Original Article

Analysis of risk factors for postoperative bleeding and polyp recurrence in adolescents with gastric polyps treated with endoscopic mucosal resection: a retrospective cohort study

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Background: The incidence of gastric polyps in adolescents has been increasing every year in recent years. Endoscopic mucosal resection (EMR) is one of the most common treatments for adults, but there are few reports on the association between EMR of gastric polyps and the occurrence of bleeding and recurrence after the procedure in adolescents. This study sought to analyze the independent risk factors for postoperative bleeding and polyp recurrence after EMR to provide a reference for reducing the occurrence of postoperative complications.

Methods: We retrospectively analyzed the data of 579 adolescent patients who developed gastric polyps from June 2016 to June 2021. Postoperative follow-up was conducted for 1 year by telephone, e-mail, and outpatient review. The general characteristics of the study population were compiled using a general information questionnaire designed by the investigators. The relationship between the patients' clinical characteristics and postoperative bleeding or recurrence was analyzed using the chi-square test. A binary logistic regression analysis was conducted to analyze the independent risk factors for the occurrence of postoperative bleeding and polyp recurrence in patients.

Results: The results of the binary logistic regression analysis showed that being female [odds ratio (OR) =0.306, P=0.009], polyps >1 cm in diameter (OR =2.557, P=0.029), polyps in gastric sinus (OR =3.889, P=0.032), sessile lesions (OR =0.398, P=0.036), the need for additional intraoperative sedation (OR =3.469, P=0.005), concurrent diverticulum (OR =3.570, P=0.004), and intraoperative bleeding (OR =4.855, P=0.001) were independent risk factors for postoperative bleeding. We also found that polyps >1 cm in diameter (OR =2.134, P=0.003), multiple polyps (OR =2.117, P=0.005), adenomatous polyps (OR =2.684, P=0.041), combined *Helicobacter pylori* infection (OR =2.036, P=0.009), the occurrence of postoperative gastrointestinal reflux (OR =1.998, P=0.015), and an operative time ≥40 min (OR =2.021, P=0.010) were independent risk factors for the recurrence of polyps.

Conclusions: There is still a high probability of postoperative bleeding and polyp recurrence after EMR in adolescents with gastric polyps. Clinicians should pay close attention to the clinical features of polyps, such as polyp size, number, morphology, and pathological type, to identify the related risk factors as early as possible and reduce the probability of postoperative bleeding and polyp recurrence in patients.

Keywords: Gastric polyps; postoperative bleeding; recurrence; endoscopic mucosal resection (EMR); retrospective study

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Introduction

Gastric polyps are protruding papillary tissues that grow on the surface of the gastric mucosa (1). This heterogeneous group of lesions can be classified as epithelial or non-epithelial, and neoplastic or non-neoplastic (1). When polyps are small, they often have no obvious symptoms and are often found incidentally during barium meal gastrointestinal imaging, gastroscopy, or surgery for other reasons. With continued advancements in medical technology, the widespread use of upper gastrointestinal endoscopy has increased the detection rate of polyps. Gastric polyps and duodenal polyps have been detected at rates as high as 6% and 4.6%, respectively (2,3). The incidence of gastric polyps has increased significantly in recent years, and a study has shown that the incidence of gastric polyps is 0.8–2.3% (4).

Based on their number, gastric polyps can be classified as multiple polyps or single polyps; based on their morphology, polyp types can be classified as flat, pedunculated, subpedunculated, or sessile (5); based on their pathological type, polyps can be classified as adenomatous polyps and non-adenomatous polyps, and non-adenomatous polyps can be further classified as inflammatory polyps, hyperplastic polyps, and gastric fundic gland polyps. Among them, gastric adenomatous polyps are considered precancerous lesions, and with a carcinogenicity rate as high as 10–20%, these polyps have a great effect on human health, and if left untreated, may recur or even gradually become cancerous in the long-term (6). In addition, gastric polyps become more cancerous as the polyp size and number increase (7). Thus, the early identification of gastric polyps and the implementation of timely and effective treatment measures are especially important in preventing gastric polyps from becoming cancerous.

