

This study included 160 patients (69 female, 91 male; mean age: 43.1 ±14.1 years) who received treatment for gallbladder polyps at two Chinese medical centres from May 2021 to May 2023, with 79 cases treated by ultrasound-guided RFA, and 81 cases treated by LC **(Figure 1)**.

The inclusion criteria for patients were as follows: *(a)* 18 years old ≤ age ≤80 years old, no sex restriction, *(b)* no more than 2 polyps, one of which has a maximum diameter between 10 mm and 20 mm, *(c)* preoperative imaging examination indicating a benign lesion without any malignant signs, *(d)* normal gallbladder contractile function, and *(e)* regular follow-up within 1-year after operation.

The exclusion criteria were as follows: *(a*) allergy to ultrasound contrast agents or pregnancy, *(b)* presence of cholecystitis or cholelithiasis, *(c)* abnormal liver function before operation, *(d)*incomplete data, and *(e)* presence of cachexia in other parts of the body.

2.2 Pre-ablation assessment

All patients underwent CUS, CT and laboratory examination

before the ablation and LC. All patients in the RFA group underwent CEUS examination preoperatively. Gallbladder shrinkage rate and lesion volume were calculated and evaluated. Gallbladder contraction rate ≥50% indicates good function, and <50% indicates poor function[18,19].

2.3Biopsy and ablation procedure

The patients fasted for about 6-8 hours before the operation, which is performed under general anesthesia with the patient in the supine position. In patients with multiple lesions, only the largest lesion was selected to be biopsied and ablated. The procedure was as follows:

(1) *Drainage of bile.* The pigtail drainage catheter set was used to puncture the gallbladder from the liver bed surface of gallbladder. After the needle core was extracted, the bile was withdrawn with a 20 ml syringe, and the gallbladder cavity was subsequently rinsed and filled with 60-80 ml of normal saline. The drainage tube was retained until one week after the operation.

(2) *Separation of the mucosal and serosa layers of the gallbladder.* A puncture needle was used to inject 50-200 ml of isolation fluid (saline and sodium hyaluronate were mixed in a ratio of 25:1) between the serosa and mucosal layers of the gallbladder (avoiding the gallbladder artery) so that the two layers could be separated by ≥10 mm to reduce the risk of bile leakage.

(3) *Biopsy of polyps.* The semi-automatic biopsy instrument is inserted from the liver bed surface or the bottom of the gallbladder so that the tip of the puncture instrument points towards the centre of the target polyp and the trigger of the puncture instrument is pressed to perform the biopsy. The needle should be inserted as parallel as possible to the gallbladder wall to increase the distance between the serosa layer and the mucosal layer at the point of needle insertion.

(4) *Ablation of polyps.* The ablation needle was inserted into the target lesion from the liver bed surface or the bottom of the gallbladder, and then the RFA power of 25W-30W covered the entire gallbladder polyp. Postoperative CEUS was used to evaluate the ablation status of the polyps, and if the ablation was incomplete, additional ablation was performed. A representative image of the entire process is shown in **Figure 2**.

2.4Laparoscopic cholecystectomy (LC)

The patient is placed in a supine position, and after general anesthesia, routine disinfection and towels are performed. A 10mm skin incision is made at the upper or lower edge of the umbilicus to insert a Veress needle and establish pneumoperitoneum, followed by the insertion of a laparoscope. Incisions are made 2 cm below the xiphoid process and 2 cm below the right costal margin along the

midclavicular line, through which laparoscopic trocars and instruments such as electrocautery hook forceps are inserted. Then the abdomen is then explored. If the surgical field is clear, a LC is performed based on the situation; if there is abdominal adhesion, laparoscopic adhesiolysis is performed before proceeding with LC. After the gallbladder is removed, hemostasis is achieved and an abdominal drain is placed[20]. After releasing the pneumoperitoneum and removing the laparoscopic instruments, all incisions were sutured.

2.5 Post-ablation instructions, follow-up, assessment and inter-group comparison

Technical success was defined as the absence of enhancement of gallbladder polyps detected by CEUS after ablation. After operation, patients were instructed to fast for at least 12 hours and bed rest for 24 hours, and the patients were given anti-infection, liver protection and stomach protection drugs for 1 to 2 days.

Accompanying complications and symptoms were recorded, including bile duct injury, vascular injury, bile leakage, abdominal pain, nausea and vomiting. All patients were followed up at 1 week, 1 month, 3 months, 6 months after ablation, every 6 months in the second year and annually thereafter. The size and volume reduction rate (VRR) of the lesions are calculated at each follow-up visit.

