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Minimally invasive treatment of gallbladder polyps

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Abstract

Gallbladder cancer is a lethal disease when diagnosed at later stages, and gallbladder polyps may have malignant potential or harbor cancer, especially as the polyp increases in size. Therefore, cholecystectomy has been recommended by guidelines for gallbladder polyps ≥ 10 mm, or smaller polyps with risk factors. In this article, we review minimally invasive approaches to the management of gallbladder polyps. The predominant method of cholecystectomy has been laparoscopic, which has advantages in faster recovery compared to open cholecystectomy. More recently, many surgeons have converted their minimally invasive techniques to robotic approaches. In addition, combined laparoscopic-endoscopic or purely endoscopic approaches have been reported. The ultimate goal of gallbladder polyp management using minimally invasive approaches is to minimize morbidity, given the low incidence of cancer within polyps, while preventing polyps with malignant potential from converting to cancer, or curing cancerous polyps.

Keywords: Minimally invasive, laparoscopic, robotic, endoscopy, gallbladder polyp

INTRODUCTION

Gallbladder polyps are estimated to have a prevalence of about 5%-15% of the population[1-4] and are most commonly discovered incidentally on abdominal ultrasound (US). In addition to abdominal US, computed tomography (CT) scan or magnetic resonance imaging (MRI) scan can be used to diagnose gallbladder polyps, but given the accuracy and lower cost of abdominal US, ultrasonography remains the preferred imaging modality. Gallbladder polyps can be classified as either pseudopolyps, which include cholesterol polyps, focal adenomyosis, hyperplastic polyps, and inflammatory polyps, or true polyps, which include

adenomatous polyps or malignant polyps[5]. Pseudopolyps make up the majority of gallbladder polyps[6] and are considered to be benign. While adenomas are also benign, there is some evidence that they can potentially transform into malignant[7-9]. The natural history of gallbladder polyps has been investigated in several long-term US follow-up studies. Studies with 8-11 years of follow-up for small gallbladder polyps less than 6 mm showed that up to about one-third of patients no longer have visible polyps on the long-term follow-up US[4,10,11]. However, another long-term follow-up of 20 years of gallbladder polyps demonstrated that even for small polyps less than 6 mm, growth of 2 mm or greater is not uncommon[12].

The treatment of gallbladder polyps with potentially a high risk of transforming into or containing adenocarcinoma is important, given the markedly improved survival of gallbladder cancer when detected in earlier stages compared to T3 or later lesions. Factors associated with increased risk of malignancy include older age, sessile polyp, single or unifocal polyp, larger size, a growth rate greater than 3 mm per year, Asian or Indian ethnicity, hyperlipidemia, and symptoms[6,13-17]. For example, Asian patients have been reported to have a rate of malignant gallbladder polyps of 14%, *vs.* 6% for European patients[18]. An additional identified risk factor for malignancy in gallbladder polyps is primary sclerosing cholangitis, with these patients demonstrating a greater than 50% rate of malignancy in gallbladder masses ranging from size 0.5 cm to over 3.0 cm[19,20]. However, these studies were small (less than 20 patients each) and retrospective in nature. There is mixed evidence as to whether gallstones are a risk factor for gallbladder cancer in patients with gallbladder polyps[17,21]. One study used a scoring system consisting of the presence of age greater than 50, symptoms, polyp size greater than 12.5 mm, single polyp, gallstones, and gallbladder wall thickness and demonstrated that when less than 4 of these factors were present, the rate of neoplastic polyp was less than 1%, while if 4 or more were present, the rate of neoplastic polyp was 63%[22]. A recent meta-analysis exhibited a low risk of gallbladder cancer in polyps less than 10 mm in size, showing that in studies with at least moderate quality, 4.6 cancers per 10,000 patients were detected in polyps less than 10 mm[23]. The risk of gallbladder cancer in polyps less than 6 mm appears to be extremely small and essentially zero[18]. However, the management of intermediate-sized gallbladder polyps is somewhat controversial, as even polyps less than 10 mm may be true or neoplastic polyps[14] and other studies have shown a small but nonzero risk of malignancy in polyps less than 10 mm[18,24], while conversely other studies including the largest cohort study of over 35,000 patients with gallbladder polyps over 20 years have seen none or exceptionally rare gallbladder cancer cases in polyps less than 10 mm[12,25].

