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Research progress on postoperative infection after thyroid cancer surgery

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Abstract. Thyroid cancer is a common clinical disease, and surgical resection remains the primary treatment modality, generally yielding a favorable prognosis. However, postoperative infections and related complications not only adversely affect patient outcomes but also prolong hospital stays, increase medical expenses, and impair quality of life. Therefore, effective prevention and management of postoperative infections have become urgent clinical priorities. Based on recent literature, this review summarizes the prevention, treatment, and current research progress regarding postoperative infections following thyroid cancer surgery. The aim is to provide evidence for the early detection, accurate diagnosis, and timely intervention of postoperative infections in patients with thyroid cancer.

Keywords: thyroid cancer, postoperative infection, review

1. Introduction

Thyroid Cancer (TC) is a common malignant tumor of the head and neck originating from thyroid epithelial cells. According to its cellular origin, TC is classified into four major types: papillary carcinoma, follicular carcinoma, medullary carcinoma, and anaplastic carcinoma. Among these, well-differentiated thyroid cancers, particularly papillary and follicular carcinomas, are the most common clinical subtypes [1]. At present, treatment options for TC include surgery, targeted therapy, radiotherapy, and chemotherapy, among which surgical treatment remains the principal therapeutic approach [2]. Nevertheless, postoperative complications such as infection, lymphatic leakage, and recurrent laryngeal nerve injury may occur following surgery. In recent years, with increasing public awareness of health, the widespread implementation of routine physical examinations, and the extensive application of diagnostic techniques such as thyroid ultrasonography and fine-needle aspiration, the detection rate of asymptomatic TC has risen rapidly worldwide [3-7]. As postoperative infection is one of the more common postoperative complications, the number of related cases has increased correspondingly. Once postoperative infection occurs, it may prolong hospitalization, increase readmission rates, impose a greater economic burden on patients, and seriously compromise both prognosis and quality of life [8]. Currently, numerous factors have been identified as contributors to postoperative infection after TC surgery. Therefore, effective prevention of postoperative infection has become a major concern for clinicians.

This article reviews the risk factors, diagnosis, prevention, treatment strategies, and recent research advances related to postoperative infection following thyroid cancer surgery.

2. Risk factors for postoperative infection after TC surgery

The occurrence of postoperative infection following thyroid cancer surgery is influenced by multiple factors. Major risk factors include advanced age, underlying diseases (such as diabetes mellitus and cardiovascular or cerebrovascular disorders), obesity, smoking history, and immune dysfunction, all of which may increase the likelihood of postoperative infection [9-11]. Elderly patients and individuals with immunodeficiency often exhibit reduced immune competence and impaired organ function [12]. Hyperglycemia can suppress the function of immune cells [13, 14], while harmful substances in cigarettes, including nicotine, may impair pulmonary function and increase the risk of respiratory infections [15]. These factors have been extensively documented in previous studies and therefore will not be discussed in detail here. In addition, several recent studies have indicated that factors such as incision size, endoscopic thyroid surgery, and postoperative drainage are also associated with the development of postoperative infection following thyroid cancer surgery.

2.1. Incision size

Several scholars have suggested that although a larger surgical incision allows adequate exposure of the operative field, it may also prolong wound healing, increase the patient's stress response, extend hospitalization, and complicate postoperative care, all of which may contribute to a higher risk of postoperative infection [9, 16-18]. Studies by Yong Che and Xiaoming Liu et al. [19, 20] found that, compared with conventional open thyroidectomy, small-incision surgery not only provides a clear and direct operative field but also offers several advantages, including reduced trauma to muscles and skin flaps, less intraoperative blood loss [21], shorter operative time, and decreased postoperative neck discomfort caused by excessive neck extension. These benefits facilitate postoperative recovery and may reduce the risk of postoperative infection. However, Dun Ye [22] argued that small-incision thyroidectomy may not be appropriate for elderly patients with thyroid tumors. Because elderly individuals often have lax cervical skin, reduced subcutaneous tissue, and prolonged recovery periods, small-incision procedures may provoke a stronger stress response, thereby increasing the likelihood of postoperative infection. In contrast, McFarland et al. [23] reported that current evidence is insufficient to determine whether incision size influences the incidence of postoperative infection. In summary, the relationship between incision size and postoperative infection following thyroid cancer surgery remains inconclusive.

