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HISTORY OF THYROID SURGERY

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The early ages

Goiter as an entity has been known in China ever since 2700 BC. The journey begins with the identification of seaweed and burnt sponges being used for the treatment of goiters in 1600 BC.[1] The Atharva Veda (2000 BC), an ancient Hindu text also mentions goiter as "galaganda" and describes various incantations for its treatment. Goiter word is derived from the Latin word "guttur" meaning throat. In Sushruta Samhita (600 BC), goiter has been described as a "Swelling which is lined/encapsulated, big or small, hanging like scrotum from neck".

निबद्धः श्वयथुर्यस्य मुष्कवल्लम्बते गले।
महान् वा यदि वा ह्रस्वो गलगण्डं तमादिशेत।।29।।

Hippocrates (331–156 BC) in his writings described goiter as"*… when glands of the neck become diseased themselves, they become tubercular and produce struma …*", although he was unable to differentiate between cervical nodes and thyroid gland.[2] Aurelius Cornelius Celsus (Figure 1.1) (25 BC–50 AD) described cystic goiters or bronchocoeles and proposed their blunt removal or use of caustics.

Aelius Galenus (130–200 AD), one of the most prominent physicians of the Greco-Roman era, and Aetios (550 AD) identified function of laryngeal nerve and the importance of protecting them.[2] Goiter has also been depicted throughout the Byzantine period in their artwork and religious paintings (Figure 1.2).

In 7th century AD, Paul of Aegina (Figure 1.3) first described struma and its operation. It was one of the earliest mentions of thyroid surgery in literature.[3] Persian physician and philosophers, Avicenna and Al-Jurjani (1000–1100 AD), described the association between neck swelling and exophthalmos.[4]

The first successful thyroidectomy was described in 500 AD by Abdul Kasan Kelebis Abis or Albucasis (Figure 1.4) under sedation where he used thermal cauterization. Early developments in thyroid surgery came from the famous school of Salerno, Italy, in 12th and 13th centuries. In 1170 AD, Roger Frugardii, a prominent

FIGURE 1.1 Aurelius Cornelius Celsus (by Wellcome Library, London. CC by 4.0).

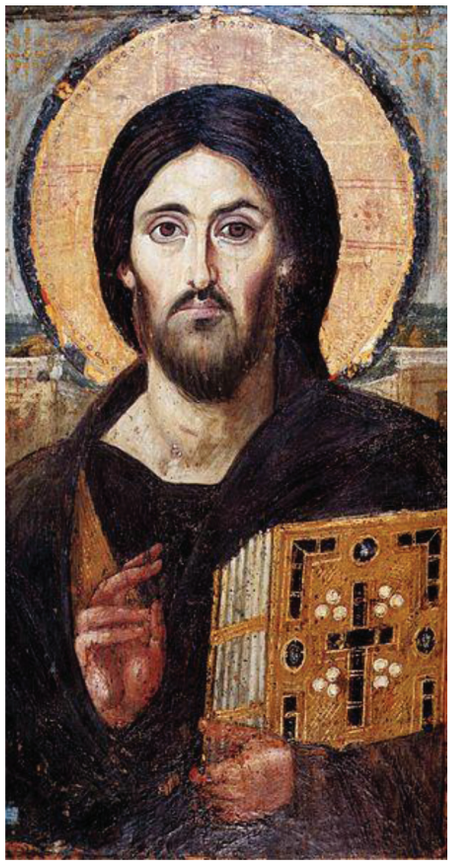

FIGURE 1.2 The Christ Pantocrator (by Sinai museum. CC by 2.0). Goiter has also been depicted throughout the Byzantine period in their artwork and religious paintings.

