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New technologies in thyroid cancer surgery

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SUMMARY

Several new technologies have advanced the practice of thyroid surgery in recent years, with some centers implementing substantial changes in the way thyroid surgery is performed. As many thyroid cancers are diagnosed at an early stage the treatment is quite effective, and the prognosis is good for most patients with differentiated thyroid cancer. With excellent long term survival, advancements in the treatment of patients with thyroid cancers are focusing on reducing complications of surgery, improving quality-of-life and delivering care in a cost-effective way. The LigaSure electrothermal bipolar vessel sealing system and Harmonic scalpel have been designed to aid in dissection with less thermal spread than conventional electrocautery. Alternative access approaches to the thyroid allow for improved cosmetic outcomes and potentially improve the view of the surgical field. The intraoperative use of gamma-probe for the localization of metastases and sentinel lymph nodes are being increasingly reported on. Surgeon performed ultrasound is promoted for improving the detection of disease, and intraoperative nerve monitoring is now widespread, aiding in laryngeal nerve detection and protection. The assay of parathyroid hormone is also in common use for predicting patients at risk for developing postoperative hypocalcemia. This article reviews the current literature on new technologies for thyroid surgery and discusses some of the implications for the future of this field of surgery.

Introduction

The practice of surgery for thyroid malignancy has seen many advancements over the past decade, with most developments relating to technologies which focus on reducing complications. Devices developed for surgical dissection with improved hemostasis and reduced heat transfer (and hence collateral tissue damage) is of particular interest in thyroid surgery. Laryngeal nerve injury and parathyroid gland dysfunction are complications of surgery with potentially devastating consequences and hence have been an area of focus for recent technological developments. Intraoperative nerve monitoring is an increasingly common adjunct to laryngeal nerve identification and preservation, and the use of parathyroid hormone assays assists in the early detection of glandular dysfunction. Modern trends in health care place ever increasing importance not only in reducing complications, but also in improving overall quality of life, and include such parameters as improved cosmesis and reduced recovery time. Intraoperative detection of parathyroid hormone levels and sentinel lymph nodes have also been an area of focus for advances over recent years.[1] In this review, we present some of the technologies which have emerged over the past 10 years and assess the evidence supporting their efficacy.

Hemostasis/prevention of bleeding: Harmonic scalpel, LigaSure

Hemostasis is of great concern in thyroid surgery. Adequate control of bleeding can prevent the need for postoperative drainage and prolonged inpatient stay. Postoperative bleeding can also lead to neck hematoma and airway compromise. Traditional techniques of hemostasis for thyroid surgery include suture ligation, with later developments in technology adding electrocautery and vascular clip application to the armamentarium. These techniques however have distinct disadvantages in thyroid surgery. Suture ligation can be time consuming and cumbersome in the confined space during dissection. Sutures may also be prone to knot slippage and may rarely cause foreign body reactions.[2] Vascular clips may also be prone to displacement with tissue manipulation in the surgical field. Vascular clips may also interfere with future imaging by CT scan or MRI. Electrocautery, while useful for hemostasis, causes temperature rises to as high as 400 °C, so are potentially hazardous in proximity to the laryngeal nerves and parathyroid glands. Monopolar electrocautery has been demonstrated to be associated with an injury zone as large as 15 mm.[3] Bipolar electrocautery is effective for control of only small vessels, but has been shown to cause less collateral thermal injury (1–6 mm from the site of contact).[4] The

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Figure 1 LigaSure small jaw handpiece.

Figure 2 FOCUS Harmonic scalpel handpiece and console.

disadvantages of traditional methods of achieving hemostasis have led to developments in technologies to improve hemostasis while reducing surgical time and risk of local tissue heat injury. Two instruments that have gained increasing acceptance over the past decade for use in thyroidectomy are the electrothermal bipolar vessel sealing system, or LigaSure™ (Velleylab, Boulder, CO, USA) and the Harmonic® scalpel (Ethicon, Cincinnati, OH, USA).