2.2. Endoscopic thyroid surgery

Following the first successful endoscopic thyroidectomy reported by Hüscher in 1997 [24], continuous advances in surgical techniques have led to the development of various endoscopic approaches, including transoral, breast, anterior chest, axillary, and subclavian approaches. Among these, the transoral approach provides the most favorable cosmetic outcome, achieving a completely scar-free appearance. Theoretically, the transoral approach converts a Class I surgical incision into a Class II incision and generally requires a longer operative time, factors that may increase the risk of postoperative infection [25]. However, numerous studies conducted both domestically and internationally have demonstrated that the transoral approach does not increase the incidence of postoperative infection [26-29]. Man Lu et al. [30, 31] reported that transoral endoscopic thyroidectomy is comparable to conventional open surgery in terms of safety while offering superior cosmetic outcomes due to the absence of visible scars, thereby promoting postoperative recovery.

In addition, several studies have shown that endoscopic thyroidectomy performed via the axillary approach [32], anterior chest approach [33], or subclavian approach [34] yields postoperative infection rates comparable to those of conventional open surgery. Therefore, considering both patients' cosmetic expectations and the goal of minimizing postoperative infection risk, endoscopic thyroid surgery represents a valuable surgical option.

2.3. Postoperative drainage

The thyroid gland has an abundant blood supply, and the lymphatic network in the head and neck region is highly developed. Placement of a drainage tube enables real-time monitoring of postoperative drainage and facilitates the timely detection and management of active bleeding. However, drainage itself may increase the risk of postoperative infection. Since the introduction of the Enhanced Recovery After Surgery (ERAS) concept [35], considerable debate has arisen regarding whether drainage tubes should be routinely placed after thyroid surgery and how long they should remain in situ.

2.3.1. Necessity of drain placement

Some researchers have argued that conventional open thyroid surgery is classified as a Class I incision and is typically associated with minimal postoperative bleeding and exudate; therefore, drainage is unnecessary and may instead increase the risk of infection because of drainage-related care procedures [36]. Most scholars, however, maintain that the decision to place a drainage tube should be individualized according to patient characteristics and the surgical procedure performed. Weifeng Yu [37] found that drainage tube placement is a significant risk factor for postoperative infection in elderly patients with a history of diabetes mellitus. Sapalidis [38] suggested that drainage may be omitted in patients with benign thyroid disease and small surgical wounds. Cuifang Zeng et al. [36, 39] reported that routine drainage is unnecessary following unilateral or bilateral thyroid lobectomy combined with central neck dissection. Yukai Chen further demonstrated that omission of drainage after endoscopic thyroidectomy via the areolar approach is feasible and safe. Therefore, the need for drainage should be determined on an individual basis. Patients undergoing shorter procedures with limited surgical extent and without major risk factors for infection may not require drainage tube placement.

2.3.2. Duration of drain placement

According to ERAS principles, drainage tubes should not be retained for prolonged periods and should be removed as early as clinically feasible [35]. Narayanan et al. [40] reported that postoperative bleeding and exudation following thyroid surgery are generally concentrated within the first 6 hours after surgery. Complications resulting from these events, such as cervical edema and tracheal compression, also occur predominantly during this period and typically resolve within 24 hours. Therefore, removal of the drainage tube after 24 hours is considered safe. Li Yan [41] reached a similar conclusion. Liu Zeyang and colleagues [42] found that the principal exudative phase following transoral vestibular endoscopic thyroidectomy occurs within the first 8 hours postoperatively and that removal of the drainage tube at approximately 32 hours after surgery is safe.

3. Diagnosis of postoperative infection after TC surgery

3.1. Surgical site infection

Postoperative Surgical Site Infection (SSI) refers to an infection involving only the skin or subcutaneous tissue at the incision site. Common manifestations include localized swelling, erythema, and marked tenderness of the wound, sometimes accompanied by purulent discharge from the incision. Patients may also experience

mild dysphagia or coughing. A diagnosis can be established when at least one of the following criteria is met: (1) Purulent drainage is present in the superficial layer of the incision; (2) Pathogenic microorganisms are isolated from cultures of superficial wound secretions; (3) At least one of the following signs or symptoms is present: pain or tenderness, localized redness, swelling, or heat, and the incision is deliberately opened by the physician; (4) The surgeon clinically diagnoses a superficial incisional infection based on professional judgment [43].

