

Incidental Discovery of Tracheal Diverticulum During Thyroidectomy: A Report of Seven Cases

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Wen He^{1,†}, Liyu Qian^{2,†}, Rongli Xie³, Jianhua Gu⁴, Xujian Xing⁵, Dongjie Shen³, Min Ding³, Dan Xu³, Donghang Huang⁶, Jing Fang⁷, Jian Fei⁸

¹General Surgery Department, United Family Hospital, 200335 Shanghai, China

²Department of Surgical Oncology, The First Affiliated Hospital of Bengbu Medical College, 233000 Bengbu, Anhui, China

³Department of General Surgery, Ruijin Hospital Lu Wan Branch, Shanghai Jiao Tong University School of Medicine, 200020 Shanghai, China

⁴Department of General Surgery, Integrated Traditional and Western Medicine Hospital of Huangpu District, 200010 Shanghai, China

⁵Department of General Surgery, Shanghai International Medical Center, 201315 Shanghai, China

⁶Department of Thyroid and Hernia Surgery, Fuzhou University Affiliated Provincial Hospital, School of Medicine, Fuzhou University, 350001 Fuzhou, Fujian, China

⁷Department of General Surgery, The Second Affiliated Hospital of Anhui Medical University, 230601 Hefei, Anhui, China

⁸Department of General Surgery, Ruijin Hospital, Shanghai Jiao Tong University School of Medicine, 200020 Shanghai, China

AIM: Tracheal diverticulum, an air-filled sac typically located on the right posterolateral aspect of the trachea, has an unclear etiology. This study evaluates the clinical management and outcomes of incidentally detected tracheal diverticula in patients with papillary thyroid carcinoma, emphasizing the need for preoperative diagnosis and selective treatment.

CASE PRESENTATION: Within our multi-center thyroid surgery cohort, seven cases of tracheal diverticula were incidentally discovered during thyroidectomy, with preoperative diagnosis achieved in only a subset of patients. Some tracheal diverticula were surgically excised, allowing for histopathological examination, whereas others were left *in situ*. All patients recovered without postoperative complications.

RESULTS: Histopathological examination of the resected tracheal diverticula confirmed benign pathology. All patients, including those with untreated tracheal diverticula, remained asymptomatic during follow-up, with no tracheal abnormalities or complications observed. High-resolution computed tomography and three-dimensional reconstruction technology proved effective for the preoperative diagnosis of tracheal diverticulum.

CONCLUSIONS: Routine surgical treatment is unnecessary for asymptomatic patients, with resection of tracheal diverticulum reserved for symptomatic cases. Diagnostic approaches such as high-resolution computed tomography and three-dimensional reconstruction serve as essential preoperative assessments before thyroidectomy, enabling accurate diagnosis of tracheal diverticulum.

Keywords: tracheal diverticulum; thyroidectomy; case report; papillary thyroid carcinoma; diagnosis

Introduction

Tracheal diverticulum (TD) is a relatively rare condition characterized by the weakening or protrusion of the tracheal wall, resulting in the formation of a pouch or diverticulum. This condition presents unique challenges during surgical procedures, particularly thyroid surgeries, where the

proximity of the diverticulum to critical structures such as the trachea and esophagus can complicate operative management. The significance of accurately identifying tracheal diverticula prior to and during thyroid surgery cannot be, as misdiagnosis or failure to recognize these structures may result in severe intraoperative complications, including pneumothorax, mediastinal emphysema, or even catastrophic airway injuries.

The global coronavirus disease 2019 (COVID-19) pandemic has led to an increase in routine preoperative chest computed tomography (CT) scans, subsequently improving the detection rate of TD [1]. As thyroid surgery continues to advance and imaging technologies evolve, there is an increasing need to deepen our understanding of tracheal diverticula and their implications for surgical practice [2]. We present case reports that highlight the potential implications of TD in thyroid surgery, focusing on preoperative and intraoperative identification methods and relevant

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Correspondence to: Donghang Huang, Department of Thyroid and Hernia Surgery, Fuzhou University Affiliated Provincial Hospital, School of Medicine, Fuzhou University, 350001 Fuzhou, Fujian, China (e-mail: hdh29@qq.com); Jing Fang, Department of General Surgery, The Second Affiliated Hospital of Anhui Medical University, 230601 Hefei, Anhui, China (e-mail: fangjing1645@sina.com).

