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Review Article

A Historical Account for Thyroid Surgery

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ABSTRACT

Thyroid surgery is nowadays considered one of the most common surgical procedures globally. For nearly 4,000 years, thyroid gland pathology and surgery have been a field of observation, research, and interventions. From ancient references or drawings regarding thyroid shape or enlargement (goiter), to more recent years when the first surgical approaches to thyroid pathology were established, until today when evolution in imaging, biochemical methods, surgical instruments and adjuncts is in everyday thyroid clinical practice, many prominent individuals add information to the current knowledge on the field. Europe, America, and Asia provide a rich historical background where outstanding scientists have devoted their entire life to thyroid surgical pathology and treatment. A brief tribute to all these distinguished pioneers — by looking into this evolutionary progress throughout the years — is attempted in this work.

Keywords: History of thyroid surgery; Ancient; Thyroid gland; Evolution; Chronology

INTRODUCTION

Thyroid pathology has been known since ancient times, surgical management of thyroid diseases, however, evolved slowly throughout the ages. The ancients conceived thyroid surgery, but it was limited to rare attempts due to the need for appropriate instruments and the lack of anesthesia and antisepsis. Much of the progress of thyroid surgery occurred from early the 1850s until early the 1900s. Two prominent surgeons, Theodor Billroth and Theodor Kocher, proclaimed to be the "fathers" of thyroid surgery, entered the operating theaters and changed the history of thyroidectomy. Pioneers in thyroid surgery during the first part of the twentieth century, significant advances regarding the management of thyroid diseases (modern imaging methods, preoperative fine-needle aspiration [FNAC]) as well as the standardization of surgical techniques, have made surgical management of thyroid disorders safe for every patient. This review aims to take a closer look into the past of thyroid surgery and to present its evolution up to the modern era.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

TIMELINE

1. Ancient times

Enlarged thyroids, appearing as a mass protruding from the neck, were mentioned in China in 2700 BC. Burnt sponge and seaweed (sources of iodine) had been reported to be used by the Chinese for the treatment of the "enlarged thyroid" since 1600 BC (1). Hippocrates did not mention goiter in his writings; he only referred to the glands "... *when glands of the neck become diseased themselves, they become tubercular and produce struma* ..." The struma is a term still used in some European countries as the medical designation of goiter. Hippocrates (331–156 BC) did not manage to differentiate between thyroid and cervical glands, while goiter was only regarded as a deformity (2). Interestingly, the idea of surgical treatment of goiter was conceived by the ancients; obviously without a clear understanding of thyroid physiology.

2. Greco-Roman period

Aulus Cornelius Celsus (25 BC–50 AD) defined the enlargement of the neck as *bronchocele;* he defined cystic goiters and proposed methods to deal with them either by bluntly removing them or by destroying them with caustics (2). In 85 AD the Chinese physician Tshui Chin-thi was the first who differentiated between solid, incurable tumors and benign movable ones. Aelius Galenus (130–200 AD), the most influential physician of the Greco-Roman period reported that aphonia was provoked by cutting the laryngeal nerves, while he described operation on 2 males to remove "tubercular" nodes that resulted in one man "mute" and the other "semi-mute."

3. Byzantine period

Aetios in 550 AD quoted a Greek surgeon who recognized the importance of protecting the vocal nerves during the surgery. One of the earliest references to thyroid operations may come from the seventh century when Paul of Aegina, described struma and its operation. However, it is unclear whether the struma in Paul's writings has the same meaning as goiter today (3). Avicenna and Aj-Jurjani, 2 Persian physicians and philosophers, described the association between of goiter and orbital disease between 1000 and 1100 AD (4). Albucasis in the tenth century is described as the first who performed the first successful thyroidectomy under opium sedation. In 1170 Roger Frugard, a prominent surgeon of the Salerno School of Medicine performed a thyroidectomy using a seton, hot irons, ligaments and caustic powders (5). Moreover, in the twelfth century, *The Bamberg Surgery* described the removal of a goiter in full details. During the fourteenth century, there were reports regarding the treatment of goiter with iodine products, while the French surgeon Guy de Chaliac recommended surgical removal of the thyroid gland. Guy de Chaliac together with other prominent surgeons of this period like Bonetus Lanfranchi and Henry de Mondeville made the revival of surgery possible. However, there are no references that any operations were performed by them (5).