FIGURE 1.3 Paul of Aegina (by Wellcome Library, London. CC by 4.0).

surgeon of Salerno School described thyroidectomy using setons, hot irons, ligaments and caustic powders. Pedunculated goiters would be ligated en masse with bootlace and excised. Patients usually died of sepsis or hemorrhage when undergoing such procedures.[5] Frugardii wrote "*Practica Chirurgiae*" which became a principle of surgery in 13th and 14th centuries. In 12th century,

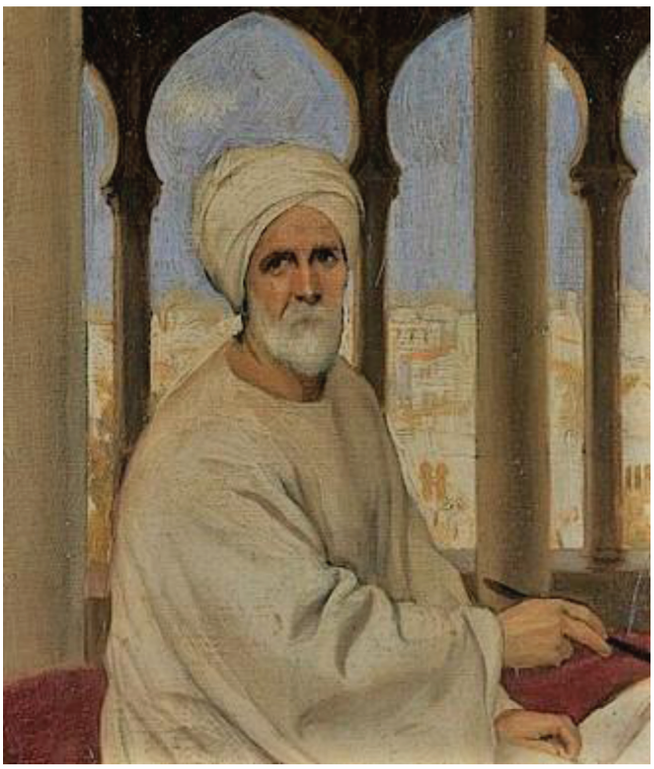

FIGURE 1.4 Albucasis (by Wellcome Library, London. CC by 4.0).

The Bamberg Surgery also described the removal of goiter in full detail.[5] Other prominent surgeons during the 14th century like French surgeon Guy de Chauliac also recommended surgical removal of goiter.[5]

The renaissance and premodern era

The period of Renaissance saw the emergence of better understanding of the anatomy and physiology of thyroid gland. It was through the works of Leonardo da Vinci (Figure 1.5) in 1511 that the anatomy of thyroid gland was finally understood, although the function was still debated upon. He drew thyroid gland as two globular glands and postulated that its purpose was to fill the empty space in the neck and holding the trachea away from the sternum.[6] Others postulated that its function was to lubricate the neck or make it more aesthetically pleasing. The Romans believed that goiter heralded the onset of puberty.[7]

Andreas Vesalius, the famous Flemish anatomist also illustrated thyroid gland in 1543. The thyroid gland did not acquire its name till the 16th century when Bartholomeo Eustachius of Rome characterized it as "glandulam thyroideam" with two lobes connected via isthmus.[8] The term thyroid gland or glandula thyroideois is accredited to Thomas Wharton, who described it in his work *Adenographia*. He gave this name either because of the shield-like shape of thyroid itself or because of the thyroid

FIGURE 1.5 Leonardo da Vinci's Madonna with clove (by José Luiz Bernardes Ribeiro/CC BY-SA 4.0). Leonardo da Vinci's artwork and various other Renaissance artworks depict their subjects with goiter.

cartilage to which it is associated.[8] In the late 18th century, Caleb Hillier Parry of Bath, England, was the first to identify exophthalmic goiter and also postulated that the glands act like a buffer between heart and brain in his work "Enlargement of the Thyroid Gland in Connection with Enlargement or Palpitation of the Heart".[9] Later, both Robert James Graves and Carl Adolph von Basedow published and confirmed their observations on exophthalmic goiter independently in 1835 and 1840, respectively.[10,11] In 1811, Bernard Courtois discovered iodine in burnt seaweed. Johann Straub and Francois Coindent studied the use of iodine to treat goiter in 1820. Coindent also recommended the use of iodine preoperatively to reduce the size and vascularity of gland. Subsequently, the use of iodine preparations became accepted and widespread.[8]

