The Evolution of Thyroid Surgery

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The early history of thyroid surgery is closely related to the manifestation of iodine deficiency as goitrous glandular enlargement. The first mention of goiter as a disease entity occurred in 2700 B BC in China. However, it was not until AD 500 that Abdul Kasan Kelibis Abis reportedly performed the first surgical excision of the thyroid gland in Baghdad. Despite significant postoperative hemorrhage, the patient survived.

Understanding of the nature of thyroid diseases was, of course, limited in ancient times, and attempts at surgery were rare. Early nonsurgical treatments for goiter included the application of toad's blood or placement of a cadaver's hand on the neck. In the twelfth and thirteenth centuries in Salerno, Italy, heated setons were placed at right angles into the substance of the gland and turned twice daily until they pierced the skin. In some cases, a large hook was placed into the goiter, the overlying skin dissected away, and a segment of tissue was extirpated. A boot lace was sometimes used to strangulate a portion of the gland prior to removal. Patients were strapped to tables and held down during these procedures, and many of them expired due to sepsis or massive bleeding. Indications for surgery during those times were primarily large goiters causing airway impingement or suppurating glands. The latter may have in fact been representative of tuberculous lymphadenitis.

Surgical advances occurred slowly and were limited by lack of anesthesia, antisepsis, and poor instrumentation. The first thyroidectomy using scalpels was performed by Wilhelm Fabricus in 1646 on a 10-year-old girl, who died, leading to his imprisonment. A successful partial thyroidectomy was achieved in Paris in 1791 by Pierre Joseph Desault, followed in 1808 by a total thyroidectomy by Guillaume Dupuytren. The latter led to the patient's demise due to postoperative "shock" despite low blood loss. A German surgeon named Johann Hedenus was the most prolific thyroid surgeon of that era, reporting on a series of six successful goiter excisions in 1821.

The first experimental use of iodine as a treatment for goiter was performed in 1820 by Johann Straub and Francois Coindet of Switzerland. Coindet suggested the preoperative use of iodine as a means to decrease the size and vascularity of goiters. Iodine was hailed as a miracle drug, and its widespread use often led to toxicity. With regard to surgical technique, a variety of incisional styles, including oblique, longitudinal, and Y-shaped, were used during that era. Incision was followed by blunt dissection, often leading to significant hemorrhage, and wounds were typically left open and packed. Bloodletting was a

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treatment used for postoperative complications despite significant blood losses during surgery.

The surgical revolution began in the mid-1800s with the development of anesthesia. The first to use sulfuric ether during surgery was Crawford W. Long in Georgia in 1842. In 1847, the first thyroidectomy using anesthesia was performed in Russia by Nikolai Pirigov. Joseph Lister introduced the concept of antisepsis in 1867, which was further promoted by the initiation of cap and gown wearing in the operating room by Gustav Neuber in 1883. This, together with the advent of steam sterilization of surgical instruments in 1886 by Ernst von Bergmann in Germany, contributed to lower postoperative infection rates and laid the foundation for current antiseptic surgical practice. Further progress in thyroid surgery was achieved due to the introduction of improved hemostatic tools, such as the self-retaining arterial forceps designed by Spencer Wells in 1872. These improvements led to the reduction of mortality from thyroid surgery from 40 % in 1850 to 20 % in 1875.

Fig. 1.1 Albert Theodor Billroth, 1867 (Reproduced with permission from Institut für Medizingeschichte, Universität Bern, Buehlstrasse 26, CH 3012 Bern)

Modern Thyroid Surgery

The age of modern thyroid surgery followed from the developments of the surgical revolution. As mortality rates declined, increased numbers of thyroid surgeries were performed, and greater understanding and teaching of thyroid physiology, anatomy, and surgical technique ensued. Among the most notable surgeons of the nineteenth century is Albert Theodor Billroth (1829–1894), who served as chair in both Zurich and Vienna, published the textbook *General Surgical Pathology and Therapeutics*, and created the *Archives of Clinical Surgery* (Fig. 1.1). He also disseminated his thyroidectomy techniques, such as division of the sternocleidomastoid muscle and incision and drainage of thyroid cysts, by founding a school of surgery. A variety of methods for hemostasis were also taught, including arterial ligation using aneurysmal needles and the use of penghawar djambi, an Indian vegetable hemostatic agent. Billroth initially abandoned thyroid surgery for over a decade due to high mortality rates. With advancement in hemostasis and antisepsis, however, patient mortality rates in Billroth's practice decreased from 40 to 8 % over his career.