[†] These authors contributed equally.

Table 1. Summary of seven newly reported cases of tracheal diverticulum associated with papillary thyroid carcinoma.

Case	Age (years)/sex	Size (mm)	Symptoms	Discovery method	Operative method	Preoperative diagnosis	Resection	Adverse events
1	70/F	10 × 5	–	CT	Open thyroidectomy	+	–	–
2	35/F	20 × 15 × 10	–	CT	Open thyroidectomy	+	–	–
3	37/F	18 × 15	–	CT	Open thyroidectomy	+	–	–
4	46/F	No record	–	Intraoperative	SPEAT	–	+	–
5	47/F	10 × 10	–	Intraoperative	SPEAT	–	+	–
6	26/M	7 × 5	–	CT	TOETVA	–	–	–
7	54/F	15 × 10	–	CT	TOETVA	–	–	–

Abbreviations: CT, computed tomography; F, female; M, male; SPEAT, single-port endoscopy-assisted thyroidectomy via the cervical gas-insufflation approach; TOETVA, transoral endoscopic thyroidectomy vestibular approach; +, yes; –, none reported.

advancements in clinical research. The aim is to elevate surgeons' awareness of TD, optimize surgical approaches, and reduce operative risks. Additionally, this review underscores the significance of routine preoperative CT examinations in thyroid surgery. This report describes seven recent cases of thyroid nodules associated with TD and discusses the diagnosis and treatment of this condition.

This case has been reported in line with the case report guidelines: Case Report (CARE) Guidelines to ensure the accuracy and completeness of the report (**Supplementary Material**).

Case Report

We present seven cases of asymptomatic TD incidentally found in patients with papillary thyroid carcinoma (PTC). None of the patients had a medical history of chronic cough or pulmonary disease. Resection of the TD was not performed during thyroidectomy in five patients, whose postoperative courses were uneventful. A summary of these cases is presented in Table 1.

Case 1

A 70-year-old woman was admitted to Shanghai International Medical Center (SIMC) in 2021, where bilateral thyroid nodules were detected during a routine physical examination. Ultrasonography revealed right-sided parenchymal thyroid nodules with multiple calcifications (Thyroid Imaging Reporting and Data System category 4a). An ultrasound-guided fine-needle aspiration biopsy (FNAB) suggested papillary thyroid carcinoma. A contrast-enhanced neck CT scan confirmed an air cavity lesion behind the cervical tracheal segment, possibly a tracheal cyst (Fig. 1A). Total thyroidectomy was performed under general anesthesia. During surgery, while excising the lymph nodes in the right central compartment, an elliptical nodule (10 × 5 mm) was observed on the posterior surface of the trachea (Fig. 1B). It resembled a lymph node and felt slightly hollow upon palpation. Based on the preoperative imaging findings, this was identified as a tracheal diverticulum. No treatment for the TD was administered, as the patient had no history of choking, respiratory difficulty, in-

flammation, or other related conditions. Follow-up at 1 and 6 months postoperatively revealed no significant abnormalities.

Case 2

A 35-year-old woman with left-sided PTC was referred to SIMC on 18 April 2023. A preoperative neck CT scan revealed low-density nodular opacities at the thoracic inlet on the right posterolateral side of the trachea, measuring approximately 20 × 15 × 10 mm (Fig. 2). These lesions were not excised during hemithyroidectomy. The 3-month postoperative follow-up revealed no abnormalities.

Case 3

A 37-year-old woman incidentally discovered a mass on the right side of her neck over one month before presentation to SIMC on 7 November 2023. FNAB at a local hospital confirmed PTC with lymph node metastasis on the right side of the neck. The patient was subsequently admitted to SIMC for further evaluation and treatment. A preoperative neck CT scan revealed a radiolucent shadow posterior to the right side of the trachea at the thoracic inlet, measuring approximately 18 × 15 mm (Fig. 3), with apparent communication with the apex of the lung. Given the absence of symptoms such as neck inflammation, coughing, or choking, no further intervention for the TD was performed. Preoperative CT imaging provided an early warning, enabling cautionary measures during central lymph node dissection to prevent pneumothorax (Fig. 4). The 3-month postoperative follow-up revealed no abnormalities.

