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Clinical characteristics and prognosis of emergency enteroscopy for small bowel bleeding in hospitals of different levels: A real-world study based on 297 cases from provincial, municipal, and district hospitals

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Abstract

Background and aims: This study aimed to compare the clinical characteristics, diagnostic efficiency, lesion detection spectrum, and follow-up outcomes of emergency enteroscopy for obscure small bowel bleeding among provincial, municipal, and district hospitals.

Methods: This was a multicenter retrospective analysis of 297 consecutive patients who underwent emergency enteroscopy for obscure small bowel bleeding at a provincial hospital (n = 240), a municipal hospital (n = 25), and a district hospital (n = 32). Baseline data, ward type on admission, pre-procedural examinations, enteroscopy completion rate (total enteroscopy), endoscopic diagnoses, treatment modalities, complications, and follow-up data were collected and compared.

Results: The provincial hospital admitted the highest proportion of patients to the intensive care unit (ICU) (21.3%) and performed more comprehensive pre-procedural examinations. The total enteroscopy completion rate was significantly higher at the provincial hospital (87.92%) than at the municipal (68.0%) and district (46.88%) hospitals. In terms of disease spectrum, the provincial hospital predominantly managed Crohn's disease (33.3%), Meckel's diverticulum (16.7%), and small bowel vascular malformations (12.5%), whereas municipal and district hospitals showed a narrower disease spectrum. Endoscopic therapy was the most common treatment across all levels. Follow-up data indicated that the provincial hospital had a lower rebleeding rate and better long-term prognosis. Among cases of incomplete enteroscopy, "bowel loop tortuosity" was a significantly more frequent cause of failure at the municipal and district hospitals.

Conclusions: Significant differences exist in the diagnostic and therapeutic capacity of emergency enteroscopy and patient composition across hospital levels. Provincial hospitals demonstrate clear advantages in procedural efficiency, lesion detection, and treatment outcomes. Establishing standardized care pathways for small bowel bleeding and strengthening technical support for primary hospitals are crucial for improving overall clinical care.

1 Introduction

Small bowel bleeding is one of the most challenging types of gastrointestinal bleeding to diagnose and treat, accounting for approximately 5%–10% of all gastrointestinal hemorrhages [1]. Because the small intestine is 6–7 meters long with tortuous loops, conventional gastroscopy and colonoscopy cannot reach it, leaving small bowel bleeding as a blind spot in gastrointestinal disease management for a long time. In recent years, advances in capsule endoscopy, enteroscopy, and angiography have greatly improved the diagnosis and treatment of small bowel bleeding [2–4]. Emergency enteroscopy refers to urgent endoscopic examination performed during active bleeding or within 24 hours after bleeding cessation, aiming for simultaneous diagnosis and treatment [5, 6]. Studies have shown that emergency enteroscopy significantly improves the detection rate of bleeding sources and allows direct endoscopic hemostasis, thereby avoiding emergency open surgical exploration and reducing patient mortality [7].

However, emergency enteroscopy is technically demanding, time-consuming, and requires a high level of operator experience and institutional comprehensive care capacity.

In China's three-tier healthcare system, provincial, municipal, and district hospitals differ objectively in terms of equipment, staffing, technical accumulation, and case volume. Provincial hospitals usually serve as regional medical centers with extensive enteroscopy experience and multidisciplinary teams; municipal hospitals act as regional backbone institutions with certain endoscopic capabilities; and district hospitals often undertake primary care tasks, with enteroscopy possibly still in early stages of development. However, systematic comparative studies of emergency enteroscopy outcomes across different hospital levels are scarce in the domestic and international literature [8–12]. Most previous studies focused on single-center experiences, lacking cross-level comparisons. This research gap precludes objective evaluation of real-world technical levels across hospitals, impedes the formulation of targeted resource allocation strategies, and hinders the establishment of rational referral mechanisms for patients with small bowel bleeding. Based on real-world clinical data from 297 patients who underwent emergency enteroscopy across three hospital levels, this study aimed to reveal the true impact of hospital level on emergency enteroscopy outcomes, provide evidence-based recommendations for optimizing diagnostic and therapeutic pathways, improving enteroscopy skills in primary hospitals, and establishing efficient emergency referral systems, ultimately enhancing the overall management of small bowel bleeding in China.

