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EDITORIAL

Motorized spiral enteroscopy: A cautious step forward in technological innovation

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Abstract

With the continuous advancement in medical technology, endoscopy has gained significant attention as a crucial diagnostic tool. The introduction of motorized spiral enteroscopy (MSE) represents a significant advancement in the diagnosis and treatment of small bowel diseases. While there are safety concerns and a high reliance on the operator's skills, MSE should not be disregarded entirely. Instead, it should be considered as a supplementary endoscopic technique, particularly in situations where conventional endoscopy proves ineffective. Through continuous research and technical optimization, MSE has the potential to become an important addition to the endoscopy toolbox in the future. We call on colleagues in the industry to work together to promote the improvement of MSE technology through continuous research and practice, with the aim to bring out its unique value in endoscopy while ensuring patient safety.

Key Words: Motorized spiral enteroscopy; Spiral enteroscopy; Device-assisted enteroscopy; Endoscopy; Small bowel diseases

Core Tip: As a major innovation in the diagnosis and management of small bowel diseases, motorized spiral enteroscopy (MSE) demonstrates significant advantages in terms of efficiency and unique operating principles. Despite technical challenges and safety considerations, MSE has been able to improve diagnostic rates, shorten examination times, and expand the range of indications. By strengthening operator training and interdisciplinary integration, MSE is expected to become an important supplement to the endoscopy toolbox in the future, especially in situations where traditional endoscopic methods are limited, ensuring its unique value in the diagnosis and management of small intestinal diseases is fully utilized.

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INTRODUCTION

Small bowel diseases (SBD) have always posed a challenge in the field of digestive system disorders, given the small bowel's length of about 4-7 meters and its winding nature[1]. Traditional endoscopy struggles to reach the depth necessary for accurate diagnosis and treatment. Nonetheless, as medical technology progresses and techniques for endoscopic diagnosis and therapy evolve, the advent of double-balloon enteroscopy (DBE) and single-balloon entero-scopy (SBE) offers new options for the examination and management of conditions affecting the small intestine. These techniques are particularly beneficial for treating arteriovenous malformations, removing foreign bodies and intestinal polyps, performing percutaneous jejunostomy, dilating stenosis, and conducting biopsies of the deep mucous membranes of the small bowel, among other traditional indications[2,3]. Overall, these advancements offer a more suitable choice for managing SBD. Spiral enteroscopy (SE) is a new technology developed on the basis of SBE or DBE, especially motorized spiral enteroscopy (MSE), which provides more possibilities for the diagnosis and treatment of SBD[4].

The core components of spiral enteroscopes consist primarily of the endoscope itself and helical outer sheaths. Its functional mechanism fuses the traits of conventional spiral enteroscopes with those of electric motors. The crucial advancement centers on embedding an electric motor within the instrument's framework. This integration enables the rotation of the sheath, thereby causing the small intestine to gather and adhere to the exterior of the sheath.to progressively navigate the inner regions of the small intestine[3,5,6], thereby significantly enhancing the diagnostic and therapeutic effectiveness of small intestine ailments while also permitting physicians to observe the small intestine's internal conditions with greater precision. The success rate of the technology for the traditional endoscopic surgery for the downstream and retrograde endoscopic surgery, respectively, is 98% and 100%. Additionally, it is applicable to individuals who have undergone surgical modifications of their anatomy, facilitating endoscopic retrograde cholangiopancreatography (ERCP) procedures. It is useful during or after surgery for gastroenteroscopic examinations in those who have received a Roux-en-Y gastric bypass, for achieving full colonoscopy in individuals with an excessively elongated colon, and for one-way gastroenteroscopy in patients possessing typical gastrointestinal structures[7]. This broadens the spectrum of uses for spiral endoscopy, serving as a crucial component in identifying and managing gastrointestinal disorders while transforming the approach to diagnosing and treating conditions of the small intestine[8].

EFFICIENCY AND ADVANTAGES

The MSE, measuring 1680 mm in length with a distal outer diameter of 11.5 mm, is designed to be comparable to a colonoscope and offers a shorter learning curve than a 200 cm dual or single balloon enteroscope[9]. The procedure is simple. Initially, the individual undergoing treatment is positioned on their left side, with a slight extension of the neck. The twirling motion initiates at the juncture of the upper tubing and the oral cavity, subsequently progressing down the esophagus with a soft application of force. The endoscope applies anterior pressure once it passes through the pylorus and straightens the gastric collaterals as necessary. Then, it moves through the ligament of Treitz, and if there is persistent small bowel "engagement", the enteroscope advances smoothly by rotating clockwise through the spiral tube. Ultimately, upon reaching the deepest point of entry, the reverse footswitch is actuated to regulate the pace of counter-rotational movement, which aids in the unraveling of the small intestine. Balloon-assisted enteroscopy is more complex and requires more time to learn[10,11].

