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Review article

Laparoscopic Roux-En-Y Gastric Bypass and Cholelithiasis: A Review

Arapis Konstantinos, Mariam El Khatib, Pelletier Anne Laure

Department of General and Digestive Surgery University, Huchard 75877 Paris France

Corresponding author: Arapis Konstantinos MD, PhD Department of General and Digestive Surgery University Hospital Bichat Claude Bernard, Paris, France

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Introduction

Obesity is a worldwide health-related problem associated with major diseases and morbidity. Gallstone disease is one of the main complications associated with obesity itself. The prevalence of gallstones varies among countries (1.4% - 21.9%;Table 1) [1-15], with a sevenfold increased risk [16] in obese patients, especially in women with BMI exceeding 45 Kg/m2. While bariatric surgery remains the best therapeutic modality to treat obesity, the rapid weight loss that follows the surgery may be as sociated with a further increase in the risk of gallstones; studies show sludge and gallstones in 10% - 25% of patients within a few weeks after surgery [17-21].

Our main concern is the complexity of treatment of gallstone disease and specifically common bile duct (CBD) stones after laparoscopic Roux-en-Y gastric bypass (LRYGBP) surgery. This is because the modification of the anatomy complicates access to the biliary tree via classical approaches, and thus complicated endoscopic and surgical techniques must be performed to remove the stones from the CBD.

To avoid these "difficult-to-treat" complications after bariatric surgeries, cholecystectomy has been suggested as a possible prophylactic modality in patients undergoing LRYGBP; however, this suggestion remains controversial as data confirming its cost effectiveness and safety are lacking.

Unfortunately, despite the widespread use of LRYGBP and the well-established impact of gallstone disease in this population, many questions remain unanswered, which causes significant confusion and uncertainty among clinicians treating these patients.

The aim of this article is to review the data available in the literature concerning the incidence of cholelithiasis and the proportion of patients who require elective or urgent cholecystectomy after LRYGBP, and the best treatment modality face a stone in the CBD in a patient underwent a LRYGBP. There has been much sporadic work on gallstone disease in relation to bariatric

Table 1. Prevalence of gallstone disease in different population.

Study	N of patients	Country	Prevalence of GB stones (%)	Prelavalence male	Prevalence female
Loria P, et al. [1]	1804	Italy	5.9	3.7	8.4
Tomecki R, et al. [2]	10133	Poland	18	8.2	6.7
Acalovschi M , et al. [3]	6275	Romania	-	6.9	17
Ansari-Moghaddam, et al. [4]	1522	Iran	2.4	1.4	4
Attili AF, et al. [5]	29739	Italy	13.8	9.5	18.9
Barbara L, et al. [6]	1911	Italy	11	6.7	14.6
Berndt H, et al. [7]	3226	East Germany	19.7	13	24.5
Caroli-Bosc FX, et al. [8]	831	France	13.9	9.6	17.7
Everhart JE, et al. [9]	14000	United States	-	5-8.9	13.9-26.7
Glambek I, et al. [10]	1371	Norway	21.9	20.3	23.3
Heaton KW, et al. [11]	1896	Great Britain	7.5	6.9	8
Jorgensen T, et al. [12]	3608	Denmark	8.8	5.6	11.5
Kratzer W, et al. [13]	2498	Germany	7.8	4.9	10.5
Misciagna G, et al. [14]	2461	Italy	9.2	6.5	12.9
Murhrbeck O, et al. [15]	556	Swede	15	11	18

Table 2. Symptomatic Gallbladder disease after LRYGBP in different studies. UDCA: Ursodeoxycholic acid, pos U/S: hepato-biliary ultrasound positive for gallbladder stones, UA: unavailable data.