MANAGEMENT OF GALLBLADDER POLYPS

Several different societies have published guidelines for the management of gallbladder polyps. The most recent guidelines from the Society of Radiologists in Ultrasound (SRU) focus on characteristics of the polyp and recommend cholecystectomy for polyps ≥ 15 mm or ≥ 7 mm if focal wall thickening is also present, and US surveillance for polyps 10-14 mm and polyps 7-9 mm the polyp is sessile or pedunculated with a thick stalk. No follow-up is needed for pedunculated polyps that are less than 10 mm in size and also have a thin stalk. The European guidelines recommend cholecystectomy for polyps that are symptomatic or ≥ 10 mm. These guidelines stratify patients with risk factors including age ≥ 60 years, primary sclerosing cholangitis, Asian ethnicity, and sessile lesion including focal gallbladder wall thickening ≥ 4 mm. For patients with small polyps and no risk factors, no follow-up is needed. For patients with small polyps and risk factors, surveillance is recommended. Finally, for patients with 7-9 mm polyps without risk factors, surveillance is recommended, but if a risk factor is present, then cholecystectomy is recommended. The Canadian Association of Radiologists (CAR) follows the American College of Radiology (ACR) white page recommendations with no follow for small polyps, US surveillance for polyps 7-9 mm, and cholecystectomy for polyps ≥ 10 mm.

Table 1. Society guidelines and recommendations regarding the management of incidentally discovered gallbladder polyps

Society	Year published	Size		
		≤ 6 mm	**7-9 mm**	**≥ 10 mm**
SRU[26]	2022	Pedunculated or sessile: no follow-up	Pedunculated, thin stalk: no follow-up	10-14 mm, pedunculated or sessile: US at 6, 12, 24, 36 mo *vs.* surgery
			Pedunculated, thick stalk or sessile: US at 12 mo, stop if decrease ≥ 4 mm	≥ 15 mm: surgery
			Focal wall thickening ≥ 4 mm: surgery	
		Focal wall thickening ≥ 4 mm: US at 6, 12, 24, 36 mo *vs.* surgery		Focal wall thickening ≥ 4mm: surgery
ESGAR, EAES, EFISDS, ESGE[27,28]	2017 with 2022 update	Symptoms present: surgery	Symptoms present: surgery	Surgery
		No risk factors*: no follow-up	No risk factors*: US at 6, 12, 24 mo; stop if no growth	
			Risk factor* present: surgery	
		Risk factor* present: US at 6, 12, 24 mo; stop if no growth		
ACR[29] CAR[30]	2013 2020	No evaluation or follow-up recommendations	Follow yearly with ultrasound; surgery if polyp grows	Surgery
			If the patient is at higher risk (> 50 years old, sessile or single polyp, PSC, Indian ethnicity), initial follow-up ultrasound at 6 months, then yearly	

ACR: American College of Radiologists; CAR: Canadian Association of Radiologists; ESGE: European Society of Gastrointestinal Endoscopy; EFISDS: International Society of Digestive Surgery - European Federation; ESGAR: European Society of Gastrointestinal and Abdominal Radiology; EAES: European Association for Endoscopic Surgery and other Interventional Techniques; SRU: Society of Radiologists in Ultrasound; US: ultrasound; *Risk factors per the ESGAR: EAES: EFISDS: and ESGE guidelines are: (1) age ≥ 60 years; (2) primary sclerosing cholangitis; (3) Asian ethnicity; (4) sessile lesion including focal gallbladder wall thickening ≥ 4 mm.

The guidelines, each described in Table 1, together can be synthesized to stratify patients based on symptoms, size of polyp, and risk factors for malignancy. We recommend first treating those who are symptomatic with cholecystectomy. Next, in asymptomatic patients, the size and presence of risk factors (age, Asian ethnicity, primary sclerosing cholangitis, and characteristics of the polyp, including sessile polyps or polyps with focal wall thickening) should be considered. Small polyps in patients without risk factors may not need further follow-up, while intermediate-size or small polyps with risk factors should undergo surveillance for growth with cholecystectomy if the size increases to greater than 1 cm. Lastly, intermediate-size polyps with risk factors or large polyps greater than 1 cm in size are generally recommended to be resected. A treatment algorithm based on these guidelines is shown in Figure 1.