In recent years, the incidence of gastric polyps has been increasing year by year in the adolescent population, and patients often have atypical symptoms, which mainly manifest as a loss of appetite, nausea, acid reflux, belching, and epigastric discomfort (8). Endoscopic mucosal resection (EMR) has become one of the most common treatments for gastric polyps, as it uses a minimally invasive technique to remove early cancerous lesions confined to the superficial or submucosal layers without the invasion of lymphatic vessels or blood vessels, and is a safe and effective conventional treatment for the removal of gastrointestinal polyps (9). EMR with surgical resection for non-polypoid tumors confined to the mucosa has comparable morbidity, mortality, and 5-year survival rates (10).

EMR has a number of advantages over standard polypectomy; for example, EMR can be used to peel the middle or deep submucosa, which provides a wider and deeper area of resection, and a greater overall resection sample for histopathological evaluation (11). However, EMR also has certain limitations, including a high number of resections during treatment, high intraoperative bleeding, and an increased operative time due to the unclear lesions. EMR also has various postoperative complications, mainly including early or late postoperative bleeding, perforation, infection, and recurrence (12). A previous study showed that the postoperative bleeding rate in EMR is 6%, and the perforation rate is 0.5% (13). Postoperative bleeding not only prolongs hospital stays, reduces the

Highlight box

Key findings

- Bleeding and polyp recurrence after EMR surgery can significantly affect the prognosis of adolescent patients. The relevant risk factors should be identified early and targeted treatment measures should be actively implemented to improve patients' quality of life postoperatively.

What is known and what is new?

- There are many independent risk factors for postoperative bleeding and the recurrence of gastric polyps in adolescents treated with EMR;
- Polyp diameter, number, morphology, and pathological type, and other clinical characteristics can affect postoperative bleeding and polyp recurrence after EMR.

What is the implication, and what should change now?

- During the treatment of EMR, targeted preventive measures should be implemented according to individual differences, including treating *Helicobacter pylori* infection before surgery, injecting epinephrine in high-risk patients during surgery, and shortening the operation time as much as possible, to reduce the possibility of postoperative bleeding and polyp recurrence and improve patients' quality of life.

perioperative quality of life of patients, and increases the additional treatment burden, but also has significant effects on the surgical outcomes and clinical prognosis of patients (14). Yokoi (15) showed that the repeat recurrence rate of EMR after fractional resection of large mucosal lesions was 17% while that after whole block resection of endoscopic submucosal dissection (ESD) was 0%. Thus, the recurrence rate after EMR is high, which increases the risk of re-treatment and reduces the therapeutic effects.

To date, few studies have been conducted on the use of EMR to treat gastric polyps in adolescents. In view of the increasing incidence of gastric polyps in adolescents, and due to the low compliance of patients, the high concern of parents for the physical and mental health of adolescents, and the low satisfaction with the postoperative outcome, it is still a great challenge to reduce the occurrence of postoperative bleeding and recurrence of gastric polyps in adolescents treated by EMR. Combined with clinical experience, we speculate that the occurrence of bleeding and recurrence after EMR may be closely related to the size and number of polyps. This study sought to analyze the clinical characteristics of adolescent patients with gastric polyps treated with EMR and the independent risk factors for postoperative bleeding and polyp recurrence to identify the relevant risk factors as early as possible and provide a reference for reducing the occurrence of postoperative complications and improving patient prognosis. We present the following article in accordance with the STROBE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-23-43/rc).

Methods

Research participants

A total of 579 adolescent patients who underwent EMR to treat gastric polyps at The Affiliated Hospital of Jiangnan University between June 2016 and June 2021 were included in this study. To be eligible for inclusion in this study, patients had to meet the following inclusion criteria: (I) be an adolescent male or female patient aged 12–18 years; (II) have been diagnosed with gastric polyps and have undergone EMR polypectomy between June 2016 and June 2021; and (III) have complete clinicopathological data. Patients were excluded from the study if they met any of the following exclusion criteria: (I) some patients with coagulopathy and a tendency toward severe bleeding; (II) had undergone a polypectomy at other centers before the start of this study; and/or (III) had incomplete data or were lost to follow-up within 14 days of the polypectomy.

The general rule is that a logistic regression analysis requires an item number to sample size ratio of 1:5–1:10. Thus, for this study, the estimate sample size of the study population was 600 patients. However, 21 patients were lost or lost to follow-up. Thus, ultimately, 579 patients were included in the study, as shown in *Figure 1*.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Affiliated Hospital of Jiangnan University (No. KY-LC2021135) and informed consent was waived because it was a retrospective study.