VRR >50% indicates the treatment is effective[21]. During each follow-up, changes in the size of any residual (non-target) lesions and the emergence of new lesions were documented. In addition, lesion disappearance rate was defined as the absence of ablated lesions in the gallbladder cavity under CUS.

The inter-group comparisons between the RFA group and the LC group included certain liver function indexes one day preoperatively and the first day postoperatively (alanine transaminase (ALT), aspartate transaminase (AST), gamma-glutamyl transferase (GGT), alkaline phosphatase (ALP), total protein (TP), total bilirubin (TBIL), direct bilirubin (DBIL), indirect bilirubin (IBIL)), certain perioperative indexes (hospital stay, operative time, postoperative anal exhaust time, postoperative eating time, Numerical Rating Scale (NRS) score at one day postoperatively, cost of treatment), the incidence of complications and symptoms within 1-year postoperatively (abdominal pain, abdominal distension, diarrhea, bile reflux gastritis, and malabsorption).

2.6Statistical analysis

The statistical analysis of the data was performed using SPSS software (IBM SPSS 27.0). The normally distributed data are expressed as mean ± standard deviation (X ± SD), and the nonnormally distributed data are expressed as median and

interquartile range (M (Q1, Q3)). The independent samples t-tests were used to compare the volume of lesions and the VRR at different follow-up time points, as well as certain liver function indexes and certain perioperative indexes between two groups. The thickness of the gallbladder wall and the gallbladder contraction rate at 1 month after ablation were compared with those before ablation by paired t tests. The incidence of bile leakage in different locations and morphologies of gallbladder polyps in the ablation group and the symptoms within 1-year postoperatively between the two groups were compared by the x^2 test. The relationship between gallbladder polyp base width and bile leakage was analysed by the rank-sum test. P value <0.05 was considered statistically significant.

3. Results

3.1 Baseline characteristics of patients and gallbladder polyps

Between May 2021 and May 2023, 175 patients who went different treatments for gallbladder polyps were reviewed. Based on the exclusion criteria, 160 patients were included in the study **(Figure 1)**. Among them, there were 91 males and 69 females, with a mean age of 37.3 ± 11.0 years. These 160 patients were divided into RFA group (79) and LC group (81). There were no statistically significant differences between the two groups of patients in terms of age, gender, lesion location, lesion shape, lesion distribution, and

the maximum diameter of the polyps (all $p > 0.05$). Additionally, in the RFA group, preoperative CEUS revealed 14 lesions with hyperenhancement, 58 lesions with isoenhancement, and 7 lesions with hypoenhancement, all of them without any malignant imaging features **(Table 1)**.

3.2Lesion Volume Changes Pre-ablation and Post-ablation

All patients were followed up for more than 1-year, with a maximum follow-up of 3 years. At 1 week, 1 month, 3 months, 6 months and 1-year after ablation, the lesion disappearance rates were 83.5% (66/79), 89.9% (71/79), 95.0% (75/79), 97.5% (77/79) and 100.0% (79/79), respectively **(Table 2)**.

At 1 week, 1month and 3 months after the ablation, the median lesion volume of non-disappeared lesions were about 0.5 (0.4, 0.7) cm^3, 0.3 (0.3, 0.4) cm^3 and 0.2 (0.1, 0.3) cm^3, respectively; the median VRRs of non-disappeared lesions were 7.0 (6.7, 7.4) %, 50.1 (48.0, 51.0) % and 76.8 (70.7, 83.5) %, respectively. At 6 months after ablation, only two patients had persistent non- disappeared lesions, with a VRR greater than 50% for them. The volume of non-disappeared lesions at 1, 3, 6 months after ablation were all smaller than those measured pre-ablation ($P<0.001$). The preoperative and postoperative volumes of the specific 13 residual ablation zones are detailed in Supplementary Table S3. No statistically significant

differences were observed in the diameter of non-target lesions when compared to the preoperative baseline at 1 week, 1 month, 3 months, 6 months, and 1 year postoperatively (all $P > 0.05$) **(Table 2)**. In other words, the non-target lesions showed no significant enlargement within one year postoperatively compared to the preoperative baseline. The specific measurements of the residual ablation zone at 1 week, 1 month, 3 months, and 6 months postoperatively are provided in *Supplementary Material 2*.

Based on the follow-up observations, we hypothesize that the lesions will dehydrate and shrivel after ablation, falling away with the renewal of the gallbladder mucosal layer or gradually absorbing and shrinking, as illustrated in **Figure 3**.

3.3 Comparison of gallbladder contraction rate and gallbladder wall thickness pre-ablation and post-ablation

Among all the patients, the mean gallbladder contraction rate before and 1 month after ablation were 72.8 ± 7.1% and 73.0 ± 6.4%, respectively. The thicknesses of the gallbladder wall before and 1 month after ablation were both 1.8 ± 0.1 mm. There was no significant difference in gallbladder wall thickness and gallbladder contraction rate between before and 1 month after ablation (all $P > 0.05$) **(Table 2)**.

