

THERAPEUTIC EFFECTS OF BIPOLAR COAGULATION FORCEPS ON OPEN THYROID SURGERY

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ABSTRACT

Background: The aim was to compare the therapeutic effects of bipolar coagulation forceps, harmonic scalpel, and conventional thyroidectomy on open thyroid surgery. **Methods:** A total of 527 patients who received open thyroid surgery in the Affiliated Drum Tower Hospital of Nanjing University Medical School between February 2013 and February 2016 were randomly divided into three groups: bipolar coagulation forceps, harmonic scalpel, and conventional thyroidectomy. There were no statistically significant differences in gender, age, disease constituents or mass diameter between the three groups. All surgeries were performed by the same surgeon. The surgical time, intraoperative blood loss, postoperative volume of drainage, postoperative hospital stay, and postoperative complications of the three surgical methods were compared. **Results:** The bipolar coagulation forceps and harmonic scalpel groups were significantly superior to the conventional thyroidectomy group ($p < 0.05$) in terms of surgical time, intraoperative blood loss, postoperative volume of drainage, and postoperative hospital stay, but the first two groups had similar outcomes ($p > 0.05$). There were significant differences between the three groups in temporary recurrent laryngeal nerve palsy and temporary hypoparathyroidism, and the results of the bipolar coagulation forceps group were significantly better than those of the other two groups ($p < 0.05$). No significant differences were found in airway depression due to postoperative bleeding or irritating cough induced by superior laryngeal nerve palsy between the three groups ($p > 0.05$). None of the patients in the three groups suffered from permanent recurrent laryngeal nerve palsy or permanent hypoparathyroidism. **Conclusions:** The effects of bipolar coagulation forceps on open thyroid surgery exceeded those of the harmonic scalpel and conventional thyroidectomy. This method is worthy of promotion in clinical practice. (Rev Inves Clin. 2016;68:256-61)

Key words: Bipolar coagulation forceps. Clinical application. Harmonic scalpel. Open thyroid surgery.

INTRODUCTION

Thyroid disease, which is currently one of the most common diseases worldwide, has been mainly treated by surgery. Albucasis, a Spanish doctor, successfully

completed the first case of thyroid surgery in AD 952, but the postoperative mortality rate was extremely high¹. Since Kocher and Billroth described the standardized method of thyroid surgery in detail for the first time in the late 19th century², thyroidectomy

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has been one of the most common head and neck surgeries. Subsequently, most thyroid diseases have been successfully treated by bilateral thyroidectomy. Due to the extremely rich blood supply in the thyroid, the mortality rate of thyroidectomy in early times was very high in the absence of effective hemostasis. Fifteen years later, the mortality rate decreased from 12.8 to 0.5% by Kocher, who managed to ligate the upper and lower polar vessels of the thyroid³. Conventional thyroid surgery uses suture and ligation for hemostasis, which leads to considerable intraoperative blood loss, a blurred surgical field that interferes with accurate identification of the parathyroid glands, and hypoparathyroidism, thus affecting the quality of life of patients and even endangering their life safety.

With the development of medical science, the harmonic scalpel has been employed to allow endoscopic thyroidectomy and anterior cervical incision endoscopy-assisted thyroidectomy by performing excision and vascular closure simultaneously. Bipolar coagulation forceps (BCF), which was designed by Malis, induces satisfactory coagulation and hemostasis for small blood vessels. Using thin electrodes, it is suitable for treating small blood vessels near the recurrent laryngeal nerve and parathyroids on the back of the thyroid. Until now, BCF has seldom been applied in open thyroid surgery and its therapeutic effects have never been compared with those of the harmonic scalpel and conventional thyroidectomy.

MATERIALS AND METHODS

Baseline clinical data

A total of 527 patients who received open thyroid surgery in the Affiliated Drum Tower Hospital of Nanjing University Medical School from February 2013 to February 2016 were selected. Inclusion criteria: All patients had surgical indications for total thyroidectomy; written consent was obtained from all patients and their family members; this study was approved by the ethics committee of our hospital. The patients were randomly divided into three groups using a computer random number table, i.e. 180 cases in the BCF group, 167 cases in the harmonic scalpel group, and 180 cases in the conventional thyroidectomy (excision and ligation) group. The three groups had similar baseline clinical data such as gender, age and histological types ($p > 0.05$).

The patients consisted of 41 males and 486 females, with a male/female ratio of 1/11.85 and mean age of 43.2 ± 4.1 years. There were 98 cases of nodular goiter, 131 cases of thyroid adenoma, and 298 cases of papillary thyroid carcinoma. Surgical methods were: 124 cases treated with single thyroid lobectomy, 158 cases by total thyroidectomy, 176 cases received total thyroidectomy plus unilateral central lymph node dissection, and 69 cases received total thyroidectomy plus bilateral central lymph node dissection.