3.2. Urinary tract infection

Most patients undergoing thyroid surgery require urinary catheterization before the operation. Postoperative Urinary Tract Infection (UTI) is defined as an infection occurring within 30 days after surgery in patients without implants, or within one year in patients with implanted devices. According to the *Chinese Guidelines for the Diagnosis and Treatment of Urological Diseases*, the diagnostic criteria include the following [44]: (1) Presence of urinary tract irritation symptoms, such as urinary frequency, urgency, dysuria, costovertebral angle tenderness, or lower back pain; (2) Urinalysis showing more than 25 white blood cells per high-power field in men or more than 10 white blood cells per high-power field in women; (3) Urine culture demonstrating bacterial growth of $\geq 10^5$ CFU/mL for Gram-negative organisms or $\geq 10^4$ CFU/mL for Gram-positive organisms.

3.3. Respiratory tract infection

Many patients experience postoperative respiratory symptoms such as coughing and sputum production, which should be differentiated from respiratory tract infection. Postoperative respiratory tract infection is characterized by newly developed cough, sputum production, or other respiratory symptoms accompanied by persistent fever (body temperature $\geq$ 38°C). Imaging examinations typically reveal patchy or diffuse infiltrative shadows or interstitial changes, while laboratory findings demonstrate either leukocytosis (white blood cell count $> 10 \times 10^9$/L) or leukopenia (white blood cell count $< 4 \times 10^9$/L) [45].

3.4. Other infections

Other postoperative infections include gastrointestinal infections and bloodstream infections. These are relatively uncommon after thyroid cancer surgery, and no universally accepted diagnostic criteria have yet been established.

4. Bacteriological characteristics of postoperative infection after TC surgery

Studies conducted by Dongqi Chen [46], Tiantian Sun [47], Junhong Yang [48], and others have shown that postoperative infections in patients with thyroid cancer most commonly occur in the respiratory system. Among Gram-positive bacteria, the most frequently isolated pathogens are *Staphylococcus aureus* and *Streptococcus pneumoniae*. The predominant Gram-negative organisms are *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, with Gram-negative bacteria accounting for the majority of infections. Fungal infections are relatively rare and are primarily caused by *Candida albicans*. Most cultured bacterial isolates exhibit relatively high resistance to antibiotics such as cefuroxime and cefepime, whereas resistance to imipenem and meropenem remains comparatively low. This phenomenon may be associated with the inappropriate or non-standardized use of antibiotics in clinical practice [49].

5. Treatment strategies for postoperative infection after TC surgery

Current treatment strategies primarily consist of incision drainage and antibiotic therapy. In clinical practice, physicians should adopt an individualized approach, selecting treatment modalities according to the site of infection, surgical procedure, and patient-specific conditions. Comprehensive management should also include enhanced postoperative nursing care.

5.1. Management of surgical site infection

Adequate local drainage is essential for the management of surgical site infection. When wound suppuration occurs, sutures should be removed promptly, the incision should be reopened and adequately enlarged, and thorough debridement should be performed. Necrotic subcutaneous tissue should be excised, sufficient drainage established, and delayed wound closure considered when appropriate [10].

5.2. Management of concomitant infections

Treatment strategies should be selected according to the location and clinical manifestations of the infection. Empirical broad-spectrum antibiotic therapy may be initiated when necessary, followed by adjustment based on bacterial culture results and antimicrobial susceptibility testing.

5.2.1. Concomitant pulmonary infection

Patients with pulmonary infection may receive postoperative therapies including expectorants, antitussive agents, bronchodilators, and nebulized inhalation treatment. If nebulization proves ineffective, medications may be adjusted based on clinical experience or management may be coordinated with respiratory specialists. For elderly, debilitated patients or those with difficulty expectorating sputum, oral and nasal suctioning should be performed when necessary to reduce the risk of aspiration and suffocation [10].

5.2.2. Concomitant urinary tract infection

Traditional surgical protocols often involve preoperative urinary catheterization. However, catheter placement may cause varying degrees of urethral mucosal injury, leading to postoperative urinary discomfort and even urinary tract infection. Wang Hailan and colleagues [50] reported that, in patients without preexisting urethral or bladder disorders, urinary catheterization does not significantly affect postoperative voiding function or the incidence of urinary tract infection. Furthermore, avoiding routine catheterization before surgery may reduce postoperative discomfort and facilitate recovery.