Surgical management of gallbladder polyps

While surveillance with US is a cost-effective strategy for small gallbladder polyps[31], once a gallbladder polyp meets the criteria for surgery, the operation most commonly performed is cholecystectomy. Given the low malignancy rate, more radical resection or lymph node dissection beyond cholecystectomy alone is not required for polyps without a histologic confirmation or otherwise high suspicion of cancer.

If, however, based on preoperative factors, there is a high suspicion of cancer within the polyp (for example, a very large single sessile polyp in an older patient), the operation should include a frozen section of the gallbladder to determine the presence of malignancy. In addition, the technique may include resection of

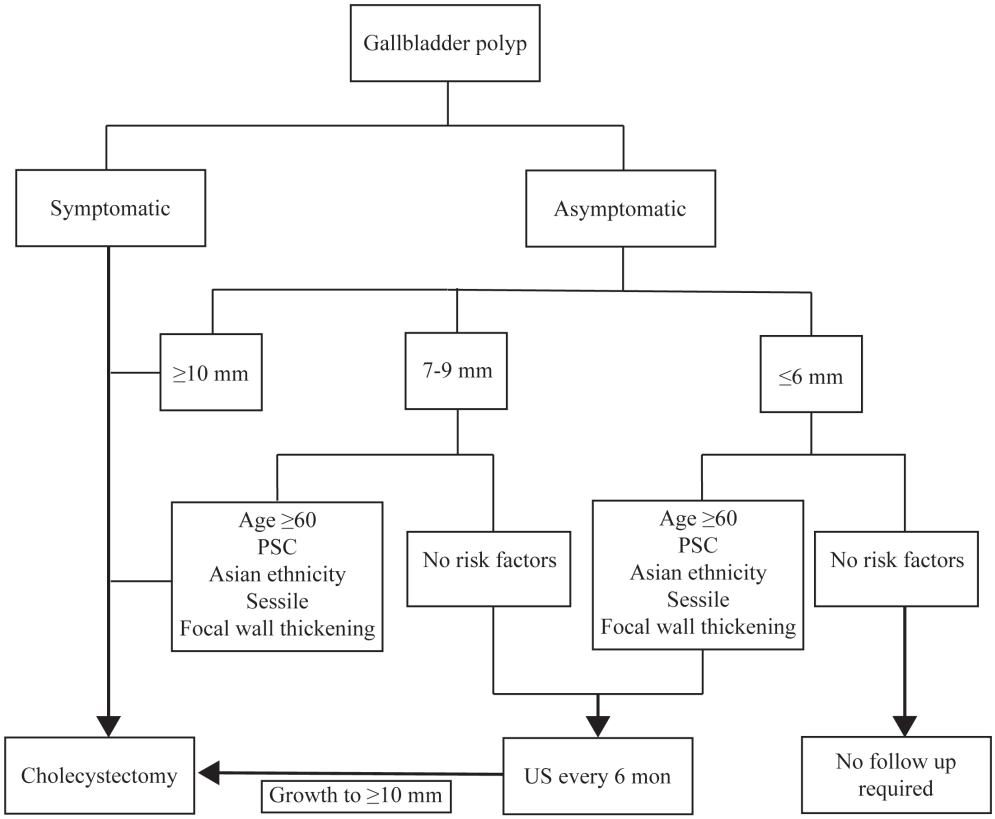

Figure 1. Flowchart for the management of a gallbladder polyp detected on ultrasound. PSC: primary sclerosing cholangitis; US: ultrasound.

