Comprehensive review on the diagnostic strategies for esophageal tuberculosis: the role of endoscopic ultrasonography

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Qi Ding and Lei-Lei Zhai were responsible for drafting and revising the first draft. Zi-Yi Guo was responsible for providing resources. Ping Yao was responsible for reviewing and supervision. All authors contributed to the article and approved the submitted version.

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Abbreviations
ET, esophageal tuberculosis; CT, computed tomography; EGD, esophagogastroduodenoscopy; EUS, endoscopic ultrasonography; EUS-FNA, endoscopic ultrasonography guided fine-needle aspiration.

Abstract
Esophageal tuberculosis (ET) is a relatively rare clinical condition, characterized by often atypical clinical features. The lack of specificity in diagnostic methods, such as esophagogastroduodenoscopy and various imaging techniques, frequently leads to misdiagnosis and inappropriate treatments. Compared to esophagogastroduodenoscopy, endoscopic ultrasonography (EUS) offers a more comprehensive examination of esophageal tuberculosis lesions, including the extent of wall layer involvement and the internal structure characteristics of the lesions. Furthermore, when necessary, endoscopic ultrasonography-guided fine-needle aspiration can be employed to acquire deeper pathological tissue, significantly aiding diagnosis. When combined with the patient’s clinical presentation, endoscopic findings, and pathological features, EUS plays a crucial role in the definitive diagnosis of ET and in the differential diagnosis process. This article meticulously reviews both national and international literature to summarize the relevant features of ET, with a focus on its appearance under EUS, and to highlight the clinical value of EUS in enhancing the diagnosis of ET and in distinguishing it from other conditions. The aim is to offer guidance for the accurate diagnosis of ET.

Keywords: esophageal tuberculosis; esophagogastroduodenoscopy; endoscopic ultrasonography; diagnosis; differential diagnosis
**Background**

Esophageal tuberculosis (ET) is an exceedingly rare condition characterized by a granulomatous inflammatory lesion of the esophageal wall caused by infection with *Mycobacterium tuberculosis* [1]. Despite a global decline in tuberculosis rates over recent decades, ET incidence remains elevated in certain regions, particularly in less developed areas [2–4]. The challenge of diagnosing ET with certainty is significant due to its low incidence and often atypical clinical symptoms [2, 5]. Diagnostic imaging methods, such as computed tomography (CT) scans and magnetic resonance imaging, while useful in detecting abnormalities, frequently struggle to definitively identify specific ET lesions, especially in early and mild cases [6]. This presents a significant challenge in diagnosing ET and differentiating it from other esophageal disorders, including cancer [7–9]. Although esophagogastroduodenoscopy (EGD) can visually assess the interior of the esophagus, it does not guarantee complete accuracy. In this scenario, endoscopic ultrasonography (EUS) emerges as a powerful tool. Its application as an endoscopic technique has become widespread in clinical diagnostic and therapeutic practices. EUS offers detailed information on the lesion, including its morphology, involvement of esophageal wall layers, origin, internal echoes, and the status of adjacent lymph nodes. This data is invaluable for the early detection of ET and can assist in formulating an appropriate treatment strategy [8, 10]. However, the role of EUS in the diagnosis of ET has not been sufficiently explored or popularized. This article aims to thoroughly review the diagnostic strategies for ET, focusing on the specific application and potential advantages of EUS in diagnosing this condition. By providing insights into the effective use of EUS, this paper seeks to contribute to the reduction of misdiagnosis and mistreatment of ET in future clinical practice.

**Relevant features of ET**

Tuberculosis impacts multiple organ systems in the body, with gastrointestinal tuberculosis accounting for 1%–3% of all cases globally [2]. Affected areas may include the esophagus, stomach, gastroduodenum, small and large intestine, anus, and peritoneum [11, 12]. ET is particularly rare, representing approximately 0.07%–3.00% of patients with gastrointestinal tuberculosis [13, 14]. In recent years, there has been a rise in the quantity of ET case reports [15]. This may be linked to clinicians’ greater awareness of the disease and the extensive use of different endoscopic diagnostic methods.

