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Surgical Techniques to Avoid Complications of Thyroid Surgery

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Abstract: ***Currently, thyroid surgery is the most common and safe operation worldwide. However, thyroidectomy is still not free from the risks of complications and death due to the anatomical structure and physiological function particularity of the thyroid gland. Postoperative complications affect the life quality and life safety of patients after surgery. The common complications include hypoparathyroidism (HP), recurrent laryngeal nerve (RLN) injury, injury to the external branch of the superior laryngeal nerve (EBSLN), postoperative bleeding (PB), thoracic duct injury, laryngeal edema, tracheospasm, tracheal injury, and esophageal injury. A severe complication, such as dyspnea, asphyxia, or thyroid crisis, might cause the death of the patient. Therefore, every thyroid surgeon's responsibility is to remain alert and aware of the occurrence of various intraoperative and postoperative complications and exercise effective prevention and treatment. complications in thyroid surgery.***

Keywords: Thyroid surgery, complication, management

1. Introduction

In 1791, Dr. Pierre Joseph Desault successfully performed the first partial thyroidectomy (1). However, the mortality associated with thyroid operations was high, and hence, thyroid surgery was banned at one point in history. In 1849, Dr. Nikolai Piringoff performed a successful thyroidectomy using ether anesthesia (1), which once again ushered in an era of thyroid surgery. Subsequently, with doctors' efforts, including Theodor Billroth, Theodor Kocher, and William Halsted, thyroid surgery developed rapidly. Especially, the surgery - related death rate declined to <0.5% due to the contributions of Dr. Theodor Kocher (2).

Currently, thyroid surgery is the most common and safe operation worldwide and is closely related to the advancement in thyroid disease researches, the increase in local anatomy knowledge, the standardization of surgical approaches, the improvement in operating skills, the application of new technologies, and the emphasis on specialty training (3 - 5). Nevertheless, despite that the techniques of thyroid surgery have been improving continually, thyroidectomy is still not free from the risks of complications and death due to the complexity of the anatomical structure and physiological function of the thyroid gland. In thyroid surgery, the overall incidence of complications is approximately 0–54.4% (6 - 9).

According to a previous meta - analysis, no significant difference was detected between the overall complication rate from traditional open surgery and that from minimally invasive (video - assisted) surgery (10). The common complications include hypoparathyroidism (HP), recurrent laryngeal nerve (RLN) injury, injury to the external branch of the superior laryngeal nerve (EBSLN), postoperative bleeding (PB), thoracic duct injury, laryngeal edema, tracheospasm, tracheal injury, and esophageal injury. A severe complication, such as dyspnea, asphyxia, or thyroid crisis, might cause the death of the patient. Therefore, vigilance against and understanding the various intraoperative and postoperative complications are mandatory skills for every thyroid surgeon in addition to preventing and treating these complications. The purpose of this study is that the various intraoperative and postoperative complications should be prevented, recognized and treated to enhance the safety profile of the thyroidectomy

2. Methods

This review has been conducted employing the PubMed, Medline, Web of Science, and Science Direct database. Articles between January 2005 and June 2020 were searched, using the key terms "thyroidectomy", "complication", "hypoparathyroidism", "hypocalcemia", "recurrent laryngeal nerve injury", "superior laryngeal nerve injury", "postoperative bleeding", "lymphatic leakage", "chylous leakage", "tracheal collapse", "tracheomalacia", "laryngeal edema", "tracheospasm", "tracheal injury", "esophageal injury", "incision scar formation", and "skin sinus formation". Specifically, the research has been restricted using variable combinations of the keywords. As inclusion criteria, the articles had to provide data on causes of post - thyroidectomy complications, management or anatomy information. Some of the articles were excluded due to irrelevance to the topic in question.

Analyses
Data were extracted from studies satisfying the inclusion and exclusion criteria. Our outcome of interest included post - thyroidectomy complication rates, complication causes, intraoperative management and postoperative treatment.