Surgical methods

Under general anesthesia, all patients received endotracheal intubation, with their shoulders boosted through hyperextension of the neck. A curved incision of about 3–5 cm was made along the dermatoglyph at a horizontal finger above the suprasternal notch. An electric scalpel was used to separate the space of loose connective tissues deep in the platysma muscle, up to the inferior margin of thyroid cartilage and down to the sternal notch. An incision was made along the *linea alba cervicalis* to find the thyroid capsule for surgery, sufficiently dissociating one or whole lobes in the space between true and false capsules. The harmonic scalpel group was treated by using an ultrasonic excision and hemostasis system (Johnson & Johnson, USA), with a 2 mm-wide Focus scalpel head. A ValleyBC BCF with a forceps tip diameter of 0.6 mm was used for the BCF group. The conventional thyroidectomy group was subjected to thyroid dissociation, forceps holding, excision, and ligation. According to thyroid lesions, the three groups underwent partial thyroidectomy, subtotal thyroidectomy, and thyroid cancer radical resection, respectively, performed by the same surgeon.

Observation indices

Surgical time (minutes)

The time of thyroidectomy was the time from thyroid exposure to resection. The time for thyroidectomy and central lymph node dissection was the time from thyroid exposure to resection and completion of central lymph node dissection.

Intraoperative blood loss (ml)

Intraoperative blood loss (unit: g, converted into ml according to the specific gravity) was the difference

between the weights of gauze before and after use. During surgery, an aspirator was not used to aspirate blood in the surgical field.

Postoperative volume of drainage (ml)

Postoperative volume of drainage was the volume drained from drainage tube placement until removal. Indication for drainage tube removal was if there was no obvious interstitial fluid under the skin flap, with the drainage volume in the tube of less than 15 ml/d.

Postoperative hospital stay

Postoperative hospital stay was from the first day after surgery to the day of discharge.

Surgical complications

Surgical complications included postoperative bleeding, recurrent laryngeal nerve palsy, hypoparathyroidism, and postoperative interstitial fluid under the skin flap.

There was active postoperative bleeding, and over 50 ml of blood was drained within one hour after surgery, which increased continuously. Space under the skin flap swelled clearly.

Recurrent laryngeal nerve palsy: All patients were subjected to fibro-laryngoscopy, and those with vocal cord paralysis were diagnosed. Temporary recurrent laryngeal nerve palsy was defined for cured, significantly or obviously relieved vocal cord paralysis after treatment, and permanent recurrent laryngeal nerve palsy was defined for unchanged paralysis. The recovery of patients with temporary recurrent laryngeal nerve palsy was examined by fibro-laryngoscopy and recorded.

Hypoparathyroidism: parathyroid hormone (PTH) and serum calcium levels were determined on the first postoperative day. Hypoparathyroidism was diagnosed when PTH levels were < 1.6 pmol/l and (or) serum calcium levels were < 1.9 mmol/l, or when patients had apparent hypocalcemia and numbness, with a serum calcium level of 1.9–2.1 mmol/l. If PTH and serum calcium levels were still below the above criteria three months after surgery, the patients were diagnosed as having permanent hypoparathyroidism. The patients

were not routinely given calcium orally or intravenously before serum calcium examination.

Postoperative interstitial fluid under the skin flap: When there was obvious interstitial fluid and swelling after removal of drainage tube, which required fluid aspiration or reposition of the tube.

Statistical analysis

All data were collected from three independent replicate experiments, analyzed by SPSS22.0 and expressed as mean \pm standard deviation. Inter-group comparisons were performed by Student's *t* test, and comparisons among multiple groups were conducted by one-way analysis of variance. A $p < 0.05$ was considered statistically significant.

RESULTS

Surgical outcomes

All excised samples were subjected to intraoperative frozen-section analysis. Total thyroidectomy and central lymph node dissection were performed for malignant tumors. The patients with lateral neck lymphatic metastasis who required lateral lymph node dissection were excluded. The surgical time, intraoperative blood loss, postoperative volume of drainage, and postoperative hospital stay of the three groups are listed in table 1. The BCF and harmonic scalpel groups had significantly better outcomes than the conventional thyroidectomy group ($p < 0.05$), whereas the former two groups had similar outcomes ($p > 0.05$).