ET can be categorized into primary and secondary infections, based on the route of infection [16]. The differentiation between primary and secondary esophageal tuberculosis is outlined in Table 1. ET arises from the direct infiltration of sputum and food containing *Mycobacterium tuberculosis* into the esophagus during swallowing – a rare clinical occurrence [17]. The rarity of this phenomenon is attributed to various protective mechanisms of the esophageal wall [18]. These mechanisms include factors such as the esophagus being lined with squamous epithelium, which is coated in mucus and saliva, in addition to aspects such as the upright position and the short retention time of food in the esophagus [18]. Secondary infections of tuberculosis in the esophagus are comparatively more common.

Numerous reports have indicated that these infections are often secondary to mediastinal or cervical lymph nodes, as well as adjacent organs such as the lungs and spine [1, 4, 15, 19–22]. Tuberculosis pathogens can spread directly from tuberculosis foci at these sites to the esophageal tissues, resulting in ET often presenting in the mid-esophagus [4, 23]. Infections are frequently caused by direct invasion and via the lymphatic system [1, 15, 19–21]; however, hematogenous transmission is also a possibility in a small percentage of ET cases [24, 25]. Pathogens infiltrate the mucosa and settle in the submucosal lymphoid tissue, leading to an inflammatory response at the affected sites. The subsequent stages include lymphangitis, endarteritis, granuloma formation, caseous necrosis, mucosal ulceration, and scarring [17, 26, 27].

The clinical manifestations of ET vary among patients and can involve a range of symptoms. Dysphagia is the most common complaint, particularly when the esophageal mucosa is inflamed or narrowed, causing difficulty, especially with solid foods [25, 28, 29]. Chest pain is also frequent, with esophageal inflammation and ulcers leading to persistent or intermittent chest pain, typically felt behind the sternum and exacerbated by dysphagia [28]. Additionally, patients may experience fever, fatigue, night sweats, and upper abdominal pain, among other symptoms [28–33]. In cases where the esophageal ulceration penetrates deeply, patients may experience severe complications such as esophageal perforation. Some reports have indicated that esophageal-aortic fistula formation can lead to massive gastrointestinal bleeding [17].

**Diagnosis of ET**

**Imaging**

Signs, such as pulmonary tuberculous lesions and enlarged mediastinal lymph nodes, can be observed on chest X-rays, which are useful in the diagnosis of ET [26, 33]. However, due to various factors such as imaging conditions and image overlap, detecting chest lesions, especially enlarged mediastinal lymph nodes, is clinically challenging; hence, ET is generally considered to lack specific features on chest radiography [34]. Barium esophagography can visualize manifestations of esophageal strictures, obstruction, and ulceration, directly demonstrating intraluminal pathology. Manifestations of extraluminal lesions, presenting as exogenous compression or protrusion into the lumen and appearing as depressions on barium examination and thickening of the involved area (with or without esophageal stenosis), may suggest possible pseudotumor masses or esophageal displacement [32, 35, 36]. However, it has been largely superseded by EGD and CT [9]. CT of the chest is a commonly used, noninvasive test that accurately depicts lesions in the esophageal wall, adjacent tissues, and organs, including esophageal wall thickening, lumen dilatation, and para-esophageal and subglottic lymhadenopathy. Lymph nodes may display uneven density with mottled calcification and peripheral thin marginal enhancement with central low density [35] (Table 2). However, CT results are also nonspecific because distinguishing ET lesions from other inflammatory and malignant lesions can be challenging. Nonetheless, lymph node masses in lung lesions and the remaining traces of other forms of tuberculosis can aid in the diagnosis [9].