Variables	Number of patients	Prior Cholecystectomy	Concomitant cholecystectomy (indication)	UDCA	Follow-up	Fol low-up patients	Lithiasis after surgery	Urgent cholecystectomy	Time after bariatriic surgery (months)
Authors					(months)				
Plecka Ostlund M, et al. [30]	6549	Not mentioned	no	no	> 36 m	6549	232/6549 3,5%	89/6549 1,35%	7 – 12 m
Caruana JA, et al. [24]	125	Not mentioned	no	UA	16 – 48 m	UA	UA	10/125 8%	3 – 21 m
Patel JA , et al. [28]	199	0	no	UA	17,8 m	UA	UA	7/199 3,5%	UA
Swartz DE, et al. [33]	417	Not mentioned	no	Yes (6 m)	7,5 m	319	UA	47/319 14,7%	6 m
Portenier DD, et al. [31]	1391	334/1391 24%	no	UA	6 - 144	984	UA	80/984 8%	29 m
Shiffman ML, et al. [32]	105	0	Yes (lithiasis) 24/105 (23%)	UA	18 m	81	31/81 (lithiasis) 10/81 (sludge)	0	UA
Amstutz S, et al. [23]	117	20/117 17%	Yes (lithiasis) 26/117 (22%)	UA	44 m	64	33/64 (51,5%)	11/64 (17%)	17 m
Taylor J , et al. [34]	535	43/535 8%	Yes(symptoms) 73/492(15%)	no	30 m	Not mentioned	UA	3%	UA
Patel KR, et al. [29]	1376	288/1376 21%	Yes (symptoms) 28/1088 (2,5%)	UA	32 m	1050		4,9%	24 m
Fuller W , et al. [26]	144	29/144	Yes (symptoms)	Yes (6 m)	12 m	106		1/106	12
Villegas L, et al. [35]	289	60/289 20,7%	Yes (pos U/S) 40/289 (13,8%)	Yes (6 m)	12 m	151	33/151 (lithiasisi) 12/151 (slugde)	3/151 1,9%	UA
Tarantino I, et al. [22]	437	48/437 10,9%	Yes (pos U/S) 167/437 (38,3%)	no	36	140	Not gmentioned	19/140 13,5%	

surgery, but few competent reviews have collected information from all these diverse sources.

Gallbladder Lithiasis and LRYGBP

Gallbladder-related disease after LRYGBP

The available data show that the rate of symptomatic gallbladder disease after LRYGBP is low but variable (Table 2) [22-35].The largest study was presented by Plecka et al. [30], who analyzed the series of the Swedish Patient Register: from 13 443 patients with history of bariatric surgeries (between 1 January 1987 and 31 December 2008) 6549 underwent LRYGBP with a follow-up exceeding 9 years and found that 8.5% of them required cholecystectomy for gallstone-related problems and only 3.2% required urgent cholecystectomy for cholecystitis, cholangitis or pancreatitis. When taking the gastric bypass subpopulation`, 3.5% of patients required cholecystectomy for gallstone-related disease (0.4% within 6 months, 1% within 7-12 months, 1.5% within 13-24 months, 1% within 2-3 years, and 2.4% in > 3 years) and 1.4% required urgent cholecystectomy (0.2% within 6 months, 0.5% within 7-12 months, 0.4% in 13-36 months, 0.8% in > 3 years). This lower rate in the gastric bypass population in that study was related to the more recent introduction of RYGP in the Swedish population compared with other types of bariatric surgery and the corresponding shorter mean follow-up. Similarly, low rates were noted in studies by Patel J.A. et al.28, Patel K.R. et al.29, and Portenier et al.[31]. In most of these studies, the risk of developing symptomatic cholelithiasis was not related to specific factors like age, gender, or preoperative BMI34. Notably the frequency of urgent cholecystectomy after LRYGBP may be similar in patients underwent LRYGBP with concomitant cholecystectomy (for lithiasis symptomatic or not) [22- 29] with patients underwent LRYGBP only [28-33].

Furthermore, while the incidence of biliary colic necessitating elective cholecystectomy is low, the rate of acute cholecystitis, pancreatitis and cholangitis necessitating emergency cholecystectomy, is much lower. For example Villegas et al.[35] found that 7% of patients undergoing LRYGBP had biliary colic due to gallbladder stones that necessitated elective cholecystectomy but only 1.98% had an indication for emergency cholecystectomy to treat acute cholecystitis and cholangitis, while Shiffman et al.[32] noted that no patients with new gallbladder stones had an indication for emergency cholecystectomy.

Higher rates of symptomatic gallstone disease were noted by Amstutz S et al. [23] and Swartz D.E. et al.[33], where 17% and 14.7% of patients underwent emergency or elective cholecystectomy for cholecystitis and symptomatic cholelithiasis after a mean time of 17 and 6 months, respectively. Similarly, Shiffman M.L et al.32 found that 16% of patients had symptomatic gallstones, most within the first 6 months, and none had an indication for urgent cholecystectomy. The highest rate was noted by Tarantino I. et al. [22], who found that 18.6% of patients had symptomatic gallbladder stones and 13.5% had an indication for emergency cholecystectomy. No obvious explanation can be extracted from the comparison of the above articles to explain the different incidences of symptomatic cholelithiasis.