4. The renaissance to the nineteenth century

The thyroid gland was not named until the sixteenth century when Bartholomeo Eustachius of Rome characterized it as a single "glandulam thyroideam" with 2 lobes connected via an isthmus (6). The exact term thyroid gland is attributed to Thomas Wharton in his work *Adenographia*. The author of the earliest thyroid image was the Florentine artist Leonardo da Vinci who drew it in 1511. Andrea Vesalius also drew the thyroid gland in 1543. Although da Vinci's drawings were anatomically correct, he incorrectly concluded that the purpose of the thyroid was to fill the interval in the neck and hold the trachea away from the sternum (7). In the late eighteenth century, Caleb Hiltier Parry of Bath was the first to identify the

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exophthalmic goiter (8). Robert James Graves in 1835 and Carl Adolf von Basedow in 1840 associated goiter, exophthalmos, palpitation, weight loss, and hyperactivity (9,10). During the Renaissance, no significant development was observed in the field of surgery despite the presence of an excellent surgeon, Ambroise Pare (11). It is highly likely that the first typical partial thyroidectomy was not successfully performed until the famous French surgeon Pierre-Joseph Desault accomplished it in 1791 (12).

5. The nineteenth century

Needless to say that improvements in the results of surgery did not occur until the middle of the nineteenth century. This growth is attributed mostly to the technical development and the work and vision of pioneer surgeons. Attempts to perform partial thyroidectomy or to suppress the gland by superior thyroid artery ligation were made by William B. Lizard in 1811 or Henry Earle in 1823. There were, however, insufficient cases of successful operations on thyroid and Halsted qualified procedures that occurred before 1850 and associated them with 40% mortality (13). Hemorrhage, asphyxia, infections, and air embolism were the main reasons that made even the most skilled surgeons unwilling to perform a thyroidectomy. The French Academy of Medicine in 1850 prohibited thyroid operations due to high mortality rate and the lack of the essential technical improvements (3).

In the middle of the nineteenth century, however, the development of anesthesia, the introduction of antisepsis, the improved hemostasis and the understanding of thyroid physiology together with the use of efficient surgical instruments illuminated the history of thyroid surgery.

The term anesthesia is attributed to Oliver Wendell Holmes. In the pre-anesthesia period surgery was a terrible experience; there was little to make the patient feel comfortable, and there were cases of patients tied to the operating table. The fear and the necessity for safe airway management especially in cases of large goiters that pressed and caused deviation and stenosis of the trachea made local anesthesia the preferred method of anesthesia (1). Sulfuric ether was used as an anesthetic for the first time in 1842 by Crawford W. Long, while W.T.G Morton in 1846 reported the efficacy of ether anesthesia at Massachusetts General Hospital. This publication attracted much attention and 3 years later was used by Nikolai Prigroff in St. Petersburg 3 years later (14).

Infections with often-fatal outcomes were a serious problem that made even the most prominent surgeons hesitant in performing non-emergent thyroid surgery. However, the use of carbolic acid as antisepsis by Joseph Lister in 1867 led to significant decrease in incidents of infection in the postoperative period (15). The introduction of intraoperative antisepsis by Gustav Neuber in 1883 and the introduction of steam sterilization of surgical instruments by Ernst von Bergmann in 1886 further assisted in the reduction in septic complication (16,17).

A significant advancement that evolved in 1879 was the introduction of artery forceps in clinical practice that offered surgeons the possibility to perform safe dissection and ligation of blood vessels enhancing thus the safety of thyroid operations that were performed by prominent surgeons like Theodor Kocher and Theodor Billroth (5).