In spite of Billroth's myriad achievements, Theodor Kocher (1841–1917) stands alone as the father of modern thyroid surgery (Fig. 1.2). He completed more than 5,000 thyroidectomies during his career as chair at the University of Bern. Mortality rates in his hands were 0.2 % by 1898 due to his adoption of antiseptic and hemostatic techniques. Kocher pioneered the standard collar incision, which now carries his name, and utilized local anesthesia with cocaine.

Kocher abandoned performing total thyroidectomy for benign disease when he discovered that patients developed the postoperative sequelae of hypothyroidism, namely myxedema, shedding light on thyroid physiology. He also established partial thyroidectomy as a treatment for Graves' disease. William Halsted, an American surgeon, visited the clinics of both Kocher and Billroth and noted that Kocher's patients often developed myxedema postoperatively but rarely tetany,

whereas the opposite was true for Billroth. This speaks to the notoriety Kocher achieved for his bloodless field, attention to detail, and completeness of surgery. In 1908, he was awarded the Nobel Prize for his contributions to the understanding of thyroid physiology and thyroid surgery. He was the first surgeon to be awarded this honor.

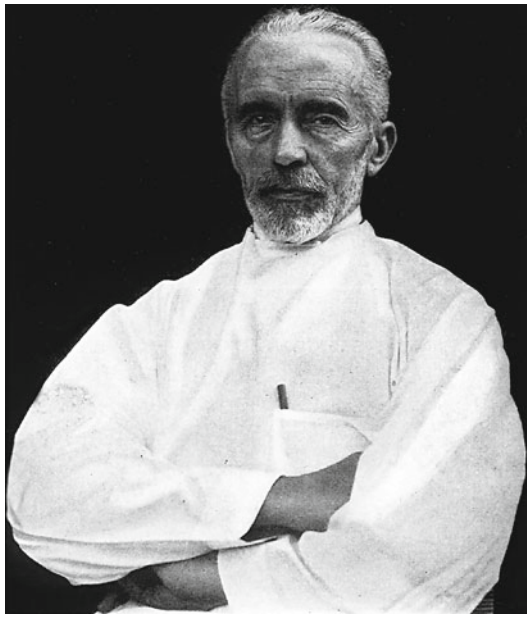

Fig. 1.2 Theodor Kocher, 1912 (Reproduced with permission from Institut für Medizingeschichte, Universität Bern, Buehlstrasse 26, CH 3012 Bern)

As a student of both Billroth and Kocher, Halsted brought his education home to the United States, where he wrote *The Operative Story of Goiter* in 1920. He helped to found Johns Hopkins Hospital, where he developed the first residency program and became the first professor of surgery. He trained many distinguished surgeons, including Cushing, Dandy, Reed, Lahey, and Crile. Among his various contributions to surgery, Crile devised an antishock garment for patient use during thyroid surgery (Fig. 1.3).

Postoperative tetany was first described by Wolfler in 1879, but it was Eugene Gley who first associated this symptom with disruption or removal of the parathyroid glands in 1891. An understanding of parathyroid physiology as it relates to calcium was discovered in 1900 by Mccallum and Carl Voegtlin. They discovered that postthyroidectomy tetany was associated with low levels of calcium in the tissues and that this could be reversed by injection of parathyroid extracts or calcium. Pfieffer and Mayer were the first to demonstrate success in the treatment of tetany with parathyroid autotransplantation. Frank Lahey further advanced the concept of autotransplantation in 1926 by advising its placement into the sternocleidomastoid muscle, while Sam Wells in 1976 showed the efficacy of subtotal parathyroidectomy with forearm autotransplantation for four-gland hyperplasia. A significant advancement in parathyroid surgery