Various "noncutting operation" techniques for thyroid were employed throughout this period. In 1840, Robert Liston of London employed the division of sternocleidomastoid muscle to reduce dyspnea caused by large compressive goiter.[12] Similarly, Samuel Cusack of Dublin propagated the division of the cervical fascia to reduce dyspnea. William Blizard, in 1811, described the ligation of thyroid arteries to reduce the size of goiter. This was followed by similar attempts by Astley Cooper and Henry Coates with successful outcomes.[13] In 1896, Jaboulay was the first to try sympathectomy for exophthalmic goiter.[8] In 1646, Wilhelm Fabricius reported the first thyroidectomy using scalpels; however, the patient who was a 10-year-old girl died within 6 hours due to massive hemorrhage and he was imprisoned. Subsequently, in 1791, Pierre-Joseph Desault (Figure 1.6) performed the first successful partial thyroidectomy in Paris.[14] Following in his footsteps, Guillaume Dupuytren (Figure 1.7) performed the first "total" thyroidectomy in 1808; however, the patient died of shock after 36 hours.

FIGURE 1.6 PJ Desault (by Wellcome Library, London. CC by 4.0).

FIGURE 1.7 Guillaume Dupuytren (by Wellcome Library, London. CC by 4.0).

One of the most successful surgeons of the time was Johann Hedenus, from Germany. By 1821, he has reported the removal of six large obstructing goiters.[8] Other surgeons who partook in thyroidectomy during the same period were William Blizzard (who also propagated ligation of superior thyroid arteries and lateral approach), Henry Earle, Heusser and Victor von Bruns.[15] However, the mortality rate during this period was 40% which was attributed to hemorrhage, sepsis, asphyxia and air embolism.[15] These complications deferred even the most skilled surgeons of the time. Robert Liston, 1846, called thyroid surgery "*a proceeding by no means to be thought of*" after performing five thyroidectomies.[16] Later, in 1848, Samuel Gross (Figure 1.8) wrote, "*Can the thyroid in the state of enlargement be removed? Emphatically, experience answers no. Should the surgeon be so foolhardy to undertake it….every stroke of the knife will be followed by a torrent of blood and lucky it would be for him if his victim lived long enough for him to finish his horrid butchery. No honest and sensible surgeon would ever engage in it*".[17] The French Academy of Medicine subsequently banned thyroid surgery in 1850.

The surgical revolution and dawn of modern thyroid surgery

Surgery, in general, started making great progress in the middle of the 19th century with the introduction of anesthesia, antisepsis and hemostatic forceps.[18] These important events made a great impact on improving the outcomes of thyroid surgery as well.

FIGURE 1.8 Samuel Gross (The Gross Clinic by Thomas Eakins. CC by 1.0).

The surgical revolution began with the discovery of anesthesia, a term which was coined by Oliver Wendell Holmes. Sulfuric ether as an anesthetic was used for the first time by Crawford W. Long in 1842 which was followed by demonstration of ether's efficacy by William Morton at Massachusetts General Hospital in 1846. In 1847, Nikolay Pirogov became the first surgeon to use general anesthesia during thyroidectomy in St. Petersburg, Russia, with successful outcome.[17] Prior to this, local anesthesia during thyroidectomy was utilized.

The next important step in the surgical revolution was the introduction of antisepsis by Joseph Lister in 1867.[19] Infection with often fatal outcomes was a serious problem that had deferred even the most prominent surgeons from performing thyroidectomy. The use of carbolic acid and concept of antisepsis, as advocated by Lister, was adopted by prominent surgeons of the time, namely, Theodor Kocher and Albert Theodor Billroth, who saw a drastic decrease in the incidence of postoperative infections.[19] Intraoperative antisepsis was introduced by Gustav Neuber in 1883 with the use of caps and gowns in the operating theater and steam sterilization of the surgical instruments was introduced in 1886 by Ernst von Bergmann of Berlin.[20,21]

The final step in the surgical revolution was improved hemostasis, which was made possible by the introduction of the hemostatic forceps by Spencer Wells and Jules pears in 1874.[22] They had devised a self-retaining forceps with a single catch which subsequently underwent additional improvements like reduction in weight and inclusion of more ratcheted catches. Consequently, from 1850 to 1875, the mortality from thyroid surgery was reduced to half.[18] With a safe intraoperative and postoperative outcome, this period saw the rise of many prominent thyroid surgeons.