3. Results and discussion

HP

Hypocalcemia caused by parathyroid gland damage is a common postoperative complication. The incidence of transient hypocalcemia is approximately 1.2–40%, while the incidence of permanent hypocalcemia is approximately 3% (11). The risk of postoperative hypocalcemia is related to gender (female), Grave's disease, lymph node dissection, surgical approach (total thyroidectomy, reoperation, or extensive surgery), and bleeding (11, 12). However, the correct identification and protection of the parathyroid glands during surgery are important prerequisites for preventing hypocalcemia (12, 13).

The first step to prevent injury is to accurately identify the parathyroid glands. Occasionally, it is difficult to distinguish these glands from fat granules and lymph nodes. Human parathyroid glands are round structures or flat ovoid, with an average size of approximately 6 mm, and usually yellowish - brown. On the surface of each gland, small blood vessels are observed, which are prominent under a magnifying glass (14). Fat granules are spherical or elliptical in shape, with different sizes, and usually golden - yellow. Also, no blood vessel pattern is visible on the surface, and a fat granule can easily float in normal saline. Interestingly, the lymph nodes are pea - shaped or round, with different sizes, and pink. In a normal lymph node, a hilum can be observed, while metastatic lymph nodes feel hard to the touch. Based on these characteristics, fat granules, lymph nodes, and parathyroid glands should be readily distinguishable.

RLN injury

RLN injury is a common complication. The incidence of transient RLN palsy is 5–8%, while that of permanent RLN palsy is 0.3–3% (28). Several factors may cause injury to the RLN, such as excessive traction/stretching, contusion, clamping, ligation, suturing, burning, and cutting (29). The injury may occur at any position of the RLN cervical segment. It is primarily detected within 2 cm before entry to the larynx, where the RLN is located at a fixed position and is closely related to Zuckerkandl's tubercle and Berry's ligament, according to the anatomy (30).

During surgery, it is easy to locate and expose the RLN at the entry to the larynx, at the junction of the inferior thyroid artery and the RLN, and in the tracheoesophageal groove at the inferior thyroid pole (30). Although RLN is fixedly located at the point to enter the larynx, it is prone to injury during dissection. However, at the junction of the inferior thyroid artery and the RLN, the nerve can be exposed easily, but bleeding may be caused in the small branches of the inferior artery. Also, RLN has great mobility in the tracheoesophageal groove at the inferior thyroid pole, expanding its anatomical range. A surgeon may select an appropriate approach based on his/her operating skills, clinical experience, and understanding of anatomy. In addition, learning about the anatomical structure of RLN is critical. In most cases, RLN approaches the larynx as a single trunk and branches off into an anterior and a posterior branch, but in some cases (approximately 10%), the RLN has branches (often two and sometimes even three) before entering the larynx (31).

EBSLN injury

Reportedly, the incidence of injury to EBSLN is as high as 58% (41), which might be related to various underlying criteria (42). The anatomical correlation between EBSLN and blood vessels of the superior thyroid pole (Cernea classification) can be categorized into three types: (I) the EBSLN crosses the superior thyroidal vessels at least 1 cm above a plane horizontal to the upper edge of the superior thyroid pole (type I); (II) the distance is <1 cm and is not below the plane (type II a); (III) the EBSLN is below the plane (type II b) (43). During handling of the superior pole vessels, type I poses the lowest risk of injury, while type II b poses the highest risk of injury. After crossing the superior thyroidal vessels, the EBSLN penetrates the inferior pharyngeal constrictor muscle from the medial side of the superior thyroid pole or courses along its surface, before reaching the cricothyroid muscle. The nerve fibers of the external branch are small, with a diameter of approximately 0.8 mm, and hence, can be easily injured during dissection and freeing (42

