Hypothesis: The technique of thyroidectomy has undergone little change in several decades. The harmonic scalpel, using ultrasonic frictional heating to ligate vessels, is widely used in laparoscopic surgery, but there is little experience in open thyroidectomy. We hypothesized that the use of the harmonic scalpel could lead to a significant reduction in operative time as compared with knot tying in thyroid surgery.

Design: Retrospective case-controlled study.

Setting: Teaching institution.

Patients: One hundred seventy-one consecutive patients undergoing lobectomy or total thyroidectomy by one surgeon (A.E.S.).

Interventions: Eighty-six patients underwent thyroid surgery with the conventional clamp-and-tie technique (lobectomy, n = 49; total thyroidectomy, n = 36) and 85 with the harmonic scalpel (lobectomy, n = 38; total thyroidectomy, n = 47).

Main Outcome Measures: Demographics, pathological characteristics, thyroid size, operative time, blood loss, and complications using a 2-tailed t test, χ² test, and Wilcoxon rank sum test.

Results: The 2 groups were similar regarding age and sex. There were no intraoperative complications. Mean ± SD thyroid size tended to be larger in the harmonic scalpel group for both lobectomy (5.1 ± 2.6 cm vs 4.2 ± 2.2 cm; P = 0.06) and total thyroidectomy specimens (6.3 ± 3.8 cm vs 4.8 ± 2.9 cm; P = 0.08) compared with the conventional technique. Mean ± SD operative time was shorter in the harmonic scalpel group compared with the conventional technique group for both lobectomy (89 ± 20 minutes vs 115 ± 25 minutes; P < 0.01) and total thyroidectomy (132 ± 39 minutes vs 161 ± 42 minutes; P < 0.01) procedures. There was no difference between the 2 techniques regarding the amount of blood loss for different procedures. There was no effect of tumor size on operative time (Pearson correlation factors: 0.14 for total, 0.21 for unilateral thyroidectomy).

Conclusions: The use of the harmonic scalpel for the control of thyroid vessels during thyroid surgery is safe, and it shortens the operative time by almost 30 minutes compared with the conventional technique for both unilateral lobectomy or total thyroidectomy procedures.

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THE HARMONIC scalpel is a new device that has been introduced to surgery during the last decade. It is a device that uses high-frequency mechanical energy to cut and coagulate tissues at the same time.1 Laparoscopists were the first ones to use this method widely. It has been proven to decrease operation time and complications in studies of abdominal solid organ surgery,2-4 adrenalectomy,5 and thoracic surgery,6,7 as well as many other procedures.8-11

Thyroid surgery initially started in the 12th century with the use of setons, hot irons, and caustic powers (often with fatal results). A major advance was the introduction of ether anesthesia, antisepsis, and artery forceps to practice.12 The pioneers of thyroid surgery, Theodor Kocher and Theodor Billroth, developed an acceptable technique of standardized thyroid surgery between the years 1873 and 1883. By 1920, the principles of safe and efficient thyroid surgery had been established.13 Since the technique has become standardized, safe, and efficient, there has not really been a major change in our technique of thyroidectomy. The only debate and change have been with regard to the choice of a certain type of operation (ie, lobectomy, total thyroidectomy, or subtotal thyroidectomy) for a given diagnosis. Some alternative methods in thyroid surgery that have been tried

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PATIENTS AND METHODS

PATIENTS

Between February 1994 and December 2000, 227 patients underwent various thyroid surgical procedures performed by one surgeon (A.E.S.) using either conventional knot tying (n=124) or the harmonic scalpel (n=103) for vessel control. Those patients undergoing either lobectomy or total thyroidectomy form the subject of this study for practical considerations. There were 85 patients operated on with the conventional technique (lobectomy, n=49; total thyroidectomy, n=36) and 86 with the harmonic scalpel (lobectomy, n=39; total thyroidectomy, n=47). The choice between the type of surgery for a given patient depended on the availability of the equipment. We started using the harmonic scalpel for thyroid procedures in April 1998. Three different models were used in the study, including the Ultracision CS (Ethicon EndoSurgery, Cincinnati, Ohio), AutoSonix Ultrashears (United States Surgical Co, Norwalk, Conn), and the Ultracision Harmonic Scalpel CS-14C (Ethicon EndoSurgery) (Figure 1 and Figure 2).