2 Materials and methods

2.1 Study population

This retrospective cohort study included consecutive patients who underwent emergency enteroscopy for small bowel bleeding at three hospitals (provincial, municipal, and district) between June 2022 and December 2025. A total of 297 patients were enrolled and divided according to hospital level: provincial hospital (n = 240), municipal hospital (n = 25), and district hospital (n = 32). Data were extracted from electronic medical records and endoscopy databases at each institution.

Inclusion criteria: (1) clinical presentation with gastrointestinal bleeding symptoms such as hematemesis, melena, or hematochezia; (2) exclusion of gastroduodenal and colorectal bleeding sources by gastroscopy and colonoscopy; (3) performance of double-balloon or single-balloon enteroscopy; (4) clear indication for emergency examination (within 24 hours of bleeding); (5) complete clinical data.

Exclusion criteria: (1) non-emergency elective enteroscopy; (2) severely incomplete clinical data precluding analysis.

2.2 Examination method

All patients underwent enteroscopy using either double-balloon enteroscopy (DBE) or single-balloon enteroscopy (SBE). Before the procedure, cardiopulmonary function was fully assessed, and all procedures were performed under general anesthesia with endotracheal intubation. Patients were placed in the left lateral position. Endoscopic procedures were conducted by experienced endoscopists assisted by a nurse. Written informed consent for enteroscopy and endoscopic therapy was obtained from all patients preoperatively. Bowel preparation was performed using sodium phosphate enemas. The antegrade (oral) approach was performed first. If no lesion was found or if the lesion was identified but its extent could not be determined, a combined approach (total enteroscopy) was attempted using both antegrade and retrograde (anal) routes.

Successful total enteroscopy was defined as visualization of the entire small bowel by confluence of the antegrade and retrograde approaches. Incomplete enteroscopy was defined as failure to complete full small bowel examination for any reason.

During emergency procedures, upon identification of the bleeding source, appropriate endoscopic therapy was selected based on lesion nature and location, including titanium clip placement, argon plasma coagulation (APC), injection hemostasis, and endoscopic submucosal resection. If endoscopic hemostasis failed or the lesion required surgical resection (e.g., tumors), the patient was referred for surgery. For conditions requiring systemic therapy, such as Crohn’s disease, intestinal tuberculosis, or lymphoma, medical treatment was initiated.

2.3 Outcome measures and definitions

The following data were collected:

(1) General clinical data: hospital level, sex, age, ward type (ICU or general ward) on admission, length of hospital stay, and pre-enteroscopy hemoglobin (Hb).

(2) Pre-procedural examinations: small bowel CT enterography findings and capsule endoscopy results before enteroscopy.

(3) Enteroscopy parameters: antegrade enteroscopy time, retrograde enteroscopy time, successful total enteroscopy, and reasons for incomplete examination.

(4) Endoscopic diagnosis and lesion detection: final endoscopic diagnosis and whether the bleeding source was identified. If the bleeding point was confirmed by surgery or endoscopy, even if total enteroscopy was not completed, the actual finding was recorded.

(5) Treatment modalities: endoscopic therapy, surgery, biologics, chemotherapy, anti-tuberculosis therapy, or combination of endoscopy with biologics.

Follow-up and prognosis: follow-up duration, occurrence of rebleeding, time to rebleeding, and treatment for rebleeding.

2.4 Statistical analysis

Statistical analysis was performed using SPSS version 26.0. Continuous variables are expressed as mean ± standard deviation (SD). For comparisons between **two groups**, an independent-sample **t-test** (or paired t-test, depending on the study design) was used; for comparisons among **multiple groups**, one-way analysis of variance (ANOVA) was performed, with post-hoc pairwise comparisons using the least significant difference (LSD) method. Categorical variables are presented as counts (%), and comparisons between groups were performed using the chi-square test or Fisher's exact test. All tests were two-sided, and $P < 0.05$ was considered statistically significant.

3 Results

3.1 Baseline clinical characteristics

A total of 297 patients were included. All three groups had a male predominance, but the proportion of male patients at the provincial hospital (73.75%) was significantly higher than at the municipal (56.0%) and district (71.88%) hospitals. The mean age was 45.8 ± 17.2 years in the provincial hospital, 54.7 ± 20.1 years in the municipal hospital, and 46.3 ± 19.8 years in the district hospital, with a statistically significant difference (t = − 2.570, P = 0.011). The mean length of hospital stay at the provincial hospital (4.80 ± 1.05 days) was significantly shorter than at the municipal (12.04 ± 6.77 days) and district (8.19 ± 6.14 days) hospitals (t = − 5.346, P < 0.001). Pre-enteroscopy Hb levels were 93.46 ± 23.50 g/L in the provincial hospital, 87.24 ± 28.18 g/L in the municipal hospital, and 89.94 ± 21.73 g/L in the district hospital, with no significant difference among groups (F = 1.235, P = 0.218). The general clinical characteristics are summarized in Table 1.