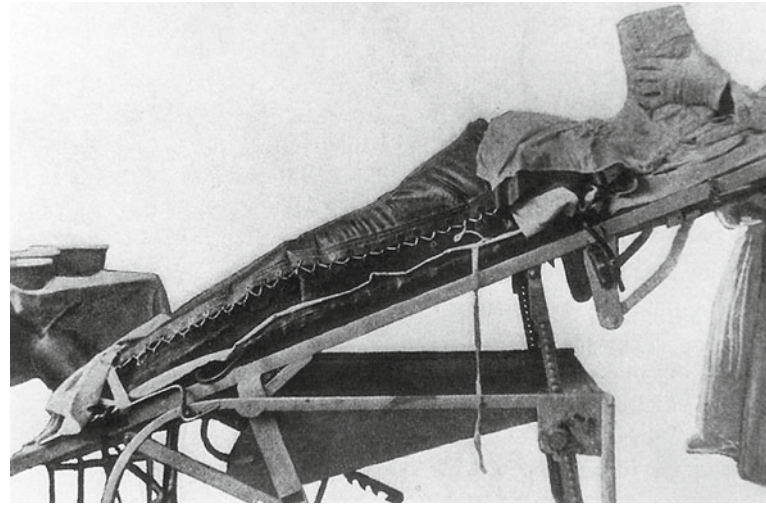

Fig. 1.3 Pneumatic antishock suit devised by Crile, used to prevent shock during thyroid surgery (From Park R. Principles and practice of modern surgery. Philadelphia: Lea and Brothers; 1907. Used with permission)

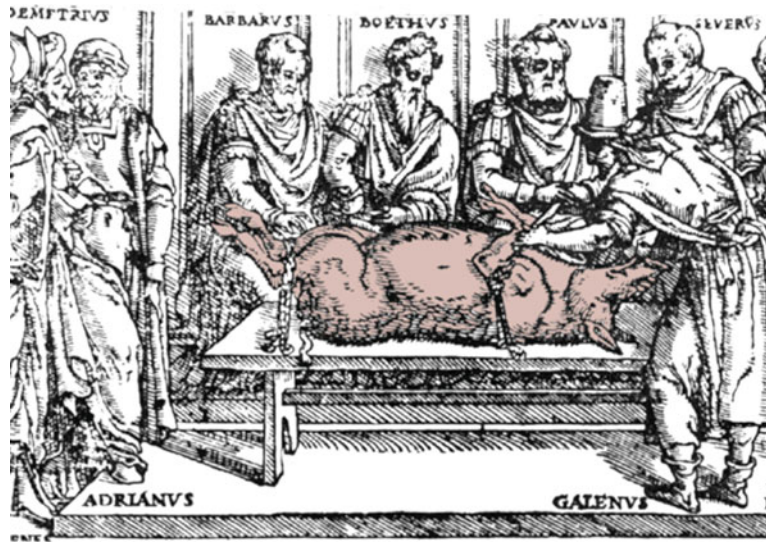

Fig. 1.4 Galen teaching Roman elders the anatomy of the recurrent laryngeal nerve in a living pig. Upon severing the nerve, the squealing pig became mute (From Galeni Liborum Quinta Classis EAM Medicinae Partem, edited by Fabius Paulinus. Published by Guinta Family of Venice, 1625. IM Rutkow. In: Surgery: an illustrated history, St. Louis: Mosby; 1993. p. 40)

occurred with the advent of the immunoassay measurement of parathyroid hormone (PTH) by Solomon Berson and Rosalyn Yalow in 1963, which earned them a Nobel Prize.