Tsirline VB et al. [36] found a frequency of cholecystectomy after LRYGB of 10.4% and noted that the risk is highest early after surgery and is mainly determined by the amount of excess weight loss within the first 3 months. Amaral JF et al. [37] also noted that the development of gallbladder disease was highest in the first 24 months and decreased significantly in subsequent years. Villegas L. et al. [35] also concluded that excess weight loss was significantly associated with gallstone formation while Karadeniz M et al. [38] found that the new BMI is not a determining factor (nor was age or gender).

Interestingly, Fuller W et al. [26] evaluated the natural history of asymptomatic cholelithiasis in patients undergoing LRYGB. Ultrasound (US) was conducted in 144 patients before they underwent bariatric surgery; 22 patients had gallbladder stones. The gallbladder was left in place in 13 patients who were asymptomatic and were treated with ursodiol during the postoperative period, though exact compliance with the medication could not be determined. Among these patients, only one developed symptoms and required cholecystectomy after 1 year of follow up.

Prophylaxis of Gallstone Diseases after LRYGBP

According to the 2009 guidelines of the Haute Autorité de Santé (the French High Authority of Health) [39], ursodeoxycholic acid (UDCA) at a dose of 600 mg/day can be offered after bariatric surgery as a medical prevention for cholelithiasis (grade B recommendation, based on moderate level of evidence). Similar recommendations were made by the European Association for the Study of the Liver (EASL 2016) [40], which stated that UDCA at a dose of at least 500 mg/day until the weight stabilizes may be recommended (moderate quality evidence, weak recommendation).

These recommendations were based on several studies. A multicenter randomized, placebo-controlled trial by Sugerman HJ et al. [41] examined the efficacy of UDCA in preventing biliary stone formation after LRYGBP. Two hundred thirty-three patients undergoing normal intraoperative US were randomized to receive either placebo or UDCA for 6 months starting within 10 days after LRYGBP. Preoperative age, race, sex, BMI, and postoperative weight loss were not significantly different between groups. Gallstone formation occurred at 6 months in 32% of patients on placebo and in 13%, 2%, and 6% of the patients on 300 mg, 600 mg and 1200 mg UDCA, respectively. At 1 year, the overall incidences of either gallstones or sludge by ultrasound detection were 12% in the UDCA group and 46% in the placebo group. Gallstones were significantly ($P<0.001$) less frequent with 600 and 1200 mg UDCA than with placebo.

In another prospective trial [42], 137 patients were divided into a control group and a group who received UDCA 150 mg twice a day for 5 months starting 30 days after LRYGBP. Gallstones were detected on US in 1% of patients in the treatment group and 26% in the control group ($p < 0.001$).

Similar rates of gallbladder stone formation and cholecystectomy were found in another small randomized placebo controlled trial [43] conducted in post-bariatric surgery patients (not specifically RYGP): 3% versus 22% at 12 months and 8% versus 30% ($P = 0.0022$) at 24 months for gallbladder stones and 4.7% versus 12% for cholecystectomy in the UDCA 500 mg and placebo groups, respectively.

In another trial using postoperative UDCA treatment [44], the incidence of cholelithiasis after 13 months of mean follow up was 32.5% in the 117 non-treated LRYGBP patients, 5.7% in the 87 LRYGBP patients treated with 250 mg twice daily ($P<.001$), and 18.6% in those treated with 500 mg once daily ($P = 0.03$).

Broomfield PH et al. [45] demonstrated in a small study that 1200 mg UDCA prevents lithogenic changes in bile and the formation of gallstones in obese subjects during weight loss. This study had an important value because it assessed bile saturation in patients with and without UDCA, and thus it tested the effect of UDCA on the pathophysiologic mechanism responsible for bile stone formation after weight loss. Similar conclusions were made by Worobetz LJ et al. [46].

However, all these trials have primary endpoint the gallstones formation and they did not provide evidences concerning the risk of symptomatic gallstone disease. The randomized controlled trial of Boerlage T et al. [47] already started two years ago hopes to give an answer to this question.

LRYGBP and Concomitant Cholecystectomy

Several approaches have been described in the literature without any international consensus on the single best approach. The American Society for Metabolic and Bariatric Surgery stated in its 2013 Clinical Practice Guidelines [48] that prophylactic cholecystectomy may be considered with LRYGBP to prevent gallbladder complications. This was based on a comparative cohort study [22] that showed that concomitant cholecystectomy is safe and that 18.6% of post RYGB patients required cholecystectomy for symptomatic cholelithiasis during a mean follow up of 3 years. The Society of American Gastrointestinal and Endoscopic Surgeons stated only that abdominal ultrasound may be performed to detect gallstones and allow the surgeon to decide on concomitant cholecystectomy [49], without making any clear recommendation for or against the cholecystectomy.

