Review Article

# Prevention and management of bleeding in thyroid surgery

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**Abstract:** Post-thyroidectomy neck hematoma represents a major concern for surgeons because it can result in severe and even life-threatening complications. In fact, postoperative hemorrhage may result in airway compression and respiratory distress, and therefore, effective hemostasis is an important goal in thyroid surgery. Postoperative hematoma occurs at a rate of approximately 0.1% to 1.1%. Almost all cases occur in the first 6 h after surgery and can be the result of several surgeon or patient factors. For many years the clamp-and-tie technique has been the most common way to divide the main vascular pedicles of the thyroid gland. Alternatively, bipolar electrocautery has been used for only very small vessels. Other hemostatic systems have been introduced and proved to be potentially very useful in neck surgery and, in particular, for thyroid surgery. This new class of instruments is generally known as "energy devices" because they use different forms of energy, such as advanced bipolar (LigaSure™ Small Jaw Medtronic, Covidien product, Mineapolis, MN, USA) and ultrasound (Harmonic Focus; Ethicon, Johnson and Johnson, Cincinnati, OH, USA), and hybrid devices that join these two technologies (Thunderbeat by Olympus, Japan). Although they all generate a significant elevation of temperature in the tissues, as in any form of energy, the temperatures reached by these instruments are never as high as the standard monopolar electrocautery. For small bleeding very close to critical structures, where energy devices are too dangerous to be used and clamp and tie is not possible, several studies have assessed the use of adjunctive hemostatic agents. In conclusion, all energy devices have been shown to significantly decrease operative times without increasing costs or complications. Adjunctive hemostatic agents have shown equivalent differences when added to standard methods from a clinically significant perspective.

**Keywords:** Thyroidectomy; hemostasis; energy devices; hemostatic agents

Submitted Apr 25, 2017. Accepted for publication Jun 22, 2017.
doi: 10.21037/gs.2017.06.14
**View this article at:** http://dx.doi.org/10.21037/gs.2017.06.14

## Introduction

Post-thyroidectomy neck hematoma represents a major concern for surgeons because it can result in severe and even life-threatening complications. In fact, postoperative hemorrhage may result in airway compression and respiratory distress, and therefore, effective hemostasis is an important goal in thyroid surgery.

Historically, intraoperative and postoperative hemorrhage was considered the major problem since the earliest surgical attempts. In 1848, Diffenbach described thyroid surgery as "one of the most thankless, most perilous undertakings which, if not altogether prohibited, should at least be restricted". Shortly after, Gross [1866] noted that "no sensible man will… attempt to extirpate a goiter of the thyroid gland… every step he takes will be environed with difficulty and every stroke of his knife followed by a torrent of blood and lucky will it be for him if his victims live long

enough to enable him to finish his horrid butchery…"

In the early 1900s, Emil Theodore Kocher was the first to use precise surgical technique and meticulous hemostasis to reduce the mortality rate to 0.5% in more than 5,000 thyroidectomies (1).

Hemostasis is of the utmost importance during thyroid surgery. In fact, bleeding during thyroidectomy blurs operative planes, thus putting the recurrent laryngeal nerve and the parathyroid glands at significant risk of injury. Ultimately, meticulous hemostasis is also important to prevent the dreaded complication of postoperative hematoma.

Postoperative hematoma occurs at a rate of approximately 0.1% to 1.1% (2). Almost all cases occur in the first 6 h after the operation and can be the result of several surgeon or patient factors. Several studies have shown that only approximately 20% of hematomas occur between 6 and 24 h postoperatively, and virtually no hematomas occur afterward (3). Prevention of symptomatic or life-threatening hematoma can also be achieved by avoiding tight reapproximation of the strap muscles, as described by Terris (4) in 2009. Although this will not prevent hematoma, it should allow earlier recognition of the process and delay the lymphatic outflow blockage that leads to laryngeal edema and dyspnea. Performing a Valsalva can also be effective to identify potential sources of bleeding before closing.

Treatment of hematomas really depends on the symptoms. Most hematomas need to be evacuated and reexplored, but only an unstable or progressively worsening hematoma in a patient requires immediate evacuation at the bedside. Reintubation in a controlled operating room environment is often possible. The most senior endoscopist should perform the intubation because significant epiglottis and arytenoid edema may be present.