3.4 Postoperative complications, associated symptoms and

pathology in two groups

The technical success rate of ablation was 100%. Among the postoperative complications in the two groups, only bile leakage showed a statistically significant difference (P=0.003). However, all patients with bile leakage recovered after percutaneous peritoneal drainage, with no significant difference in the duration of drainage between the groups (P=0.115). The differences in other postoperative complications, including abdominal pain, abdominal distension, nausea, and fever, were not statistically significant (all P>0.05) **(Table 3)**.

Post-biopsy pathology confirmed that in the RFA group, there were 61 cases of cholesterol polyps, 12 cases of adenomas, and 6 cases of inflammatory polyps. Postoperative pathology confirmed that in the surgical group, there were 61 cases of cholesterol polyps, 13 cases of adenomas, and 7 cases of inflammatory polyps. There was no statistically significant difference in pathological results between the two groups (P=0.955) **(Table 3)**.

3.5Comparison of certain liver function indexes and perioperative indexes in two groups

There were no statistically significant differences in preoperative certain liver function tests between the RFA group and the surgical group (all P>0.05). However, postoperative levels of

ALT, AST, and TP showed statistically significant differences between the two groups (all P <0.05) **(Table S1)**. Compared with the LC group, the RFA group exhibited lower postoperative ALT and AST levels, but higher TP levels. There were also statistically significant differences in hospital stay, operative time, postoperative anal exhaust time, postoperative eating time, and NRS scores on the first postoperative day between the two groups (all P <0.05). The incidence of complications (excluding minor abdominal pain, distension, and nausea) and treatment costs between the two groups showed no statistically significant differences (P =0.066). The comparison of the incidence of complications in this study primarily encompassed bile leakage, postoperative hemorrhage, and postoperative high fever. Additionally, the mean ablation duration was 2.1 ± 0.7 minutes and the mean sub-serosal water injection was 94.2 ± 31.6 ml in the RFA group **(Table S2)**.

3.6Comparison of postoperative symptoms within 1-year in two groups

During the postoperative follow-up at 1 month, 3 months, 6 months and 1-year, there were statistically significant differences between the two groups in terms of abdominal pain, abdominal distension, diarrhea, and malabsorption (including weight loss and anemia) (all P<0.05) **(Table 4)**. This indicates that, compared to the

LC group, the RFA group demonstrated a lower risk of developing the aforementioned symptoms within 1-year postoperatively. At the 6 months and 1-year postoperative follow-ups, the differences in bile reflux gastritis between the two groups were statistically significant (all $P<0.05$) **(Table 4)**. Compared with the LC group, the RFA group demonstrated a lower incidence of bile reflux gastritis within 1-year postoperatively. These findings indicate that ultrasound-guided RFA has minimal long-term impact on patients.

3.7 Factors that may be associated with the occurrence of bile leakage in RFA group

This study found a statistically significant difference in the bile leakage rate between pedunculated and sessile polyps in the RFA group, with sessile polyps being associated with a higher incidence of leakage after RFA ($P=0.038$). Additionally, polyps associated with bile leakage were found to have a wider base ($P=0.004$). However, no statistically significant difference was found in the incidence of bile leakage based on the different locations of the gallbladder polyps ($P>0.05$) **(Table 5)**. This suggests that sessile, wide-based polyps may be more prone to bile leakage during the ablation procedure.

4. Discussion

The gallbladder plays a crucial role in the digestive and

absorptive processes of the human body and is considered as a protective organ[22,23]. Currently, the laparoscopic combined with choledochoscope gallbladder-preserving surgery is a relatively mature technique, but it is prone to complications such as hemorrhage and intra-abdominal adhesions[19,24]. In contrast, ultrasound-guided radiofrequency ablation (RFA) has fewer complications, less invasive, and fast restorable[25,26]. In this study, the lesion disappearance rate can reach 100.0% within 1-year after operation, and the technique of ablation had no effect on gallbladder contractility (P >0.05). The sloughing off of lesions is attributed to the high cell turnover rate of the gallbladder mucosa, which is similar to that of the intestinal epithelium[27].

In this study, the gallbladder wall was protected to avoid the bile leakage by the isolation fluid injection between the serosa and mucosal layers until the gap between them could be separated by ≥10mm[18,28]. Isolation fluid can flow back into the liver through the lymphatic and venous systems, and oedema usually resolves spontaneously within 1 day after the operation[28].However, 16 patients still developed bile leakage. The possible reasons include insufficient sub-serosa water injection, rapid diffusion of the isolating solution and inappropriate proportion of isolation fluid. The draining of the bile in advance can reduce the possibility of bile

leakage, and the drainage tube should be preserved until 1 week after the operation[29,30]. Percutaneous peritoneal drainage should be performed promptly if intraoperative or postoperative bile leakage occurs.