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**Table 1** Differences of primary and secondary esophageal tuberculosis

<table>
<thead>
<tr>
<th>Classification</th>
<th>Direct causes</th>
<th>Etiology</th>
<th>Frequency</th>
<th>Extra-ET</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary ET</strong></td>
<td>Swallow food containing tuberculosis bacilli</td>
<td><em>Mycobacterium tuberculosis</em> invades the esophagus whose protective barrier has been compromised.</td>
<td>Uncommon</td>
<td>Absence</td>
<td>[15, 17–20]</td>
</tr>
<tr>
<td><strong>Secondary ET</strong></td>
<td>Secondary to tuberculosis foci in adjacent organs</td>
<td>Tuberculosis pathogens spread directly from adjacent tuberculosis foci to the esophagus.</td>
<td>Common</td>
<td>Present</td>
<td>[1, 4, 21–23]</td>
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</table>

ET, esophageal tuberculosis.
Table 2: The advantages and drawbacks of imaging examinations

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Drawbacks</th>
<th>Reference</th>
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<tbody>
<tr>
<td>X-ray</td>
<td>It can show signs like pulmonary TB lesions and swollen mediastinal lymph nodes.</td>
<td>It lacks specificity due to imaging conditions and overlapping images.</td>
</tr>
<tr>
<td>Barium esophagography</td>
<td>It can be used to directly observe the manifestations of esophageal stricture, obstruction, and ulcers.</td>
<td>It has been largely replaced by EGD and CT.</td>
</tr>
<tr>
<td>CT</td>
<td>It is a non-invasive diagnostic method that can accurately display lesions of the esophageal wall, adjacent tissues, and organs.</td>
<td>It is difficult to distinguish ET lesions from other inflammatory and malignant lesions</td>
</tr>
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ET, esophageal tuberculosis; EGD, esophagogastroduodenoscopy; CT, computed tomography.

EGD

EGD is a crucial method for diagnosing ET. In cases where ET is suspected, EGD facilitates the direct visualization of alterations in the esophageal lining, such as ulcers, granulomas, and strictures, enabling physicians to assess the extent, scope, and severity of lesions. ET demonstrates a variety of appearances on gastrointestinal tract, which may include ulceration, bulging, external pressure stenosis, and sinuses, with ulceration and bulging being more common. The occurrence of ulcerated ET (Figure 1B1) is predominantly observed in the middle segment of the esophagus. Progression of the disease leads to necrosis of tuberculous bacilli and infiltrating cells within the granuloma, forming a caseous granuloma. Consequently, the ulcer collapses into the lumen, typically presenting as a linear ulcer with irregular borders and gray membranous necrosis visible at the base. Large and deep ulcers may tend to bleed, and in some cases, ulcers may invade the aorta, causing fatal hemorrhage. Bulging ET is categorized into internal protrusion and exogenous compression. The surface of a bulging lesion is smooth (Figure 1A1, C1), with ulcers, erosion (Figure 1D1), and sinus tracts often observed [8, 10, 40, 41]. A distinctive characteristic is the fibrosis of the esophageal wall, forming a pseudotumor that protrudes into the lumen, which can lead to esophageal stenosis. Bulging lymph nodes may also compress the esophagus, manifesting as exogenous bulging. Mediastinal fibrosis can compress the esophagus, causing exogenous bulging or pulling of a diverticulum. Such bulging lesions, when resulting in luminal stenosis, often lead to varying degrees of dysphagia. Combined with weight loss, these symptoms can be easily mistaken for esophageal cancer. EGD also allows for biopsy sampling for pathological examination, playing a vital role in enhancing diagnostic accuracy. However, visual examination via EGD does not guarantee absolute accuracy. For instance, initial and atypical cases of ET may be challenging to diagnose solely by endoscopic examination. When endoscopic lesions appear bulging, they can be mistaken for submucosal esophageal masses, such as leiomyomas. Conversely, when lesions present as ulcerative, they can be confused with ulcerative esophageal carcinoma [8, 9]. Therefore, although EGD plays a significant role in diagnosing ET, it should be complemented with other diagnostic means, such as clinical presentation, blood tests, and imaging examinations, to improve the accuracy and comprehensiveness of the diagnosis.