Case 4

A 46-year-old woman with PTC presented to Fujian Provincial Hospital on 24 June 2022. No routine preoperative contrast-enhanced neck CT scan was performed. During single-port endoscopy-assisted thyroidectomy via the cervical gas-insufflation approach (SPEAT, also known as the Huang procedure) [3], a cystic lesion was identified originating from the posterior aspect of the right tracheal wall. Intraoperative neuromonitoring (IONM) confirmed that the recurrent laryngeal nerve (RLN) was not involved. The diverticular base was suture-ligated with 4-0 Vicryl, followed

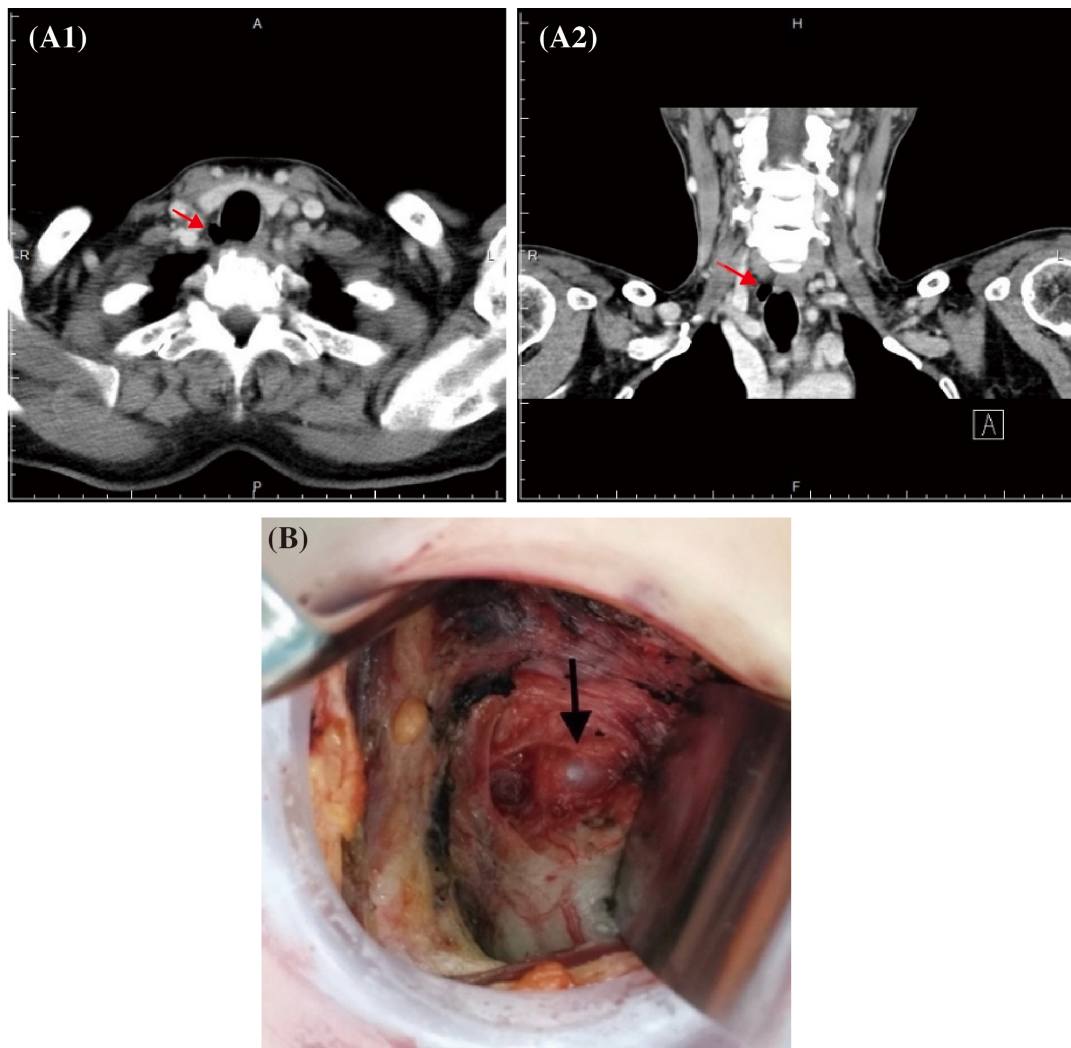


Fig. 1. Radiographic and intraoperative findings of a tracheal diverticulum. (A1) Axial view of a contrast-enhanced neck computed tomography (CT) showing an air-filled cyst (red arrow) located posterior to the right thyroid lobe and communicating with the trachea. (A2) Coronal view of a contrast-enhanced neck CT showing an air-filled cyst (red arrow) communicating with the trachea. (B) Intraoperative view identifying the exposed tracheal diverticulum (black arrow).