Theodor Billroth, the most distinguished surgeon of the nineteenth century according to many medical historians, was appointed in 1860 chairman of the surgical department in Zurich. In Zurich, he performed 20 thyroidectomies with a mortality rate of 40%. These

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disappointing results discouraged him and prompted him to abandon thyroid surgery. Later in Vienna (1877–1881) he decided to again operate on a thyroid. This decision was prompted by the significant improvement in antisepsis and hemostasis and the results did justice to his decision. He performed 48 thyroidectomies with only 4 deaths (mortality 8.3%). Billroth was also an excellent teacher and his pupil Theodor Kocher is clear proof of this.

Kocher was appointed to the Chair of Surgery in Berne in 1872 at the age of 31. During the first 10 years in Berne, he performed 101 thyroidectomies with a mortality rate of 12.8%. Another 250 cases were recorded in 1889 with a mortality rate of 2.4%. By 1895 the mortality rate was further reduced to 1%. For his operation he used a transverse incision; he used a vertical midline approach or an incision along the anterior border of the sternocleidomastoid. Regarding the anesthesia method, he used only local anesthesia and cocaine, because one of his deaths was due to anesthesia with chloroform. In 1883 he published a famous paper that described how total thyroidectomy affected the whole body (18). His greatest contribution to physiology was that he proved the importance of thyroid gland for human health. He also recognized recurrent laryngeal nerve (RLN) injury and tetany as postoperative complications, implicating the need for a more cautious resection. Kocher was awarded the Nobel Prize in 1909 in recognition of all his achievements in thyroid surgery. In his acceptance speech, he discussed once again the importance of adequate thyroid function and its influence on the "whole" patient.

Anton Wolfer and Jan Mickulicz Radecki, both Billroth's pupils were the first that paid attention to the tetany caused by the loss of parathyroid glands and tried to develop surgical techniques to preserve parathyroid glands. Wolfer assumed the chair of surgery at Graz in 1886 and described postoperative tetany in detail. He was the first to discuss the danger of operative injury to the RLN. Mickulicz, professor of surgery in Krakow since 1882, suggested the new approach to thyroidectomy with preservation of the posterior aspect of both lobes. He also showed that thyroid parenchyma could be crushed, divided and ligated without fear of uncontrollable hemorrhage or impairment of wound healing (5).

In the 1890s European advances in thyroid surgery were taken to the USA. William Stewart Halsted, one of the most prominent American surgeons of the nineteenth and early twentieth century, reported that he never saw or heard of an operation for goiter, except for one where he assisted Dr. Sands in the removal of a small tumor of the right lobe of thyroid. Up to 1883 Halsted reported that he was able to find reports for only 45 operations for thyroid (5). Halsted's interest in thyroid surgery increased in the summer of 1899 when he first met Theodor Kocher, and later visited Berne every chance he got. By 1907 he had performed 90 operations for Graves' disease with a mortality rate 2%. His contribution to the evolution of thyroid surgery can be summarized by the development of a standardized technique of thyroidectomy, the use and popularization of hemostatic forceps and other surgical instruments in the USA, as well as the introduction and extensive use of local infiltration anesthesia with reduced morbidity and mortality.

6. The twentieth century

This century was marked by significant advances regarding the management of thyroid diseases (19). Advances included the use of blood transfusion, the patients' follow-up, the introduction of frozen section histopathology that can help the decision-making process during surgery. Moreover, the development of staging system for all cancers offered the possibility of selecting the most appropriate method of treatment depending on the

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histological type and stage of thyroid disease. FNAC of the thyroid was described in 1952 and has been available since the 1970s (20). Nowadays, FNAC together with neck ultrasonography which has been in use since the 1980s is considered the gold standard in the diagnostic evaluation of patients with thyroid nodules. Cytologists are now very adept at diagnosing high quality slides — although producing representative material of high-quality remains a challenge, particularly for aspirators who see few cases of thyroid disease.