5.3. Enhanced postoperative nursing care

In addition to standard medical treatment, the implementation of scientifically designed dietary interventions and comprehensive nursing measures can promote postoperative recovery. Recommended strategies include a low-fat diet, enhanced patient education regarding postoperative care, the use of music therapy to alleviate anxiety and psychological stress [51], and appropriate cervical functional exercises [52], all of which contribute to wound healing and overall recovery.

5.4. Postoperative administration of pseudomonas aeruginosa injection

Pseudomonas aeruginosa injection [53] is a biological preparation produced through attenuation passage, plasmid DNA extraction and transfer, followed by attenuation, inactivation, and purification of *Pseudomonas aeruginosa*. Studies by Wei Tao [54] and Junda Li et al. [55] demonstrated that *Pseudomonas aeruginosa* injection can effectively prevent and treat postoperative lymphatic leakage following thyroid cancer surgery,

promote wound healing, shorten drainage duration, and reduce nutritional and metabolic disturbances. Furthermore, it may lower the risk of postoperative infection and facilitate patient recovery.

6. Preventive measures for postoperative infection after TC surgery

Because postoperative infection can impose substantial economic and psychological burdens on patients and their families, reduce treatment compliance, and negatively affect overall therapeutic outcomes, prevention is of paramount importance. Furthermore, the use of antimicrobial agents after infection increases the risk of antibiotic misuse, which may adversely affect patient health. In cases requiring reoperation, patients may develop resistance or reluctance toward further treatment, thereby compromising treatment efficacy. Consequently, effective prevention of postoperative infection may lead to more favorable clinical outcomes.

6.1. Perioperative antibiotic prophylaxis

At present, the prophylactic use of antimicrobial agents during the perioperative period remains one of the principal strategies for reducing and preventing surgical site infections. Among these agents, ceftazidime is commonly used for prophylactic purposes. Chaofeng Lü [56] reported that preoperative prophylactic administration of ceftazidime can reduce the incidence of postoperative infection in elderly patients undergoing thyroid surgery. Similarly, Jianbo Luo [57] found that prophylactic administration of cephradine before surgery may help prevent pathogenic bacterial invasion, decrease the risk of infection, attenuate inflammatory responses, and reduce postoperative neck discomfort.

However, some studies have suggested that perioperative antibiotic administration does not significantly decrease the incidence of postoperative wound infection. Zucai Jiang [58] demonstrated that prophylactic antimicrobial therapy may be unnecessary for this type of Class I surgical incision and has no significant effect on incision healing following thyroid surgery. In addition, inappropriate antibiotic use has itself been identified as a risk factor for postoperative infection [59]. Xueqiu Chen and colleagues [60] further observed a significantly higher incidence of postoperative infection among patients exposed to antibiotic misuse.

Therefore, no consensus has yet been reached regarding the effectiveness of perioperative antibiotic prophylaxis for preventing postoperative infection after thyroid cancer surgery. Surgeons should formulate individualized prophylactic strategies based on patient characteristics and the specific surgical procedure performed.

6.2. Standardized surgical technique

Adherence to standardized surgical procedures is an effective means of preventing postoperative wound infection. Essential measures include proper protection of the skin surrounding the incision, strict aseptic preparation of the operative field, and meticulous surgical technique. Research has shown that experienced surgeons can substantially reduce operative time and intraoperative blood loss while maintaining higher procedural standards [61]. Moreover, skilled surgeons are better able to select the most appropriate surgical approach according to individual patient characteristics and needs. Therefore, the surgeon's technical proficiency is itself an important factor influencing postoperative infection risk.

6.3. Preoperative oral preparation

Compared with conventional open thyroidectomy, transoral endoscopic thyroid surgery combined with a submental approach carries a potentially higher risk of infection because of the presence of the normal oral microbial flora. Consequently, both preoperative oral preparation and postoperative oral care are particularly

important. Jinfen Han and colleagues [62] reported that the use of chlorhexidine mouthwash before and after surgery effectively reduces the oral bacterial load and thereby lowers the risk of postoperative infection.

6.4. Routine postoperative care

Qiongling Liu and colleagues [63] suggested that the use of a mandibular compression garment following transoral thyroid surgery can reduce postoperative swelling, facilitate drainage of exudates, promote recovery, and decrease the risk of infection. In addition, Qiong Guo et al. [64] found that the application of fibrin glue after thyroid surgery may accelerate wound healing and shorten recovery time, thereby contributing to infection prevention.