Histopathology

The definitive clinical diagnosis of ET relies on specimens from esophageal lesions or pathogenetic examinations. Access to these specimens is often via endoscopic biopsy or direct surgical methods. Endoscopic specimens are primarily obtained through the resection of the esophageal mucosa with biopsy forceps or via endoscopic ultrasonography-guided fine-needle aspiration (EUS-FNA). Generally, in clinical practice, direct excision of the esophageal mucosa using biopsy forceps is preferred. This method is not only straightforward to perform but also more cost-effective for obtaining specimens. Characteristic tuberculosis lesions caused by Mycobacterium tuberculosis manifest as epithelioid granulomas or as presenting central granular caseous necrosis – surrounded by aggregates of macrophages, epithelial cells, and Langhans giant cells, with varying degrees of central caseous necrosis. However, classic granulomatous lesions are uncommon, possibly due to the fact that classic granulomas are typically located in the submucosa, a region that endoscopic biopsies often find challenging to reach [46, 47]. As a result, the positivity rate of biopsies using biopsy forceps is relatively low, and multiple biopsies from different sites are usually required to increase the detection rate [21, 48, 49]. In contrast, EUS-FNA is a more effective sampling method, featuring high specificity and sensitivity [9, 18, 24, 37, 49]. This technique can acquire tissue from subglottic, paratracheal, and mediastinal lymph nodes – all critical areas for biopsy in most cases of secondary ET. EUS-FNA allows precise localization of the lesion and enables simultaneous use of ultrasound and endoscopic guidance, facilitating fine-needle aspiration of deep tissue specimens. This approach has led to an improvement in the positive biopsy rate [37].

EUS features of ET

EUS reveals that ET often presents as localized or widespread esophageal wall thickening (Figure 1A2), likely due to the inflammatory response of the esophageal wall and the formation of tuberculous foci [10, 18, 47, 51]. This thickening may involve fracture, loss, or blurring of some or all layers of the esophageal wall (Figure 1B2). Lesions typically appear homogeneous or heterogeneous with hypoechoic or mixed echogenicity (Figure 1D2), accompanied by a disrupted outer membrane [37, 41, 51]. Within these areas, punctate or striated hyperechoic patterns can be observed (Figure 1C2), often with indistinct borders and potentially surrounded by an inflammatory response [52, 53]. Tubular hypoechoic structures within some lesions suggest the formation of sinus tracts [54]. Additionally, ET may lead to the development of abscesses or fluid-filled regions, which appear as anechoic or hypoechoic on EUS [37, 53]. ET frequently causes enlargement of lymph nodes around the esophagus. These enlarged lymph nodes, observable in the para-esophageal or mediastinal regions, tend to be closely adhered to the esophageal wall, appear hypoechoic, and may present with well-defined or ill-defined borders [51, 53]. Inside these lymph nodes, hyperechoic shadows, suggestive of dispersed calcification foci, can be detected [53]. Puri R and colleagues described the progression of lymph node tuberculosis in four stages [18]. In the first stage, the lesion displays a homogeneous hypoechoic appearance on EUS due to dense capillaries and an abundance of lymphocytes with minimal casation. In stages II and III, punctate or linear hyperechoic patterns within the hypoechoic tissue manifest due to caseation and the disruption of the outer membrane; these patterns may represent calcification foci [51]. The fourth stage involves the release of caseous material and the development of a resultant cavity with a distinct linear, echo-free area that traverses the esophageal wall and extramural lymph nodes, a finding rarely seen in the mediastinum [52, 55]. Repeated EUS exams submit a manuscript: https://www.tnpjournals.com/ghr
enable the observation of ET progression and facilitate the assessment of treatment efficacy and prognosis.