PROCEDURE

All patients had routine preoperative workup for their disease and the same anesthetic and hospital care regardless of the surgical technique employed. All patients were admitted on the morning of the scheduled operation and had a 23-hour hospital stay. All procedures were performed using endotracheal general anesthesia. The patients were positioned and draped in the conventional manner. A 4- to 6-cm incision (depending on the size of the thyroid) was made over the level of the thyroid isthmus. Subplatysmal flaps were developed, and the strap muscles were separated in the midline and laterally reflected. The inferior, middle, and superior thyroid vessels were then divided either with the harmonic scalpel or with conventional knot tying (Figure 3). The thyroid lobe was then medially rotated, and the vessels in the ligament of Berry, with the nerve under direct vision, were clamped and tied in both groups. The same steps are repeated for removal of the contralateral lobe. Finally, the wound was irrigated and closed using interrupted 3-0 polyglactin sutures to approximate the strap muscles and the platysmal layer. The skin was closed using Michel clips, which were removed on postoperative day 1.

ANALYSIS

Medical records of the patients enrolled in the study were reviewed from the first author’s endocrine surgery database, and the patients in the 2 surgical groups were compared regarding age, sex, diagnosis, thyroid size, operative time, estimated blood loss, and complications using a 2-tailed t test, χ² test, and Wilcoxon rank sum test. Statistical significance was reached at P<.05. Patients with previous neck surgery, those with extrathyroidal invasion of malignant tumors of the thyroid, and those undergoing an accompanying additional procedure (ie, parathyroidectomy, lymph node dissection) were not considered for analysis. No additional time was spent in any case for waiting for the frozen-section pathology report.

To investigate the effect of histopathology on surgery time, histopathology was divided into 2 major categories: focal pathologies, comprising benign and malignant thyroid tumors; and diffuse pathologies, including goiter, thyroiditis, and Graves disease. Subtotal thyroidectomies were also considered under total thyroidectomy cases for practical reasons. All patients were followed up with office visits 2 weeks after surgery.

Figure 1. Ultrasonic coagulating shears used in this study. Top, Ultracision CS (Ethicon EndoSurgery, Cincinnati, Ohio). Center, AutoSonix Ultrashears (United States Surgical Co, Norwalk, Conn). Bottom, Ultracision Harmonic Scalpel CS-14C (Ethicon EndoSurgery). All have a shaft length shorter than their counterparts used in laparoscopic surgery. The older devices (top) had a shaft 10 mm in diameter. Newer devices have a shaft 5 mm in diameter that takes up less room in the small incisions used for thyroid surgery.

The 2 groups were similar regarding age and sex. For the total thyroidectomy procedure, there was no difference between groups regarding the distribution of focal vs diffuse pathologies. For unilateral lobectomy, there was no...
difference between the side of lobectomy (right vs left) between the 2 groups; however, the patients in the conventional knot-tying group had a greater likelihood of having a focal pathology (76%) vs the harmonic scalpel group (54%) ($P < .05$) (Table).

There were no intraoperative complications. Mean ± SD thyroid size tended to be larger in the harmonic scalpel group for both lobectomy (5.1 ± 2.6 cm vs 4.2 ± 2.2 cm; $P = .06$) and total thyroidectomy specimens (6.3 ± 3.8 cm vs 4.8 ± 2.9 cm; $P = .08$) compared with the conventional technique. Mean ± SD operative time was shorter in the harmonic scalpel group compared with the conventional technique for both lobectomy (89 ± 20 minutes vs 115 ± 25 minutes; $P < .01$) and total thyroidectomy (132 ± 39 minutes vs 161 ± 42 minutes; $P = .01$) procedures (Figure 4).