Postoperative complications

The common complications after open thyroid surgery include postoperative bleeding, superior/recurrent laryngeal nerve injuries, and parathyroid dysfunction (Table 2). All three groups underwent airway depression due to postoperative bleeding resulting from uncontrolled high blood pressure. This symptom was effectively relieved by eliminating the hematoma using emergency treatment. Recurrent laryngeal nerve and parathyroid injuries were mainly manifested as temporary nerve palsy and temporary hypoparathyroidism, with the incidence rates of the

Table 1. Surgical outcomes ($x \pm s$) in the three techniques of open thyroid surgery: bipolar coagulation forceps, harmonic scalpel, and conventional thyroidectomy

Observation index	Single thyroid lobectomy			Total thyroidectomy			Total thyroidectomy + unilateral central lymph node dissection			Total thyroidectomy + bilateral central lymph node dissection		
	BCF	Harmonic scalpel	Conventional thyroidectomy	BCF	Harmonic scalpel	Conventional thyroidectomy	BCF	Harmonic scalpel	Conventional thyroidectomy	BCF	Harmonic scalpel	Conventional thyroidectomy
Case number (n)	48	45	31	51	47	60	56	54	66	25	21	23
Surgical time (minutes)	39.5 \pm 1.3	40.2 \pm 1.5*	46.6 \pm 2.3 ^{††}	63.1 \pm 3.1	59.8 \pm 2.9*	71.6 \pm 5.1 ^{††}	61.2 \pm 3.0	57.1 \pm 2.1*	72.3 \pm 4.3 ^{††}	71.4 \pm 6.1	62.3 \pm 3.7*	75.4 \pm 5.8 ^{††}
Intraoperative blood loss (ml)	24.9 \pm 0.6	21.1 \pm 0.9*	30.2 \pm 1.3 ^{††}	39.8 \pm 3.1	41.9 \pm 3.8*	50.1 \pm 3.8 ^{††}	52.6 \pm 4.7	45.9 \pm 3.9*	55.3 \pm 3.8 ^{††}	57.9 \pm 4.0	55.8 \pm 4.1*	60.4 \pm 5.1 ^{††}
Postoperative volume of drainage (ml)	41.2 \pm 4.2	49.5 \pm 4.4*	55.1 \pm 4.8 ^{††}	88.4 \pm 8.7	98.6 \pm 10.1*	110.2 \pm 11.5 ^{††}	63.1 \pm 5.4	78.6 \pm 6.1*	82.8 \pm 6.8 ^{††}	126.2 \pm 11.4	135.1 \pm 12.1*	154.6 \pm 12.4 ^{††}
Postoperative hospital stay (days)	3.2 \pm 0.4	3.6 \pm 0.5*	4.1 \pm 0.7 ^{††}	4.6 \pm 0.4	4.2 \pm 0.6*	4.7 \pm 0.6 ^{††}	4.9 \pm 0.7	4.7 \pm 0.4*	5.1 \pm 0.7 ^{††}	5.2 \pm 0.8	5.8 \pm 0.6*	6.1 \pm 0.7 ^{††}

Comparison between harmonic scalpel and bipolar coagulation forceps groups, * $p > 0.05$; comparison between conventional thyroidectomy and BCF groups, [†] $p < 0.05$; comparison between conventional thyroidectomy and harmonic scalpel groups, ^{††} $p < 0.05$.

BCF: bipolar coagulation forceps.

Table 2. Postoperative complications (case [%]) in the three groups of open thyroid surgery: bipolar coagulation forceps, harmonic scalpel, and conventional thyroidectomy

Complication	BCF (n = 180)	Harmonic scalpel (n = 167)	p	BCF (n = 180)	Conventional thyroidectomy (n = 180)	p	Harmonic scalpel (n = 167)	Conventional thyroidectomy (n = 180)	p
Airway depression due to postoperative bleeding	1 (0.5)	1.0 (0.6)	> 0.05	1.0 (0.5)	3.0 (1.7)	> 0.05	1.0 (0.6)	3.0 (1.7)	> 0.05
Temporary recurrent laryngeal nerve palsy	2 (1.1 \pm 0.12)	14.0 (8.4 \pm 1.01)	< 0.05	2.0 (1.1 \pm 0.12)	27.0 (15 \pm 2.37)	< 0.05	14.0 (8.4 \pm 1.01)	27.0 (15 \pm 2.37)	< 0.05
Permanent recurrent laryngeal nerve palsy	0 (0)	0 (0)	> 0.05	0 (0)	0 (0)	> 0.05	0 (0)	0 (0)	> 0.05
Temporary hypoparathyroidism	4 (16)	3.0 (14.3)	< 0.05	4.0 (17.4)	7.0 (30.4)	< 0.05	3.0 (14.3)	7.0 (30.4)	< 0.05
Permanent hypoparathyroidism	0 (0)	0 (0)	> 0.05	0 (0)	0 (0)	> 0.05	0 (0)	0 (0)	> 0.05
Irritating coughing induced by superior laryngeal nerve palsy	2 (1.1)	6.0 (3.6)	> 0.05	2.0 (1.1)	10.0 (5.6)	> 0.05	6.0 (3.6)	10.0 (5.6)	> 0.05

BCF: bipolar coagulation forceps.

conventional thyroidectomy group significantly exceeding those of the other two groups ($p < 0.05$). All the affected patients suffered from hoarseness and numbness from the postoperative day 2-3, although without permanent injury. No significant differences were found in irritating cough induced by superior laryngeal nerve palsy between the three groups ($p > 0.05$).