Additionally, no bile leakage occurred during ultrasound-guided biopsy of gallbladder polyps in this study, indicating that the use of a short-range biopsy instrument for biopsy within the appropriate range is safe and feasible. The post-biopsy pathology in this study confirmed that all ablated gallbladder polyps were benign, indicating that CEUS has high application value in preliminarily excluding malignant lesions. But due to the relatively small sample size, the accuracy of CEUS in the diagnosis of benign and malignant polyps needs to be further verified.

It is notable that compared to the LC group, the RFA group had fewer patients experiencing abdominal pain, abdominal distension, diarrhea, bile reflux gastritis, and malabsorption within 1-year postoperatively, and the RFA group had shorter hospital stays, shorter operative time, shorter postoperative anal exhaust time, and lower NRS scores. These are all advantages of ultrasound-guided radiofrequency ablation of gallbladder polyps. Significant differences in ALT, AST, and TP were observed postoperatively between the two groups. The higher levels of ALT and AST in the LC

group may be due to greater trauma. The higher TP levels in the RFA group could be related to the activation of the immune system leading to an increase in immunoglobulins. Additionally, the reason for the delayed postoperative eating time in the RFA group compared to the LC group is the concern that eating may trigger gallbladder contraction, leading to bile leakage from the ablation needle tract. This study found that sessile, wide-based polyps may be more susceptible to bile leakage during the ablation procedure ($P < 0.05$), which could be due to a larger area of gallbladder wall damage during the ablation. In addition, no biliary obstruction was observed during follow-up.

This study has several limitations. First, as a retrospective study, it carries inherent limitations. The case selection process may be influenced by human factors, potentially introducing selection bias into the results. Second, the sample size of this study was relatively small, additional clinical studies with larger sample sizes are needed to further validate the findings of this study. Furthermore, the follow-up time of this study was relatively short. Although obstruction caused by post-ablation polyp shedding or formation of stones in the bile duct by post-ablation polyp shedding was not observed, this possibility of stone formation cannot be ruled out. Therefore, the follow-up time after the RFA should be extended. Finally, there may

be errors in the biopsy results, which may lead to missed diagnoses of focal cancer. It is necessary to improve the method of puncture biopsy.

In conclusion, ultrasound-guided RFA is an effective and feasible alternative to LC for gallbladder polyps. It can effectively inactivate the polyps while preserving the gallbladder. Compared to LC, ultrasound-guided RFA of gallbladder polyps not only retains the gallbladder but also demonstrates that patients have minimal issues with postoperative digestive disorders and malabsorption in long-term follow-up. This provides a new treatment option for both clinicians and patients.

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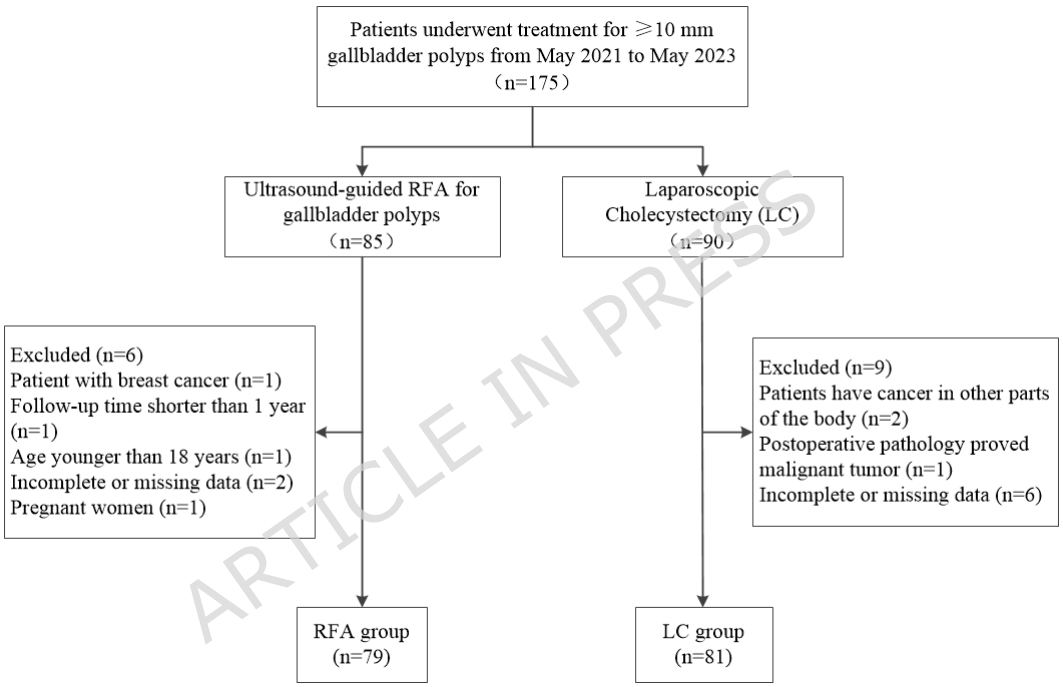
Figures and Tables