by complete excision of the cystic sac. Final pathology confirmed TD without malignant features. Postoperative histology indicated a bronchogenic origin of the cyst, confirming it as a TD. There were no postoperative complications, and the 3-month follow-up was unremarkable.

Case 5

Similar to the patient in Case 4, a 47-year-old woman with PTC presented to Fujian Provincial Hospital on 8 December 2021. No routine preoperative contrast-enhanced neck CT scan was performed. During SPEAT, a grey-white cyst with a maximum diameter of 1 cm was identified on the posterior right aspect of the trachea. Building on prior technical experience, we implemented an identical protocol: IONM confirmed no adhesion to the recurrent laryngeal nerve, followed by suture ligation of the cyst base and complete resection. Pathological findings were consistent with a cyst of

foregut origin, confirming it as TD. No postoperative complications were observed. Clinical follow-up at 6 months revealed no signs of recurrence.

Case 6

A 26-year-old man with bilateral PTC presented on 28 November 2022, to the Department of Oncology Surgery at the First Affiliated Hospital of Bengbu Medical College. To treat the PTC, the patient underwent total thyroidectomy with central compartment lymph node dissection using the transoral endoscopic thyroidectomy vestibular approach (TOETVA). During surgery, while clearing the central compartment lymph nodes, a cystic mass measuring approximately 7×5 mm was found posterior to the right side of the trachea. A preoperative contrast-enhanced neck CT scan had revealed a tracheal cyst. As the patient had no related complaints, no additional intervention for the cyst



Fig. 2. Preoperative neck CT scan. Axial and coronal views of a contrast-enhanced CT scan showing an air-filled cyst (red arrows) located posterior to the right thyroid lobe and communicating with the trachea.

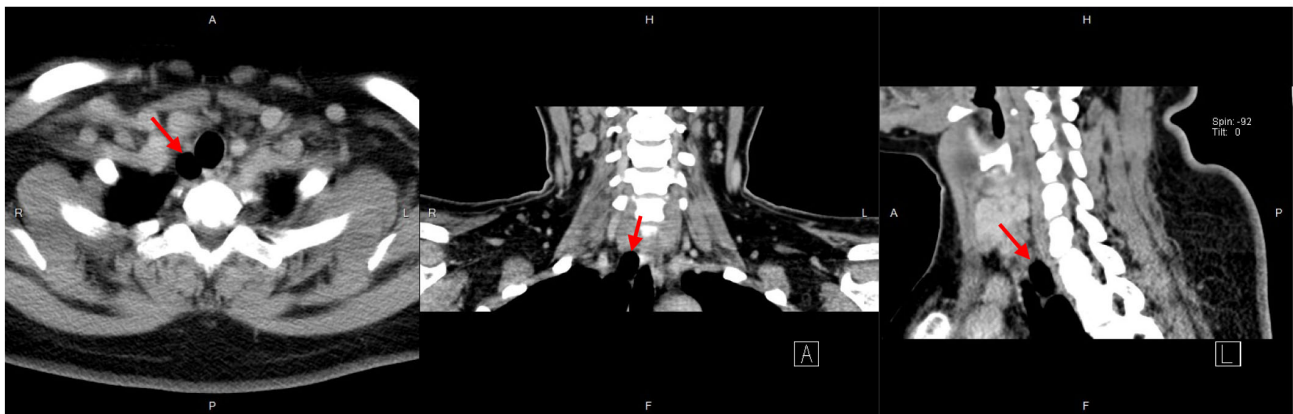


Fig. 3. Preoperative neck CT scan. Axial, coronal, and sagittal views of a contrast-enhanced neck CT scan showing an air-filled cyst (red arrows) located posterior to the right thyroid lobe and communicating with the trachea.

was performed during surgery. At the 2-month follow-up, the patient remained asymptomatic.