Albert Theodor Billroth (1829–1894)

Albert Theodor Billroth (Figure 1.9), an Austrian surgeon, is regarded as one of the most distinguished surgeons of the 19th century. He was an assistant to Bernhard von Langenbeck, the noted director of the University of Berlin, following which he was appointed to the chair of surgery in the University of Zurich in 1860 at the age of 31.[23] During his initial years at Zurich, he performed 20 thyroidectomies with a 40% mortality rate; hence, he abandoned thyroid surgery for a period of almost 10 years. With the use of better instrumentation and antisepsis, Billroth resumed thyroid surgery after 1877. Between 1877 and 1881, he had performed a total of 48 thyroidectomies with an 8.3% mortality. Billroth's technique involved division of the sternocleidomastoid muscle and incision and drainage of thyroid cysts. The Swedish surgeon, John Berg, in his comment about Billroth said, *"His entire attitude, like his speech, bore witness to a scientific genius to one of Europe's admittedly best and most trusted surgeons. While it may be said that he (Billroth) was aware of his superior gift, I saw no sign of haughtiness and often admired his tolerance towards the younger trainees"*.[3]

Although by the early 1880s Billroth had become one of the most experienced thyroid surgeons in the world, he broadly widened other fields of surgery as well. In 1873, he performed the first successful total laryngectomy, in 1881 the first successful gastrectomy, in 1882 the first esophagectomy and in 1884 the first total pancreatectomy. He later became known as *"Father of Abdominal Surgery"*.[23]

Many notable surgeons studied under him, including Anton Wölfler, Johann von Mikulicz, Anton von Eiselsberg and Theodor Kocher. Anton Wölfler's significant contributions to thyroid

FIGURE 1.9 Theodor Billroth (by Wellcome Library, London. CC by 4.0).

surgery were made during his time as Billroth's assistant. He was the first to describe tetany in postthyroidectomy patient in 1879 and the danger of operative injury to the recurrent laryngeal nerve.[24] Anton von Eiselsberg succeeded Wölfler as Billroth's assistant and continued his work on postoperative tetany. However, it was not until 1891, when Gley demonstrated that tetany is due to the removal of parathyroid gland or interference of blood supply to these glands.[25] Following this, Eiselsberg did early experimental work on transplantation of thyroid and parathyroid glandular tissue. Johann von Mikulicz, another one of Billroth's assistant and later chair of surgery in Krakow in 1882, suggested new approach to thyroidectomy with preservation of posterior aspects of both lobes, which he termed as "resection" as opposed to total excision or extirpation of the thyroid gland. This was proposed to reduce the incidence of injury to the nerve along with reducing the incidence of postoperative tetany. He, hence, showed that thyroid parenchyma could be crushed, divided or ligated without the fear of uncontrollable hemorrhage, thus laying the foundation of subtotal thyroidectomy.[23]

Theodor Kocher (1841–1917)

Theodor Kocher (Figure 1.10) has been widely and deservedly hailed as the "*Father of Thyroid Surgery*". Born in Switzerland, he was a pupil of Langenbeck and Billroth, before he was appointed as the Professor of Surgery at the University of Berne in 1872 at the age of 31.[23] During the first decade of his tenure, he had performed 101 thyroid surgeries with a mortality rate of 12.8%.