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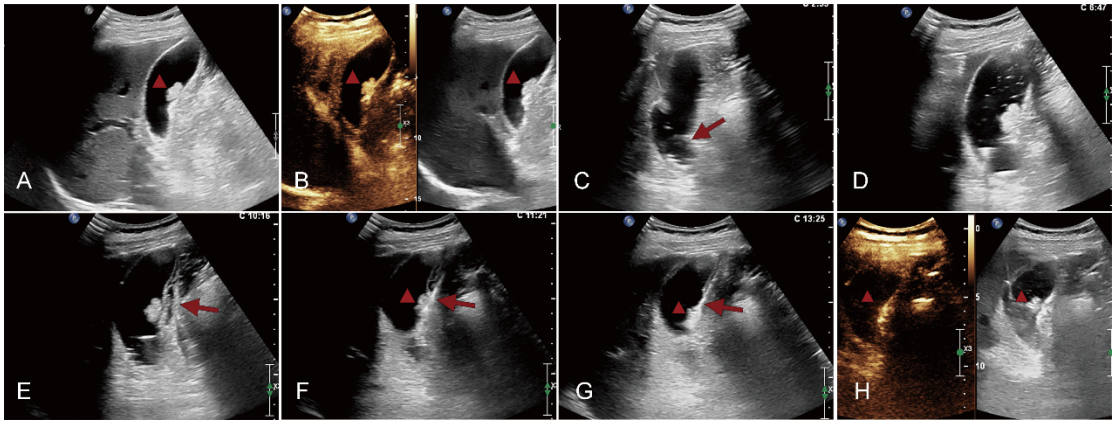

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Postoperative CEUS showed no enhancement of the lesion during the whole period (The tailless arrow indicates gallbladder polyp). RFA= radiofrequency ablation. CUS= conventional ultrasound. CEUS= contrast-enhanced ultrasound.

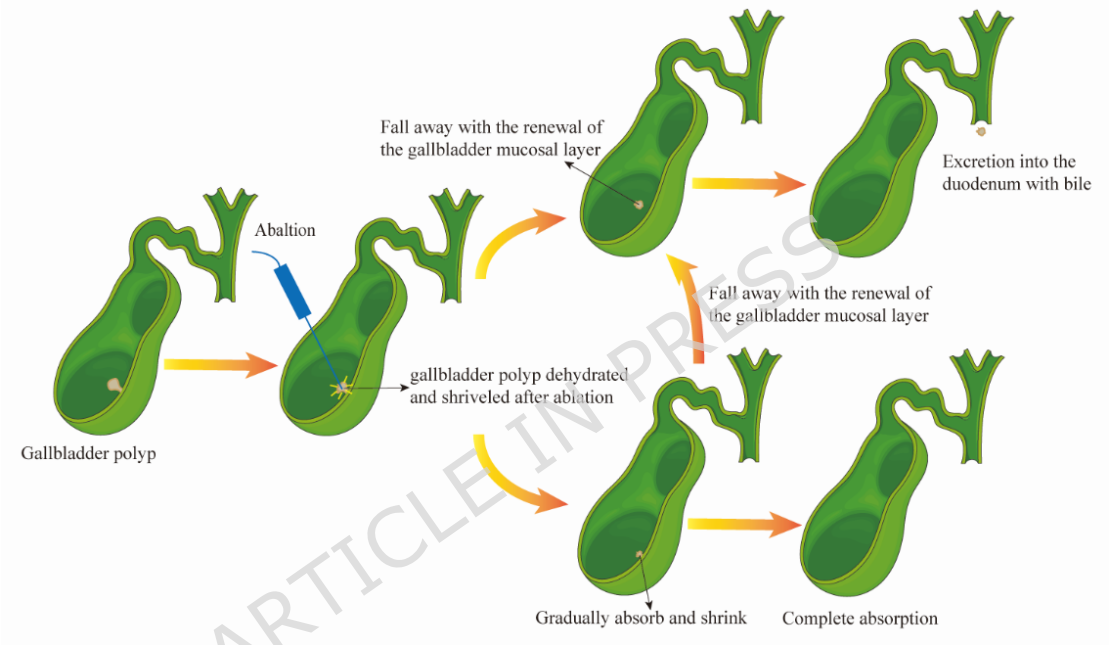

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Table 1. Baseline Characteristics of Patients and Gallbladder Polyps