Case 7

Similar to the patient in Case 6, a 54-year-old woman with PTC was admitted to the First Affiliated Hospital of the University of Science and Technology of China on 6 July 2022. She subsequently underwent TOETVA. During the procedure, a mass measuring approximately 15×10 mm was identified on the posterior right side of the trachea. The preoperative contrast-enhanced CT neck scan suggested the possibility of a TD. No additional interventions for the TD were performed during surgery.

Discussion

The pathogenesis and etiology of TD, which constitutes the majority of paratracheal air cysts [4,5], remain incompletely understood, though evidence supports both congenital and

acquired origins. Congenital TDs are attributed to developmental anomalies during embryogenesis, potentially involving aberrant development of the 4th–6th branchial arches. Proposed mechanisms include persistent supernumerary lung buds, incomplete tracheoesophageal septum fusion, or defective tracheal cartilage rings leading to focal structural weakness [6]. In contrast, acquired TDs result from chronically elevated intratracheal pressure, causing mucosal herniation through structurally vulnerable regions of the tracheal wall, typically the right posterolateral wall between cartilaginous rings [7]. This pathophysiology is strongly linked to conditions producing repetitive cough-induced pressure surges, such as chronic obstructive pulmonary disease (COPD), asthma, and chronic bronchitis [7]. Iatrogenic factors like prolonged intubation or tracheostomy, causing localized trauma, are also established contributors [8], as are occupations involving excessive vocal exertion or sustained pulmonary effort [4]. Thus, TD

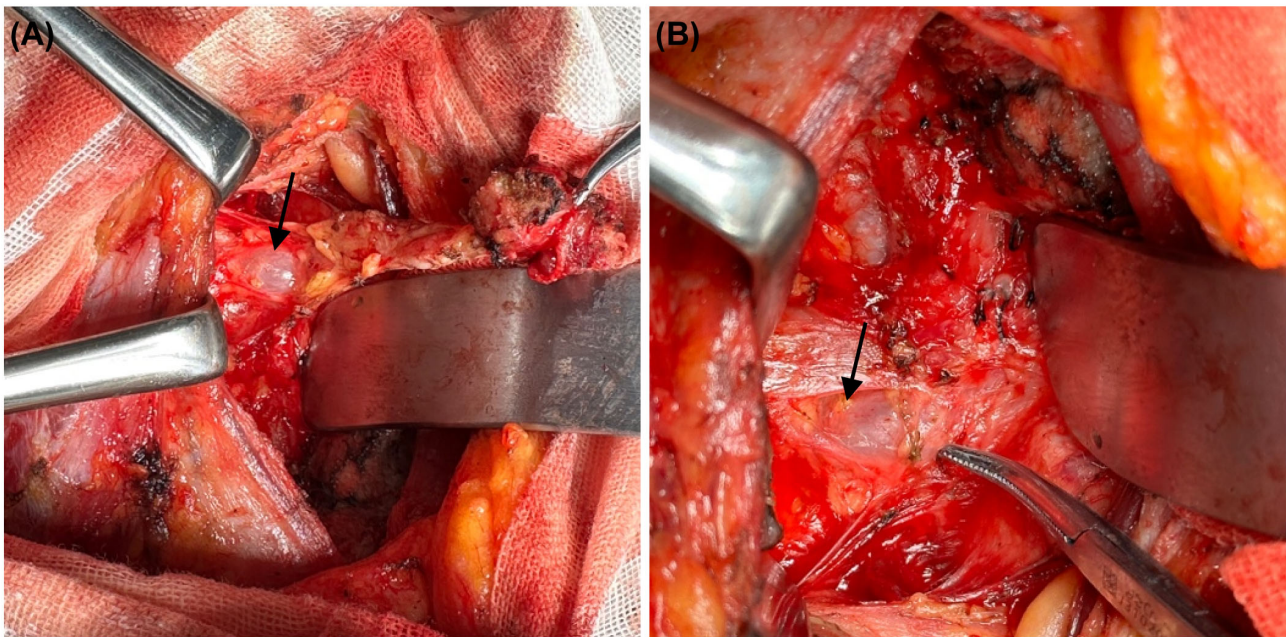


Fig. 4. Intraoperative findings during right neck dissection (level IV). (A) During lymph node dissection, the wall of the tracheal diverticulum (black arrow) is identified after lifting the mass, which expands and contracts with ventilation. (B) Operative field following completion of cervical lymph node dissection, tracheal diverticulum preserved in situ (black arrow).