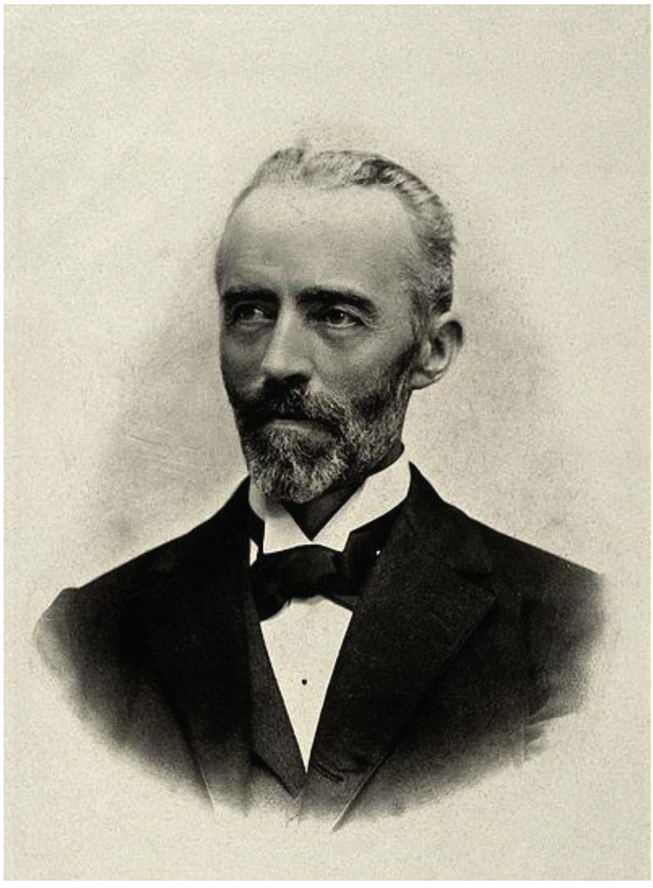

FIGURE 1.10 Theodor Kocher (by Wellcome Library, London. CC by 4.0).

He had performed additional 250 cases by the year 1889, with a mortality rate of 2.4%, which subsequently dropped to 1% and 0.2% in 1895 and 1898, respectively. In 1917, he made his final appearance before the Swiss Surgical Congress prior to his death, where he reviewed his entire surgical experience involving approximately 5000 operations with a mortality rate of about 0.5%.[26] As far as his surgical technique was concerned, Kocher was a meticulous surgeon, with careful attention to hemostasis. He propagated initial ligation of inferior thyroid arteries to reduce the risk of hemorrhage, along with preservation of strap muscles. He propagated the collar neck incision, which bears his name to date, as opposed to the oblique incision propagated by Billroth. Due to mortality secondary to chloroform anesthesia in one of his patients, he only used local anesthesia with cocaine.[26]

In 1883, Kocher published the historic paper in which he considered the ill effects of total thyroidectomy, thereby indicating that thyroid gland was essential for overall health and metabolism. He presented the famous case of Marie Richelle, the 11-year-old girl on whom he had performed total thyroidectomy, before the German Surgical Congress, where he said, "*....concerning one patient upon whom I had operated on January 8th, 1874, the referring physician incidentally reported that the girl had undergone marked change in her personality. Indeed, he finally informed me that she had become quite cretinoid. This seemed to me so important that I made every effort to examine the girl, which was not easy since this physician had died very shortly after making his report. We were all the more intent upon it since our colleague, Reverdin of Geneva, had informed us that he had observed two patients who had suffered diminution of mental capacity following goiter operations. I was highly astonished at the striking appearance of my patient. To crystallize somewhat your impressions I shall show photographs of the girl and her younger sister, taken before and after the operation. At the time of the operation, according to her mother, both girls looked so much alike that they were frequently mistaken for each other. Whereas in the ensuing 9 years the younger sister blossomed into a very pretty young woman, the one operated upon remained small and has an ugly, almost idiotic appearance. As soon as this was determined I immediately requested all of my goiter patients to return for examination*".[27] Out of the 24 patients who have undergone total thyroid gland removal by Kocher, 18 returned for examination; out of these, 16 showed features of cretinism, which he termed as "cachexia strumipriva". Shocked and distraught by the discover, Kocher vowed to never again perform a total extirpation of the gland. Thereafter, he propagated only lobectomy, reserving total excision only in cases of malignancy or when bilateral lobectomy was required for tracheal decompression.[26]