Variable	Total	RFA group	LC group	*P* value
Age(year)	37.3 ± 11.0	35.8 ± 11.8	38.9 ± 10.0	0.074
Sex				0.053
Male	91	51	40	
Female	69	28	41	
Lesion location				0.712
Middle of liver bed surface	91	46	45	
Bottom of liver bed surface	13	5	8	
Middle of gallbladder free surface	56	28	28	
Lesion morphology				0.880
Pedicled	84	41	43	
Sessile	76	38	38	
Lesion distribution				0.485
Single	101	52	49	
Multiple	59	27	32	
Lesion maximum diameter (mm)	11.8 ± 2.2	12.1 ± 2.5	11.5 ± 1.8	0.056
Lesion base width (mm)	—	7.4 ± 4.2	—	
Pre-ablation CEUS				

Hyperenhancement	—	14	—
Iso-enhancement	—	58	—
Hypo-enhancement	—	7	—

RFA = radiofrequency ablation. LC = Laparoscopic Cholecystectomy. CEUS= Contrast-enhanced ultrasound. Data were expressed as X±SD.

P value < 0.05 indicated that difference was statistically significant.

Table 2. Changes of gallbladder and lesion pre-ablation and post-ablation

Follow-up Time	Pre-ablation	Post-ablation					*P* value
		1W	1M	3M	6M	1Y	
Disappeared lesion (n)	0	66	71	75	77	79	
Lesion disappearance rate (%)	0	83.5% (66/79)	89.9% (71/79)	95.0% (75/79)	97.5% (77/79)	100.0% (79/79)	
Lesion presence							
Lesion number (n)	79	13	8	4	2	0	
Volume (cm^3)	0.3 (0.2□0.5)	0.5 (0.4□0.7)	0.3 (0.3□0.4)	0.2 (0.1□0.3)	0.1 0.1	0	
VRR (%)		7.0 (6.7□7.4)	50.1 (48.0□51.0)	76.8 (70.7□83.5)	89.2 90.2	100	
P value		0.613	□0.001	□0.001	□0.001	0.000	
Diameter of non-target lesion (mm)	5.1 ± 1.7	5.1 ± 1.7	5.1 ± 1.7	5.2 ± 1.7	5.2 ± 1.7	5.2 ± 1.7	
P value		0.994	0.987	0.955	0.911	0.891	
Gallbladder wall thickness(mm)	1.8 ± 0.1	—	1.8 ± 0.1	—	—	—	0.596

Gallbladder shrinkage rate (%)	72.8 ± 7.1	—	73.0 ± 6.4	—	—	—	0.824

Data were expressed as median (M) and quartile (Q1, Q3). *P* value is for post-ablation (1 week, 1 month, 3 months, 6 months, 1-year) versus pre-ablation values, respectively. *P* value < 0.05 indicated that difference was statistically significant. W=week. M=month. Y=year.

Table 3. Postoperative complications and pathology in two groups

Variable	RFA group	LC group	*P* value
Abdominal pain (case)	6	5	0.722
Bile leakage (case)	16	4	0.003
Drainage (day)	9.1 ± 1.3	10.3 ± 1.3	0.115
Postoperative nausea (case)	1	4	0.182
Postoperative abdominal distension (case)	1	5	0.102
Postoperative fever (case)	2	3	0.670
Postoperative hemorrhage (case)	0	1	0.322
Pathology (case)			0.955
Cholesterol polyp	61	61	
Adenoma	12	13	
Inflammatory polyp	6	7	

RFA = radiofrequency ablation. LC = Laparoscopic Cholecystectomy.

P value < 0.05 indicated that difference was statistically significant.

Table 4. Comparison of postoperative symptoms within one year in two groups

Follow-up Time	1M			3M			6M			1Y		
	RFA (n=79)	LC (n=81)	*P* value	RFA (n=79)	LC (n=81)	*P* value	RFA (n=79)	LC (n=81)	*P* value	RFA (n=79)	LC (n=81)	*P* value
Abdominal pain	4	16	0.005	2	13	0.003	0	10	0.001	0	6	0.017
Abdominal distension	4	21	<0.001	3	18	<0.001	1	13	<0.001	0	10	0.001
Diarrhea	2	17	<0.001	1	15	<0.001	0	12	<0.001	0	11	<0.001
Bile reflux gastritis	0	2	0.160	0	3	0.084	0	4	0.045	0	4	0.045
Malabsorption	0	8	0.004	0	9	0.002	0	10	0.001	0	12	<0.001

RFA = radiofrequency ablation. LC = Laparoscopic Cholecystectomy. M=month. Y=year. P value < 0.05 indicated that difference was statistically significant.