the cystic plate en bloc with the gallbladder, particularly if the polyp is located on the hepatic side of the gallbladder, as T2 tumors on the hepatic side are much more likely to have cancer cells remaining in the gallbladder bed after simple cholecystectomy than tumors on the peritoneal side of the gallbladder[32]. Care should be taken to avoid spillage of bile during the cholecystectomy, as intraoperative bile spillage and surgical drain placement are associated with worse progression-free and overall survival[33]. In order to ensure negative margins, a frozen section of the cystic duct on the gallbladder specimen and sampling of the cystic duct node are reasonable. If malignancy is confirmed on intraoperative frozen sections and hepatobiliary expertise is available, then definitive radical resection can be performed at the same operation. If cancer is discovered at cholecystectomy but experience with portal dissection and hepatectomy or other hepatobiliary expertise is not available for radical resection at the center performing the cholecystectomy, documentation of all findings and referral to a center with hepatobiliary expertise is also an option. An alternative scenario of the discovery of an incidental adenocarcinoma occurs postoperatively following cholecystectomy on the final pathologic analysis of the gallbladder specimen. When malignancy is found and the final stage is T1a or only involves the lamina propria with negative margins, then cholecystectomy alone is sufficient. However, if any margins are positive, the pathologic stage is T1b (invading the muscle layer) or greater, or any node is positive, then complete staging is followed by a second operation for radical resection consisting of hepatectomy with segment IVb/V resection and portal lymphadenectomy to achieve negative margins and an R0 resection is warranted[34,35]. Data suggests that immediate or early reoperation for radical resection is not required, and, in fact, delay of radical resection to about 4-8 weeks is

oncologically safe[36] and that disease biology, rather than time to reoperation, is more significant in determining the overall outcome[37].

Minimally invasive surgery for gallbladder polyps

The historical method of gallbladder resection was open cholecystectomy (OC), usually with a subcostal incision. Laparoscopic cholecystectomy (LC) was first reported in 1987[38] and was subsequently shown to have lower complication rate and faster recovery compared to OC for benign gallbladder disease, including cholelithiasis and acute cholecystitis[39-41]. The laparoscopic approach for cholecystectomy was then expanded to include gallbladder polyps as the majority are in fact benign. The laparoscopic approach was initially utilized for gallbladder polyps with caution, given their malignant potential, as a 1998 study reported 2 cases of disseminated gallbladder cancer after LC, including one for a gallbladder polyp[42]. However, other early case series of laparoscopic cholecystectomies for gallbladder polyps [Table 2][43-46] each concluded that laparoscopic resection of even early T1 malignant lesions arising in gallbladder polyps was safe. More recently, advances in laparoscopic technique have reported the utilization of a single port laparoscopic approach to LC. While multiple studies have evaluated single port LC (SP-LC), Choi *et al.*[47] compared 56 SP-LC specifically for gallbladder polyps to an equal number of conventional LC and found no difference in complication rate, bile spillage, postoperative pain, or hospital stay, and all conversions to open were in the conventional LC cohort. The findings suggest SP-LC is a safe minimally invasive surgical approach to the management of gallbladder polyps in addition to standard LC.

In the mid-1990s, the robotic approach to cholecystectomy was first described[48,49]. The United States Food and Drug Administration (FDA) approved the da Vinci robotic surgical system in 2000. The robotic technique allows for several advantages over laparoscopy, including 3D camera visualization and wrist articulation of the instruments. Early series of robotic cholecystectomy (RC) for benign disease included small percentages of cholecystectomies performed for polyps and showed that RC was safe without complications or conversions to open [Table 2][50]. In general, systematic reviews and meta-analyses of LC *vs.* RC show that LC has shorter operative times, but there are no significant differences in complications, hospital length of stay, or readmission rate for RC or LC[51,52]. A recent retrospective study compared outcomes of 612 LC and RC that included a total of 19 gallbladder polyps (3.1% of the cholecystectomies were for gallbladder polyps). Amongst all cases, the authors found that RC had improved hospital length of stay, blood loss, and conversion to open compared to LC, with no difference in grade 3 or higher Clavien-Dindo complications[53]. A randomized controlled trial of single incision RC (SI-RC) *vs.* LC with conventional 4 ports included gallbladder polyps as inclusion criteria for cholecystectomy and demonstrated no statistically significant differences between SI-RC and LC in postoperative pain or adverse events including bile spillage and bleeding, while SI-RC had improved cosmesis[54]. Therefore, for those with experience and comfort with robotic surgery, RC can be a viable alternative to LC for minimally invasive treatment of gallbladder polyps.