General information questionnaire

The general information questionnaire was designed to gather demographic data (e.g., gender and age) and clinical data [polyp size, polyp number, polyp morphology, polyp location, type of pathology, diverticulum (yes/no), time of operation, *Helicobacter pylori* infection (yes/no) tested by the C_{14} breath test, intraoperative bleeding (yes/no), additional intraoperative sedation required (yes/no), gastroesophageal reflux (yes/no), and postoperative complications].

Postoperative complications

The use of EMR to remove gastric polyps allows patients to avoid the high risks and costs of gastrectomy. Inevitably, complications, such as bleeding, perforation, myocardial infarction, cerebrovascular accident, arrhythmia, pneumonia, and sepsis, can also occur after EMR (16). Postoperative bleeding can be divided into early bleeding and delayed bleeding. Early bleeding refers to bleeding that occurs within 12 h postoperatively, while delayed bleeding refers to bleeding that occurs 12 h–14 d postoperatively, and is combined with at least 2 of the following conditions: (I) hematemesis or dizziness; (II) a decrease in hemoglobin >2 g/dL; and (III) a decrease in blood pressure >20 mmHg or an increase in pulse rate >20.0% at the baseline, and include bleeding observed on repeat gastroscopy >14 days later (17).

Postoperative polyp recurrence

Polyp recurrence was defined as the recurrence of polyps at the location at which EMR was performed during the follow-up period. For relapsed patients are performed an upper endoscopy to define recurrence of polyps. All of the

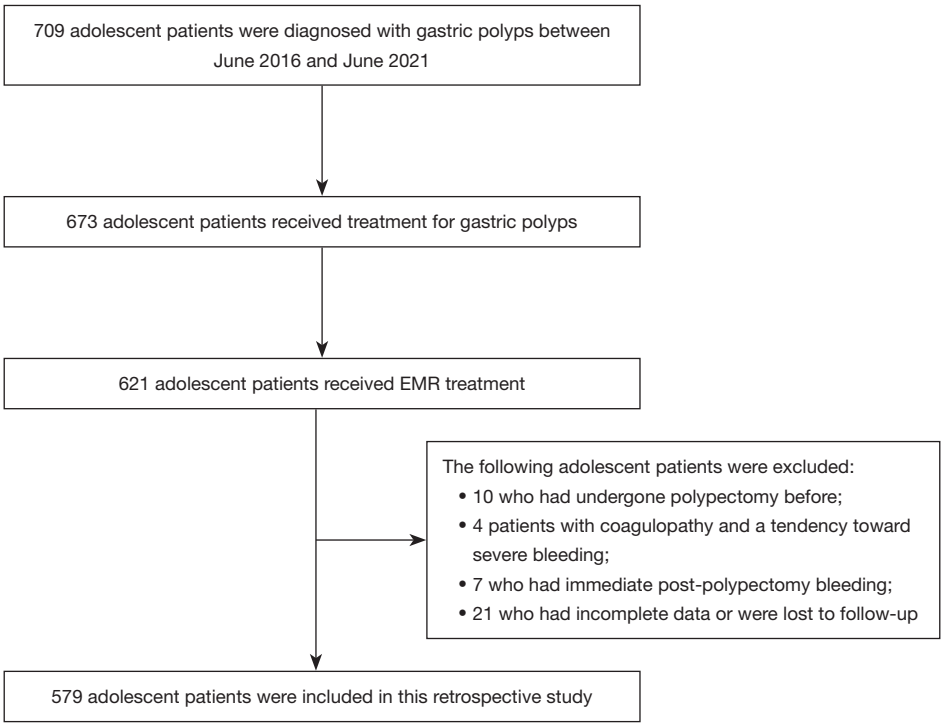

Figure 1 Flow chart of patient selection. EMR, endoscopic mucosal resection.

enrolled patients were followed-up for 1 year by telephone, internet, or outpatient visits to determine the absence of polyp recurrence. Postoperative follow-up was conducted for 1 year by telephone, e-mail, and outpatient review. The last follow-up occurred in June 2022.

Statistical analysis

The results of each scale were entered into the computer for score conversion, and the statistical analysis was performed using SPSS 26 (IBM SPSS, USA). The measured data are expressed as the mean and standard deviation. The count data are expressed as the frequency and percentage. Statistical analyses between groups were performed using the *t*-test and chi-square test, and the factors affecting the occurrence of bleeding and polyp recurrence after surgery were analyzed by binary logistic regression analyses. A two-sided P value <0.05 was considered statistically significant.