Thus surgeons' decisions vary and remain institution-dependent.

The first approach is the prophylactic approach, in which cholecystectomy is performed systematically at the time of LRYGB regardless of the presence of gallbladder stones and related symptoms.

Despite the above data showing the overall low incidence of post bariatric surgery symptomatic cholelithiasis, some authors still suggest routine prophylactic cholecystectomy. Fobi M et al. [25] reviewed the data of 761 patients who underwent LRYGB and found positive imaging findings in 20% of patients on preoperative US and positive pathologic findings in 75% of patients with normal preoperative US. Despite the high incidence of gallbladder disease in this study, these results cannot be used to suggest cholecystectomy because the author did not mention any results regarding the incidence of symptomatic cholelithiasis and the pathologic findings noted included (in addition to cholecystitis and cholelithiasis) cholesterolosis, which may not have any clinical implications.

Another study conducted by Nouguou A et al. [27] on 772 patients, in which cholecystectomy was performed during bariatric surgery in 91.7% of patients either prophylactically or for asymptomatic gallstones, showed that 81% of gallbladders removed during LRYGBP had abnormal histological findings (mainly chronic cholecystitis and cholesterolosis, and fewer had cholesterol polyps, metaplasia, dysplasia, adenomyosis and unknown gallstones). They concluded that routine prophylactic cholecystectomy is justified because it is safe and does not prolong hospital stay. However, despite the increased percentage of abnormal histological findings, these abnormalities may be asymptomatic and some may not present a true indication for cholecystectomy. Therefore, we cannot suggest routine prophylactic cholecystectomy based solely on increased incidence of histological abnormalities.

Taken together, these data lead us to suggest using the same approach as the general population: reserving cholecystectomy for patients with symptomatic gallbladder disease and avoiding additional surgical interventions in asymptomatic patients. Furthermore, the sensitivity of trans-abdominal US in detecting biliary stones in morbidly obese patients may be decreased because of high fat content within the abdominal wall and around the intra-abdominal organs [50]. The rate of false negative pre-operative US may be as high as 54% [37].

Another controversial issue is whether cholecystectomy, when indicated for symptomatic cholelithiasis, should be performed concomitantly with LRYGBP.

In the following section, we present several retrospective studies comparing the outcomes of LRYGBP alone versus concomitant LRYGBP and cholecystectomy. These studies are presented in Figure 1.

As shown in this table, adding cholecystectomy to LRYGBP did not increase the complication rate in the studies of Nougou A et al. [27], Kim JJ et al. [51], Ahmed AR et al. [52], and Escalona A et al. [53]. However, it did significantly increase this rate in three other [54-56] studies, especially the risks of infection, port-site dehiscence, acute kidney injury, and bleeding. However, the parameters of complications measured may have differed in these studies, which complicates direct comparison. Regardless, the overall complication rate remains consistently elevated.