Table 1
Comparison of general clinical characteristics among the three groups

Characteristic	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)	Statistic	P value
Male, n (%)	177 (73.75%)	14 (56.0%)	23 (71.88%)	F = 1.175	0.171
Age (years, mean ± SD)	45.32 ± 17.11	54.88 ± 19.89	45.25 ± 18.18	t = − 2.570	0.011
Hospital stay (days, mean ± SD)	4.80 ± 1.05	12.04 ± 6.77	8.19 ± 6.14	t = − 5.346	< 0.001
Pre-enteroscopy Hb (g/L, mean ± SD)	93.46 ± 23.50	87.24 ± 28.18	89.94 ± 21.73	F = 1.235	0.218

3.2 Ward type on admission

The provincial hospital admitted 15.0% of patients directly to the ICU, which was significantly higher than the municipal (4.0%) and district (0%) hospitals ($\chi^2 = 3.869$, P = 0.022) (Table 2).

Table 2
Comparison of ward type on admission

Ward type	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)	Statistic	P value
ICU, n (%)	36 (15.0%)	1 (4.0%)	0 (0%)	χ^2 = 3.869	0.022
General ward, n (%)	204 (85.0%)	24 (96.0%)	32 (100%)		

3.3 Preoperative examinations

3.3.1 CT findings before enteroscopy

CT is one of the most important localization methods for emergency small bowel bleeding. In this cohort, the CT positivity rate was 23.33% at the provincial hospital, compared with 36.0% at the municipal hospital and 37.5% at the district hospital, with no statistically significant difference (Table 3).

Table 3
Comparison of CT findings before enteroscopy

CT result	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)	Statistic	P value
Positive, n (%)	56 (23.33%)	9 (36.0%)	12 (37.50%)	F = 0.401	0.670
Normal, n (%)	172 (71.67%)	10 (40.0%)	16 (50.0%)		
Not performed, n (%)	12 (5.0%)	6 (24.0%)	4 (12.50%)		

3.3.2 Capsule endoscopy before enteroscopy

The proportion of patients who did not undergo capsule endoscopy before enteroscopy was high across all groups: 95.83% at the provincial hospital, 100% at the municipal hospital, and 50.0% at the district hospital (Table 4).

Table 4
Comparison of capsule endoscopy results before enteroscopy

Capsule endoscopy	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)
Not performed, n (%)	230 (95.83%)	25 (100%)	16 (50.0%)

3.4 Enteroscopy parameters and total enteroscopy completion rate

3.4.1 Total enteroscopy completion

Total enteroscopy completion rate is a core indicator of full small bowel examination and technical proficiency. In this study, the completion rate was 87.92% at the provincial hospital, significantly higher than at the municipal (68.0%) and district (46.88%) hospitals ($\chi^2 = 67.34$, $P < 0.001$) (Table 5).

Table 5
Comparison of total enteroscopy completion

Total enteroscopy	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)	Statistic	P value
Completed, n (%)	211 (87.92%)	17 (68.0%)	15 (46.88%)	$\chi^2 = 67.34$	< 0.001
Incomplete, n (%)	29 (12.08%)	8 (32.0%)	17 (53.12%)		

3.4.2 Reasons for incomplete enteroscopy

Stenosis and deep ulcers were more frequent causes of incomplete enteroscopy at the provincial hospital, whereas bowel loop tortuosity was a significantly more common cause at the municipal and district hospitals (Table 6).

Table 6
Comparison of reasons for incomplete enteroscopy

Reason	Provincial hospital (n = 29)	Municipal hospital (n = 8)	District hospital (n = 17)	Statistic	P value
Stenosis, n (%)	10 (34.48%)	1 (12.5%)	1 (5.88%)	F = 6.931	0.002
Loop tortuosity, n (%)	4 (13.79%)	5 (62.5%)	12 (70.59%)		
Deep ulcer, n (%)	14 (48.28%)	2 (25%)	4 (23.53%)		

3.4.3 Enteroscopy procedure time

Antegrade enteroscopy time at the provincial hospital (43.59 ± 8.65 min) was significantly shorter than at the municipal (87.24 ± 28.18 min) and district (81.19 ± 35.78 min) hospitals ($t = -11.502$, $P < 0.001$). Retrograde enteroscopy time at the provincial hospital (29.90 ± 10.38 min) was also significantly shorter than at the municipal (46.52 ± 17.23 min) and district (67.84 ± 37.27 min) hospitals ($t = -4.732$, $P < 0.001$) (Table 7).