William Halstead, a pupil of both Billroth and Kocher, made an interesting observation between the surgical techniques of the two infamous surgeons. He noted that Kocher's patients developed myxedema after thyroidectomy but rarely tetany, whereas the reverse was true for Billroth's patients. He attributed this to the meticulous technique used by Kocher, where he paid attention on the removal of the whole gland and preservation of surrounding structures as opposed to Billroth's rapid approach, which resulted in parathyroid injury along with large remnant thyroid tissue.[28]

Other notable contributions to the field of thyroid surgery, apart from perfecting the technique of thyroid surgery, as noted by Halstead, were the studies with his friend Langhans of malignant thyroid tumors, study into operative treatment of Graves' disease and other forms of milder hyperthyroidism, demonstration of

ligation of arteries as an important preliminary step in lobectomy in toxic cases (staged surgery) and danger of indiscriminate use of iodine in patients with goiter. Apart from thyroid, Kocher's contributions to other fields are numerous – diseases of genitourinary tract, subcostal incision for cholecystectomy, operation of hernia, work with gunshot wounds, localization of spinal cord lesions, osteomyelitis, method of mobilizing the duodenum to expose retroperitoneal structures, operative technique for carcinoma rectum and reduction of dislocated shoulder – to name a few.[23] Kocher became the first surgeon to ever receive a Nobel Prize in Medicine and Physiology, in 1909, in honor of his life's work on the physiology, pathology and surgery of the thyroid gland.

William Halsted (1852–1922)

William Halsted (Figure 1.11), a pupil of Kocher, brought Kocher's surgical philosophy to the American surgical society. Following his graduation from Yale in 1879, he toured throughout Europe, in German and Austrian clinics, where he was influenced by the work of both Billroth and Kocher. Upon his return to America, he introduced the knowledge of antisepsis and modern hemostatic forceps in the United States. Halstead helped lay the foundation of the John Hopkins Hospital, where he assumed his lifelong professorship in surgery. He introduced residency training and trained many surgeons, including Cushing, Dandy, Reed, Charles, Horace, Frank Lahey and George Crile. Halstead reported injection studies that demonstrated parathyroid blood supply and demonstrated relief of tetany from injection or ingestion of parathyroid extracts.[29] He also showed that canine tetany could be controlled by ingestion of calcium salts.[30] He followed in the footsteps of Kocher and advocated preservation of parathyroid blood supply, ultra-ligation of thyroid arteries and staged surgery for toxic patients. His other contributions included improvement in the design of hemostatic forceps which still bear his name, introduction of retractors, ligature carriers, aneurysm needles, scalpels and dissectors in 1888–1889 and introduction of thin rubber latex gloves during operations thereby bettering antisepsis during surgery. He published the famous manuscript "*The Operatives Story of Goiter: The Authors Operation*" in 1920, which described the advances made in thyroid surgery.[29]

FIGURE 1.11 William Halsted (by Wellcome Library, London. CC by 4.0).

Other notable surgeons

Charles Mayo (1863–1939) started his thyroid journey in 1890, with a high mortality rate. Subsequently, with better surgical techniques, his mortality rate fell, and he began to tackle the difficult cases of "hyperthyroidism", a term which he first used. Initially, he adopted Kocher's staged operation with the exception of division of strap muscles. By 1912, Mayo had a case series of 278 successful thyroidectomies in Graves' disease patients.[31] His success was much credited to his medical colleague, Plummer, who recognized the benefit of preoperative iodine administration in hyperthyroid patients. With Plummer's preoperative preparation, Mayo's mortality rate for toxic patients sunk to less than 1%.[32]

George Crile (1864–1943) was a very notable American thyroid surgeon from Cleveland, who has said to have undertaken almost 25,000 thyroid surgeries throughout his career, largely for thyrotoxicosis, with an average mortality of 1%.[33] He had special interest in surgical shock and did extensive research on the same. He had postulated that thyroid storm was a result of preoperative fear and apprehension and, hence. had devised the process of "anoci-association" to allay the fear of surgery in patients by "stealing" the gland. His anesthetist would preoperatively attend the patient for several days prior to surgery, prescribing innocuous inhalations. On the day of surgery, unknown to the conditioned patient, the anesthetist would administer ether anesthesia.[34]