Figure 2. Active tips of the ultrasonic coagulating shears. All employ a rigid active lower blade through which the vibrating energy is transmitted. The movable upper jaw is used to compress the vessel against the lower blade, thus allowing transfer of the vibrational energy. The top 2 devices have straight blades. The bottom device has a curved blade facilitating perpendicular placement across vessels.

Figure 3. A “double ligation technique” to divide the inferior thyroid vein. A, The device is applied across the vein near the thyroid for approximately 3 seconds until the vessel is sealed, but not yet divided. B, The device is then moved along the vessel several millimeters away from the thyroid, and the vessel is sealed and divided. C, The cut vessel end is seen with an additional segment sealed adjacent to the thyroid. This double ligation technique minimizes the chance of vessel hemorrhage.

There was no difference between the 2 techniques regarding the amount of blood loss for different procedures. There was no effect of tumor size on operative time (Pearson correlation factor: 0.14 for total thyroidectomy, 0.21 for unilateral thyroidectomy) (Figure 5 and Figure 6).
Hemostasis is of utmost importance in thyroid surgery to control and divide the numerous vessels before excision of the gland. Traditional surgery involves hand-tied ligatures to control the 2 ends of a vessel before division. Although many sophisticated means of achieving vessel control (eg, bipolar electrocautery, lasers, clips, and staples) found widespread applications in many other types of procedures, the only modification of the thyroidectomy technique during the past decades included the use of monopolar electrocautery for dissection due to various technical, anatomical, and practical reasons. Clips work for large vessels and are subject to dislodgment; whereas staples are wasted and costly for multiple single-vessel applications. Lasers are hindered by the risk of injury to many vital structures (such as the recurrent nerves) in the operative field, and bipolar electrocautery does not give the surgeon the freedom of applicability at different angles.

The development of ultrasonically activated coagulating shears in the early 1990s has provided an alternative to other methods of controlling blood vessels. The device divides tissue by using high-frequency (550 kHz) ultrasonic energy transmitted between the instrument blades. The active blade of the instrument vibrates longitudinally against an inactive blade over an excursion of 50 to 100 µm. This mechanical action disrupts protein hydrogen bonds within the tissue. This takes place at a relatively low temperature (80°C) causing a lesser tissue injury (<1.5 mm) compared with both electrocautery and laser. Because the water in the tissue does not boil due to this mild increase in temperature, the proteoglycans and collagen fibers in the tissue become denatured and mix with intracellular and interstitial fluids to form a gel-like substance (a coagulum).

With our initial experience from laparoscopic surgery, we started using the harmonic scalpel in 1998 for thyroid surgery. We have so far assessed its use in more than 120 patients undergoing various thyroid and parathyroid procedures, including lobectomy; subtotal, total, or completion thyroidectomy; neck dissections; and parathyroidectomy. To the best of our knowledge, in this article, we report the largest experience in the literature...
about the use of the harmonic scalpel in thyroid surgery. We showed that the use of the harmonic scalpel for the control of thyroid vessels during thyroid surgery is safe, and that it shortens the operative time by almost 30 minutes compared with the conventional technique for both unilateral lobectomy or total thyroidectomy procedures despite the larger size of the thyroid removed with the harmonic scalpel. Both groups were comparable with regard to demographics and histopathological findings, except for the lobectomy patients in the conventional knot-tying group, who had a greater likelihood of harboring a focal pathological entity (76%) compared with the harmonic scalpel group (34%), and this actually supported our results. These results have implications for significant hospital cost savings. By shortening the general anesthesia time, the use of the harmonic scalpel might also accelerate postoperative recovery. We did not encounter any complications related to the use of the harmonic scalpel. Voutilainen and Haglund in the other hand, reported 2 transient postoperative recurrent laryngeal nerve palsies in 36 patients undergoing thyroid surgery (6%).

