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Electrosurgical energy. Is it a risk factor for post-thyroidectomy hypocalcaemia?

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ABSTRACT

Aim and objective: The aim of this study was to investigate a relationship between the different types of electrosurgical energy (monopolar, bipolar, and ultrasonic-harmonic scalpel) and postoperative hypocalcaemia after total thyroidectomy. Additionally, to analyze the frequency of postoperative hypocalcaemia, according to age group, gender, and pathological diagnosis. **Materials and Methods:** An observational, retrospective and correlational study was carried out in a series of patients who underwent total thyroidectomy in a public and a private hospital in Quito, Ecuador, South America, from January 2016 to July 2019. **Results:** Among 665 patients, post-thyroidectomy hypocalcaemia was observed in 127 (18.8%) patients. There was no significant difference between males and females. Hypocalcaemia was significantly higher in patients aged between 26 and 35 years, patients operated for malignant tumors and in patients in whom at least one parathyroid gland was removed. Postoperative hypocalcaemia occurred in 52.2% of patients (n = 24) [RR: 3.14; 95% CI: 2.26-4.36; p: 0.001] in the bipolar group, 29.2% (n = 7) [RR: 1.56; 95% CI: 0.82-2.97; p: 0.087] in the harmonic group, 17.3% (n = 34) [RR: 0.87; 95% CI: 0.61-1.24; p: 0.219] in the monopolar group, and 15.2% (n= 60) [RR: 0.61; 95% CI 0.45-0.84; p: 0.001] in the monopolar + harmonic group. **Conclusions and clinical significance:** The use of a bipolar device appears to be a risk factor for hypocalcaemia, while the use of monopolar + harmonic seems to be a protective factor. Although, when analyzing monopolar + harmonic vs monopolar alone, the addition of the harmonic scalpel didn't provide statistically significant additional protection against hypocalcaemia.

Keywords: Electrosurgery; thyroidectomy; hypocalcaemia

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INTRODUCTION

Thyroid cancer has steadily increased in the last decades, while benign thyroid disorders have remained roughly stable. Nowadays, thyroid malignancy is the most common endocrinologic cancer, particularly in women. [1] During 2017, INEC, the Ecuadorian Institute of Census and Statistics, reported 4041 new thyroid cancer cases. [2] In Ecuador, the incidence is 6.6 and 35.0 per 100.000 for men and women, respectively. [3] This incidence in Ecuadorian women is the fifth highest in the world. On the other hand, mortality has remained low: 0.5 per 100.000 inhabitants in the United States and 0.3 and 1.8 for men and women, respectively, in Ecuador. [3] Thyroid surgery, as any other surgical procedure, entails risks and complications, including hypocalcaemia due to parathyroid gland injury. Hypocalcaemia incidence can vary from 6.9% to 49%, but most authors agree on an average of 30%. [4] It can be transitory or permanent (5%) depending on the extension of the parathyroid injury, but, especially, it can be detrimental to the patient's quality of life. For this reason, prevention and diagnosis are very important. [5,6] There is variability in diagnosis and incidence of this complication due to the lack of standard values of blood calcium and parathyroid hormone (PTH) to define hypocalcaemia. Biochemical hypoparathyroidism and hypocalcaemia are defined as low intact PTH levels and low total calcium levels, respectively. Clinical hypoparathyroidism is defined as biochemical hypoparathyroidism accompanied by some clinical manifestations such as perioral paresthesia, hand and feet numbness, muscular spasms, Chvostek and Trousseau signs, tetany, confusion, seizures, and arrhythmias. [7,8,9]

Risk factors for hypocalcaemia following thyroidectomy have been widely described, including thyroidectomy extension, patient's age, sex, and surgical technique. On the other hand, information about electrosurgical energy as a risk factor has been controversial among different series, and there has been no consensus in most cases. [10,12]