Several options exist for the intraoperative ligation of blood vessels. Conventional techniques include clamp, tie, and cut methods, with or without cautery. Some surgeons use monopolar cautery; however, this causes a significant amount of heat dispersion and puts adjacent structures at risk for injury. Bipolar cautery is more pinpoint and allows less dispersion of heat.

## Surgical technique

For many years the clamp-and-tie technique has been the most common way to divide the main vascular pedicles of the thyroid gland. Alternatively, bipolar electrocautery has been used for only very small vessels. This coagulation system is still considered appropriate to thyroid surgery because it concentrates all of the electrical energy in one limited point, thus reducing the heat transmission to the critical structures. Electrocautery is not, however, effective to obtain hemostasis on larger vessels, and therefore, the clamp-and-tie technique cannot be avoided.

Other hemostatic systems introduced in the last decade have proved to be potentially very useful in neck surgery and particularly for thyroid surgery. This new class of instruments is generally better known as "energy devices", because they all use different forms of energy such as radiofrequency or ultrasound. Although they all generate a significant elevation of temperature in the tissues, as in any form of energy, the temperatures reached by these instruments are never as high as the standard monopolar electrocautery.

## Energy devices

### *Radiofrequency*

The energy in this system is delivered in a quick on-and-off modality, defined as "pulsing". When the energy delivery turns off, the system assesses the state of the tissue, and output is variable according to the received feedback based on tissue resistance to the power flow and to its impedance. Therefore, the power interruption produces cooling of the tissue for a short time, reducing the overall temperature.

The most recent generators use non-pulsing energy delivery (fusion algorithms technology). The adjustments made by the generator during the fusion cycle are controlled through the tissue reaction in real time. This eliminates the energy pulsing and thus accelerates the process of fusion: the shorter interval of energy application supposedly reduces the thermal spread.

A recent study investigating lateral thermal spread after *ex vivo* application of four commonly used energy devices—monopolar cautery, bipolar diathermy, ultrasonic scissors, and radiofrequency—found that radiofrequency resulted in the lowest temperature developed at the tip of the instrument, 44 ℃, after a 5-s application at the highest power setting. Furthermore, the same study found that the temperature at the bipolar device tip after use for 15 s on porcine muscle remained above 42 ℃ for 15 s (5). Because it is a closed loop system, virtually no heat dispersion occurs.

The main weak point of bipolar devices was that coagulating and cutting with the same instrument was not possible, but during the last few years, a subtle blade has been introduced

 

inside one of the shears that cuts the grabbed tissue at the end of coagulation. The LigaSure™ (LSJ Medtronic, Covidien product, Mineapolis, MN, USA), an instrument that uses this technology, can seal vessels up to 7 mm in maximum diameter (6).

### *Harmonic technology*

This device transforms electric energy into mechanical vibration, with one shear vibrating at 55,000 Hz/s while the other shear is completely inactive. The transformation from one to the other form of energy is provided by a transducer that electrically activates two piezoelectric ceramic plates that cause the active shear to vibrate. Effects of this ultrasonic movement are represented by vaporization occurring at much lower temperature than usual, protein coaptation, and rupture of hydrogen bonds and protein denaturation.

These effects are obtained at a temperature lower than 100 ℃, and generally optimal coagulation and division of the structures is reached at a temperature of 60 ℃. Electrocautery reaches temperatures as high as 400 ℃, with carbonization of tissue. One could argue that the ultrasonic system is able to give optimal coagulation at relatively "cold" temperatures compared with electrocautery, but the surgeon should refrain from being too confident and remain aware that even relatively "low" temperatures are able to damage critical structures, such as the recurrent nerve or the external branch of the superior laryngeal nerve, and even the blood supply to the parathyroid glands. Furthermore, the tip of the ultrasonic instrument, which is not protected as in radiofrequency instruments, reaches the maximum temperature very quickly and might be responsible for some injuries to the trachea and major vessels (carotid, internal jugular vein). Instruments using this technology, one of which is the Harmonic Scalpel (Harmonic Focus; Ethicon, Johnson and Johnson, Cincinnati, OH, USA), and can seal vessels up to 5 mm in maximum diameter (7).