Minimally invasive surgery for incidentally discovered gallbladder cancer

A minimally invasive approach for radical resection of gallbladder cancer using laparoscopy was shown in institutional case series to have low blood loss, minimal morbidity, and negative margins[55]. A retrospective institutional series comparing laparoscopic management of patients with known gallbladder cancer to those with incidentally discovered gallbladder cancer showed that the conversion rate was higher without statistical significance in known cancer *vs.* incidentally discovered cancer groups (29% *vs.* 9%, respectively). 73% of the procedures had at least 7 lymph nodes retrieved during the lymphadenectomy[56]. In comparing laparoscopic radical resection *vs.* open, another retrospective study showed lower blood loss and hospital stay with laparoscopy with similar 1-year overall survival[57]. Mayo reported institutional data showing less blood loss and shorter length of stay for laparoscopic *vs.* open liver resection for intrahepatic

Table 2. Studies evaluating minimally invasive surgery that specifically include gallbladder polyps

Authors	Surgery	Polyps	Malignant	Notes
Kubota *et al.*[43]	Lap	26	3	Laparoscopy feasible even with early cancer
Kubota *et al.*[44]	Lap	34	4	Laparoscopy feasible even with early cancer
Yeh *et al.*[45]	Lap	123	7	Laparoscopy safe and feasible but suspect cancer when > 15 mm
Huang *et al.*[46]	Lap	143	6	5/6 patients with early cancer had no recurrence at 2-3 year follow-up
Miller *et al.*[50]	Rob	2	0	No complications or conversions to open with RC
Choi *et al.*[47]	SP Lap	56 SP Lap, 56 Lap	1 SP Lap, 1 Lap	No difference in LOS, bile spillage, conversion to open, or complication between SP lap and lap
Pietrabissa *et al.*[54]	Lap and SI Rob	NR	NR	No difference in postoperative pain, bleeding, or bile spillage
Tao *et al.*[53]	Rob and Lap	12 (2.7%) Lap, 7 (4.1%) Rob ($P > 0.05$)	NR	RC superior in LOS, EBL, or conversion to open ($P < 0.05$)

EBL: Estimated blood loss; Lap: laparoscopic; LOS: length of stay; Lap: single port laparoscopic; NR: not reported; Rob: robotic; SP Lap: single port laparoscopic; SI Rob: single incision robotic.

cholangiocarcinoma and gallbladder cancer, with no difference in negative margin rate, complete lymphadenectomy rate, and 3-year overall and disease-free survival rate[58]. The similar survival rate between open and laparoscopic surgery for gallbladder cancer was shown to be consistent in T2 cancers regardless of nodal status (N0 or N1)[59]. Two meta-analyses of laparoscopic *vs.* open surgery for gallbladder cancer[60,61] showed less intraoperative blood loss and shorter hospital stay for laparoscopic surgery with no differences in overall or disease-free survival. Robotic radical resection for gallbladder cancer is also feasible, with studies showing median lymph node retrieval of > 7 and the ability to achieve negative margins[62]. A retrospective single-institution study of 8 patients who underwent robotic surgery for suspected or confirmed gallbladder cancer also demonstrated safety, with intraoperative blood loss of 199 mL, no conversions to open, one (12.5%) complication for postoperative bleeding, and one (12.5%) complication for port site hernia[63]. Comparisons of open and minimally invasive surgery for gallbladder cancer are summarized in Table 3. While no prospective or randomized controlled trials have been performed due to the relatively low frequency of gallbladder cancer, the literature supports the assertion that either a laparoscopic or robotic approach to radical gallbladder resection for a cancer if found at the time of cholecystectomy for polyps or other benign disease appears to be safe at experienced laparoscopic or robotic centers but may not be generalizable to all centers.

Endoscopic management of gallbladder polyps

Given the low rate of malignancy within polyps, especially those that are small in size, the drive for more minimally invasive procedures has led to studies investigating the use of endoscopy without gallbladder resection to manage gallbladder polyps. A described minimally invasive alternative to cholecystectomy is a combined laparoscopic/endoscopic approach with polyp removal but instead sparing of the gallbladder. In 2014, Wang *et al.* reported on 9 pigs that were treated with microwaves 50-70 mA for 9 seconds and experienced recovery of gallbladder mucosa to normal 2 weeks later, and then applied this technique to 60 patients with gallbladder polyps. The polyps were cauterized and removed, with the procedure taking 60-135 min with a 93% technical success rate. Finally, the authors report that at 3 months, the polyps had not recurred[72]. A separate group from China reported a similar case report of a combined endoscopic and laparoscopic gallbladder preserving treatment of a 13 × 9 mm gallbladder polyp. The procedure describes a laparoscopic incision to open and access the gallbladder, followed by placing the endoscope through an umbilical laparoscopic port to perform a polypectomy of the gallbladder, and finally, closure of the gallbladder incision using laparoscopic suturing[73].