In the twentieth century, extreme progress was marked in pharmaceutical supplements. Isolation of the hormone thyroxin (T4) was accomplished by Edward C. Kendall in 1914 (21). In the early 1940s, antithyroid drugs and radioiodine therapy were introduced and used for the treatment of hyperthyroidism. Propranolol was utilized in the perioperative management of patients with thyrotoxicosis in 1965 (22). Better instrumentation, as well as the evolution of anesthesia techniques, greatly facilitates the operative procedure. The patient's recovery has been made easier by absorbable internal sutures, subcuticular prolene and the avoidance of drainage when possible (14,18).

One of the pioneers in thyroid surgery in the twentieth century, Thomas Peel Dunhill, began his work on the problems of goiter and thyrotoxicosis in Melbourne in 1910 had performed 312 operations, 200 of which were for exophthalmic goiter. Dunhill adopted a technique of total lobectomy on one side and subtotal on the other side after reading Frank Harley's paper which was published in 1907 (23). He used his technique under local anesthesia at first and later under light general anesthesia. At that time the mortality for this operation was 30% in hospitals in London and with his method, he achieved a mortality of less than 3%, despite accepting the most severely ill patients suffering from uncontrolled atrial fibrillation (24). The technique that he adopted — total lobectomy by a pericapsular dissection technique — is even now considered by many surgeons the optimal method of resection. He also described later operation on retrosternal goiter by splitting the sternum and in 1920 he produced his outstanding paper in an early issue of *British Journal of Surgery* (25). In the same year, Sistrunk described his radical operation for the thyroglossal tract that included the resection of the middle third of hyoid at the base of the tongue. In 1932 Cecil Joll published in Royal Free Hospital a comprehensive book on thyroid surgery (26). Interestingly this book reported significant remnants after subtotal lobectomy, while the incidence of tetany was very low. This book also recorded high incidence of nerve injury due to the use of a retrograde technique and also illustrated the thyrotoxic crisis.

Charles Mayo, a highly respected American surgeon, was the most experienced thyroid surgeon of his time. In 1907 he used the term hyperthyroidism and treated hyperthyroidism with thyroidectomy (1). By 1908 he had operated on 234 patients with thyrotoxicosis with a mortality rate of 6%. In his attempt to improve these results he employed in 1908 unilateral or bilateral pole ligation as a preliminary to partial thyroidectomy. In 1912 he operated on a consecutive series of 278 patients with exophthalmic goiter without a death and with only one case of tetany. In 1918 he completed his large series with 5,000 thyroidectomies. He also started using iodine in the preoperative preparation of patients with hyperthyroidism, a practice that resulted in a decrease in mortality rate to less than 1% and a reduction in the incidence of multistage operations from over 50% to 2% (5). For all his contributions, he has been named The Father of American Thyroid Surgery.

George W. Crile was a famous thyroid surgeon as well as a productive research scientist who was very interested in hyperthyroidism (5). Dr. Crile observed that the thyrotoxic patient was

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likely to develop prostration during crisis due to overactivity of the central nervous system and contended that this condition could be obviated by preventing noxious stimuli from leaving the operative site with local anesthesia. He is considered the father of head and neck cancer surgery; in 1906 he described the procedure of radical neck lymph node dissection for head and neck cancer in 132 patients (27). Crile believed that the surgeon should never expose the RLNs during thyroid surgery. It was Frank Lahey (1880–1953) who proposed the division of the strap muscles, full exposure of superior poles and visualization of the RLN and parathyroid. He showed that the RLN could be dissected along its course and that this could be a safer way of operating on the thyroid (5). The use of intraoperative nerve monitoring (intermittent) — I-IONM — of the RLN in thyroid surgery was proposed about 45 years ago in an attempt to diminish the risk of injury to the nerve (28). Intraoperative nerve monitoring (IONM) has nowadays become one of the most used adjuncts in thyroid surgery, for both the identification and assessment of the RLN's anatomic and functional integrity. Several studies support its use, especially in cases of reoperation, whereas others did not find statistically significant differences in RLN injuries with its use (29).