Frank Lahey (1880–1953) was another notable surgeon from Boston who had carried out more than 10,000 thyroidectomies during his lifetime with a mortality rate of 0.1%. He was a strong advocate of preserving the recurrent laryngeal nerve by actively visualizing the nerve and keeping it in view throughout, along with lateral ligation of inferior thyroid arteries to avoid injury to the nerve. He had a very low nerve palsy rate compared to his contemporaries at 0.3%. Lahey also established basal metabolic rate as a preoperative marker for hyperthyroidism and allowed his patients to rest in hospital several days prior to surgery to settle their basal metabolic rates.[35]

Thomas Peel Dunhill (1876–1957) of Australia is known for his remarkable work with thyrotoxic patients. At a time when it was considered foolhardy to operate a thyrotoxic patient with atrial fibrillations and cardiac failure, Dunhill considered these patients for a subtotal resection based on the principles of Mikulicz. In a case series of 230 exophthalmic goiter patients, only 4 deaths were reported. His success was in part due to his physician colleagues who helped with the preoperative preparation and stabilization of such patients.[36] In 1912, he presented his work in London, where it was met with skepticism as the mortality rate of thyrotoxic patients in Britain was as high as 33%. He later relocated to Britain where he forged a reputation with Joll as the leading thyroid surgeons of the time. He also described a technique of total lobectomy, on one side, and subtotal resection, on the other side (Dunhill's procedure), for thyrotoxic patients, and sternal splitting technique for retrosternal goiters.[37]

Other advances in the field of thyroidology

The hypothesis regarding the etiopathogenesis of goiter was a topic during the 18th and 19th centuries. Billroth believed that goiter was a local expression of general infections. Kocher believed that iodine was present in the thyroid gland, as iodine was often used for the treatment of goiter. It was, however, Fugen Bauman (1846–1896) who demonstrated the presence of iodine in thyroid gland. By the 1940s, iodine deficiency was accepted as a cause of goiter in endemic areas.[38]

Caleb Hillier Parry was the first to identify exophthalmic goiter.[9] Later, both Robert James Graves and Carl Adolph von Basedow published and confirmed their observations on exophthalmic goiter independently in 1835 and 1840, respectively.[10,11] The basis of Graves' disease was not known till 1886, when P.J. Moebius postulated that the etiopathogenesis was disordered function of thyroid gland itself. In 1896, Bernhard Riedel reported Riedel thyroiditis, wherein he described the case of fibrosis of thyroid gland mimicking malignancy.[39] In 1902, de Quervain described nonbacterial thyroiditis characterized by pain and inflammation, sometimes accompanied by transient thyrotoxicosis. In 1912, Hakaru Hashimoto described four cases of lymphocytic infiltration of thyroid, which he described as struma lymphomatosa.[8] In 1956, Deborah Doniach and colleagues discovered thyroid antibodies, which led to postulation of autoimmune theory in thyroiditis.[40]

Advances in other disciplines of medical sciences, namely, pathology, radiology, physiology, pharmaceuticals and anesthesia, contributed significantly toward surgical treatment of thyroid diseases. Fine needle aspiration cytology (FNAC) was first described in 1952 by Soderstorm, which resulted in an advancement in diagnosis. FNAC with ultrasonography for thyroid nodule was first described in the 1980s, which has now considered the gold standard in evaluation of thyroid nodule.[41]

William Ord described symptoms of hypothyroidism in 1877 and labeled the syndrome as myxedema.[42] Kocher described similar symptoms in his total thyroidectomy patients in 1883.[27] Victor Horsley and Felix Semon believed that these symptoms were due to the stoppage of thyroid gland function.[43] In 1891, George Murray demonstrated that injected thyroid extracts were useful in treating the complications of Kocher's procedure.[44] In 1914, Edward C. Kendall crystallized and isolated thyroxine hormone, thereby enabling the analysis of its chemistry.[45] Within 12 years of its crystallization, Harrington and Barger were able to synthesize thyroxine, which became an important landmark in the treatment of hypothyroidism.[46]