### *Hybrid technology*

The hybrid system, Thunderbeat by Olympus, was developed in the last 5 years joins and improves the harmonic and radiofrequency technologies. These new devices have two blades, the active blade works as a harmonic scalpel and at the same time as one of the two bipolar electrodes, and the inactive blade is also the other electrode of the bipolar technology. Bipolar action is on the edge of the two blades, while the harmonic technology is in the middle part, acting as the cutting system. The bipolar sealing effect can be used independently for a better hemostatic result without cutting. The two technologies, working together at the same time, develop a higher working temperature on the blades and a higher thermal spread, which are balanced by the shorter time of application on tissue (8). This device can be used safely at 3 mm from the recurrent laryngeal nerve but must be used for less than 8 s at more proximal locations (6).

## Revision of the literature about energy devices

In 2010, Ecker and colleagues (9) performed a meta-analysis of 12 randomized controlled trials, including 1,153 subjects, of standard ligation techniques compared with the harmonic scalpel. Surgery was performed for both benign and malignant disease; however, benign disease dominated the series. Operative time was significantly shorter by 22.67 minutes, intraoperative blood loss was decreased by 20.03 mL, and postoperative pain was decreased in a few studies by 0.86 points on a 1 to 10 scale in favor of the harmonic scalpel. Hospital length of stay, wound drainage, and rate of complications were not significantly different between the groups.

Similarly, in 2009, Yao and colleagues (10) performed a meta-analysis of standard ligation techniques compared with the LigaSure tissue sealing system. The study included nine prospective trials, four of which were randomized. Most of the disease was benign goiter. Operative time was decreased with the LigaSure by 20.32 minutes. Hospital stay, blood loss, and complications between the two techniques were similar.

All three techniques were combined in a smaller trial that enrolled 20 subjects in each arm. Only benign thyroid disease was evaluated. Operative time was significantly less in the LigaSure and Harmonic Scalpel groups compared with conventional techniques by 37 and 8 minutes, respectively. Blood loss and pain medication consumption were also significantly less with the harmonic scalpel and LigaSure techniques. Again, no differences were identified in hospital stay, seroma formation, drain output, or other perioperative complications.

In 2014, Ruggiero and colleagues (11) performed a larger randomized trial of 400 subjects comparing the LigaSure system to the harmonic scalpel. A drain was left in all cases to assess postoperative blood loss. There was no significant difference in blood loss, postoperative drain

 

output or bleeding, hospital stay, or complications. They concluded that no differences existed between the systems and that surgeon preference and comfort should drive use of a particular device. Similar conclusions have been drawn by Pons and colleagues (12) and by Hammad and colleagues (13) in their studies.

Based on the review of all these studies, it seems that either the harmonic scalpel or LigaSure system significantly decrease operative times (14-16). When choosing a system to use, surgeon comfort with the respective instrument is paramount and should take precedent because no single instrument has been found to be better than the other in thyroid surgery. Although products like the LigaSure and Harmonic Scalpel may be useful for larger vessels at the inferior and superior pole, more precise vessel ligation with clamp, cut, and tie, surgical clips, or bipolar electrocautery may be the method of choice for control of vessels immediately adjacent to the nerve, parathyroid glands, or on the Berry ligament.

## Hemostatic agents

All surgeons have encountered the situation of minimal but persistent ooze from the superior pedicle or from the area directly adjacent to the nerve during thyroid surgery. Use of any of the previously described techniques to control this type of bleeding can markedly increase the risk of nerve injury. Several studies have assessed the use of adjunctive hemostatic agents during thyroidectomy.

Surgicel is an oxidized cellulose mesh that adheres to tissue especially in areas of bleeding and helps form a hemostatic clot. In 2013, Amit and colleagues (17) performed a study of 190 consecutive subjects undergoing total thyroidectomy. They placed a 2 cm × 2 cm patch of surgicel in the thyroid bed and avoided placement on the recurrent laryngeal nerve. They found no difference in the hematoma rate between the two groups; however, they found significantly higher postoperative drain output (133 *vs.* 93 mL), delayed time of drain removal (1.87 *vs.* 1.4 days), and longer hospital stay (2.7 *vs.* 1.8 days) in the surgicel group compared with the control group.