7. Present-modern era

The tendency to produce better cosmetic results, to develop smaller incisions, to shorten hospital stay and reduce postoperative complications and discomfort, led to the development of minimally invasive techniques that have been applied to both thyroid and parathyroid surgery. Some support that only operations with cervical incision less than 3 cm, which permits direct access to the thyroid gland and other adjacent structures should be classified as minimally invasive (30). The most common minimally invasive technique is minimally invasive video-assisted thyroidectomy (MIVAT) that has been set and described for the first time by Miccoli and his colleagues in Pisa (31). MIVAT is characterized by a single access of 1.5 cm in the middle area of the neck approximately 2 cm above the sternal notch. The midline is incised and a blunt dissection is carried out to separate the strap muscles from the underlying thyroid lobe. Afterwards, the procedure is performed endoscopically on a gasless basis. Careful patient selection for minimally invasive thyroidectomy influences the outcome. Most supporting authors consider size limits of 30 mL in volume, thyroid nodule size of <30 mm in diameter and actual cancer size of <20 mm to be considered eligible for minimally invasive surgical techniques (32).

The need for an aesthetically perfect scar after thyroid surgery led to the development of endoscopic surgery in the neck. The endoscopic thyroidectomy by breast approach is performed with 2 working ports that are inserted through circumareolar incisions on both breasts. This method provides a view of the surgical field equivalent to that obtained during open surgery while scars conceal easily by wearing undergarments. Therefore, it has become the most popular procedure in Asian countries (33).

The introduction of robotic technology was a revolution in the field of surgery for prostate cancer. The stereoscopic visualization together with the flexible instrumentation that it offers suggested that it could be well suited for head and neck surgery (34-36). The patient is positioned in a supine position on a small shoulder roll with the ipsilateral arm placed on an arm board and extended cephalic to expose the axilla. A 5 to 6 cm incision is made along the line marked in the axilla at the posterior aspect of the pectoralis and a small incision is made on the medial line of the anterior chests wall. Indications for this procedure include minimally invasive follicular thyroid carcinoma 4 cm or less in diameter or papillary carcinoma 2 cm or less (34,35). Previous neck operations, prior vocal fold paralysis,

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malignancy with extrathyroid invasion, multiple neck node metastases, distant metastasis and a lesion located in the dorsal thyroid area are some criteria that exclude patients from robotic thyroidectomy. As a new procedure, it requires special skills, operative time is increased, and costs are higher.

The most recent operative technique that promises excellent cosmetic result was presented by its inventor, A. Anuwong, in 2016 (37). Anuwong published his experience in Transoral Endoscopic Thyroidectomy Vestibular Approach (TOETVA) from the first 60 human cases. The author describes his scarless 3-port technique through the oral vestibule creating an anterior subplatysmal space with CO_2 insufflation. In that way, the surgeon creates his working space from the oral vestibule to the sternal notch and proceeds to the thyroidectomy endoscopically. This new method promises perfect cosmetic results accompanied by safe, maximum curative results in all participating patients. As a newly applied practice knowledge is still growing, but several authors have followed Anuwong's procedure in different places around the world with promising results (38,39).

Overwhelmed by the lack of real-time information about RLN's functional integrity that I-IONM has, many authors turned and supported the development and use of continuous IONM (C-IONM) (40). The evolution in monitored thyroidectomies allows, nowadays, even to the experienced endocrine surgeon to have real-time information regarding RLN's functional integrity. Therefore, IONM (I-IONM and C-IONM) gives the surgeon the advantage of modifying his originally planned surgery (total thyroidectomy) to a safe 2-stage procedure in order to minimize the most feared complication of thyroid surgery — the bilateral RLN palsy (41-44).

CONCLUSION

Thyroid surgery is going to become one of the most common operations performed. A review of the significant development and progress in thyroid surgery throughout history allows us to appreciate the changing nature of our profession and the importance of the continuous effort to improve our surgical skills in order to help our patients in the best way with minimal risk.

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