The use of iodine in patients with toxic goiter gained momentum when Plummer, in 1923, published results of 600 patients who had underwent surgery after using Lugol's iodine preoperatively. He demonstrated that mortality dropped to 1% with the use of preoperative iodine.[47] In 1942, radioactive iodine was introduced and incorporated in the treatment of toxic goiters by Means, Evans and Hertz.[48] In 1943, Edwin Bennet Astwood introduced thiouracil, thereby paving the path for incorporation of antithyroid drugs in the treatment of toxic goiters.[18] Beta blockers were first utilized in perioperative management of patients with toxic goiters in 1965.[48]

Present era

Our understanding and practice of thyroid surgery continues to evolve over time. From a procedure performed by general surgeons to becoming a subspecialty in itself, thyroid surgery has become safer and more effective. Advances in radiology, endoscopy, neuromonitoring and robotic surgery have taken thyroid surgery to further heights. The focus has shifted to better identification of nerves, preservation of parathyroid and cosmetic outcomes. The tendency to produce a better cosmesis with smaller incisions, and to shorten hospital stay and reduce complications, minimally invasive techniques has become a recent addition to thyroid surgery.

Minimal access surgery had a slow acceptance curve in head and neck surgery. Gagner and colleagues, in 1996, were the first to report feasibility of endoscopic approach to parathyroid glands.[49] Over a short period of time, a number of minimally invasive techniques simultaneously evolved. They were classified as pure endoscopic techniques, video-assisted techniques and minimally invasive open surgery. Minimally invasive open surgeries were defined as those procedures with cervical incisions less than 3 cm, which permits direct access to the thyroid gland and surrounding structures.[50] Minimally invasive video-assisted thyroidectomy (MIVAT) was popularized by Miccoli and his colleagues in Pisa, Italy.[51] 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. Afterward, the procedure is performed endoscopically on a gasless basis.[51] Pure endoscopic techniques differed in terms of routes being used to approach thyroid compartment, with or without carbon dioxide insufflation – the routes of access being lateral neck,[52] axilla,[53] anterior chest[54] and breast.[55] The breast approach was popularized by Ohgami M in 2000 and transaxillary approach by Ikeda in 2001. These approaches were combined and developed further into the axillary bilateral breast approach (ABBA) by Kenzo Shimazu in 2003 and bilateral axillary breast approach by Jun Ho Choe in 2007.[56,57]

The most recent technique that has shown excellent cosmetic results with low complication rates is that of NOTES. Transoral endoscopic thyroidectomy was first attempted by Wilhelm in 2010 via the floor of mouth but was abandoned due to high complication rate. Subsequently, in 2016, A. Anuwong of Thailand published a series of 60 human cases having undergone transoral endoscopic thyroidectomy vestibular approach (TOETVA).[58] In this method, three-port technique through the oral vestibule was used, creating an anterior subplatysmal space with CO_2 insufflation. With the introduction of robotic technology to the field of head and neck surgery, minimally invasive thyroid surgery has taken a further leap. The stereoscopic visualization with flexible instrumentation helps in better visualization and expert handling of thyroid during surgery.[59] Although safe and feasible, minimally invasive techniques come with their own learning curve, increased intraoperative time and high cost of equipment.

Conclusion

From an operation that was once predestined for failure, thyroid surgery has come a long way. The understanding of thyroid anatomy, physiology and pathology has seen tremendous changes throughout the ages. With better understanding and improved treatment modalities, combined with advancement in other medical specialties, thyroid surgery has become one of the safest surgeries in the hands of an experienced surgeon, with excellent surgical outcomes. The journey to improve upon the prevailing techniques still continues, and as we move into newer avenues and better technologies, it is prudent that we do not forget the

contributions and legacies of the great pioneers of thyroid surgery. As rightly penned down by Sir Berkeley Moynihan in *The British Medical Journal* few days after Kocher's death – "*The chief legacy which a surgeon can bequeath is a gift of the spirit. To inspire many successors with a firm belief in the high destiny of our calling, and with a confident and unwavering intention both to search out the secrets of medicine in her inner most recesses, and to practice the knowledge so acquired with lofty purpose, high ideals and generous heart, for the benefit of humanity – that is the best that a man can transmit*".[60]

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