A systematic review in China analyzed nine reports with a total of 733 cases of operation results and estimated that the overall success rate of MSE technology is approximately 95.91%, with the success rate of the transoral approach being about 95.44%, and the success rate of the transanal approach being about 96.94%[12]. Technical success with antegrade MSE was significantly higher (81.4%) than antegrade SBE (33.3%) for lesions in the proximal ileum and beyond[13]. Large studies and meta-analyses have shown that the spiral enteroscope achieved better results in pathologic diagnosis rate, treatment outcome, and total bowel examination rate were 75.07%, 55.26% and 70% respectively[14-17]. A multicenter study including 1411 cases of conventional balloon-assisted enteroscopy showed an overall diagnostic rate of 63% and a therapeutic success rate of 52%[18]. Another multicenter retrospective analysis involving 4 medical centers and a total of 1786 cases of conventional balloon-assisted enteroscopy showed a diagnostic rate of 76% and a therapeutic success rate of

50%[19]. In a meta-analysis encompassing 12823 procedures, the rate of full small bowel examination with DBE was 44%, with the transoral intubation rate accounting for only 1.6%[9].

The total examination time for MSE was comparatively shorter. It took 51 ± 4 minutes on average (ranging from 26 minutes to 89 minutes) for routine retrograde enteroscopy, 55 ± 3 minutes (ranging from minutes 23 to 107 minutes) for another instance of routine antegrade enteroscopy, 65 ± 4 minutes (ranging from 43 to 89 minutes) for enteroscopy-assisted ERCP, patients undergoing Roux-en-Y gastric bypass spent an average of 61 minutes, with a standard deviation of 7 minutes (spanning 49 minutes to 89 minutes) to access the altered stomach portion, while the time taken for a unidirectional complete bowel assessment was on average 94 minutes, with a variation of 5 minutes. These intervals exceed the typical duration for a single balloon small bowel enteroscopy, which is approximately 114.2 minutes and has a standard deviation of 33.5 minutes. The median duration for a magnetic stimulation enterography intervention registered at 6 minutes for the retrograde approach (with times between 1 minutes and 20 minutes), and 3 minutes for the anterograde technique (time range of 1 minutes to 10 minutes) as documented[7,20,21]. In terms of another key metric, the maximum depth of insertion (DMI), MSE excels, with a median DMI of 490 cm (ranging from 160 cm to 600 cm) for the extra-Treitz ligament and 120 cm (ranging from 40 cm to 600 cm) for the retrograde approach in retrograde MSE[21].

SAFETY CONSIDERATIONS

Upon conducting a meta-analysis combined with a systematic review of nine studies, it was discovered that adverse events linked to MSE were present in 17% of the instances documented. When comparing the side effect rates of different enteroscopy technologies, we referred to research and meta-analyses from the past five years, including MSE, DBE, DBE-assisted ERCP, and SBE. Research indicated in references reveals that while there is a 16% incidence of minor complications associated with MSE, the occurrence of significant complications is comparable to that seen with SBE and DBE, remaining below 1% without any resulting fatalities[9,16,17,22-25]. Notable severe complications involve instances of gastrointestinal perforation, pancreatitis, and hemorrhage. Moreover, the probability of serious adverse events in DBE-assisted ERCP can reach 8%[23]. The aforementioned literature also points out that the homogeneity of the articles studying the side effects of the aforementioned technologies is poor, and there is a certain bias in the conclusions (Table 1).

Most adverse events with MSE are linked to the spiral device itself, particularly the risk of the device causing deep lacerations and perforations in the proximal esophagus during withdrawal[15]. MSE spiral outer casing is out of connection with the motor of the scope may lead to interruption of the operation or injury to the patient. Since the diameter model of the MSE outer casing is unique, there may be adaptation problems for different body sizes, especially for patients with short stature or narrow esophageal diameters, leading to operation failure or patient injury[26,27]. In the event of esophageal perforation during MSE, immediate conservative treatment or endoscopic closure should be adopted, and surgical intervention should be conducted when necessary[15,21]. How can we reduce the risk of this serious complication? First, we must ensure that the operator has received adequate training and has experience with MSE. Concurrently, it is imperative to carry out a comprehensive review of the patient's medical background and a thorough physical assessment prior to the surgical procedure in order to identify candidates who are appropriate for MSE and to eliminate those with elevated risk factors[17]. An experienced anesthesiologist should manage anesthesia, and well-designed and well-maintained equipment should be used. Throughout the procedure, it's imperative to keep a steady watch on the patient's critical indicators while managing the penetration depth and velocity to prevent over-insertion and hurried progression, thereby minimizing harm to the gut lining. Post-procedure, rigorous vigilance for the patient is necessary to swiftly detect and address any arising issues[9,28].