The anatomy of the recurrent laryngeal nerves was first detailed by Galen in the second century (Fig. 1.4). Due to his widespread influence, this knowledge was transmitted to generations of scholars and surgeons to come. A great deal was thus known by the 1700s about both the anatomy of the recurrent nerves and the sequelae of injury. The original approach of Kocher and Billroth to preserve the nerve was to ligate the inferior thyroid artery, away from the nerve–artery crossing point. Both Kocher and Miculicz advised leaving a small portion of thyroid tissue behind to cover and protect the nerve. Many other surgeons, including Prioleau, believed that the best strategy for avoiding nerve injury was to avoid visualizing it. It was Lahey in 1938 who demonstrated the importance and safety of nerve identification and dissection when he reported on a series of 3,000 thyroidectomies performed by he and his colleagues over a 3-year period. The significance of the superior laryngeal nerve was not recognized until much later in 1935 when goiter surgery brought an end to singer Amelita Galli-Curci's operatic career.

The turn of the twentieth century led to significant advancement in thyroid disease management with the advent of blood transfusions, frozen section pathology, improvement in patient follow-up and research, and thyroid cancer staging systems. Treatment of hypothyroidism began with the transplantation of thyroid tissue into the spleen of a patient's myxedematous daughter by E. Payr in 1906. Thereafter, surgeons began the practice of thyroid tissue transplantation to control symptoms of hypothyroidism after thyroidectomy. This was replaced by the development of animal thyroid extracts and later thyroxine, which was isolated by Edward C. Kendall in 1914. The treatment of hyperthyroidism was advanced with the development of antithyroid drugs and radioiodine therapy in the 1940s, providing alternatives to surgical excision, and propranolol was introduced for perioperative management in 1965. In the last quarter of the twentieth century, scintigraphy was developed and utilized as a diagnostic tool in thyroid disease workup but was largely supplanted by ultrasound in the 1980s. This allowed for discovery of small, subcentimeter nodules that were not clinically palpable. Further advancements in imaging, including with computed tomography and magnetic resonance imaging (MRI), allowed for assessment of substernal extension of goiters

and for evaluation of metastatic lymphadenopathy in cases of thyroid cancer. N. Söderström was the first to develop fine-needle aspiration cytology for thyroid disease in 1952. This became widely available in the 1970s, allowing for the preoperative diagnosis of cancer to be made, resulting in improved surgical decision-making and prioritization. Improved anesthetic agents, lighting, and instrumentation, such as advanced energy devices for hemostasis, further modernized the field. Development of the intraoperative PTH assay led to additional real-time assessment of parathyroid status during surgery for hyperparathyroidism.

Riddell in 1970 first described the use of recurrent laryngeal nerve (RLN) stimulation as a method for intraoperative detection of neural functionality. This was performed by using a finger to feel for laryngeal twitch as well as visualizing cricothyroid contraction upon stimulation of the laryngeal nerves with a handheld stimulator. Riddell also described direct laryngoscopic evaluation of vocal fold motion with RLN stimulation intraoperatively after completion of surgery on the first side. At the same time, Flisburg and Lindholm introduced the technique of insertion of intramuscular electrodes through the cricothyroid membrane into the vocalis muscle for intraoperative EMG monitoring. In 1978, Rea and Davis instead used an endoscopically placed vocal fold electrode. Intramuscular electrode placement required separate endoscopic or other procedures to be performed, as well as expertise and precision of placement in order for them to function properly. Intramuscular electrodes were also easily dislodged and thus difficult to use. These shortcomings were improved upon with the advent of noninvasive surface electrodes. This technology was first described by Davis in 1979, who reported on a gold foil electrode wrapped around an endotracheal tube in dog studies. In 1990, Goldstone used an endotracheal tube with two paired wires connected to electrodes that were exposed at the level of the vocal folds. These, in turn, were connected to an electromyogram (EMG) monitor. This became the basis for the development of the modern RLN endotracheal tube-based monitoring system, which has enhanced the capability of the surgeon both to identify the nerve intraoperatively and to detect its function in real time.