**Differential diagnosis by EUS**

**Esophageal cancer**

ET and esophageal cancer share similarities in clinical presentation; for instance, both conditions can present with persistent difficulty eating, painful swallowing, and weight loss [2, 7, 29, 35]. Some imaging characteristics of ET and esophageal cancer, such as the area and shape of the lesion, may appear similar during imaging examinations, including X-ray and CT scans. This ambiguity can make it challenging to differentiate between the two based solely on a single imaging finding [2, 7, 35]. ET is relatively rare, and when an EGD reveals an ulcerative lesion, it can closely resemble ulcerative esophageal cancer, leading clinicians to often consider esophageal cancer as the primary diagnosis [8, 9]. This inclination can result in misdiagnosis or missed diagnosis of ET [7–9]. EUS can provide an effective differential diagnosis by detailing the hierarchical structure of the esophageal wall, the internal echogenicity of the lesion, and the surrounding extramural lymph nodes. Key distinguishing features on EUS include the following: esophageal cancer lesions typically originate from the mucosal layer, and the lesions or metastatic lymph nodes present as inhomogeneous hypoechoic masses without punctate or striated hyperechoic areas—characteristics often seen in ET lesions [10, 56]. Additionally, lymph nodes involved in mediastinal metastasis from esophageal cancer are generally round or oval, whereas ET-related lymph nodes appear irregular in shape, with blurred borders and partial fusion. Lymph nodes from mediastinal metastases of esophageal cancer tend not to adhere tightly to the esophageal outer membrane, so most of the outer membrane will not appear thickened [52]. In contrast, esophageal wall lesions in ET may coincide with enlarged para-esophageal lymph nodes, and thickening of the esophageal outer membrane is often observed [57] (Table 3). These features can significantly assist in the differential diagnosis with ET. Therefore, when distinguishing between ET and esophageal cancer, it is crucial to analyze the endoscopic characteristics of the patient, the origin of the lesion under EUS, the echogenic properties of the lesion, and its relationship to surrounding tissues in detail to correctly differentiate between the two conditions.

![Figure 1 EGD and EUS images were obtained from four patients diagnosed with ET at the First Affiliated Hospital of Xinjiang Medical University. Those with corner marker 1 are EGD images and those with corner marker 2 are EUS images.](image-url)

<table>
<thead>
<tr>
<th>Table 3 Key points in differentiating ET from esophageal cancer and esophageal leiomyoma</th>
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<tr>
<td><strong>EUS findings</strong></td>
</tr>
<tr>
<td>Lesions mostly originate from the submucosa.</td>
</tr>
<tr>
<td>The lesions tend to be heterogeneously hypoechoic or mixed echoes with irregular borders.</td>
</tr>
<tr>
<td>Dotate hyperechoic areas are frequently observed in lesions.</td>
</tr>
<tr>
<td>Lesions can be associated with paraesophageal lymph node enlargement.</td>
</tr>
<tr>
<td>The outer esophageal membrane can be thickened.</td>
</tr>
<tr>
<td>Lesions commonly arise from the esophageal mucosal layer.</td>
</tr>
<tr>
<td>The lesions tend to be heterogeneously hypoechoic.</td>
</tr>
<tr>
<td>There are no punctate or striated areas of hyperechoic within the lesion.</td>
</tr>
<tr>
<td>The metastatic lymph nodes often do not fit closely to the outer esophageal membrane.</td>
</tr>
<tr>
<td>The outer esophageal membrane is mostly unthickened.</td>
</tr>
<tr>
<td>Lesions generally originate from the lamina propria or muscularis mucosa of the esophagus.</td>
</tr>
<tr>
<td>The lesions mostly showed uniformly hypoechoic, boundary rules, and often semicircle or elliptic.</td>
</tr>
<tr>
<td><strong>Esophageal leiomyoma</strong></td>
</tr>
<tr>
<td>There are no punctate or striated areas of hyperechoic within the lesion.</td>
</tr>
<tr>
<td>Absence of enlarged lymph nodes.</td>
</tr>
<tr>
<td>The outer esophageal membrane is unthickened.</td>
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</tbody>
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EUS, endoscopic ultrasonography.
Esophageal submucosal tumors