However, according to Hamad GG et al. [55], this increased

Authors / Variables	Dorman RB et al[53]			Hamad GG et al[54]			Worni M et al[55]			Nougou A, Suter M[27]			Kim JJ, Schirmer B[50]			Ahmed AR, et al[51]			Escalona A, et al[52]		
Procedures	LRYGBP	LRYGBP+C	p	LRYGBP	LRYGBP + C	p	LRYGBP	LRYGBP + C	p	LRYGBP	LRYGBP + C	p	LRYGBP	LRYGBP + C	p	LRYGBP	LRYGBP + C	p	LRYGBP	LRYGBP + C	p
Number of patients	31,215	1,731		462	94		63,885	6,402		59	655		329	109		200	200		1046	128	
Age (mean, Y)	UA	UA		42,2	44,8	0,01	43,1	42,7	0,01	44,6	38,9	0,0001	42,6	44,7	0,41	42	44	UA	36,3	38,5	0,02
BMI (mean, kg/m²)	47,3	47	0,01	48,8	48,6	0,85	UA	UA		46,7	45,4	0,04	51,7	50,4	0,16				40,5	41,6	0,001
Indication for cholecystectomy	Not reported			Preoperative gallstone diagnosis			Independently of gallstone diagnosis			Independently of gallstone diagnosis			Preoperative gallstone diagnosis			Preoperative gallstone diagnosis			Preoperative gallstone diagnosis		
OR time (mean, m)	UA	UA		244	293	0,001				158	142	0,0001	177	198	0,001	96	125	0,01	108	129	0,001
Mortality (%)	0,19	0,35	0,16	0,2	1,06	0,67	0,09	0,2	0,012	UA	UA		0,6	0	1	UA	UA		0	0	
Total complication(%)	4,9	6,6	0,0001	8,6	19,1	0,004	5	6,2	0,01	UA	UA	``	`18,5	18,3	0,1	8,5	8,3	0,21	7,1	7	0,8
Conversion (%)	UA	UA		1,1	1,7	0,99	1,9	2,9		UA	UA		UA	UA		UA	UA		0,9	2,3	0,7
Infection (%)	1,1	1,9	0,6	0,8	1,2	0,4	0,4	0,8	0,002	UA	UA		1,8	4,6	0,2	0,5	1,5	UA	0,8	1,56	UA
Leak (%)	UA	UA		0,5	5,4	0,0001	UA	UA					2,9	3,3	0,5	2	2	0,43	4,1	3,6	0,2
Bile duct compl. (%)	UA	UA		UA	UA		0,005	0,03	0,03	0	0,15		1,7	0,9	UA	0	0,5	UA	UA	UA	
Acute renal failure	0,18	0,46	0,01	0,6	2,1	0,004	0,3	0,4	0,08	UA	UA		UA	UA		UA	UA		UA	UA	
Haemorrhage (%)	0,33	0,58	0,08	2,2	3,2	0,004	1,39	1,55		UA	UA		2,1	1,8	1	1,5	0,5	UA	1,17	0,78	UA
Return to OR (%)	2,88	4,1	0,003	UA	UA		0,47	0,73	0,005	UA	UA		UA	UA		UA	UA		2	3,1	0,5
LOS (days)	2,5	2,6		2,69	4,35	0,007	2,22	2,61	0,0001	4	4		2,9	3,3	0,5	2	2	0,43	4	3,6	0,2
Trocar Hernia (%)	0,27	0,58	0,02	0,20	1,23	0,004	UA	UA		UA	UA		UA	UA		UA	UA		UA	UA	

Figure1. Outcome comparing studies between LRYGBP with or without concomitant cholecystectomy.

C: cholecystectomy BMI: body mass index, OR: procedure duration, LOS: period of admission, UA: unavailable data

complication rate is not necessarily attributed to the cholecystectomy itself because many patients undergoing the concomitant approach had also undergone other procedures and none of the major complications were related to biliary tract and thus not related to the gallbladder removal.

The mean operative time was significantly increased in the studies of Hamad GG et al.[55], Kim JJ et al.[51], Escalona A et al.[53], and Ahmed A.R. et al.[52], while it was surprisingly shorter in a study by Nougou A. et al.27. Nougou et al. explained that this decreased operative time reflects the technical difficulties encountered during the performance of gastric bypass in patients in whom cholecystectomy was deemed too risky and thus not performed concomitantly with the LRYGBP.

Despite the significantly increased operative time, this increase is around only 20-30 min in most of the studies and practically may not be problematic. Only Hamad GG et al. [55] found an increase in operative time of approximately 50 minutes (293.4 ± 79.8 min versus 244.8 ± 77.2 min), which may be related to technical difficulties due to a high incidence of cholecystitis found incidentally, unusual anatomy, performance of additional procedures (such as liver biopsies or hernia repair) and surgeon learning curve. Therefore, the increase in operative time should not be attributed exclusively to cholecystectomy.

The length of hospital stay was increased by adding cholecystectomy in two of these studies while the other five showed no significant increase.

Patient BMI was significantly higher in the concomitant approach group in a study by Escalona A et al. [53], but this higher BMI did not translate into higher morbidity related to cholecystectomy even though higher BMI is usually a predictive factor of postoperative morbidity and mortality.