7. Discussion and future perspectives

In summary, postoperative infection is one of the most common complications following thyroid cancer surgery. Its occurrence adversely affects patient prognosis, prolongs hospitalization, and increases healthcare costs. Clinicians should therefore carefully assess the risk of postoperative infection and implement timely preventive interventions to minimize its occurrence. With continuous advances in endoscopic technology and surgical instruments, endoscopic thyroid surgery has emerged as an increasingly mature technique in the management of thyroid diseases. It has demonstrated notable advantages in both cosmetic outcomes and infection prevention. Nevertheless, endoscopic procedures are technically demanding and require a high level of surgical expertise. Consequently, surgeons must continually enhance their professional skills and engage in ongoing simulation-based training to improve operative proficiency.

Although omission of postoperative drainage tubes eliminates the possibility of direct observation of drainage output, it necessitates more individualized perioperative management. Comprehensive preoperative, intraoperative, and postoperative assessments are essential for the prompt identification and management of complications, thereby ensuring optimal postoperative recovery [65]. In cases of complications such as chyle leakage, the duration of drainage should be extended when clinically indicated.

Driven by the growing popularity of minimally invasive surgical concepts and patients' increasing demand for improved cosmetic outcomes, small-incision thyroidectomy has been widely adopted. Numerous studies have demonstrated that both incision size and the choice of surgical approach may influence the likelihood of postoperative infection [19, 25]. Therefore, surgeons should consider the patient's medical history, personal preferences, and clinical circumstances, together with their own surgical experience, when selecting the most appropriate operative strategy.

Multiple studies have also shown that the bacterial pathogens commonly associated with postoperative infection exhibit varying degrees of resistance to frequently used antibiotics, a phenomenon closely related to inappropriate antimicrobial use in clinical practice. Furthermore, *Staphylococcus aureus* is one of the most common pathogens implicated in postoperative infection following thyroid cancer surgery. Yuan Wu [66] reported that *Staphylococcus aureus* associated with postoperative wound infection may promote autophagy and inhibit apoptosis of thyroid cancer cells through upregulation of the TLR2/PI3K signaling pathway. This mechanism may facilitate the proliferation of residual thyroid cancer cells and potentially contribute to tumor recurrence. Therefore, prevention of postoperative infection may not only improve postoperative recovery and quality of life but may also have important clinical implications for reducing the risk of thyroid cancer recurrence.

8. Conclusion

Postoperative infection following thyroid cancer surgery is a common complication resulting from the combined effects of multiple factors, including patients' baseline health status, surgical approach, intraoperative techniques, postoperative care, and clinical medication use. Respiratory tract infections and surgical site infections are the most prevalent forms of postoperative infection. Gram-negative bacteria are the predominant pathogens, and widespread resistance to commonly used antibiotics has made infection prevention and control increasingly challenging. At present, considerable controversy remains regarding the associations between postoperative infection and factors such as incision size, endoscopic surgical approaches, postoperative drainage tube placement, and perioperative antibiotic administration. Consequently, no universally accepted standardized protocol for the prevention and management of postoperative infection has yet been established. Clinical evidence suggests that the most effective strategies for reducing postoperative infection rates include meticulous adherence to standardized surgical techniques, individualized selection of surgical approaches and drainage strategies, enhanced oral care for patients undergoing transoral procedures, and comprehensive postoperative management throughout the perioperative period. These measures are fundamental to improving surgical outcomes and minimizing infection risk. Moreover, postoperative infection not only increases the physical, psychological, and financial burden on patients and delays recovery, but may also influence tumor cell proliferation and apoptosis through specific molecular pathways. As a result, postoperative infection may have a potential association with thyroid cancer recurrence. Future research should focus on large-scale, multicenter clinical studies to establish standardized infection prevention and control protocols for various surgical approaches, clarify the indications for rational antibiotic use, and further elucidate the molecular mechanisms linking postoperative infection to tumor recurrence. Such efforts will contribute to the development of a systematic and individualized perioperative infection prevention framework. By balancing cosmetic outcomes, adhering to the principles of enhanced recovery after surgery, and minimizing the risk of postoperative infection, clinicians may ultimately improve the long-term prognosis and quality of life of patients with thyroid cancer.

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