Table 3. Retrospective studies comparing minimally invasive *vs.* open radical resection for gallbladder cancer

Authors	Patients	EBL, mL	LOS, days	Complication/Morbidity rate	Oncologic outcome
Agarwal *et al.*[64]	Open: 123 Lap: 24	Open: 275 Lap: 200	Open: 5 Lap: 5	Open: 17% Lap: 13%	No difference in R0 rate or number of lymph nodes resected
Feng *et al.*[65]	Open: 61 Lap: 41	Open: 386 Lap: 358	Open: 11 Lap: 5	Open: 9.8% Lap: 7.3%	5-year OS Open: 56% Lap: 52%
Vega *et al.*[66]	Open: 190 Lap: 65	Open: 200 Lap: 300	Open: 6 Lap 4	Open: 20% Lap: 18%	3-year OS Open: 62% Lap: 87%
Dou *et al.*[57]	Open: 31 Lap: 32	Open: 503 Lap: 267	Open: 14 Lap: 11	No difference in the rate of Clavien-Dindo grade 0-2 or 3-4 events	1-year OS Open: 48% Lap: 73% (P = 0.09)
Navarro *et al.*[67]	Open: 43 Lap: 43	Open: 208 Lap: 72	Open: 13 Lap 6	Open: 4 Clavien-Dindo ≥ 2 Lap: 0 Clavien-Dindo ≥ 2	5-year OS Open: 64% Lap: 80% (P = 0.21)
Yang *et al.*[68]	Open: 56 Rob: 28	Open: 156 Rob: 99	Open: 13 Rob: 10	Open: 21% Rob: 10%	3-year OS Open: 63% Rob: 75%
Lee *et al.*[69]	Open: 24 Lap: 20	Open: 594 Lap: 320	Open: 12 Lap: 11	Open: 21% Lap: 10%	5-year OS Open: 54% Lap: 80%
Cho *et al.*[70]	Open: 19 Lap: 19	NR	Open: 14 Lap: 8	Open: 10% Lap: 21%	5-year OS Open: 82% Lap: 78%
Dou *et al.*[71]	Open: 30 Lap: 30	Open: 484 Lap: 257	Open: 14 Lap: 10	Open: 7% Lap: 10%	3-year OS Open: 30% Lap: 40%

EBL: estimated blood loss; LOS: length of stay; Lap, laparoscopic; NR: not reported; OS: overall survival; Rob: robotic.

Another technique aimed to use endoscopy alone and was first described for the treatment of gallstones. One study uses endoscopic ultrasound-guided cholecystostomy (either via cholecystoduodenostomy or cholecystogastrostomy) to place a metal stent for access to the gallbladder. Several days later, the patient returns for endoscopic per oral gallbladder polypectomy. Shen *et al.*[74] report their experience with 4 patients with multiple polyps using this technique (3 cholecystoduodenostomy and 1 cholecystogastrostomy) and found that 1 patient developed significant pancreatitis and another later underwent LC for cholelithiasis, but none of the 4 patients developed gallbladder polyp recurrence at 3-15 months and all eventually had the stent removed. Another group reported on 22 patients who underwent a similar technique of endoscopic gallbladder polypectomy, but as one procedure without metal stent placement. Zhang *et al.*[75] describe an endoscopic anterior gastrotomy and introduction of the endoscope into the peritoneal cavity, followed by identification and incision into the gallbladder. After suctioning bile, polypectomy is performed with snare, biopsy forceps, or argon beam coagulation. The cholecystotomy is closed with clips and the gastrotomy is closed with endoloop and clips. This study reports a median hospital stay of 5 days and 4 (18.2%) patients with complications of localized peritonitis. One patient developed recurrent gallstones but wished not to undergo LC as he was asymptomatic. Another endoscopic strategy employed is embryonic-natural orifice transumbilical endoscopic surgery (E-NOTES), which uses a 10 mm trochar placed through the umbilicus, followed by gallbladder incision with an endoscope, polypectomy, and gallbladder closure with clips. He *et al.*[76] report their experience of 12 patients who underwent E-NOTES and describe minimal post-procedural pain and satisfactory cosmetic outcome with no recurrence of polyps at 12 months. As the current literature is retrospective, subject to publication bias, and includes less than 100 total patients, additional data is needed to confirm the safety and efficacy of these approaches,