PB

Bleeding is a severe complication that occurs within 24–48 h post - surgery, with an incidence of approximately 0–4.2% (45). According to a meta - analysis of 25 studies (424, 563 patients) by Liu et al., bleeding after thyroid surgery is associated with older age, male gender, Graves' disease, anticoagulants, bilateral thyroid surgery, cervical lymph node dissection, and thyroid reoperation (46). In the early stage of bleeding, if the drainage is unobstructed, a large amount of fresh blood can be seen in the drain, or blood oozing from the incision is increased. When the amount of blood loss reaches a certain level, fresh blood in the drain begins to coagulate and accumulate in the surgical cavity. Patients should be aware that pain usually is a pre - emptive symptom before significant neck swelling. The patient feels difficulty in breathing when the blood accumulates to the point that the skin flaps swell. The degree of difficulty in breathing is related to not only the amount of blood loss but also the bleeding speed (47). In the case of acute arterial bleeding, the patient has difficulty in breathing and may even suffocate or die. Following surgery, the bleeding may be triggered by sneezing, coughing, emotional agitation, and intense neck movements, or even without any cause. In addition to systemic reasons such as the patient's coagulation mechanism disorder, PB is closely related to the surgeon's operating skills, experience, and seriousness (9). Bleeding can be divided into the following types. (I) Bleeding in the space between the skin flap and the anterior cervical muscle: It is manifested by the apparent bulging of the neck incision after surgery.

Right lymphatic duct or thoracic duct injury

Right lymphatic duct or thoracic duct injury induces lymphatic leakage and chylous leakage, with the incidence in simple thyroid surgery as 0.5–1.4% and that in neck dissection as 2–8% (52). The risk of lymphatic leak is based on lymph node dissection. The risk of lymphatic leak is much higher in lateral neck dissection compared to central neck dissection. Additionally, as the left side poses much higher risk due to the location of the thoracic duct. Simple lymphatic leakage has little effect on patients' whole - body condition, while massive chylous leakage causes blood electrolyte disorder, decreased blood volume, local infection, mediastinal infection, and flap necrosis in patients, leading to neck macrovascular hemorrhage and be life - threatening.

Tracheomalacia and tracheal collapse

Asphyxia occurs in the event of tracheomalacia and tracheal collapse, which is associated with the surgeon's misjudgment of the disease. In the cases with long medical history and huge goiter, preoperative examinations aid in making a risk judgment of tracheomalacia and tracheal collapse. For patients with huge goiter, prolonged compression of the trachea leads to poor blood circulation in the tracheal wall and degenerative changes, thinning, weakened elasticity, and atrophy of the cricoid tracheal cartilage. Concurrently, tracheal respiration is maintained with the support of the

thyroid and the surrounding tissue (55). After the thyroid tissue is surgically removed, the trachea loses dependence and support, and the softened trachea collapses, causing airway obstruction. If the number of the softened cricoid cartilage is <3, the tracheal suspension is performed intraoperatively (56), wherein the trachea is suspended anterolaterally to both sides of the tracheal wall; otherwise, tracheotomy is conducted. When it is difficult to judge whether the trachea is softened intraoperatively, tracheotomy is recommended to ensure smooth airway in the patients (57).

Laryngeal edema

According to the literature, the incidence of laryngeal edema after thyroid surgery is about 3% (58). Asphyxia caused by laryngeal edema is fatal. The common causes are as follows: (I) tracheal intubation is not smooth during anesthesia, and repeated operations lead to laryngeal contusion and edema; (II) hemorrhage and hematoma lead to disrupted laryngeal venous return, further causing laryngeal edema; (III) prolonged lymphatic leakage or venous bleeding leads to laryngeal edema; (IV) prolonged surgical time and repeated operations near the larynx stimulate the organ and cause laryngeal edema; (V) patients with concurrent respiratory tract infections exhibit postoperative symptoms of increased secretion and recurrent cough and undergo laryngeal edema and viscous sputum blockage, which induces asphyxia.