Voutilainen et al observed a mean advantage of 54 minutes with the use of the harmonic scalpel vs use of the conventional technique in an initial matched-pair study for thyroidectomy (n = 6 pairs) and lobectomy (n = 1 pair). They subsequently randomized 36 patients undergoing thyroidectomy or lobectomy into ultrasonically activated shears (n = 19) and conventional surgery (n = 17) groups. The Voutilainen and Haglund study reported that average operating room time savings with the Harmonic scalpel was 35.8 minutes, with no difference in complications between harmonic scalpel and traditional groups.

In a French study, Meurisse et al randomized 34 patients with euthyroid multinodular goiter undergoing total thyroidectomy to either ultracision or conventional hemostasis and demonstrated an average 26-minute reduction in operating time as well as reductions in blood loss, postoperative analgesic consumption, and the incidence of transient hypothyroidism. They also reported that the use of the harmonic scalpel was no more expensive than conventional hemostasis as long as a minimum of 15 patients shared the initial unit cost of the device. To our knowledge, the present study is the first North American study in the literature reporting the use of the harmonic scalpel in thyroid surgery, and its unique features include the enrollment of a larger number of patients with a wide spectrum of thyroid pathologies and the inclusion of the thyroid size in the analysis as a variable that might affect operative time. There was no difference in the amount of estimated blood loss between the 2 techniques in our study because we used the harmonic scalpel for vessel ligation, but not dissection to raise flaps and expose the thyroid. Nevertheless, we noted that it provides a superior hemostasis for the transection of the thyroid parenchyma.

The generation of local water vapor was questioned for the release of cancer cells; however, Nduka et al demonstrated in an animal study that viable airborne cancer cells are not released with the use of the harmonic scalpel. The fact that the shaft of the instrument remains cool and there is no electrical current conducted through the handpiece decreases the risk of inadvertent injury to vital structures to practically nil. In addition, the amount of heat produced is also low, preventing conduction of coagulation to adjacent tissues.

One edge of the active blade is relatively sharp for cutting, and the other is blunt for coagulation purposes. The device is operated using foot pedal control in 5 power settings. The “full power” mode, level V, is used for cutting; and the “variable power” level, level III, is for coagulation. The blades are opened and closed using a scissor grip. The speed of cutting is increased by increasing the force of grip. Each vessel is divided using the “double welding” technique, in which each end of the vessel is sealed using power level III just to the point before division, and then the vessel is divided in between again with the harmonic scalpel. It is important to wait patiently until the tissues fall apart by themselves for complete hemostasis.

The security of vessel control obtained with ultrasonically activated shears has been demonstrated in many animal and human studies. The ultrasonically activated device has been shown to provide a mean bursting pressure of 1204 mm Hg at 70%, and 1193 mm Hg at 100% power level in small- to medium-sized intraperitoneal arteries of anesthetized living pigs—much greater than the normal intravascular pressure. In humans, the security of coagulating vessels up to 6 mm with a tissue-welding technique has been demonstrated during laparoscopic splenectomy, colonic resections, and Nissen fundoplication procedures, during which bleeding is seldomly seen even with division of major arteries and veins. The harmonic scalpel has also been shown to decrease bleeding and operative time compared with the multifeature clip applicator for the division of the short gastric vessels during laparoscopic Nissen fundoplication in a randomized study.

In conclusion, with this initial case-controlled study, we demonstrated that the use of the harmonic scalpel for the control of thyroid vessels during thyroid surgery is safe and shortens operative time by almost 30 minutes compared with the conventional technique for both unilateral lobectomy or total thyroidectomy procedures. This represents a refinement of our current technique, with decreased anesthesia and operating time, and significant cost savings. As the next step, we are in the process of starting a randomized clinical trial to further assess the use of the harmonic scalpel in thyroid surgery.

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REFERENCES

The motor function of the axillary nerve is tested by abduction of the shoulder, the musculocutaneous nerve by flexion of the elbow, the radial nerve by extension of the thumb, the median nerve by flexion of the thumb at the interphalangeal joint, and the ulnar nerve by abduction of the index finger.