Results

Baseline data

The baseline characteristics of the patients are set out in *Tables 1,2*. A total of 579 adolescent patients undergoing EMR surgery were included in this study, of whom 295 were male (50.9%) and 284 were female (49.1%). The patients had an average age of 14.86±1.758 years. There were 32 cases of postoperative bleeding and 89 cases of postoperative polyp recurrence. In the postoperative hemorrhage group, there were 10 males (31.3%) and 22 females (68.8%) with an average age of 14.66±1.771 years. In total, 9 (28.1%) patients had an operation time ≥40 min, 16 (50.0%) patients had polyps diameter >1 cm, 10 (31.3%) patients had multiple polyps, 22 (68.8%) patients had no pedicle polyps, 4 (12.5%) patients had adenomatous polyps, and 19 (59.4%) patients had antrum polyps. In total, 8 (25.0%) patients had *Helicobacter pylori* infection, 9 (28.1%) patients had postoperative gastroesophageal reflux, 11 (34.4%) patients had intraoperative bleeding, 20 (62.5%) patients had diverticulum, and 13 (40.6%) patients required additional sedation.

There were significant differences in gender, polyp diameter, polyp morphology, polyp location, intraoperative bleeding, diverticulum, and additional sedation between the postoperative bleeding and non-bleeding groups (P<0.05). In the postoperative polyp recurrence group, there were 44 males (49.4%) and 45 females (50.6%), with

Table 1 Baseline data of the patients

Parameters	Mean ± SD or n (%)
Number	579
Sex	
Male	295 (50.9)
Female	284 (49.1)
Age (years)	14.86±1.758
Time of operation	
≥40 min	131 (22.6)
<40 min	448 (77.4)
Polyp size	
>1 cm	159 (27.5)
≤1 cm	420 (72.5)
Polyp number	
Single	432 (74.6)
Multiple	147 (25.4)
Polyp morphology	
Pedunculated lesions	318 (54.9)
Sessile lesions	261 (45.1)
Polyp pathology	
Inflammatory polyps	52 (9.0)
Hyperplastic polyps	409 (70.6)
Sporadic fundic gland polyp	36 (6.2)
Adenomas	77 (13.3)
Others	5 (0.9)
Polyp location	
Antrum	141 (24.4)
Stomach body	214 (37.0)
Fundus	127 (21.9)
Other	97 (16.8)
Helicobacter pylori infection	
Yes	140 (24.2)
No	439 (75.8)
Postoperative gastrointestinal reflux	
Yes	122 (21.1)
No	457 (78.9)
Bleeding during the operation	
Yes	73 (12.6)
No	506 (87.4)
Diverticulum	
Yes	215 (37.1)
No	364 (62.9)
Required additional sedation during the operation	
Yes	127 (21.9)
No	452 (78.1)

SD, standard deviation.

an average age of 14.83±1.760 years. Additionally, in the postoperative polyp recurrence group, 33 (37.1%) patients had an operation time ≥40 min, 41 (46.1%) patients had polyps >1 cm in diameter, 34 (38.2%) patients had multiple polyps, 42 (47.2%) patients had pedicular polyps, 27 (30.3%) patients had adenomatous polyps, and 22 (24.7%) patients had polyps in the antrum. Further, 35 (39.3%) of these patients had *pylori infection*, 28 (31.5%) patients had postoperative gastroesophageal reflux, 12 (13.5%) patients had intraoperative bleeding, 36 (40.4%) patients had diverticulum, and 23 (25.8%) patients required additional sedation. There were also significant differences in the operation time, polyp size, polyp number, pathological type of polyp, *Helicobacter pylori* infection, and postoperative gastroesophageal reflux between the recurrence and non-recurrence groups ($P<0.05$).