formation generally arises from a convergence of intrinsic structural vulnerability and sustained pressure gradients. The incidence of TD in the general population ranges from 2% to 3.7% [6,9]. It is commonly observed in individuals aged 50–60 years [10–12], with a higher occurrence in women than in men [9,10,13,14]. The axial size of a diverticulum ranges from 1 to 30 mm, and its vertical dimension typically measures 5 to 25 mm [6,9,15]. A diverticulum with a diameter of 2–6 mm is generally considered a small TD. Approximately 97% of these diverticula are solitary [16], whereas only 1.3% of cases involve multiple diverticula [17]. Approximately 98% of TDs are located on the right posterolateral side of the trachea, most commonly between the T1 and T2 vertebrae at the thoracic inlet. This distribution can be explained by the relative anatomical positions of the trachea, esophagus, and aorta, where the esophagus and aorta provide supportive reinforcement to the left posterolateral tracheal wall, while support on the right posterolateral side is comparatively weaker [8,16–19].

The diagnostic landscape for TD has evolved significantly with advancements in imaging technology. CT has emerged as the most sensitive imaging modality for TD detection, with a sensitivity of up to 95% [20]. This high sensitivity is crucial for preoperative planning, as unrecognized diverticula may result in severe complications during surgical procedures, especially in thoracic surgeries. In contrast, conventional ultrasound demonstrates a detection rate below 30%, highlighting its limitations in visualizing the tracheal wall and adjacent structures [20]. While ultrasound remains useful for some applications, its inability to provide

a comprehensive assessment renders it less effective for TD diagnosis. Magnetic resonance imaging (MRI) has unique value in evaluating the spatial relationship between the diverticulum and surrounding critical anatomical structures, such as the recurrent laryngeal nerve [21]. Its radiation-free nature and superior soft tissue contrast make it an invaluable tool, particularly in patients with complex anatomical considerations or those requiring repeated imaging. However, MRI use in routine TD diagnosis remains limited due to cost, accessibility, and the need for specialized expertise. Under China's diagnosis-related groups (DRG) and diagnosis-intervention packet payment system [22–25], as well as in most commercial health insurance plans, MRI is excluded from standard preoperative assessments for thyroid surgery. Therefore, while CT remains the gold standard for initial diagnosis, MRI offers complementary insights in specific clinical scenarios. Integrating of these imaging modalities into a comprehensive diagnostic framework is essential to optimize patient outcomes and minimize intraoperative risks associated with TD.

In the management of TD, conservative treatment is generally preferred for asymptomatic or small diverticula. Regular follow-up with CT or MRI allows monitoring of key parameters, including diverticulum size, morphology, and associated complications. This proactive approach helps to prevent potential complications, such as respiratory infections or airway obstruction, that may arise from untreated diverticula. Surgical intervention may be warranted if imaging reveals significant tracheal compression or recurrent episodes of pneumonia linked to the diverticulum.

Table 2. Reported cases of tracheal diverticulum over the past 10 years, with the initial diagnosis and treatment approaches.