The use of electrosurgical energy devices has increased and replaced conventional methods such as ligation and suture. Its use has also reduced complications and mean operative time. [13] However, hypocalcaemia following total thyroidectomy remains an important complication with a high incidence despite this technological progress. [14] These electrosurgical energy devices work by using heat energy to denature proteins, and its lateral dispersion may lead to incidental lateral thermic damage towards adjacent tissues. In the specific case of thyroid tissue, temperature above 42ºC causes irreversible damage. [15,16] Monopolar and bipolar electrocoagulation use a high-frequency thermic effect (300 Hz) while ultrasound-based harmonic scalpel (ultracision) uses 55.5 kHz frequency. [15,17] As to possible thermic lesion of the parathyroid gland, the monopolar and bipolar lateral thermic effect spreads about 15 mm and 1-6 mm, respectively. On the other hand, a harmonic scalpel using 55 to 100ºC, reaches 0.2-2 mm causing less collateral damage. Nevertheless, using temperatures above 100ºC during more than 20s can cause significant damage. [18]

The goal of this study was to assess post-thyroidectomy biochemical hypocalcaemia with the use of different types of electrosurgical energy devices (monopolar, bipolar, and harmonic ultrasonic scalpel) and, additionally, according to other parameters such as age, sex, pathological diagnosis as risk factors for postoperative hypocalcaemia.

MATERIAL AND METHODS

An observational, retrospective, and correlational study was performed on 665 patients from a private and a public hospital in Quito, operated on from 2016 to 2019. Expert surgical teams, more than 25 thyroidectomies yearly, performed the surgical interventions [19]. All patients signed a consent form previously to surgery. Inclusion criteria were age over 16 years and total thyroidectomy as a surgical modality. Exclusion criteria were an incomplete or inaccessible medical record, partial thyroidectomy, thyroidectomy performed in more than one surgical procedure, reinterventions, and previous calcium metabolism pathology. The following electrosurgical surgical

devices were used: monopolar in 197 patients, bipolar in 46, harmonic scalpel in 24, monopolar + harmonic scalpel in 396, and bipolar + harmonic scalpel in 2. All patients had serum ionic calcium measurements 6 and 24 hours after surgery. Most of them also had a PTH level measurement. Hypocalcaemia was considered when ionic calcium was below 4.8 mg/dL (1.20 mmol/L) and hypoparathyroidism when parathyroid hormone (PTH) was below 10 pg, besides clinical manifestations.

Statistical analysis was performed using SPSS version 25 statistical platform and Excel. The study comparing the type of electrosurgical energy used and the presence of hypocalcaemia according to the established criteria consists of the following. We analyzed two nominal variables, the independent being the type of energy device [6] and the dependent being the presence of hypocalcaemia (yes/no) including clinical and laboratory definitions using ionic calcium measured 6 and 24 hours after surgery as well as PTH values measured 6 and 24 hours after surgery. Regarding the types of electrosurgical energy devices, we proceeded to compare each individual device and the combination of the monopolar with harmonic, converting them into binomial variables and the dichotomous dependent variable: hypocalcaemia (yes / no). Also, according to the analysis of the pathological result, a correlation was made between the presence or absence of hypocalcaemia and the incidental excision of one or more parathyroid glands.

RESULTS

Regarding sex distribution, 574 (86%) patients were women and 91 (13%) were men. Mean age was 45.97 (16-78) years (SD: 13.36), (24.4% between 46 and 55 years). Regarding the pathological report, 307 (46%) patients had malignant lesions: infiltrating follicular (n= 3), papillary cancer (n= 286) and follicular cancer (n= 21). The remaining 358 (54%) patients had a benign lesion: thyroiditis (n= 21), nodular hyperplasia (n= 32), multinodular goiter (n= 294), follicular adenoma (n= 9) and colloid goiter (n= 2). (Fig. 1,2)

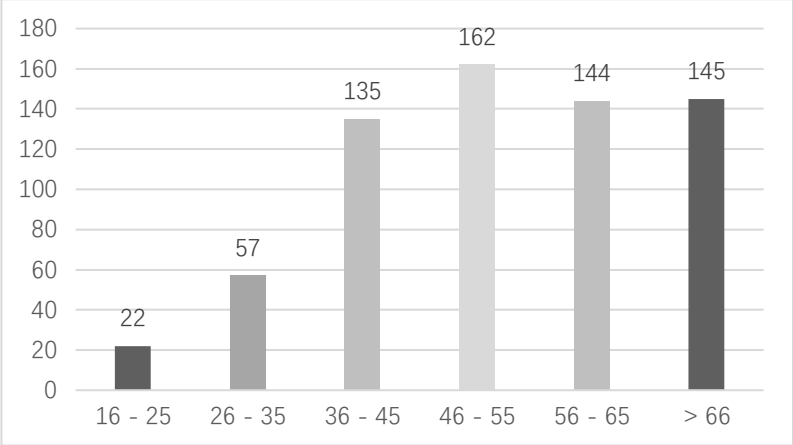

Figure 1. Age distribution.