Postoperative complications

Postoperative complications were observed in 140 patients (24.2%) after EMR. Specifically, early postoperative hemorrhage was observed in 30 (5.2%) patients, delayed hemorrhage was observed in 2 (0.3%) patients, perforation was observed in 1 (0.2%) patient, postoperative polyp recurrence one year after surgery was observed in 89 (15.4%) patients, and other complications were observed in 18 (3.1%) patients (*Table 3*). The statistical results showed that the number of patients with minor bleeding in the early post-polypectomy bleeding group was the highest on the

Table 2 Comparisons of the baseline data between the patients with and without complications

Parameters	Post-polypectomy bleeding			Post-polypectomy recurrence		
	No	Yes	P value	No	Yes	P value
Number	547 (94.5)	32 (5.5)	–	490 (84.6)	89 (15.4)	–
Sex			0.022			0.756
Male	285 (52.1)	10 (31.3)		251 (51.2)	44 (49.4)	
Female	262 (47.9)	22 (68.8)		239 (48.8)	45 (50.6)	
Age (years)	14.87±1.759	14.66±1.771	0.508	14.86±1.760	14.83±1.760	0.883
Time of operation			0.444			<0.001
≥40 min	122 (22.3)	9 (28.1)		98 (20.0)	33 (37.1)	
<40 min	425 (77.7)	23 (71.9)		392 (80.0)	56 (62.9)	
Polyp size			0.003			<0.001
>1 cm	143 (26.1)	16 (50.0)		118 (24.1)	41 (46.1)	
≤1 cm	404 (73.9)	16 (50.0)		372 (75.9)	48 (53.9)	
Polyp number			0.433			0.003
Single	410 (75.0)	22 (68.8)		377 (76.9)	55 (61.8)	
Multiple	137 (25.0)	10 (31.3)		113 (23.1)	34 (38.2)	
Polyp morphology			0.006			0.663
Pedunculated lesions	308 (56.3)	10 (31.3)		271 (55.3)	47 (52.8)	
Sessile lesions	239 (43.7)	22 (68.8)		219 (44.7)	42 (47.2)	
Polyp pathology			0.848			<0.001
Inflammatory polyps	50 (9.1)	2 (6.3)		43 (8.8)	9 (10.1)	
Hyperplastic polyps	384 (70.2)	25 (78.1)		362 (73.9)	47 (52.8)	
Sporadic fundic gland polyp	35 (6.4)	1 (3.1)		31 (6.3)	5 (5.6)	
Adenomas	73 (13.3)	4 (12.5)		50 (10.2)	27 (30.3)	
Others	5 (0.9)	0 (0.0)		4 (0.8)	1 (1.1)	
Polyp location			<0.001			0.997
Antrum	122 (22.3)	19 (59.4)		119 (24.3)	22 (24.7)	
Stomach body	210 (38.4)	4 (12.5)		182 (37.1)	32 (36.0)	
Fundus	122 (22.3)	5 (15.6)		107 (21.8)	20 (22.5)	
Others	93 (17.0)	4 (12.5)		82 (16.7)	15 (16.9)	
Helicobacter pylori infection			0.911			<0.001
Yes	132 (24.1)	8 (25.0)		105 (21.4)	35 (39.3)	
No	415 (75.9)	24 (75.0)		385 (78.6)	54 (60.7)	
Postoperative gastrointestinal reflux			0.314			0.009
Yes	113 (20.7)	9 (28.1)		94 (19.2)	28 (31.5)	
No	434 (79.3)	23 (71.9)		396 (80.8)	61 (68.5)	

Table 2 (*continued*)

Table 2 (*continued*)

Parameters	Post-polypectomy bleeding			Post-polypectomy recurrence		
	No	Yes	P value	No	Yes	P value
Bleeding during the operation			<0.001			0.787
Yes	62 (11.3)	11 (34.4)		61 (12.4)	12 (13.5)	
No	485 (88.7)	21 (65.6)		429 (87.6)	77 (86.5)	
Diverticulum			0.002			0.481
Yes	195 (35.6)	20 (62.5)		179 (36.5)	36 (40.4)	
No	352 (64.4)	12 (37.5)		311 (63.5)	53 (59.6)	
Required additional sedation during the operation			0.009			0.333
Yes	114 (20.8)	13 (40.6)		104 (21.2)	23 (25.8)	
No	433 (79.2)	19 (59.4)		386 (78.8)	66 (74.2)	

Data are presented as mean ± SD or n (%). SD, standard deviation.

Table 3 Complications in patients.