THE POTENTIAL AND TRAINING CHALLENGES

Given the numerous limitations of spiral endoscopy as a new technology, and considering that its long-term results and safety are still under clinical study and observation, should we continue to use it? Is MSE more capable in identifying and managing illnesses of the small intestine? The answer should be yes. The existing evidence indicates that compared with traditional enteroscopy methods, MSE allows for deeper access to the small bowel, improving the diagnostic rate, and is a safe and effective procedure especially for patients with a history of major abdominal surgery[14]. MSE has its advantages, especially for complex small bowel lesions, which benefit from a wider field of view. A meta-analysis by Papaefthymiou *et al*[17] also confirmed that the incidence of serious adverse reactions associated with MSE is low and it is safe when performed by experienced operators. With proper operator training and strict patient selection, MSE can be used safely and effectively in specialized centers. The limitations of MSE are thought to include a long learning period, but some studies suggest that mastering MSE techniques may only require 5 to 10 cases of operational training. Moreover, as the number of MSE procedures increases, it does not significantly alter the average DMI or the transoral small bowel intubation rate. This is mainly due to the device's avoidance of the push-pull operation on the overtube, which is crucial in balloon-assisted enteroscopy and relatively difficult to master[16,17]. Presently, a shortage persists in stringent comparative analyses pertaining to the proficiency developments associated with diverse small bowel endoscopic procedures; however, the available evidence suggests that MSE procedures tend to yield comparably favorable outcomes with fewer instructional instances[16,29-32].

Table 1 Comparison of adverse events in motorized spiral enteroscopy, devices assisted enteroscopy-assisted endoscopic retrograde cholangiopancreatography, single-balloon enteroscopy, and double-balloon enteroscopy

	MSE	DAE-assisted ERCP	SBE	DBE
Adverse events, *n* (%)	151/959 (17)	14/173 (8)	120/3728 (3)	202/2017 (10.1)
Severe, *n*	13/959 (1)	14/173 (8)	26/3728 (0.7)	61/9047 (0.7)
Perforation or deep intramural defects, *n*	2	3	11	20
Postprocedure pancreatitis, *n*	2	11	9	17
Significant hemorrhage, *n*	6	/	2	6

MSE: Motorized spiral enteroscopy; DAE: Devices assisted enteroscopy; ERCP: Endoscopic retrograde cholangiopancreatography; SBE: Single-balloon enteroscopy; DBE: Double-balloon enteroscopy.

FUTURE PERSPECTIVES

Before the invention of the SE, traditional push enteroscopy was mainly relied upon for small bowel examinations. This often required insufflating the bowel, relying on the natural peristalsis of the intestine or the operator's experience to advance the endoscope. It was difficult to insert the endoscope deep with the push technique. To better access the small bowel, Japanese researchers invented DBE in 2001, which significantly improved the accessibility of the small bowel by installing balloons at both ends of the endoscope[33], providing a new solution for the diagnosis of SBD. SBE was developed in 2007, which simplified the operation process by installing a balloon at the front end of the endoscope[5]. SE, introduced in the United States in 2008 as a novel technique for small bowel examination, consists of an endoscope and a spiral-overtube[34]. The design of SE allows the endoscope to be advanced by rotating the outer sheath, reducing the dependence on balloons and increasing the flexibility of the operation. Neuhaus *et al*[35] first reported a case of successful treatment of jejunal vascular malformations using MSE in 2016. The principle of advancement and withdrawal of the device is similar to that of the traditional SE. Its main innovation lies in the an electric motor that can remotely control the rotation of the outer sheath, which allows the advancement and withdrawal process to be completed independently by a single person, and the operation is more time-saving and less labor-intensive compared to traditional devices assisted enteroscopy[14,16].

The MSE represents an innovative tool within the realm of small intestine diagnostics and therapy, consistently progressing in its technological evolution. In the future, we may see more efficient motor integration, more advanced spiral outer casing design, and a smarter operator interface. The development of softer and more adaptable balloon materials may reduce damage to the intestinal wall, along with the design of smarter balloon control systems for more precise inflation and deflation adjustments. By engaging in systematic instruction and progressively gathering expertise, we are capable of diminishing the likelihood of procedural issues. Furthermore, it may be beneficial to integrate helical small bowel enteroscopy with cutting-edge methodologies, including robotic assistance and magnetic steering systems [10], to enhance the procedure's precision, consistency, and security.

CONCLUSION

In the face of evolving difficulties and demands, MSE continues to be a vital instrument for identifying and managing disorders of the small intestine. It's imperative that our quest for advancement persists, aiming to discover solutions that are not only safer and more effective but also enhance patient comfort. As artificial intelligence and robotic technologies advance, the sophistication and automating capabilities of MSE are expected to progress accordingly. In the future, it may be possible to achieve more accurate operation and more efficient diagnosis. With the ongoing advancements in medical science and technology, it is anticipated that MSE will continue to improve and become more refined. Anticipated to be pivotal in diagnosing and treating small intestine conditions, this advanced method promises to extend hope to an increased patient populace.

FOOTNOTES

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