First author/year	Age (years)/sex	Size (mm)	Primary diagnosis	Symptoms	Discovery method	Operative method	Treatment	Complications
Wan [1], 2023	59/F	22 × 14 × 17	Right thyroid nodules	–	CT	Right thyroidectomy	Untreated (the right posterior TD not identified intraoperatively)	None
Lu [29], 2022	27/F	N/A	Parathyroid adenoma	–	CT	Parathyroidectomy	Untreated	None
Kim [30], 2021	68/F	23	PTC	–	CT	Bilateral total thyroidectomy with ipsilateral central compartment neck dissection	Resection	None
Ellis [31], 2019	20s*/M	42.16 × 18.9	Lymphoma	–	CT	Lateral cervical approach	Resection	None
Yagyu [26], 2017	70/M	13 × 13	Esophageal cancer	–	During surgery and preoperative CT	Thoracoscopic subtotal esophagectomy	Resection (using a linear stapler)	None
Okumura [27], 2021	71/M	11	Esophageal cancer	–	CT	Thoracoscopic esophagectomy	Untreated	None
	73/M	14	Esophageal cancer	–	CT	Thoracoscopic esophagectomy	Untreated	None
	76/M	19	Esophageal cancer	–	CT	Thoracoscopic esophagectomy	Resection	None
Zhang [39], 2015	74/F	31 × 21	Esophageal cancer	Laryngeal friction and mucous sputum	CT	Thoracoscopic esophagectomy	Untreated	None
Maquet [32], 2020	22/F	33 × 29 × 35	Cough	Cough	CT (Valsalva maneuver) & tracheoscopy	N/A	Resection	None
Toscano [33], 2019	26/M	15	Respiratory tract infections	Hemoptysis	CT	N/A	Resection	Minor dysphonia (72 hours postoperatively)
Inam [17], 2019	61/F	24 × 20 × 11.7	Dysphagia		CT	N/A	Resection	None
Gao [34], 2019	61/F	40 × 50	Dysphagia and dizziness		CT	N/A	Interventional sclerotherapy, transcervical resection after recurrence	None
Rhee [35], 2016	59/M	25 × 20, 25 × 17	Voice change		CT	N/A	Resection	None
Chaudhry [28], 2014	54/F	30 × 40	Cough and hoarseness		CT	N/A	Resection	None
Garefis [36], 2023	63/M	33	COVID-19 positive	Tachypnea, decreased oxygen saturation	CT	N/A	Antibiotic, antiviral, and oxygen therapy	None
Kallel [37], 2022	14/M	11	Odynophagia		CT	N/A	3 months of follow-up (asymptomatic)	None
	28/F	9.6 × 6.9	Anterior neck mass	Pain, fever	CT	N/A	Resection after antibiotic therapy	None
Akabane [38], 2016	65/M	No record	Fever, lower neck pain, dyspnea		CT	N/A	Resection (emergency intubation & surgical abscess drainage)	None

*, patient age is expressed in years; “20s” indicates age between 20 and 29 years. Abbreviations: COVID-19, coronavirus disease 2019; PTC, papillary thyroid carcinoma; TD, tracheal diverticulum; –, none reported; N/A, not available.

Therefore, thorough imaging evaluation remains essential in guiding management decisions, especially in symptomatic patients [2].

In addition to reporting seven new cases of TD, we reviewed prior adult TD cases reported over the past 10 years [1,17,26–39]. The diagnostic and treatment modalities in these cases are summarized in Table 2 (Ref. [1,17,26–39]). These cases were initially diagnosed across different clinical departments. In surgical cases [1,26,27,29–31,39], patients were asymptomatic, and TD was incidentally discovered either during preoperative CT scans or intraoperatively. In thyroid-related surgeries [1,29], surgeons more frequently opted for non-intervention, whereas in esophageal cancer-related surgeries, synchronous excision was more common [26,27]. This is attributed to the need for clearance of para-recurrent laryngeal nerve lymph nodes during radical esophagectomy, which increases the likelihood of inadvertent injury to or synchronous excision of TD. Cases originating from the internal medicine department presented with various symptoms [17,28,32–38], most of which were compressive in nature, including chronic cough, dysphonia, stridor, dysphagia, palpable neck mass, and vocal fold paralysis [28]. However, physicians often did not initially consider TD based on routine clinical experience. Instead, TD was typically identified only after a series of internal medicine treatments failed, prompting further investigations. In all these cases, diagnosis was ultimately confirmed using CT imaging.

When TD is discovered preoperatively, surgery should be avoided if the patient has an active respiratory tract infection or if a foreign body is identified within the TD during bronchoscopy [39]. In the absence of contraindications for surgery, anesthesiologists must carefully account for TD during airway management [40,41]. If the distal end of the tracheal intubation tube comes into direct contact with the TD wall, it may lead to ineffective ventilation, trauma, or rupture of the TD. Furthermore, in cases of successful intubation with inadequate ventilation, considering the possibility of a TD-related complication is essential.