Table 5. Factors that may be associated with the occurrence of bile leakage

Variable	Bile leakage	No bile leakage	*P* value
Lesion location			0.140
Middle of liver bed surface	6 (46)	40 (46)	
Bottom of liver bed surface	1 (5)	4 (5)	
Middle of gallbladder free surface	9 (28)	19 (28)	
Lesion morphology			0.038
Pedunculated	4 (38)	34 (38)	
Sessile	12 (41)	29 (41)	
Lesion base width (mm)	7.1 ± 1.7	4.9 ± 2.9	0.004

The numbers in parentheses represent the total cases for this variable. *P* value < 0.05 indicated that difference was statistically significant.

Author contribution:

Conceptualization: H.Z., G.D., B.C.; **Data curation:** H.Z., Y.C.; **Formal analysis:** H.Z., G.D., Z.Z., Y.C., B.C.; F**unding acquisition:** B.C., Z.Z., S.Z., X.W.; **Investigation:** H.Z., B.C., Y.C.; **Methodology:** H.Z., B.C.; **Project administration:** H.Z., B.C.; **Visualization:** H.Z., B.C.; **Writing-original draft:** H.Z.; **Writing-review & editing:** H.Z., Z.Z., Y.C., B.C.; and all authors have read and approved the final manuscript.

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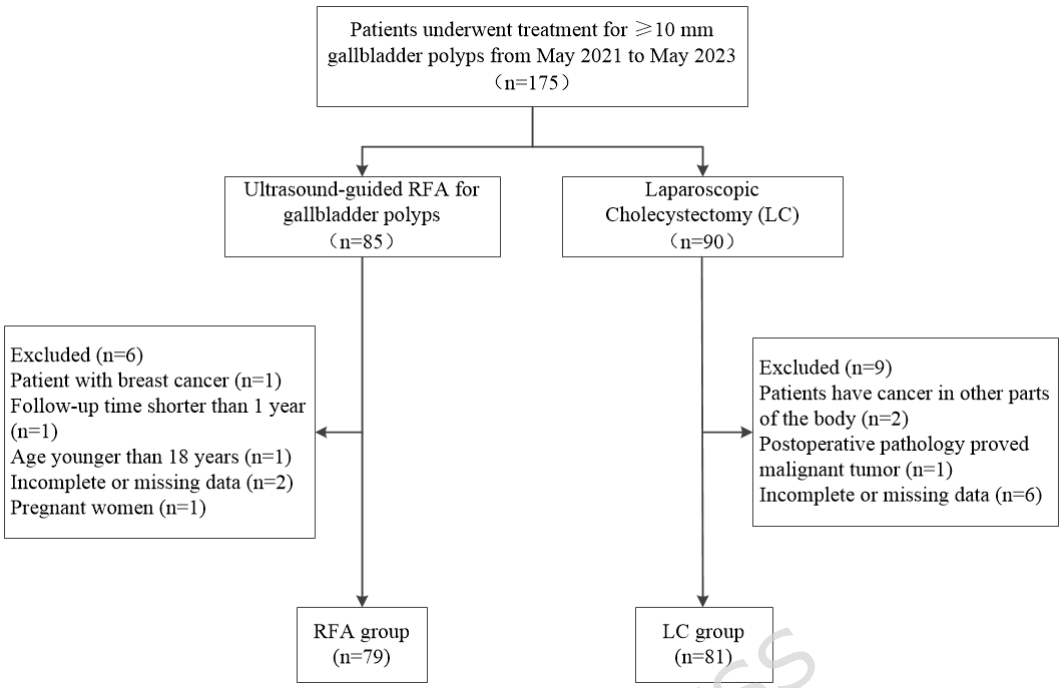
Data availability statement: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Statement: Due to the retrospective nature of the study, (Institutional Review Board of the Affiliated Hospital of Jiangsu University and Institutional Review Board of the First Affiliated Hospital of Zhengzhou University) waived the need of obtaining informed consent.

Acknowledgments: Not applicable.

Competing interests: The authors declare no competing interests.

Figure 1.