When observing the patient’s lesion under EGD, if the nodule has not penetrated the mucosal layer, it may only manifest as a submucosal bulge with a smooth surface and pronounced prominence. This presentation, coupled with the symptom of dysphagia, makes it challenging to differentiate it from esophageal submucosal tumors. The inability of plain EGD to ascertain the lesion’s size, origin, and relationship with surrounding tissues makes it highly prone to misdiagnosis [58]. Conversely, EUS plays a significant role in diagnosing esophageal submucosal tumors [59]. Esophageal leiomyomas are the most common benign tumors among esophageal submucosal tumors, typically originating from the lamina propria of the esophagus but also partially from the mucosal muscular layer [60]. These lesions tend to appear homogeneous and hypoechoic, with regular borders, often semicircular or oval. Additionally, normal mediastinal lymph nodes and no thickening of the outer membrane are generally observed [8, 41, 58, 59, 61]. In contrast, most cases of ET originate in the submucosal layer, with the lesion tending to be hypoechoic or of mixed echogenicity. Hypoechoic dots or streaks may be present within the lesion. ET is often secondary to mediastinal lymph nodes, leading to irregular borders and lesions appearing as irregular foci [37, 41, 51]. The esophageal wall typically exhibits uniform thickening, along with thickening of the outer membrane, and enlarged lymph nodes are often observed in the mediastinal region. In comparison, patients with esophageal leiomyomas almost lack enlarged lymph nodes in the mediastinum [41] (Table 3). When EGD fails to further differentiate ET from esophageal leiomyomas, EUS can be employed for additional clarification. However, differentiation becomes challenging when encountering certain malignant submucosal tumors, such as smooth muscle sarcoma and neurofibrosarcoma, which tend to have poorly defined borders and extensive infiltration, thus potentially being confused with ET [37]. Given these circumstances, EUS-FNA plays a crucial role in clarifying the diagnosis.

Other esophageal diseases

Esophageal Crohn’s disease and nodular disease are conditions that can be easily confused with ET during diagnosis [8]. Laube et al. reported the prevalence of esophageal Crohn’s disease to be only 0.3%-10% [62]. Esophageal Crohn’s disease shows heterogeneous echogenicity on EUS, with disruption of the five-layered structure of the esophageal wall, and extra-esophageal lymph nodes may be hyperplastic, which tend to be hypoechoic. These features are difficult to differentiate from ET, and therefore, the differential diagnosis relies on the observation of patients with extra-intestinal manifestations or typical ileocecal ulcers [8, 62, 63]. Nodular disease, a noncaseating necrotizing granulomatous disorder that affects multiple organs, most often the lungs and mediastinal lymph nodes, presents distinctively in EUS [64]. Mediastinal lymph nodes associated with nodular disease appear isoechoic, well-marginated, and aggregated, thus providing a basis for EUS to be an effective discriminator between nodular disease and ET [65, 66].

Limitations of EUS in the diagnosis of ET and ideas for improvement

EUS may not provide complete visualization of certain regions of the deep esophagus, especially when inflammation, bleeding, or other pathological changes are present. Both conventional EUS and high-frequency ultrasound devices have limitations in image resolution, which can hinder the accurate identification and characterization of small lesions. The quality of ultrasound images, and thus the diagnostic results, may also be affected by poor patient cooperation, the inability to suppress coughing, rapid breathing, excessive tension, and other factors. EUS can cause discomfort for some patients. Furthermore, the cost of equipment and operation may restrict the widespread adoption and application of EUS in some regions and medical institutions. Additionally, the diagnostic results from EUS depend significantly on the operator’s skill and experience, presenting challenges for less experienced practitioners.