Table 7
Comparison of enteroscopy procedure times (minutes, mean ± SD)

Procedure time	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)	t value	P value
Antegrade enteroscopy time (min)	43.59 ± 8.65	87.24 ± 28.18	81.19 ± 35.78	–11.502	< 0.001
Retrograde enteroscopy time (min)	29.90 ± 10.38	46.52 ± 17.23	67.84 ± 37.27	–4.732	< 0.001

3.5 Lesion detection and disease spectrum

3.5.1 Bleeding source detection rate

The bleeding source detection rate at the provincial hospital was 97.92%, compared with 64.0% (16/25) at the municipal hospital and 93.75% (30/32) at the district hospital, with a highly significant difference ($\chi^2 = 49.126$, $P < 0.001$) (Table 8).

Table 8
Comparison of bleeding source detection rates

Bleeding source identified	Provincial hospital (n = 240)	Municipal hospital (n = 25)	District hospital (n = 32)	Statistic	P value
Yes, n (%)	235 (97.92%)	16 (64.0%)	30 (93.75%)	$\chi^2 = 49.126$	< 0.001
No, n (%)	5 (2.08%)	9 (36.0%)	2 (6.25%)		

3.5.2 Disease spectrum

The provincial hospital had the most diverse disease spectrum, covering 14 types of lesions with relatively even distribution. Crohn's disease (28.51%) was the most common, followed by Meckel's diverticulum (18.72%) and vascular malformations (10.64%). Among patients with confirmed diagnoses at the municipal hospital, vascular malformations (31.25%), Crohn's disease (25.0%), and Meckel's diverticulum (12.0%) were most frequent. At the district hospital, Crohn's disease was the leading diagnosis (40%), followed by Meckel's diverticulum (16.67%) and vascular malformations (13.33%), with a narrower overall spectrum than at the provincial hospital (Table 9).

Table 9
Comparison of endoscopic disease spectrum

Diagnosis	Provincial hospital (n = 235)	Municipal hospital (n = 16)	District hospital (n = 30)
Crohn's disease, n (%)	67 (28.51%)	4 (25.0%)	12 (40%)
Meckel's diverticulum, n (%)	44 (18.72%)	3 (12.0%)	5 (16.67%)
Small bowel vascular malformation, n (%)	25 (10.64%)	5 (31.25%)	4 (13.33%)
Small bowel hemangioma, n (%)	12 (5.11%)	0 (0%)	1 (3.33%)
Small bowel stromal tumor, n (%)	16 (6.81%)	1 (5.26%)	3 (10%)
Jejunal diverticulum, n (%)	16 (6.81%)	2 (1.25%)	1 (3.33%)
Small bowel lymphangioma, n (%)	7 (2.98%)	0 (0%)	0 (0%)
Drug-related small bowel ulcer, n (%)	14 (5.96%)	1 (5.26%)	0 (0%)
Postoperative anastomotic bleeding, n (%)	10 (4.26%)	0 (0%)	1 (3.33%)
Intestinal tuberculosis, n (%)	4 (1.70%)	0 (0%)	0 (0%)
Small bowel lymphoma, n (%)	7 (2.99%)	0 (0%)	0 (0%)
Small bowel adenoma, n (%)	4 (1.70%)	0 (0%)	1 (3.33%)
Lipoma, n (%)	2 (0.85%)	0 (0%)	0 (0%)
Peutz-Jeghers syndrome, n (%)	2 (0.85%)	0 (0%)	1 (3.33%)
Gangliocytic paraganglioma, n (%)	0 (0%)	0 (0%)	1 (3.33%)
Small bowel neuroendocrine tumor, n (%)	3 (1.28%)	0 (0%)	0 (0%)
CEAS, n (%)	2 (0.85%)	0 (0%)	1 (3.33%)

CEAS, chronic enteropathy associated with SLCO2A1 gene.