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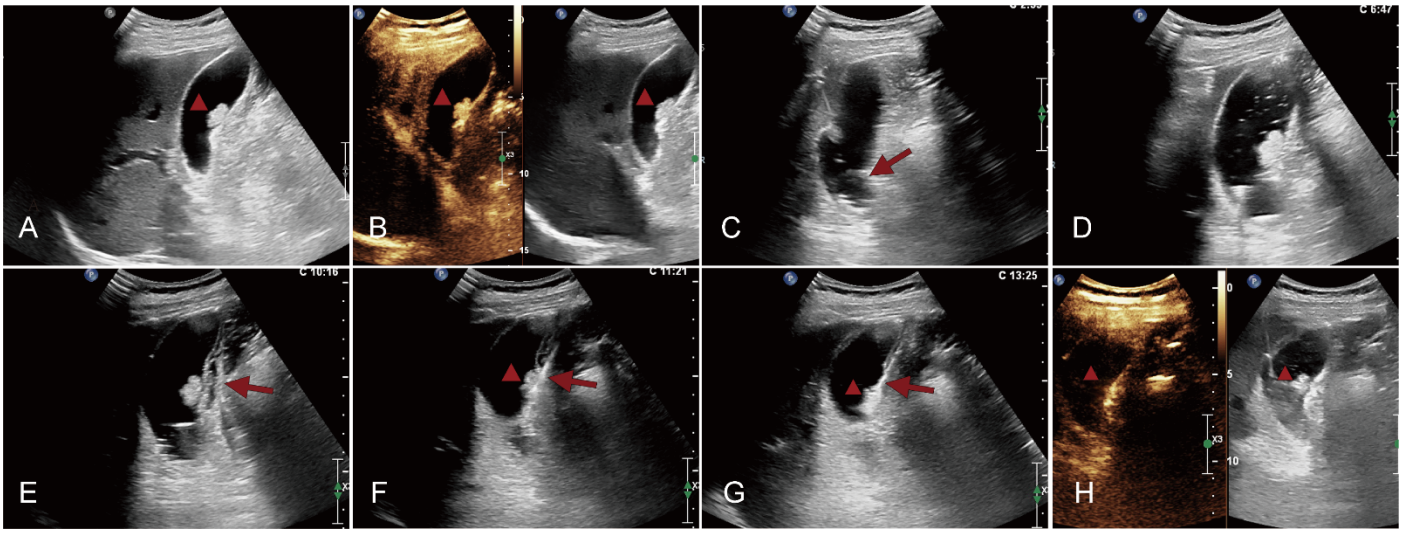

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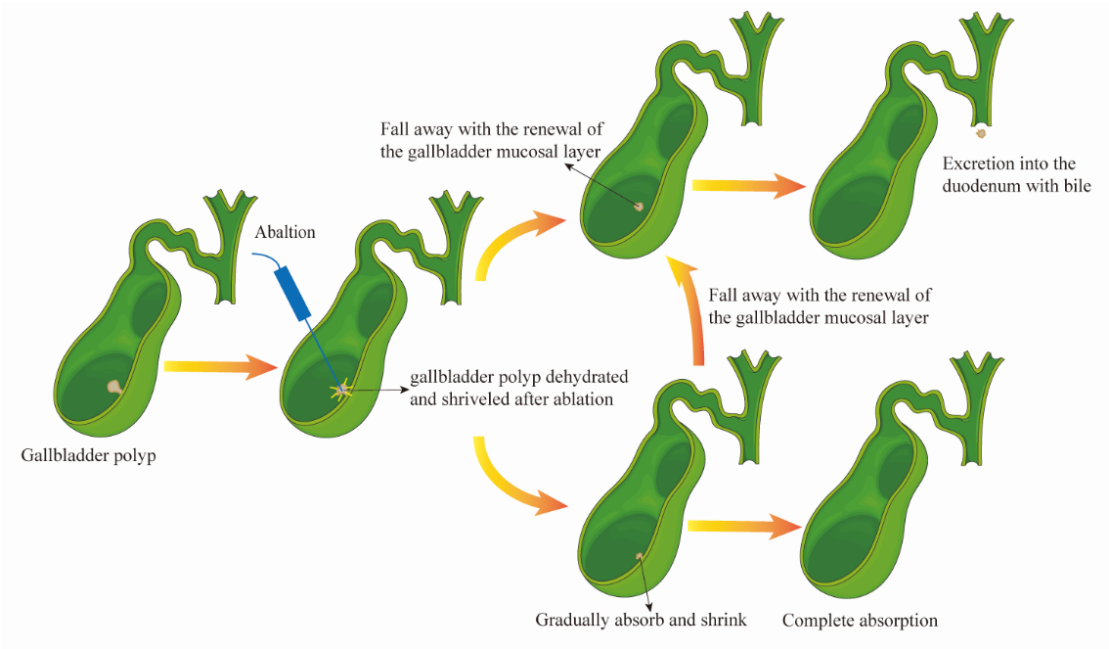

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