Testini and colleagues (18) compared conventional surgery alone to conventional surgery with the addition of FloSeal or a standard cellulose patch intraoperatively. They evaluated 155 subjects treated by a single surgeon; of these, 49 had surgery alone, a cellulose patch was placed in 52, and FloSeal was applied in 54. Operative times, time to drain removal, and hospital stay were all significantly longer in subjects treated with surgery alone and surgery with the cellulose patch, respectively. There were, however, no differences in postoperative hematoma or other complications related to thyroid surgery among the three groups. Another study compared the Harmonic Scalpel with the addition of FloSeal to conventional techniques. It evaluated 165 subjects with a primary end point of 24 h drain output. The group treated with the Harmonic Scalpel and FloSeal showed significantly lower volumes of drain output in the first 24 h compared with the conventionally treated group (48.1 *vs.* 97.9 mL) (19). Unfortunately, no comparison was made to subjects treated only with the Harmonic Scalpel, thus making it difficult to interpret whether the decreased drain output was from the use of the instrument or the hemostatic product.

## Postsurgical drains

Almost all studies assessing the effect of different approaches to hemostasis during thyroid surgery have used a drain to measure postoperative blood loss. The question remains, however, "are drains even necessary in thyroidectomy to prevent life-threatening hematomas?" Two meta-analyses have been completed to attempt to address that question.

In 2007, a Cochrane review was performed by Samraj and Gurusamy (20) evaluating 1,646 subjects in 13 eligible studies. When comparing drain *vs.* no drain after a total thyroidectomy, subjects showed no significant difference in reoperation rates, risk of respiratory distress, or wound infections. Subjects without drains did have significantly higher rates of seroma. However, this difference was no longer noted when only high-quality studies were evaluated. Subjects with drains had significantly longer hospital stays by 1.18 days and increased postoperative pain. Overall, drains did not seem to improve surgical outcomes. Even with a higher rate of seroma formation in the no-drain group, this did not lead to increased morbidity such as wound infection.

In 2014, a second meta-analysis was completed that included 25 studies. These studies assessed 2,939 subjects evenly distributed between drain *vs.* no-drain groups. Postoperative pain was assessed in six studies (938 subjects) showing significantly lower pain scores by 1.46 on a 10-point scale. Hospital stay was evaluated in 18 studies (2,192 subjects), with a significantly longer hospital stay by 1.26 days in the postoperative drain group. Wound infection rates were actually increased in the drain group when 17 studies were evaluated (2,035 subjects), with a

 

relative risk increase of 2.53; however, this fell out after sensitivity analysis was performed. Finally, no difference in hematoma, reoperation rate, or seroma as assessed by postoperative ultrasound was observed (21). Once again, no obvious benefit to drain usage could be identified.

## Conclusions

Hemostasis in thyroid surgery continues to be the most important goal after preserving vital structures. The harmonic scalpel and LigaSure systems have been shown to significantly decrease operative times without increasing costs or complications.

Adjunctive hemostatic agents have shown equivalent differences when added to standard methods from a clinically significant perspective. Surgicel has actually shown increases in drain output, making its use less desirable in routine thyroid surgery.

Postoperative drain use plays no role in routine thyroid surgery because it increases hospital stay and pain without improving patient outcomes. However, the use of a hemostatic agent and drain are recommended in particular cases, such as:

(I) Debulking procedures for unresectable thyroid carcinoma, where a neoplastic bleeding surface remains in the neck;
(II) In case of large and massive dissection for locally advanced carcinoma with multiple metastatic lymph nodes at all cervical levels;
(III) Huge mediastinal goiter;
(IV) Huge uncontrolled hypervascularized diffuse toxic goiter.

## Acknowledgements

None.