DISCUSSION

After decades of development in open thyroid surgery, the requirements for specialist physicians have increased owing to continuously improved anesthetic techniques and updated surgical instruments⁴. Due to an increased incidence rate and a change in disease spectrum⁵, single thyroid lobectomy and total thyroidectomy have been performed in most cases^{6,7}. Therefore, protecting recurrent/superior laryngeal nerves and especially the parathyroid glands is the key to reducing surgical complications⁸. State-of-the-art surgical instruments should allow for an improvement in surgical efficiency and reduction in the incidence rates of complications as well.

This study compared the therapeutic effects of BCF, harmonic scalpel, and conventional thyroidectomy on open thyroid surgery, proving that BCF decreased the incidence rates of complications. Although traditional electric scalpel can effectively control bleeding, it causes considerable thermal damage, and the resulting smoke also easily affects the surgical field. On the other hand, the high-frequency electric scalpel inevitably stimulates nerves⁹. The harmonic scalpel system, which has been widely used in breast as well as head and neck surgeries¹⁰, can stop bleeding by generating ultrasonic waves through the metal tip vibration to vaporize water in tissues and cells and to produce vascular closure through protein coagulation. Therefore, the harmonic scalpel is capable of performing tissue excision and hemostasis simultaneously so as to reduce vascular ligation¹¹ and to shorten surgical time¹² as advantages¹³⁻¹⁵. Nevertheless, in this study, harmonic scalpel produced intense heat between the tip and its surrounding tissues during firing, which induced significant thermal burns to the tender recurrent laryngeal nerve, superior laryngeal nerve, parathyroid, and even the skin of incision. Similar to a previous report¹⁶, there were a large number of cases

with postoperative temporary recurrent laryngeal nerve palsy and hypoparathyroidism. BCF, which has most commonly been used for ear nose and throat surgery and neurosurgery, causes hemostasis by using two tips to provide high-frequency electrical energy for tissues with lesions, aiming to dehydrate blood vessels between both tips^{17,18}. Since BCF only works for the range between two tips, adjacent tissues are barely damaged or affected and remain safe¹⁹. We herein verified the advantages of BCF by comparing the treatment outcomes of three groups. First, similar to an ordinary forceps in shape, BCF can be flexibly used. Being capable of small vessel coagulation, it can reduce vascular ligation and contribute to surgeries with small incisions. Second, compared with harmonic scalpel, the tips of BCF are as tiny as 0.6 mm, so it is particularly suitable for delicate surgeries such as hemostasis of small blood vessels surrounding recurrent or superior laryngeal nerves. In addition, BCF can stop bleeding accurately and effectively without thermal burns to nerves²⁰. Third, after a short time of firing, the electric current passes between the two tips of BCF so it only affects a few held tissues. Additionally, the temperature of the BCF tip is much lower than that of the harmonic scalpel tip so it does not cause thermal damage to surrounding tissues, which is a striking advantage. In this study, mitigation of temporary recurrent laryngeal nerve palsy and temporary hypoparathyroidism in the BCF group provided the best evidence. And fourth, BCF is readily applicable in primary hospitals due to its low cost and high cost-effectiveness ratio.

Regarding the surgical time, intraoperative blood loss, postoperative volume of drainage, and postoperative hospital stay, the BCF group and the harmonic scalpel group were superior to the conventional thyroidectomy group ($p < 0.05$), although without significant differences between the former two groups ($p > 0.05$). There were significant differences in temporary recurrent laryngeal nerve palsy and temporary hyperparathyroidism between the three groups, and the results of the BCF group significantly surpassed those of the other two groups ($p < 0.05$). The incidence rates of airway depression due to postoperative bleeding or irritating coughing induced by superior laryngeal nerve palsy were not significantly different among the three groups ($p > 0.05$). There were no cases of permanent recurrent laryngeal nerve palsy or permanent hyperparathyroidism in the three groups.

In summary, open thyroid surgery has become increasingly sophisticated, specialized, and minimally invasive, meeting with aesthetic requirements as well. Being both safe and feasible for open thyroid surgery, BCF allows performing thyroidectomy with small incisions. Well-trained specialist physicians can perform open thyroid surgery with ease after mastering the skills for using BCF. The low-cost, widely applicable BCF can decrease surgical expenses, have therapeutic effects similar to those of the harmonic scalpel, and also prevent complications, and thereby is worthy of promotion in the clinical practice.

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