Table 4. Studies evaluating endoscopic gallbladder polyp management

Authors	Technique	*n*	Outcomes
Wang *et al.*[72]	Combined lap and endo, with lap cholecystotomy and endo polypectomy	60	93% technical success with no polyp recurrence at 3 months
Shen *et al.*[74]	EUS guided cholecystostomy with metal stent placement, followed by second endo gallbladder polypectomy	4	1 patient with pancreatitis, 1 patient underwent LC for gallstones, no polyp recurrence
Zheng *et al.*[73]	Combined lap and endo with laparoscopy used to identify and incise gallbladder, followed by transumbilical endo electroresection, and lap suture of gallbladder	1	Operative time 96 min with EBL of 10 mL
Zhang *et al.*[75]	Endo gastrotomy to allow endoscope into peritoneum followed by endo incision in gallbladder for access to polypectomy, endoloop and clips to close both	22	4 patients with localized peritonitis, median LOS 5 days, 1 recurrent gallstone
He *et al.*[76]	E-NOTES: insertion of endoscope via 10 mm umbilical trochar to incise gallbladder, perform polypectomy, and close gallbladder with clips	12	No recurrence of polyps at 12 months

Endo: Endoscopic; EUS: endoscopic ultrasound; EBL: estimated blood loss; E-NOTES: embryonic-natural orifice transumbilical endoscopic surgery; Lap: laparoscopic; LC: laparoscopic cholecystectomy; LOS: length of stay.

and only patients with very low risk of cancer are appropriate for these techniques as they involve cholecystotomy and significant risk of bile spillage which would worsen survival in the event a cancerous polyp was discovered. The endoscopic techniques summarized in Table 4 nonetheless represent continued advancement and innovation toward increasingly minimally invasive and organ-sparing treatment of gallbladder polyps.

CONCLUSION

Gallbladder polyps are occasionally encountered on abdominal US, given the overall common incidence of cholelithiasis. A minimally invasive strategy for managing gallbladder polyps not only aims to minimize procedural morbidity but also balances the overall low risk of either harboring or developing into gallbladder cancer, with a high rate of mortality from gallbladder cancer when diagnosed at later stages. In select low-risk patients, no follow-up or US follow-up is appropriate. When cholecystectomy is indicated, laparoscopic cholecystectomy is preferred and single port or single incision laparoscopic surgery has been used for gallbladder polyps as well with acceptable results. In addition to laparoscopic surgery, robotic surgery has advantages that include wrist motion of the instruments and 3D visualization from the camera, and potential benefits include future technological advances in indocyanine green (ICG) fluorescence, artificial intelligence, or augmented reality applications to the robotic platform. Laparoscopic and robotic surgery not only has benefits over open surgery with respect to short-term outcomes, but also appears to be oncologically safe in the event that either an early cancer that can be treated with cholecystectomy alone is encountered, or in the event a more radical resection is required in experienced centers. Finally, several authors have attempted gallbladder sparing polypectomies using either combined endoscopic/laparoscopic or purely endoscopic techniques for benign gallbladder polyps to further reduce the invasiveness of the management of gallbladder polyps. Small retrospective studies appear to demonstrate some safety and feasibility of these techniques in select patients with polyps without a high risk of harboring cancer; however, more evidence is required before broad adoption of these approaches over the standard laparoscopic or robotic cholecystectomy.

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Authors' contributions

Literature review, writing manuscript, editing and review: Sullivan KM, Fong Y

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Fong Y is a paid scientific consultant for Medtronics, Johnson & Johnson, and Imugene. Fong Y receives royalties for inventions from Merck and Imugene. Sullivan KM declares no conflict of interest.

Ethical approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

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