Therefore, the addition of cholecystectomy cannot be considered unsafe as we have evidences for higher morbidity [54-56]. Accordingly, this and in light of the fact that symptomatic gallstones disease is an indication for cholecystectomy in patients with LRYGBP a staged procedure with cholecystectomy first / or concomitant cholecystectomy should be proposed. In

Table 3. Efficacy and outcome of Single and Double balloon or Spiral assisted enteroscopy ERCP or Laparoscopic Assisted (LA) ERCP in the treatment of common bile duct stone after LRYGBP

	N, Anatomy	Technique (N)	Reaching papilla	Cannulation rate	Procedure success	Mean duration	Adverse events
SCHREINER MA ET AL74	56, LRYGBP	BE-ERCP (32)	23/32 (72%)	19/23 (83%)	19/32 (59%)	106 m	1/32 (3,1%)
		LA-ERCP (24)	24/24 (100%)		24/24(100%)	172 m	2/24 (8%)
Ali MF et al62	28, LRYGBP	SE - ERCP	24/28 (86%)	24/24 (100%)	24/28 (86%) 7/25 (28%)	190 m	UA
Lennon AM et al71	54, LRYGBP or other RY anatomy	SE-ERCP (25)	16/25 (64%)	10/16 (62,5%)	7/25 (28%)	81 m	0
		SBE-ERCP (29)	16/29 (55,2%)	14/16 (87,5%)	14/29 (48,3%)	72 m	1/29 (3,5%)
Shah RJ et al75	41, LRYGBP	SE – ERCP	19/26 (73%)	16/19 (84,2%)	16/26 (62%)	90-120	UA
		(26) DBE-ERCP (15)	13/15 (87%)	10/13 (82%)	10/15 (88%)	98	
Zouhairi ME et al79	42, RYGP (39) and other RY anatomy	SE - ERCP	32/42 (76%)	26/32 (81,2%)	24/42 (57%)	UA	2/42 (3%)
Wang AY et al78	6, LRYGBP	SBE-ERCP	UA	UA	6/6 (100%)	105 m	UA
Choi EK et al66	32, LRYGBP	DBE-ERCP	25/32 (78%)	20/25(80%)	6/6 (100%)	101 m	
Emmett DS et al68	8, LRYGBP	DBE-ERCP	8/8 (100%)	7/8 (88%)	UA	99 m	1/32 (3,1%)
De Koning et al67	24, LRYBBP (22) and other RY anatomy	DBE/SBE - ERCP	UA	UA	58%	UA	0
Siddiqui AA et al76	39, LRYGBP	sDBE - ERCP	32/39 (82%)	29/32 (91%)	20/30 (60%)	UA	UA
Bukhari M et al65	30, LRYGBP	DBE – ERCP (19)	24/30 (80%)	UA	98%	90 m	UA
		SBE – ERCP (11)					
Abbas AM et al61	579, LRYGBP	LA - ERCP	99%	98%	98%	183 m	18%
Kedia P et al70	43, LRYGBP	LA - ERCP	UA	UA	98%	180 m	19%
Snauwaert C et al77	23, LRYGBP	LA - ERCP	21/23 (91%)	20/21 (95%)	20/23 (87%)	UA	4%
Falcao M et al69	23, LRYGBP	LA - ERCP	100%	100%	100%	92 m	4%
Saleem A et all73	15, LRYGBP	LA - ERCP	100%	100%	100%	45	UA
Bayoumi M et al63	12, LRYGBP	LA - ERCP	100%	83%	83%	67	17%
Bowman E et al64	11, LRYGBP	LA - ERCP	100%	100%	100%	NA	9%
Lopes TL et al72	10, LRYGBP (9)	LA - ERCP	UA	90%	90%	89	2%

SBE: single balloon enteroscopy , DBL: double balloon enteroscopy, sDBE: short double balloon enteroscopy, SE: spiral enteroscopy, UA: unavailable data, ERCP: Endoscopic retrograde cholangiopancreatography

the case of asymptomatic cholelithiasis cholecystectomy is not recommended. An advantage of delayed cholecystectomy is that the operation is technically easier to perform.

Common Bile Duct Stone and LRYGBP

In patients with non-altered anatomy, endoscopic retrograde cholangio-pancreatography (ERCP) is usually performed using a duodenoscope. It has an elevator and side-viewing imaging to facilitate the identification of the papilla and a large accessory channel that allows the use of all the instruments needed in therapeutic ERCP. Unfortunately, duodenoscope use is associated with a low success rate in reaching the major papilla [57] in long Roux limbs because more than 150 cm of bowel must be traversed to reach it and the lack of special accessories makes the more longer enteroscopes less efficient also [58]. However, we can find studies with better reports [59-60].

To overcome the technical difficulties of small bowel examination using push-enteroscopy, many devices have been added to the enteroscope to simplify endoscopic examination61. Three main techniques have been introduced: single balloon enteroscopy, double balloon enteroscopy and spiral enteroscopy. Many studies comparing these methods have been published.