3.6 Treatment modalities

Endoscopic therapy was the most commonly used modality across all levels, accounting for 60.4% at the provincial hospital, 52.0% at the municipal hospital, and 53.1% at the district hospital, with no significant difference among groups (P = 0.493). Surgical resection was performed in 17.1% of provincial hospital patients, compared with 8.0% and 12.5% at the municipal and district hospitals, respectively (P = 0.341).

For Crohn's disease, biologics alone or in combination with endoscopic therapy were more frequently used at the provincial hospital (18.8% vs. 12.0% at municipal and 12.6% at district hospitals) (Table 10).

Table 10
Comparison of treatment modalities

Treatment	Provincial hospital (n = 235)	Municipal hospital (n = 16)	District hospital (n = 30)	Statistic	P value
Endoscopic therapy, n (%)	142 (60.4%)	13 (52.0%)	17 (53.1%)	χ^2 = 1.414	0.493
Surgery, n (%)	40 (17.1%)	2 (8.0%)	4 (12.5%)	χ^2 = 2.151	0.341
Biologics, n (%)	44 (18.8%)	3 (12.0%)	4 (12.6%)	–	–
Endoscopy + biologics, n (%)	9 (3.8%)	0 (0%)	1 (3.3%)	–	–
Others (chemotherapy, anti-TB), n (%)	0 (0%)	0 (0%)	1 (3.3%)	–	–

3.7 Follow-up and rebleeding

The mean follow-up duration at the provincial hospital (32.1 ± 16.8 months) was significantly longer than at the municipal (20.9 ± 10.2 months) and district (18.3 ± 10.5 months) hospitals (F = 7.89, P < 0.001). The rebleeding rate was 4.17% (10/240) at the provincial hospital, 8.0% (2/25) at the municipal hospital, and 18.75% (6/32) at the district hospital, with a highly significant difference (χ^2 = 5.509, P = 0.004). No significant difference was observed in the time to rebleeding among the three groups (F = 1.793, P = 0.103). Regarding the management of rebleeding, all 10 patients at the provincial hospital underwent surgical treatment; among the 2 municipal patients, one received endoscopic therapy and the other underwent surgery; at the district hospital, 8 patients underwent endoscopic therapy and 2 received biologics (Table 11).

Table 11
Comparison of follow-up and rebleeding

Follow-up indicator	Provincial hospital	Municipal hospital	District hospital	Statistic	P value
Follow-up duration (months, mean ± SD)	32.16 ± 18.00	20.68 ± 9.53	16.84 ± 9.98	F = 5.141	< 0.001
Rebleeding, n (%)	10/240 (4.17%)	2/25 (8.0%)	6/32 (18.75%)	χ^2 = 5.509	0.004
Time to rebleeding (months, mean ± SD)	–	–	–	F = 1.793	0.103

4 Discussion

4.1 Comprehensive impact of hospital level on emergency enteroscopy outcomes

Based on real-world data from 297 patients, this study systematically and quantitatively revealed the profound influence of hospital level on the diagnostic and therapeutic outcomes of emergency enteroscopy. Our results clearly demonstrate that the provincial hospital significantly outperformed municipal and district hospitals in key metrics, including total enteroscopy completion rate, bleeding source detection rate, procedure time, and rebleeding rate, with all differences being highly statistically significant ($P < 0.001$). To date, this is the largest and most comprehensive multicenter comparative study of emergency enteroscopy across hospital levels in China, providing clinically relevant and policy-relevant insights.

4.2 Deep-seated reasons for baseline differences among patient groups

Our study revealed that patients admitted to the provincial hospital exhibited a “three high, one low” profile: high ICU admission rate, high male proportion, short hospital stay, and high proportion of normal CT findings. These seemingly contradictory findings reflect the operational logic of China’s three-tier healthcare system: (1) Patient triage via referral mechanisms: As regional medical centers, provincial hospitals receive a large proportion of referred patients from lower-tier hospitals. These patients often have undergone initial workup but remain unstable due to uncontrolled bleeding, explaining the high ICU admission rate. Moreover, because many examinations have already been performed at the referring institutions, the pre-procedural CT positivity rate at the provincial hospital was paradoxically lower. (2) Hierarchical differences in care efficiency: The shorter hospital stay at the provincial hospital was not due to less severe disease but rather to more streamlined and efficient diagnostic and therapeutic workflows. At municipal and district hospitals, prolonged stays are often attributable to bottlenecks in resource availability, such as waiting time for operating rooms, anesthesiologists, and endoscopy equipment. (3) Concentration of young, critically ill patients: indicating that many young male patients with small bowel bleeding were either directly admitted or referred to the provincial hospital. Despite their younger age, these patients often had massive bleeding and hemodynamic instability, necessitating ICU care.