Other recent additions to thyroid disease management include the use of molecular genetic analysis and testing. The discovery of the *ret* proto-oncogene has led to its use in the prophylactic management of the children of patients with multiple endocrine neoplasia 2 (MEN-2) syndrome. Continued discoveries and understanding of genetic mutations associated with aggressive phenotypes of differentiated thyroid cancer show promise in improving the diagnostic accuracy of fine-needle aspiration biopsy (FNAB) and in predicting prognosis.

Over the last decade, there has been an increasing interest in minimally invasive thyroid and parathyroid techniques. These all represent extensions of previous innovations in the field. This book focuses on these concepts and techniques.

Recommended Reading

Becker WF. Presidential address: pioneers in thyroid surgery. Ann Surg. 1977;5:493–504.

Berson SA, Yalow RS, Aurbach GD, et al. Immunoassay of bovine and human parathyroid hormone. Proc Natl Acad Sci U S A. 1963;49:613.

Davis WE, Rea JL, Templer J. Recurrent laryngeal nerve localization using a microlaryngeal electrode. Otolaryngol Head Neck Surg. 1979;87(3):330–3.

Flisburg K, Lindholm T. Electrical stimulation of the human recurrent laryngeal nerve during thyroid operation. Acta Otolaryngol. 1970;263:63.

Garrison FH. An introduction to the history of medicine. 4th ed. Philadelphia: WB Saunders; 1929.

Goldstone A, Schettino RL. The electrode endotracheal tube: a state of the art method for monitoring recurrent laryngeal nerve vocal cord muscle integrity in the intubated patient. Otolaryngol Head Neck Surg. 1990;103:249.

Halstead WS. The operative story of goitre. Johns Hopkins Hosp Rep. 1920;19:71.

Kendall E. The isolation in crystalline form of the compound which occurs in the thyroid: its chemical nature and physiologic activity. JAMA. 1915;64:2042.

Lahey F. Routine dissection and demonstration of the recurrent laryngeal nerve in subtotal thyroidectomy. Surg Gynecol Obstet. 1938;66:775.

MacCallum WJ, Voegtlin C. On the relations of tetany to the parathyroid glands and to calcium metabolism. J Exp Med. 1900;11:118.

McGreevy PS, Miller FA. Biography of Theodor Kocher. Surgery. 1969;65:990.

Merke F. History and iconography of endemic goitre and cretinism. Lancaster/Boston: MTP Press; 1984. xi, 339 p.

Nuland SB. Doctors: the biography of medicine. New York: Alfred A. Knopf; 1988.

Organ Jr CH. The history of parathyroid surgery, 1850–1996: The Excelsior Surgical Society 1998 Edward D. Churchill Lecture. J Am Coll Surg. 2000; 191:284.

Randolph G. Surgery of the thyroid and parathyroid glands. 2nd ed. Philadelphia: Saunders/Elsevier; 2013.

Riddell V. Thyroidectomy: prevention of bilateral recurrent nerve palsy. Results of identification of the nerve over 23 consecutive years (1946–69) with a description of an additional safety measure. Br J Surg. 1970;57(1):1–11.

Roses DF. Traditions in surgery, vol. 2. New York: The Exeter Group; 1996.

Schlich T. The origins of organ transplantation: surgery and laboratory science, 1880–1930. Rochester: University of Rochester Press; 2010. p. 355.

Shedd DP. Historical landmarks in head and neck cancer surgery. Pittsburgh: American Head and Neck Society; 1999.

Söderström N. Puncture of goiters for aspiration biopsy. Acta Med Scand. 1952;144(3):237–44.

Ureles AL, Freedman ZR. Thyroidology: reflections on twentieth century history. In: Falk S, editor. Thyroid disease: endocrinology, surgery, nuclear medicine, and radiotherapy. 2nd ed. Philadelphia: Lippincott-Raven; 1997.

Welbourn RB. The history of endocrine surgery. New York: Praeger; 1990 xvi, 385 p.

Wells S. The use of torsion in surgical operations. Br Med J. 1974;1:47.

Wells SA. Parathyroid autotransplantation in primary parathyroid hyperplasia. N Engl J Med. 1976;295:57.