## Footnote

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

## References

1. Hannan SA. The magnificent seven: a history of modern thyroid surgery. Int J Surg 2006;4:187-91.
2. Terris DJ, Snyder S, Carneiro-Pla D, et al. American Thyroid Association statement on outpatient thyroidectomy. Thyroid 2013;23:1193-202.
3. Shaha AR, Jaffe BM. Practical management of post-thyroidectomy hematoma. J Surg Oncol 1994;57:235-8.
4. Terris DJ. Novel surgical maneuvers in modern thyroid surgery. Oper Tech Otolayngol Head Neck Surg 2009,20:23-8.
5. Sutton PA, Awad S, Perkins AC, et al. Comparison of lateral thermal spread using monopolar and bipolar diathermy, the Harmonic Scalpel and the Ligasure. Br J Surg 2010;97:428-33.
6. Dionigi G, Wu CW, Kim HY, et al. Safety of energy based devices for hemostasis in thyroid surgery. Gland Surg 2016;5:490-4.
7. Bandi G, Wen CC, Wilkinson EA, et al. Comparison of blade temperature dynamics after activation of Harmonic Ace scalpel and the Ultracision Harmonic Scalpel LCS-K5. J Endourol 2008;22:333-6.
8. Applewhite MK, White MG, James BC, et al. Ultrasonic, bipolar, and integrated energy devices: comparing heat spread in collateral tissues. J Surg Res 2017;207:249-54.
9. Ecker T, Carvalho AL, Choe JH, et al. Hemostasis in thyroid surgery: harmonic scalpel versus other techniques--a meta-analysis. Otolaryngol Head Neck Surg 2010;143:17-25.
10. Yao HS, Wang Q, Wang WJ, et al. Prospective clinical trials of thyroidectomy with LigaSure vs conventional vessel ligation: a systematic review and meta-analysis. Arch Surg 2009;144:1167-74.
11. Ruggiero R, Gubitosi A, Conzo G, et al. Sutureless thyroidectomy. Int J Surg 2014;12 Suppl 1:S189-93.
12. Pons Y, Gauthier J, Ukkola-Pons E, et al. Comparison of LigaSure vessel sealing system, harmonic scalpel, and conventional hemostasis in total thyroidectomy. Otolaryngol Head Neck Surg 2009;141:496-501.
13. Hammad AY, Deniwar A, Al-Qurayshi Z, et al. A Prospective Study Comparing the Efficacy and Surgical Outcomes of Harmonic Focus Scalpel Versus LigaSure Small Jaw in Thyroid and Parathyroid Surgery. Surg Innov 2016;23:486-9.
14. Hwang SO, Jung JH, Park HY, et al. A Prospective, Randomized Study between the Small Jaw® and the Harmonic Focus® in Open Thyroidectomy. Otolaryngol Head Neck Surg 2014;150:943-8.
15. Garas G, Okabayashi K, Ashrafian H, et al. Which hemostatic device in thyroid surgery? A network meta-analysis of surgical technologies. Thyroid 2013;23:1138-50.
16. Dionigi G, Boni L, Rausei S, et al. The safety of energy-based devices in open thyroidectomy: a prospective,

 

randomised study comparing the LigaSure™ (LF1212) and the Harmonic® FOCUS. Langenbecks Arch Surg 2012;397:817-23.
17. Amit M, Binenbaum Y, Cohen JT, et al. Effectiveness of an oxidized cellulose patch hemostatic agent in thyroid surgery: a prospective, randomized, controlled study. J Am Coll Surg 2013;217:221-5.
18. Testini M, Marzaioli R, Lissidini G, et al. The effectiveness of FloSeal matrix hemostatic agent in thyroid surgery: a prospective, randomized, control study. Langenbecks Arch Surg 2009;394:837-42.
19. Docimo G, Tolone S, Ruggiero R, et al. Total thyroidectomy with harmonic scalpel combined to gelatin-thrombin matrix hemostatic agent: is it safe and effective? A single-center prospective study. Int J Surg 2014;12 Suppl 1:S209-12.
20. Samraj K, Gurusamy KS. Wound drains following thyroid surgery. Cochrane Database Syst Rev 2007;4:CD006099.
21. Woods RS, Woods JF, Duignan ES, et al. Systematic review and meta-analysis of wound drains after thyroid surgery. Br J Surg 2014;101:446-56.

**Cite this article as:** Materazzi G, Ambrosini CE, Fregoli L, De Napoli L, Frustaci G, Matteucci V, Papini P, Bakkar S, Miccoli P. Prevention and management of bleeding in thyroid surgery. Gland Surg 2017;6(5):510-515. doi: 10.21037/gs.2017.06.14

 