4.3 Clinical significance and influencing factors of total enteroscopy completion rate

Total enteroscopy completion rate was the most significant indicator of hospital-level differences in this study. It is not merely a technical metric but the gold standard for evaluating whether the entire small bowel has been examined. Successful total enteroscopy ensures that the entire small intestine is visualized, minimizing the risk of missed lesions due to blind spots [13, 14]. Conversely, incomplete examination leaves at least part of the small bowel unexamined, where a bleeding source could easily be missed.

Two core factors influence the completion rate: (1) Operator proficiency: Success depends on skills such as bowel shortening, loop reduction, and navigation through angles and strictures. Operators at the provincial hospital perform large numbers of enteroscopies annually and are highly experienced, whereas those at primary hospitals often perform fewer than 20 cases per year, which is insufficient to accumulate adequate expertise. (2) Anatomical and pathological factors: Adhesions, prior abdominal surgery, congenital tortuosity, Crohn's strictures, and tumor infiltration all contribute to technical difficulty. Among incomplete cases at the provincial hospital, "stricture" accounted for 45.2%, indicating that the provincial hospital faced more complex pathological challenges.

4.4 Biological and clinical explanations for differences in bleeding source detection rate

The bleeding source detection rate at the provincial hospital reached 97.92%. This high rate resulted from multiple synergistic factors: (1) high total enteroscopy completion rate ensured full visualization; (2) experienced operators could identify subtle vascular malformations and minute bleeding spots; (3) thorough intraprocedural suctioning and irrigation minimized interference from blood clots; (4) preoperative CT and capsule endoscopy provided target localization, aiding focused examination. The lower detection rates at primary hospitals were fundamentally due to incomplete enteroscopy leading to missed lesions, as well as insufficient diagnostic capacity: vascular malformations may appear only as subtle submucosal red patches or spider-like lesions and can easily be misinterpreted as mucosal hyperemia or post-irrigation erythema. Additionally, advanced techniques such as chromoendoscopy, narrow-band imaging, confocal laser endomicroscopy, and small bowel endoscopic ultrasound were available at the provincial hospital, but were not generally accessible at primary hospitals [15, 16].

4.5 Disease spectrum differences: referral bias and regional epidemiological characteristics

The richness and composition of the disease spectrum at the provincial hospital contrasted sharply with that at municipal and district hospitals. The provincial hospital covered almost all etiologies of small bowel bleeding, with Crohn's diseas, Meckel's diverticulum, and vascular malformations predominating, whereas municipal and district hospitals more often documented "no abnormality" and simple vascular malformations. This reflects two important phenomena: (1) Referral bias: Once diagnosed with Crohn's disease, patients require long-term specialized follow-up and biologic therapy, which are often difficult to manage at primary hospitals; hence, these patients are concentrated at the provincial hospital. Similarly, patients with suspected stromal tumors or lymphomas are promptly transferred to the provincial hospital for definitive diagnosis and surgery after initial screening at lower-level institutions. (2) Diagnostic "ceiling" effect: Primary hospitals have limited awareness of rare diseases, and even if such lesions are visualized endoscopically, they may not be correctly diagnosed. In contrast, provincial hospitals have well-established diagnostic pathways for rare diseases, supported by robust pathology and gastroenterology departments.

4.6 Evidence-based treatment selection and cost-effectiveness analysis

Although endoscopic therapy rates did not differ significantly among groups (P = 0.493), the proportion of patients undergoing surgery showed meaningful variation. This difference reflects not only technical capacity but also divergent treatment philosophies: (1) Standardized care pathways: The provincial hospital has established evidence-based treatment pathways for various diseases. Primary hospitals often lack such clear pathways, leading to more variable or incomplete management [17, 18]. (2) Multidisciplinary team (MDT) advantage: At the provincial hospital, treatment decisions are made jointly by gastroenterology, general surgery, radiology, pathology, and oncology teams, ensuring optimal individualized plans. In contrast, primary hospitals generally lack MDT mechanisms, and decisions are often made by single specialists, which may introduce bias.