The LigaSure is an enhancement of bipolar electrocautery which uses computer controlled impedance monitoring and feedback to actively adjust the electrical energy delivered during applications (Fig. 1). The LigaSure achieves hemostasis by tissue coagulation, with the aid of pressure applied by apposition of the tines against the tissue. Radiofrequency bipolar energy is delivered with a high current (4 A) and low voltage (less than 200 V) to denature collagen and elastin and form a coagulative sealant.[2] When tissue coagulation is completed, changes in the impedance trigger automatic interruption of the electrical current. The adjustments in current achieve hemostasis while minimizing energy and heat transference to adjacent tissues. Several studies have shown the field of tissue injury from thermal spread to be within 3 mm,[4–8] which compares favorably to tissue damage found up to 6 mm for conventional bipolar electrocautery.[4] Manouras et al. reviewed 22 studies comparing LigaSure and traditional hemostasis techniques during thyroidectomy and found all but two studies revealed a significantly shorter operation time with the LigaSure.[2] All studies confirmed safety of the technique and three of the studies demonstrated decreased transient hypocalcemia.[9–11] More recent studies have added strength to the evidence, showing the LigaSure to reduce surgical time by 10–29 min compared to conventional hemostatic techniques.[12,13]

The Harmonic scalpel employs ultrasound vibration of a blade at 55 kHz over a distance of 80 μm.[1] The resulting mechanical energy, rather than heat, denatures proteins by cleaving hydrogen bonds. It has the benefit of producing less heat than electrocautery methods (60–80 °C) and does not transmit any current to the patient. A significant advantage is the ability to coagulate and cut tissues with the same instrument, allowing for efficient dissection. It is also reported to produce less smoke and charring than other methods of hemostasis.[14] The system consists of a generator/console and hand piece. Newer devices such as the FOCUS™ shears, designed for thyroid surgery, are hand-activated (Fig. 2). The instrument design is similar to scissors, with one portion housing a transducer attached to a blunt oscillating blade. When the instrument is engaged, the oscillating blade is opposed to an inactive broader blade, which protects underlying tissue from injury. Studies have shown the zone of collateral tissue injury to be 2.2 mm or less[4,7,15] and collateral nerve injury has been shown to be significantly less than that seen with monopolar or bipolar electrocautery.[16] In a recent meta-analysis comparing Harmonic scalpel thyroidectomy to other techniques by Ecker et al. all 12 prospective randomized studies have shown a shorter operating time with the Harmonic scalpel without any increase in complications.[17] A subsequent study also demonstrated shorter duration of surgery with the use of the Harmonic scalpel.[18]

Experimental studies have demonstrated that the LigaSure can seal vessels up to 7 mm in diameter at blood pressures well above physiologic levels.[4,6–8,19,20] The mean burst pressure was also higher for vessels 4–7 mm when compared to the Harmonic scalpel or standard bipolar cautery.[7,8] The FOCUS device is FDA approved to seal vessels up to 5 mm, less than the 7 mm vessel size approved for the LigaSure. When local tissue injury zones of the LigaSure are compared to the Harmonic scalpel, studies have demonstrated equivocal results, with some demonstrating less thermal spread with the LigaSure,[21] no difference,[7] and more thermal spread with the LigaSure.[4,22] An experimental animal study has shown less collateral tissue injury with the use of LigaSure and Harmonic devices compared to traditional methods.[5]

Although the newer technologies may help in reducing complications of thyroid surgery compared to standard methods of hemostasis, this has not been demonstrated by Pons and colleagues who found no difference in the complication rates between surgery using the Harmonic scalpel, LigaSure or conventional hemostatic methods.[12] A publication in 2008 by Sartori et al. found complication rates of thyroidectomy to be higher for patients who had new technology devices used, including lower postoperative serum calcium levels.[23] In more recent studies, the complications of thyroid surgery were no different between use of the Harmonic scalpel and LigaSure, but the Harmonic scalpel was shown to reduce operative time compared to the LigaSure.[12,24] Several other reports have also found no difference in complication rates using newer technologies.[2,13,17,18]

There is growing evidence to support the use of new technologies for thyroidectomy, as they have been shown to reduce operative time without additional risk to the patient, but this must be weighed against the additional costs of the devices. In the randomized controlled trial by Pons et al. comparing conventional thyroidectomy to surgery with the LigaSure and Harmonic scalpel, the newer technologies were found to have a cost savings of 11 and 85 dollars respectively, due to the reduced surgical time.[12] It appears, however, that new devices have not