Parameters	Total, n (%)
Number	579
All complications	140 (24.2)
Early post-polypectomy bleeding	30 (5.2)
Delayed post-polypectomy bleeding	2 (0.3)
Post-polypectomy perforation	1 (0.2)
Polyp recurrence	89 (15.4)
Some other complications	18 (3.1)

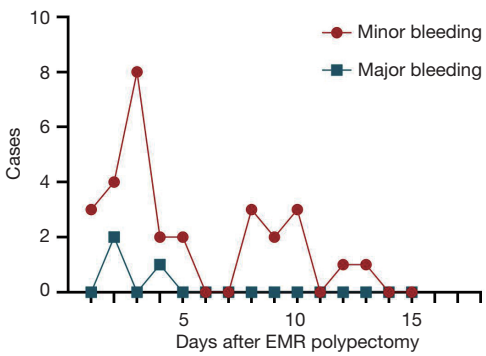

Figure 2 Period of early post-polypectomy bleeding occurrence. EMR, endoscopic mucosal resection.

2nd day (4 patients) and 3rd day (8 patients). The number of patients in the major bleeding group after polypectomy was the highest on the 2nd day (2 patients) (*Figure 2*).

Risk factors of post-polypectomy bleeding and polyp recurrence analyzed by binary logistic regression models

The results of the binary the logistic regression analysis showed that being female, polyps >1 cm in diameter, antral polyps, non-pedicular polyps, the need for additional sedation during surgery, diverticulum, and intraoperative bleeding were independent risk factors for postoperative bleeding (*Table 4*, *Figure 3A*). Polyps >1 cm in diameter, multiple polyps, adenomatous polyps, *Helicobacter pylori* infection, postoperative gastrointestinal reflux, and an operation time ≥40 min were independent risk factors for polyp recurrence (*Table 5*, *Figure 3B*).

Discussion

Gastric polyps are mainly derived from a mass protruding from the growth and aggregation area of human gastric mucosa cells into the stomach cavity. Gastric polyps present as nodular or granular uplift of local gastric mucosa, and commonly occur in the stomach body and gastric antrum. At present, gastric polyps are thought to be closely related

Table 4 Risk factors for post-polypectomy bleeding as analyzed by binary logistic regression models

Parameters	B	SE	Wald	P	OR	95% CI	
						Upper limit	Lower limit
Sex	–1.185	0.452	6.880	0.009	0.306	0.741	0.126
Age (years)	–0.019	0.123	0.025	0.874	0.981	1.247	0.771
Time of operation ≥40 min	0.102	0.485	0.044	0.833	1.107	2.865	0.428
Polyp size >1 cm	0.939	0.430	4.771	0.029	2.557	5.938	1.101
Multiple polyps	0.158	0.467	0.114	0.735	1.171	2.925	0.469
Polyp morphology	–0.922	0.440	4.382	0.036	0.398	0.943	0.168
Adenomas polyps	0.431	0.985	0.191	0.662	1.538	10.611	0.223
Antrum polyps	1.358	0.633	4.605	0.032	3.889	13.446	1.125
Helicobacter pylori infection	0.487	0.505	0.930	0.335	1.627	4.376	0.605
Postoperative gastrointestinal reflux	0.366	0.499	0.539	0.463	1.442	3.833	0.543
Bleeding during the operation	1.580	0.493	10.266	0.001	4.855	12.764	1.847
With diverticulum	1.273	0.437	8.481	0.004	3.570	8.407	1.516
Required additional sedation during the operation	1.244	0.445	7.812	0.005	3.469	8.299	1.450

SE, standard error; OR, odds ratio; CI, confidence interval.