Tracheospasm and laryngospasm

Main tracheospasm refers to the pathological phenomenon wherein patients undergo dyspnea, asphyxia, and also die because of increased tracheal resistance and impaired ventilation due to tracheal smooth muscle contraction and narrowing of the tracheal cavity (59). Intraoperative hypoxia and intraoperative tracheal stimulation (repeated physical stimulation of the trachea and thermal energy of electric knife and other equipment during surgery) might induce main tracheospasm; postoperative extubation and irritable cough are also triggering factors. Most of the patients with tracheospasm have a history of airway hyperresponsiveness, asthma, and smoking. As a result, the preoperative prediction of possible tracheospasm is the key to prevention. (I) Dexamethasone should be administered intraoperatively to reduce stress response; (II) surgical operations should be gentle to avoid overstimulation of the trachea; (III) sharp excision is recommended at the time of separating the thyroid from the trachea; (IV) postoperative nebulized inhalation lubricates the airway to reduce its hyperresponsiveness and avoid irritable cough. Emergency tracheal intubation is performed in the event of tracheospasm, and tracheotomy is required when necessary (60). Similarly, laryngospasm after thyroidectomy could also result to dyspnea, and asphyxia.

Tracheal or esophageal injury

Tracheal or esophageal injury is a rare complication, and intraoperative esophageal injury is even rarer due to the anatomical position of the esophagus (64). Tracheal or esophageal injury caused by endoscopic surgery or energy equipment might be difficult to detect during surgery, leading to severe postoperative consequences. Postoperative patients with tracheal injury exhibit subcutaneous emphysema, which is worsened after cough, possibly followed by mediastinal emphysema. In the case of patients with complicated malignant tumor surgery or surgical history, the evaluation of the correlation among lesion and trachea should be based on the results of the preoperative imaging examination. Then, preparations are made for intraoperative tracheotomy. When a partial trachea is removed to reconstruct the airway during surgery, the suture line should run through the whole layer of the trachea. Also, knot tightness needs to be consistent to prevent postoperative tracheal leakage. After suturing, saline is injected into the surgical site, and the anesthesiologist pressurizes the airway to observe for air leakage (64). The treatment of some rare cases, such as tracheal cyst, is based on the clinical experience of surgeons. In the event of postoperative tracheal leakage, if the air leakage is small, most patients recover by reinforced suction and pressure dressing. Otherwise, the tracheal leak is repaired surgically and tracheotomy.

Incision scar formation

Moderate scar formation after thyroid surgery is a normal response of the body to repair trauma, but a hypertrophic scar caused by excessive scar formation is a pathological manifestation, which is a frequent occurrence in the incisions of open thyroid surgery, especially in the “L” - shaped incisions of neck dissection. The hypertrophic scars bring psychological and physical pain to patients with a severe impact on their social activities and neck functions (66). People with yellow skin have thick dermal tissue and high collagen content promote the occurrence of scar formation in those with white skin. Mechanical tension plays a critical role in neck scar formation, which is the result of excessive tension, excessive proliferation of skin fibroblasts, and increased collagen synthesis (68).

Skin sinus formation

Skin sinus formation is one of the rare complications after thyroid surgery, with an incidence of about 0.08% (72). Patients exhibit the following symptoms: when the suture of the incision is removed and the incision heals after thyroid surgery, there are discomfort and pain in the surgical site, ulceration, and suppuration in the neck skin. However, after a dressing change, the infection is controlled, and the incision heals gradually. But ulceration and suppuration recur, following which the infected area shows scarring, and then the sinus tract is formed, with or without general malaise and fever. Intriguingly, sinus formation is closely associated with the surgical method and foreign body residues in the thyroid fossa (72). The principle of surgery is to eliminate the etiology, remove the foreign body, clear the infected area, and resect the sinus tract.

4. Conclusions

Thyroid surgery has become a routine and safe procedure of operation with a decline in the overall morbidity and mortality due to complications. However, operative complications might contribute to negative impact on quality of life after surgery. Therefore, it is the responsibility of every thyroid surgeon to remain alert and aware of the occurrence of various intraoperative and postoperative complications and exercise effective prevention and treatment. In addition, many complications that effect patients are much better tolerated if the patient has appropriate expectations of what the complications are and how to treat them. If patients are more aware of the complications going into surgery, they have less

anxiety when they occur because they knew what to expect and are aware of the possible treatments. Open communication between surgeon and patient optimizes the potential negative effects that complications may have on patients' quality of life.

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