In the new cases presented in this report, we identified three critical clinical considerations. First, none of the patients with TD exhibited any symptoms, supporting its characterization as a benign lesion. Second, asymptomatic TD and thyroid nodules exhibited similar ultrasonographic features, including the presence of thyroid capsules, thyroid adenomas with calcification, and other overlapping characteristics. Symptomatic TD may present similarly to thyroid nodules, as compression of the vagus nerve leads to vagal stimulation, and compression of the recurrent laryngeal nerve may cause hoarseness. Therefore, ultrasound screening may demonstrate low specificity for detecting TD. The third and most crucial finding is that CT can facilitate diagnosis. TD may radiographically appear as a solitary, small, air-filled sac resulting from localized weakness in the right posterior tracheal wall. Using lung window settings on CT

scans can enhance the visualization of a communication channel. Additionally, multiplanar reformatted and three-dimensional reconstructed images can better delineate the anatomical relationship between the trachea and associated air cysts [6,42].

Thyroidectomy is considered a low-risk surgery, and tracheal injury is an exceedingly rare complication associated with this procedure. Gosnell *et al.* [43] reviewed 11,917 thyroidectomies performed over 45 years and reported tracheal perforations in only 0.06% of cases. Notably, all perforations occurred on the posterolateral aspect of the trachea. Surgical resection may not benefit patients with acquired TD, and treatment is generally unnecessary for asymptomatic patients [13]. During right cervical lymph node dissection in thyroidectomy, TD may be inadvertently damaged or mistaken for lymph nodes and excised. However, intraoperative recognition is possible because of the characteristic “pressing on a ping pong ball” tactile sensation when palpated. Moreover, because TD lies beneath the plane of the endotracheal tube cuff, cuff inflation can cause the diverticulum to appear larger and more filled. If the TD is inadvertently punctured during surgery, this may trigger an alert from the anesthesia machine [43]. Safeguarding the diverticulum during lymph node dissection is critical due to its delicate nature, preventing perforation or tracheoesophageal fistula formation [39]. If a TD is mistakenly excised during surgery, tracheal repair becomes necessary. Performing thyroidectomy using endoscopic techniques increases the technical difficulty of the operation and imposes greater demands on the surgeon. In complex cases, intraoperative consultation with thoracic surgeons may be required for combined procedures, increasing the risk of iatrogenic injury and extending the hospital stay for asymptomatic TD patients.

Limitations and Future Directions

The sample size in this study was relatively small despite multi-center participation. The retrospective design carries inherent limitations, including dependency on medical records that may be affected by omissions or incomplete documentation. The absence of standardized preoperative imaging screening for TD contributed to missed preoperative diagnoses: some centers did not perform routine CT scans, while others performed CT imaging but lacked adequate surgical review of imaging findings. Additionally, post-thyroidectomy surveillance primarily emphasized thyroid function assessment and ultrasonography. For the two tracheal diverticulectomy cases (case 3 and case 4), no CT re-evaluation was performed during their 3- and 6-month follow-ups due to the absence of symptoms, precluding longitudinal assessment of diverticular disease progression. Looking ahead, the management of tracheal diverticula is poised for significant advancements, driven by the ongoing evolution of imaging technologies and the increasing emphasis on multidisciplinary collaboration. Innovations such

as enhanced imaging algorithms, artificial intelligence, and machine learning are expected to refine diagnostic capabilities, enabling earlier detection and more precise characterization of tracheal diverticula. Additionally, the establishment of collaborative frameworks among specialists will facilitate the sharing of insights and best practices, ultimately improving patient outcomes.

Conclusions

In conclusion, right-sided TD at the thoracic inlet level is uncommon and typically presents with non-specific symptoms. With the increasing use of endoscopic techniques, avoiding misidentification of these lesions as thyroid nodules or lymph nodes is essential. CT should be routinely performed as part of the preoperative assessment for thyroidectomy. General surgeons must thoroughly review CT scans and maintain a comprehensive understanding of localized anatomy to optimize surgical planning. For asymptomatic patients with small TD, conservative management combined with regular imaging follow-up is often sufficient.

Availability of Data and Materials

The data analyzed are available from the corresponding authors upon reasonable request.

Author Contributions

WH and JFei designed the research study, performed the research, wrote, reviewed and edited the manuscript. WH, JFei, LYQ, DHH, JFang, XJX, RLX, DJS, MD and DX analyzed the data. JHG, RLX, XJX, DJS, MD and DX were involved in surgical care of the patients. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was approved by the ethics committee of the Shanghai International Medical Center (SIMC; approval number: 2024-037-01; date of approval: 9 February 2024). As the patients were not named and the images were deidentified, the ethics committee exempts informed consent. This study adhered to the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.62713/ai.c.4206>.

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