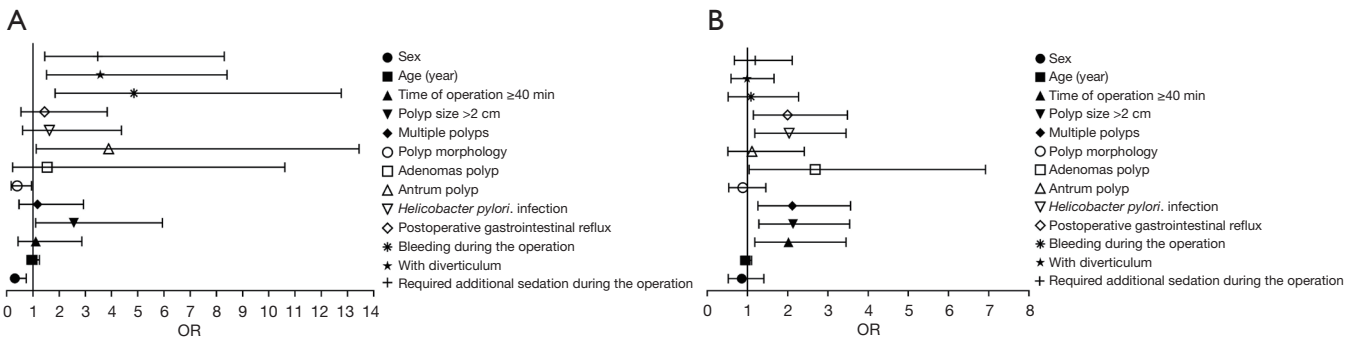

Figure 3 Binary logistic regression analysis of post-polypectomy bleeding and recurrence. (A) Binary logistic regression analysis of post-polypectomy bleeding; (B) binary logistic regression analysis of post-polypectomy recurrence. OR, odds ratio.

to precancerous lesions, especially polyps with a broad base and adenomatous polyps ≥1 cm in diameter, all of which may further increase the risk of gastric cancer developing (2,18,19). Endoscopic resection is a technique used to remove large benign lesions and early precancerous or cancerous tumors from the gastrointestinal lumen. It is a common diagnosis and treatment method for gastric polyps (20). Endoscopic resection includes EMR and ESD. EMR is usually used to remove upper gastrointestinal lesions 1 cm in diameter and those with a low risk of submucosal invasion (11). However, it is inevitable that there may be bleeding, perforation, myocardial infarction, cerebrovascular accident, arrhythmia, pneumonia, sepsis and other complications after EMR.

A Study has shown that the postoperative bleeding rate of EMR is 6% and the perforation rate is 0.5% (13). The statistical results of the present study showed that the postoperative bleeding rate of adolescent patients was 5.53%, and the perforation rate was 0.2%, which is similar to the above-mentioned findings. Thus, the incidence of

Table 5 Risk factors for post-polypectomy recurrence as analyzed by binary logistic regression models

Parameters	B	SE	Wald	P	OR	95% CI	
						Upper limit	Lower limit
Sex	–0.154	0.253	0.372	0.524	0.857	1.408	0.522
Age (years)	–0.043	0.072	0.347	0.556	0.958	1.104	0.832
Time of operation ≥40 min	0.703	0.273	6.629	0.010	2.021	3.452	1.183
Polyp size >1 cm	0.758	0.259	8.577	0.003	2.134	3.544	1.285
Multiple polyps	0.750	0.266	7.968	0.005	2.117	3.563	1.258
Polyp morphology	–0.125	0.255	0.238	0.626	0.883	1.457	0.535
Adenomas polyps	0.987	0.483	4.176	0.041	2.684	6.921	1.041
Antrum polyps	0.106	0.396	0.071	0.789	1.111	2.413	0.512
Helicobacter pylori infection	0.711	0.273	6.767	0.009	2.036	3.452	1.183
Postoperative gastrointestinal reflux	0.692	0.284	5.937	0.015	1.998	3.488	1.145
Bleeding during the operation	0.083	0.3766	0.049	0.825	1.087	2.271	0.520
With diverticulum	–0.010	0.264	0.001	0.971	0.990	1.661	0.591
Required additional sedation during the operation	0.177	0.291	0.373	0.542	1.194	2.112	0.675

SE, standard error; OR, odds ratio; CI, confidence interval.

postoperative complications for EMR remains high.

In addition, our study showed that there were significant differences in gender, polyp diameter, polyp morphology, polyp location, the occurrence (or not) of intraoperative bleeding, the occurrence (or not) of diverticulum, and the need (or lack of any need) for additional sedation during surgery between the postoperative bleeding and non-bleeding groups (P<0.05). The results of the binary logistic regression analysis showed that being female, polyps >1 cm in diameter, antral polyps, non-vertical polyps, the need for additional sedation during surgery, diverticulum, and intraoperative bleeding were independent risk factors for postoperative hemorrhage. This may be because the larger the polyp, the thicker the blood vessels, the stronger the pulsation, and the more difficult the endoscopic excision, and thus the greater the risk of bleeding. A wound with a pedicled polyp is smaller than that without a pedicled polyp, so it is less likely to bleed. In addition, the complication of diverticulum may lead to postoperative bleeding, as diverticulum is often close to the vascular branch and is prone to diverticulitis. Intraoperative bleeding and the need for extra sedation may be due to the fact that the body is in a state of constant stress due to these conditions, which may easily lead to postoperative bleeding.

