



Energy-based devices in thyroid surgery—an overview

Sohail Bakkar¹, Theodosios S. Papavramidis², Qusai Aljarrah³, Gabriele Materazzi⁴, Paolo Miccoli⁴

¹Department of Surgery, Faculty of Medicine, The Hashemite University, Zarqa, Jordan; ²1st Propaedeutic Surgical Department, University Hospital of Thessaloniki AHEPA, Aristotle University of Thessaloniki (AUTH), Thessaloniki, Greece; ³Department of Surgery, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan; ⁴Department of Surgical, Medical, Pathology, and Critical Care, The University of Pisa, Pisa, Italy

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Correspondence to: Sohail Bakkar, MD, MS, PhD. Asst. Prof. Endocrine and General Surgery, Department of Surgery, Faculty of Medicine, The Hashemite University, Zarqa 13133, Jordan. Email: sohail.bakkar@gmail.com.

Abstract: In the mid-20th century Theodor Kocher standardized the conventional clamp-and-tie thyroidectomy, and a procedure that was banned or prohibited for so long was labeled as “extremely safe and efficient”. Ever since, innovations and refinements in the field of thyroid surgery have focused on improving patient clinical outcome profiles, and offering patients procedures that are tailored to their concerns and desires without compromising the concepts of safety and efficacy. This led to a paradigm shift in thyroid surgery and the introduction of minimal access thyroid procedures. Unsurprisingly, this paralleled the constant technological evolution in surgical devices. Advanced energy-based devices were introduced into thyroid surgery more than a decade ago. Initially, their introduction was surrounded by skepticism, and was considered a double-edged sword equally giving accolade and criticism. Ultimately, they have proved to be very useful in thyroid surgery, and pivotal to its evolution. In experienced hands, thyroid surgery performed using an advanced energy-based device is considered ‘at least’ as safe and effective as its conventional clamp-and-tie counterpart. Furthermore, it offers additional advantages that meet the best interest of the patient, surgeon, health care facility, and the society. This article provides an overview on the introduction of innovative technology into thyroid surgery.

Keywords: Thyroid surgery; energy-based devices; surgical innovation; minimal access surgery

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“The extirpation of the thyroid gland for goiter typifies perhaps better than any other operation the supreme triumph of the surgeon’s art.”—William Halsted, 1852–1922 (1).

A century of dedication and hard work was required to transform a procedure that was associated with considerable morbidity and mortality, and therefore, banned or prohibited, into one labeled as “extremely safe and efficient” (1). Indeed, the standardization and popularization of the conventional clamp-and-tie thyroidectomy symbolizes a triumph for surgery as a blend of art and science.

Recent years have witnessed an unprecedented growth in

technical and technological innovation in surgical practice. Unsurprisingly, this was paralleled by a constant evolution in thyroid surgery, and the birth of the era of minimal access thyroid surgery (2). The three broad classes of minimal access thyroid procedures include: (I) completely endoscopic procedures whether performed via a direct or remote access; (II) partly endoscopic gasless procedures, and (III) non-endoscopic mini-incision procedures (3). The use of innovative advanced energy-based devices is an integral component of all these procedures.

To safeguard patient interests and promote the beneficial

effects of innovation in patient care, the committee on emerging surgical technology and education of the American College of Surgeons stated that “*The worth of any newly introduced surgical technology is measured on the basis of the value and safety it confers for patients*”. Therefore, how a technical and/or technological innovation compares to existing and proven methods of dealing with the same clinical situation is an integral part of its evaluation process (4). In thyroid surgery, technical and technological innovation is contrasted against the time-honored conventional clamp-and-tie technique. However, several potential confounders may limit an effective and objective comparison. These include: sponsor agenda, failure of authors to disclose competing interests, and making pairwise comparisons instead of comparing multiple treatments. To overcome these obstacles, a network meta-analysis was conducted by Garas *et al.* (5). It demonstrated that applying an energy-based device in thyroid surgery resulted in a superior clinical outcome profile to the conventional clamp-and-tie technique in terms of: operative time, postoperative hypoparathyroidism, intraoperative blood loss, drain output, and cost. However, a reverse trend applied with the clinically important complication of recurrent laryngeal nerve (RLN) palsy, which seemingly related to a major confounder not accounted for in the meta-analysis; surgeon’s experience and volume. The potential adverse implication that the use of energy-based devices in thyroid surgery may impact on the RLN, was also highlighted in a ‘Note of caution’ (6). The note acknowledged that the history of thyroid surgery reflected the evolution of surgical hemostasis, which in turn is an index of surgical precision, and that the advent of energy-based devices was set to achieve this goal. However, it implied that hemostasis was likely to suffer from the infidelity of energy-based devices that could serve as invisible enemies causing invisible thermal insult to the RLN. Concluding that trading such a serious potential complication for a few minutes gain in operative time offered by these instruments could not be justified. As expected, a reply to this note came in, underscoring the concepts of surgeon’s experience and the proper introduction of new technology into surgical practice (7).