In Table 3, we present the available studies comparing single balloon enteroscopy, double balloon enteroscopy, and spiral enteroscopy. We ill extract outcomes for post-bariatric LRYGBP patients because the results in this subgroup may differ widely from other post-surgical patients [62-80].

In most of these studies, the papilla is successfully reached in more than 70% of cases using device-assisted enteroscopy. Once the papilla is reached, the cannulation rate is usually high (reaching 80%-100%), which reflects into a high diagnostic yield. Similarly, the therapeutic success is very high (90%-100%), which is an expected outcome once the papilla is reached and cannulated.

However, in a study by Lennon AM et al. [72] that compared spiral enteroscopy ERCP and single balloon enteroscopy ERCP in patients with RY anatomy, the papilla was reached in only 55% of patients in the spiral enteroscopy ERCP group, which is significantly lower than the rates achieved in other studies. The authors explained this low rate as a result of RY limb length, which is the most common factor reducing enteroscopy success. However, this factor is also present in other studies, and thus it cannot fully explain this difference. Another important factor noted by the authors was the learning curve. When the operator experience was assessed over quartiles, there was a statistically significant ($P = 0.01$) increase in diagnostic yield using single balloon enteroscopy ERCP, which reflects the major importance of endoscopist experience. Schreiner M.A. et al. [75] also highlighted the importance of limb length and stated that the decision to use balloon enteroscopy assisted ERCP should be based on the “roux + ligament of Treitz to jejunojejunal anastomosis limb” length. Enteroscopy can be used when the length is less than 150 cm.

The overall ERCP success rate, which is the result of the combination of all the parameters (reaching the papilla with successful cannulation and successful therapeutic intervention when indicated), is less encouraging and ranges between 58% and 62%.

A significantly higher overall ERCP success rate of 86% was noted by Ali MF et al. [63] in a retrospective series of spiral enteroscopy ERCP in patients with post-bariatric RY anatomy: the papilla was reached in 86% of patients and cannulated in all of these patients, and therapeutic interventions were successfully performed whenever indicated. The high success rate in this series is probably related to the routine use of a short straight transparent distal cap at the tip of the enteroscope, which greatly facilitates enteroscopy and cannulation of the native papilla. Additionally, the spiral overtube (Endo-Ease Overtube, Spirus Medical, LCC, West Bridgewater, MA, United States) may result in a straight, stiff, and stable endoscope platform that simplifies the enteroscopy compared with the use of balloon overtube. However, superiority over balloon assisted enteroscopy is not consistent in all studies.

The use of a distal cap was also demonstrated in a study by Shah RJ et al. [76], where it was associated with 85% ERCP success rate because of its ability to minimize enteroscope tip slippage during endoscope loop reduction and bring to view (in forward viewing endoscopy) the native papilla by mucosal suctioning.

The success rate was also elevated (100%) in a small study by Wang AY et al. [79], which comprised six patients with bariatric RYGP. In this study, a guidewire was used to facilitate the passage of the enteroscope (similar to the technique used by Wright et al. which was discussed earlier in this review). This technique probably contributed to this very high success rate.

However, according to these studies, the success rate seems to be similar in single balloon, double balloon, and spiral enteroscopy assisted ERCP but differ widely according to endoscopist experience. De Koning M et al.68 noted an increasing success rate from 50% during the endoscopist’s first year to over 70% thereafter.

To summarize, spiral/balloon-enteroscopy assisted ERCP is a minimally invasive endoscopic technique with an acceptable success rate that depends mainly on endoscopist experience (learning curve) and bowel limb length. Its usefulness is limited by the lack of an elevator, the absence of side view, the long procedure time, and the limited availability of specially designed accessories. Therefore, in ideal circumstances, in which experience and adapted accessories are available, this technique may be the best approach to treat choledocholithiasis in RYGP patients.

Therefore, when expertise is available, it may be reasonable to start with enteroscopy-assisted ERCP before attempting more invasive procedures.

The most widely used technique is currently laparoscopy assisted ERCP (LA-ERCP). One of the largest studies evaluating this technique was a study conducted by Abbas AM et al. [62] which was a retrospective multicenter study comprising 579 patients with RYGB undergoing LA-ERCP, mainly for biliary disease. It showed a very high success rate of 98%, which is not surprising because this approach comprises accessing the remnant stomach and performing ERCP via the usual route using the usual duodenoscope. Therefore, we can expect a success rate similar to that in patients with normal anatomy. However, because this approach uses an invasive technique to access the stomach remnant, the safety profile is the main criterion on which we should judge it. The authors noted a total adverse event rate of 18%, which is significantly higher than the rate found in enteroscopy assisted ERCP. The rate of adverse events related to the ERCP itself is similar to that of conventional ERCP, but additional events were added because of the laparoscopy, which increased the overall adverse events. Although, most of these events were classified as mild to moderate, 8% were severe and included viscus perforation (0.5% of laparoscopy-related perforations).