For patients at high risk of bleeding after EMR surgery, several preventive measures should be implemented. At present, submucosal epinephrine injection is usually used for prophylaxis. Tullavardhana *et al.* (21) conducted a meta-analysis of 6 randomized controlled studies to observe the efficacy of submucosal epinephrine injection in the treatment of intraoperative and postoperative bleeding and found that prophylactic submucosal epinephrine injection significantly reduced the incidence of overall bleeding in patients.

Polyp recurrence after EMR is also relatively common, with multiple studies reporting an overall polyp recurrence rate of approximately 15% (22-26). The present study found that there were significant differences in the duration of surgery, polyp size, polyp number, pathological type of polyp, *Helicobacter pylori* infection, and postoperative gastroesophageal reflux between the recurrence and non-recurrence groups. The results of the binary logistic regression analysis showed that polyps >1 cm in diameter, multiple polyps, adenomatous polyps, *Helicobacter pylori* infection, postoperative gastrointestinal reflux, and an operation time ≥40 min were independent risk factors for

polyp recurrence. Among them, *Helicobacter pylori* infection has been recognized as a pathogenic factor of chronic gastritis, peptic ulcer, lymphoma, and gastric cancer. A study (27) has shown that *Helicobacter pylori* infection can release a variety of cytokines and inflammatory mediators, damage gastric mucosa, stimulate the proliferation of gastric epithelial cells, and cause polyps. Elhanafi *et al.* (28) and Conteduca *et al.* (29) confirmed that the successful eradication of *Helicobacter pylori* infection is conducive to the regression and cure of gastric polyps. Thus, *Helicobacter pylori* infection should be actively eliminated as a risk factor for patients at high risk of polyp recurrence after EMR surgery. However, in our study, only 25% of patients had *Helicobacter pylori* infection and the main histological type is hyperplastic polyps. We speculate the main reason is that with the enhancement of patients' self-health awareness, especially some patients once received *Helicobacter pylori* treatment in outpatient department due to gastrointestinal discomfort.

Multiple polyps and polyps >1 cm in diameter are also risk factors for the recurrence of gastric polyps. The reasons may be as follows: polyps with diameters >1 cm have a wider base, a longer existence time, many surface vessels, and a rich blood supply, which leads to a fast growth rate. Adenomatous polyps are usually pedunculated, large in size, spherical or hemispherical, and have a mostly smooth surface, but a few may be strip shaped, lobular or flat, and are mainly formed by glandular hyperplasia, concave epithelial hyperplasia, and surface epithelial hyperplasia. Compared to inflammatory polyps and hyperplastic polyps, adenomatous polyps have a rapid growth rate and tissue division process, which is more likely to cause polyp recurrence and canceration. A randomized controlled trial published in 2019 showed that post-EMR ablation of the excised edge using snare-tip soft coagulation reduced the recurrence rate of adenomas in large and non-treeless neoplastic colon polyps to 5% (30). These low relapse rates were also confirmed in another large study (31). All these findings provide insights into how the recurrence of gastric polyps after EMR surgery in adolescents can be prevented. According our study, the limit of EMR as a treatment of gastric polyps is that the diameter of polyps is generally 1.5 cm or less, and the maximum limit should be less than 2 cm.

The main shortcoming of this study is the relatively short follow-up time, which was due to the limited time and manpower. It is recommended that a longer follow-up time be adopted in future studies.

Conclusions

The probability of postoperative bleeding and polyp recurrence after EMR for adolescents with gastric polyps is high. Clinicians should pay close attention to the clinical features of polyps, such as the polyp size, number, morphology, and pathological type, to identify related risk factors as early as possible, and actively implement individualized treatment measures to reduce the probability of postoperative bleeding and polyp recurrence in patients.

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Footnote

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Conflicts of Interest: All the authors have completed the ICMJE uniform disclosure form (available at https://tp.amegroups.com/article/view/10.21037/tp-23-43/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Affiliated Hospital of Jiangnan University (No. KY-LC2021135) and informed consent was waived because it was a retrospective study.

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