To address these issues, we propose the following improvements: Training and education for physicians and related professionals on the proper use and interpretation of EUS could enhance the examination’s accuracy and reliability. Sharing case studies and experiences in diagnosing ET through academic exchanges and seminars can improve doctors’ knowledge and disease awareness, thereby boosting their diagnostic skills. Forming multidisciplinary diagnostic teams that include specialists from gastroenterology, thoracic surgery, imaging, pathology, and other relevant fields to participate in the diagnosis and treatment of patients with ET could enhance diagnostic precision and treatment outcomes. Establishing a comprehensive diagnostic process for ET, which incorporates clinical manifestations, laboratory tests, imaging studies, and additional data, can ensure diagnostic accuracy. For patients with suspected ET, the development of appropriate diagnostic and treatment guidelines and recommendations is crucial for guiding clinical practice.

Hopes for the development of EUS for the diagnosis of ET

The landscape of medical diagnostics is rapidly evolving, with cutting-edge advancements paving the way for more sophisticated and efficient methodologies, particularly in the realm of remote diagnosis and treatment of diseases such as ET [67]. The integration of telemedicine with ET technology epitomizes this progress, offering the potential to transcend geographical barriers and bring advanced medical services to remote or resource-poor areas, thereby enhancing healthcare efficiency and reducing patient waiting times. Furthermore, the advent of artificial intelligence and machine learning has given rise to intelligent identification systems that, when paired with EUS, have shown remarkable effectiveness in diagnosing certain digestive diseases [68-70]. It is envisaged that artificial intelligence-enhanced EUS will soon be capable of automatically recognizing and analyzing esophageal tuberculosis images, thus significantly improving the accuracy and speed of diagnoses.

Moreover, the application of three-dimensional reconstruction technology in endoscopy, including its future integration into EUS, promises to revolutionize the diagnosis of ET by offering a clearer and more intuitive visualization of the esophageal structure [71, 72]. This advancement will not only facilitate a more convenient observation by doctors but also improve the evaluation of esophageal lesions. Additionally, contrast-enhanced harmonic endoscopic ultrasonography is emerging as a pivotal tool in assessing the blood flow and vascular structure of ET lesions. This technique aids in distinguishing between benign and malignant lesions and is anticipated to become an essential component of EUS in the diagnosis of ET [8]. Collectively, these innovations highlight a future where the diagnosis of esophageal tuberculosis and similar conditions will be markedly more accurate, swift, and accessible.

Discussion

This review offers a comprehensive examination of the epidemiologic features, pathogenesis, clinical manifestations, and diagnostic methods of ET. ET is a relatively rare tuberculous lesion with diverse clinical presentations that can easily be misdiagnosed or missed. Thus, a deep understanding of ET’s characteristics is crucial for improving diagnostic accuracy and developing effective treatment plans. This article also focuses on the features of ET as observed under EUS and provides an in-depth review of the role of EUS in diagnosing ET, including current methods and research. Through our analysis, we have underscored the significance of EUS in the diagnosis of ET, particularly in enhancing diagnostic precision and reducing the rates of misdiagnosis and missed diagnoses. Although EUS has made considerable progress in diagnosing ET, it still confronts various challenges, such as standardization of techniques, procedural norms, and minimally invasive operations. Looking forward, we anticipate further innovations in hardware, software algorithms, and intelligent recognition systems, as well as efforts to broaden the accessibility of

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EUS to enhance the accuracy and efficiency of ET diagnosis. Moreover, we envisage that in the forthcoming years, EUS will be integrated with other advanced technologies for the precise diagnosis of ET, personalized treatment, and ongoing disease management. It is our hope that through continued research, practice, and innovation, EUS technology will increasingly offer more accurate diagnoses, more effective treatments, and improved quality of life for patients with ET.

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