4.7 Important implications of rebleeding rate and long-term prognosis

Rebleeding not only necessitates rehospitalization and repeat procedures but also significantly increases healthcare costs and patient psychological burden. The higher rebleeding rates at primary hospitals are likely related to deficiencies in postoperative management [19]. First, Crohn's disease patients have high relapse rates without sustained biologic maintenance therapy, and primary hospitals lack experience in biologic maintenance. Second, the provincial hospital has established a comprehensive follow-up system with regular telephone or outpatient reviews, whereas primary hospitals have higher loss-to-follow-up rates, preventing early detection of rebleeding signals.

4.8 Policy recommendations for healthcare resource allocation and hierarchical care

Based on our findings, we propose the following actionable policy recommendations: (1) Establish a regional referral network for small bowel bleeding: Provincial hospitals should serve as regional referral centers. Municipal and district hospitals, when encountering cases with failed total enteroscopy, unclear diagnoses, or unmanageable bleeding, should transfer patients to the provincial hospital within 24 hours after completing preliminary examinations (CT, gastroscopy, colonoscopy), avoiding prolonged "watchful waiting" that may worsen the condition. Complete imaging and clinical records should be transmitted during transfer. (2) Strengthen enteroscopy training at primary hospitals: Municipal and district hospitals should, under the guidance of provincial hospitals, implement structured training programs following a "simulator training → animal experiments → clinical proctoring → independent practice" pathway, with a focus on overcoming the challenging scenarios of "bowel loop tortuosity" and "strictures" [20]. (3) Enhance full-cycle patient management: Establish a dedicated database for small bowel bleeding patients, with routine follow-up at 3, 6, 12, and 24 months post-procedure, to monitor hemoglobin, nutritional status, and early signs of rebleeding. Provincial hospitals should provide remote guidance and support for postoperative management at primary hospitals.

4.9 Study limitations

This study has several limitations. First, as a retrospective analysis, some data relied on medical records and may be subject to information bias. Second, the sample sizes were unbalanced, and future prospective, multicenter studies with balanced enrollment are warranted to confirm our findings. Third, we did not include operator experience level as a variable; we did not record the annual enteroscopy volume, years of practice, or specialty training of each operator, which may have introduced confounding. Subsequent studies should collect operator qualification data and apply mixed-effects models. Fourth, selection bias may exist: patients transferred from primary hospitals to the provincial hospital may have more severe disease or more difficult diagnoses. This would mean that the provincial hospital treated a more complex baseline population, yet achieved superior outcomes, which paradoxically underscores its diagnostic and therapeutic advantage.

5 Conclusions

Hospital level is a key factor influencing the outcomes of emergency enteroscopy. Provincial hospitals significantly outperformed municipal and district hospitals in terms of total enteroscopy completion rate, bleeding source detection rate, and procedure time, demonstrating a clear hierarchical advantage. Despite managing more critically ill patients, the provincial hospital achieved shorter hospital stays, reflecting its superior emergency care efficiency and multidisciplinary collaboration. The primary reason for incomplete enteroscopy at municipal and district hospitals was anatomical difficulty, predominantly bowel loop tortuosity, suggesting that primary hospitals should focus on improving skills in navigating tortuous loops. Disease spectra differed significantly across levels, with the provincial hospital covering a broader and more comprehensive range of pathologies. Rebleeding rates increased significantly as hospital level decreased, indicating deficiencies in postoperative maintenance therapy and long-term follow-up at primary hospitals, which require strengthening of full-cycle patient management and early warning mechanisms for recurrent bleeding. We recommend establishing a regional collaborative network for small bowel bleeding centered on provincial hospitals, through technical support, teleconsultation, standardized referral, and uniform follow-up, to narrow the gaps among hospital levels and ultimately improve the overall prognosis of patients with small bowel bleeding in China.

Declarations

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Author contributions

Liu Zhongcheng: conceptualization, methodology, writing-review&editing. Han Yingxiong, Wei Xiaolan: data curation and formal analysis. Zhou Xiaoqian, Zhou Zhiwei and Guo Qin: project administration. All authors approved the final manuscript.

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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to participant privacy and institutional restrictions but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of **the Sixth Affiliated Hospital of Sun Yat-Sen University** (approval number: 2023ZSLYEC-264). All procedures involving human participants were performed in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Written informed consent was obtained from all participants prior to inclusion in the study.

Consent for publication

Not applicable

Competing interests

The authors declare no competing interests.

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