Two other small retrospective studies [64-73] have also shown satisfactory results with overall success rate of 83% and 90% and low complication rates (minor bleeding at the surgical site, rapidly controlled and mild post ERCP pancreatitis).

This approach may be most useful in patients whose gallbladder remains in place and thus both CBD exploration and cholecystectomy are indicated [81]. Its main limitations are the invasive nature and related adverse events and organizing the complicated schedule, which necessitates the cooperation of surgical and endoscopic teams. Additionally, patients with multiple prior surgeries may have multiple adhesions, which prevents transgastric access via laparoscopy and necessitates mini laparotomy [78].

Another way to reach the gastric remnant is for an interventional radiologist to percutaneously place a gastrostomy tube and use the tube tract to insert the endoscope.

This method was successful and safe in a series of six patients with RYGB. Three patients underwent ERCP through this percutaneous transgastric route [82].

However, a relatively high complication rate related to the gastrostomy was noted in a study comparing ERCP via gastrostomy to DBE-assisted ERCP67. Additionally, the procedure is usually completed over at least two sessions, which makes it less useful in case of urgent ERCP.

Further studies are needed before we recommend use of this endoscopic technique.

Internal Endoscopic Ultrasound-guided transgastric ERCP is another novel technique that comprises creating a fistulous tract between the gastric remnant and the excluded stomach and using a fully covered metal stent through which the endoscope is introduced to perform the antegrade ERCP [83]. ERCP via this technique had a success rate of 60% without major complications or weight regain in a small series of five patients [83] and of 90%-100 % in four other series[66,71,84,85] (Table 4).

The main advantage of this novel approach is the possibility of performing the whole procedure in a minimally invasive fashion, in only one session, and by a single team.

Because randomized trials comparing these procedures are not available, it is difficult to make strong recommendations regarding the choice of a single best technique and the choice remains to be determined mainly by the expertise of endoscopists in each institution.

However, we can make some general suggestions. In patients with suspected or confirmed CBD stones needing cholecystectomy and CBD exploration for stone extraction, laparoscopic cholecystectomy with concomitant laparoscopically assisted ERCP may be a practical and reasonable approach.

In patients with prior cholecystectomy, if ERCP is indicated, enteroscopy-assisted ERCP may be attempted when an experienced endoscopist is available, leaving the laparoscopic technique as a second line treatment in cases of enteroscopy failure. Such an approach may enable the avoidance of an invasive approach in many patients.

More data are needed before making specific suggestions on the use of Internal Endoscopic Ultrasound-guided ERCP. Finally, because the use of bariatric surgery is widely growing and CBD stones remain a "difficult-to-treat" complication in patients with RYGB, it is necessary to develop more experience in endoscopic techniques to allow a rapid and minimally invasive treatment without major complications that can be performed by the endoscopy team using specialized equipment that is customized to this specific indication and population.

Conclusion

Gallstones remain an important problem in patients undergoing bariatric surgery. Routine prophylactic cholecystectomy concomitant with the LRYBBP is not recommended in the literature. In symptomatic patients the option of staged approach with cholecystectomy before LRYGBP must be considered. In asymptomatic patients the option of latest cholecystectomy must be considered due to a reduction in intraabdominal fat. However, in the case of patients with LRYGBP presenting with CBD stones, enteroscopy-assisted ERCP can be attempted, when an experienced endoscopist is available, before proceeding to LA-ERCP.

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Table 4. Efficacy and outcome of Endo-Ultra-Sound (EUS) guided transgastric ERCP

	EUS – guided transgastric ERCP					
Variables / Authors	Patients	Fistula success	ERCP success	Procedure time (mean, min)	Complication	Stent Dislodgment
Bukhari M, et al. [65]	30	100%	100%	49,8	6,7%	6,7%
Kedia P, et al. [82]	29	96,5%	96,5%	73	24%	UA
Tyberg A, et al. [84]	16	100%	90%	UA	6,25%	19%
Ngamrueng-phong S, et al. [83]	13	100%	100%	UA	0	15%

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