Surgeon’s experience reflected by volume or annual case-load is the most important denominator in thyroid surgery irrespective of the technique applied (8). The consensus statement of the American Head and Neck Society on the surgical management of the RLN in thyroidectomy reported that compared to high-volume surgeons, lower-

volume surgeons had considerably higher complication rates and lengthier hospital stays (9). With the introduction of energy-based devices into thyroid surgery, the term experience broadens to include familiarity with device’s mechanism of action, and familiarity with the principles of safety distance, activation time, and lag time as fundamental elements for delivering a safe procedure, and preserving nearby critical neck structures, namely the RLNs and parathyroids (10). The safety distance, and the activation and lag times vary according to the type of energy device used. These principles gain additional importance when the implications of thermal injury to the RLN are well acknowledged. As opposed to traction nerve injury that only disrupts the outer layer of the nerve and mostly results in a transient vocal fold palsy, thermal injury is more severe. It damages the inner endoneurium and is more likely to result in a permanent vocal fold palsy (11). Furthermore, some tips on how to use or handle the instrument can only be mentored by an expert surgeon; such as how the instrument’s jaw should be positioned to avoid injury to adjacent structures, dealing with persistent ooze in close proximity to the RLN, and applying the double coagulation technique for larger vessels (12). Therefore, the safe and effective introduction of a new surgical technique and/or technology into practice should follow a proper preparatory phase of knowledge acquisition, both theoretical and technical. Furthermore, essential to such an educational approach is observing an expert surgeon/mentor followed by mentored hands-on training (13). Further testimony to that experience governs the outcome of using energy-based devices in thyroid surgery, comes from the results of a national multicenter register study from Sweden (14). The study compared thyroidectomy performed using various energy-based-devices to the conventional clamp-and-tie technique incorporating data from small and large centers, and specialized and non-specialized units. It reported, a considerably higher requirement for the use of topical hemostatic agents in the energy-based-device groups compared with the conventional clamp-and-tie group; contradicting the true essence of instrument use.

Based on the mechanism of hemostasis/vascular sealing provided, energy-based-devices could be broadly classified into three categories: ultrasonic systems, electrothermal bipolar (radiofrequency) systems, and hybrid systems combining both energy modalities (15,16). Ultrasonic systems deliver mechanical energy in the form of ultrasonic vibrations at a rate of 55 KHz/s, disrupting tissue hydrogen bonds and creating an endovascular coagulum that is

capable of sealing off vessels up to 5 mm in diameter. On the other hand, two components are responsible for the sealing effect provided by electrothermal bipolar (radiofrequency) systems: direct pressure and a closed loop bipolar electrocautery system. The enhanced bipolar electrocautery system uses computer-controlled impedance (tissue resistance) monitoring and feedback to adjust the electrical energy given to the tissue, delivering high current and low voltage radiofrequency energy that denatures collagen and elastin in vascular walls, merging vessels with surrounding soft tissue. Vessels up to 7 mm in diameter can be controlled with these systems. Although a considerable elevation in tissue temperature is generated by all these systems, the temperatures seldom reach the levels generated by standard electrocautery, considerably minimizing lateral thermal spread (16). These surgical technologies, developed by competing companies, are constantly evolving to improve device performance. None of the available sealing technologies has been found to be superior to the other in terms of clinical outcome, and the choice of system used remains a matter of personal preference (15-19).

Hemostasis is the cornerstone of any surgical procedure. An emphasis on its utmost importance is clearly inferred from Halsted's description of hemorrhage as "*the only weapon with which the unconscious patient could immediately retaliate on the surgeon*" (20). In thyroid surgery, the importance of hemostasis is augmented because of the relatively limited and highly vascular space, and intimately related critical neck structures. Therefore, even minimal bleeding could blur the operative field, impairing visualization and the proper identification of critical neck structures, and increasing their likelihood of injury. The advent of energy-based devices and their introduction into thyroid surgery targeted a superior hemostasis, and hence, a better patient clinical outcome profile. However, in terms of safety and hemostasis adequacy, energy-based devices did not prove to be superior to the cold, and sharp dissection of conventional thyroidectomy (21). Nevertheless, their use was associated with additional considerable advantages. A considerable reduction in operative time, drain output, postoperative pain and the consumption of pain medication; outcomes that could be attributed to a rapid and effective hemostasis with minimal tissue damage. Furthermore, their applicability through narrower incisions allowed for shorter and cosmetically favorable outcomes. All these advantages, have allowed for the popularization of ambulatory (day-case) thyroid surgery. Surprisingly, these additional advantages do not impart an additional overall cost. The cost of the

single-use device is counterbalanced by the considerable reduction in operative time which in turn means performing more procedures in the same surgical session, cutting-off anesthesia and pain medication cost, and shortening hospital stay (22-24).

To conclude, applying innovative advanced energy-based devices in thyroid surgery has proved to be beneficial to patients, surgeons, healthcare facilities, and the society. Nevertheless, to safeguard patient interests and promote the beneficial effects of innovation in patient care, their adoption and introduction into surgical practice should follow a mentored and monitored step-wise educational process.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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