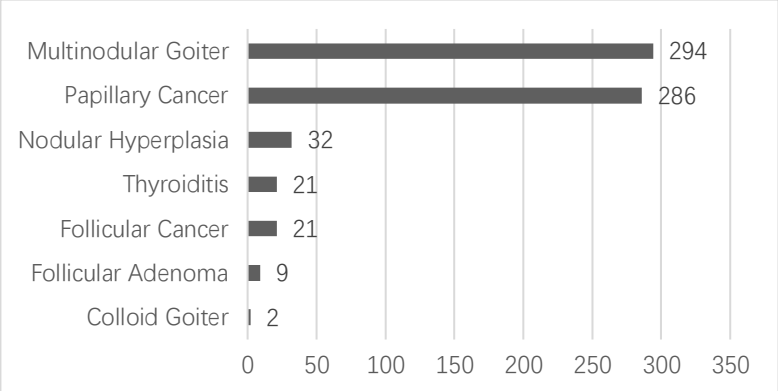

Figure 2. Pathological diagnosis distribution.

Postoperative hypocalcaemia was observed in 127 (19%) patients. There was no significant difference between males and females. (Table 1)

Table 1. Hypocalcaemia distribution, according to sex.

	Hypocalcaemia			
Sex	Yes		No	
Female	110	19.2%	464	80.8%
Male	17	18.7%	74	81.3%
Total	127 (18.8%)		538 (81.2%)	

p = 0.9252

Hypocalcaemia was lower (6.9%) in the group of patients aged between 56 and 65 years showing statistical significance (p<0.001), and higher (31.5%) in the group of patients aged between 26 and 35 years showing statistical significance (p<0.025). (Table 2)

Table 2. Distribution of hypocalcaemia according to age.

	Hypocalcaemia				χ^2	p
	Yes		No			
16 – 25	6	27.3%	16	72.7%	0.9841	0.30
26 – 35	18	31.5%	39	68.4%	6.2858	<0.025
36 - 45	36	26.7%	99	73.3%	6.2806	<0.025
46 – 55	34	21.0%	128	79.0%	0.4951	0.35
56 - 65	10	6.9%	134	93.1%	17.5708	<0.001
>66	23	15.9%	122	84.1%	1.2565	0.20
Total	127 (18.8%)		538 (81.2%)			

Postoperative hypocalcaemia was statistically significantly more frequent after thyroidectomy for malignant tumors than for benign lesions. (Table 3)

Table 3. Distribution of hypocalcaemia according to pathological diagnosis.

	Hypocalcaemia			
Type of lesion	Yes		No	
Benign	58	16.20%	300	83.80%
Malignant	69	22.48%	238	77.52%
Total	127 (18.8%)		538 (81.2%)	

p = 0.04016

Regarding the type of electrosurgical energy used, (Table 4), frequency of postoperative hypocalcaemia was higher in the bipolar group, 52.2% (n= 24) [RR: 3.14; 95% CI: 2.26-4.36; p: 0.001], with statistical significance and harmful relationship. Hypocalcaemia in the harmonic group, 29.2% (n= 7) [RR: 1.56; 95% CI: 0.82-2.97; p: 0.087], and in the monopolar group, 17.3 % (n= 34) [RR: 0.87; 95% CI: 0.61-1.24; p: 0.219], had no statistical significance. On the other hand, the lowest frequency of hypocalcaemia was seen in the monopolar + harmonic group, with a value of 15.2% (n= 60) [RR: 0.61; 95% CI 0.45-0.84; p: 0.001] had statistical significance and protective relationship.

Table 4. Distribution of hypocalcaemia according to the type of electrosurgical energy device.

Electrosurgical device	Hypocalcemia				RR	IC 95%	X2	p
	Yes		No					
Monopolar	34	17.3%	163	82.7%	0.87	0.61, 1.24	0.7032	0.219
Bipolar	24	52.2%	22	47.8%	3.14	2.26, 4.36	35.1867	0.001
Harmonic	7	29.2%	17	70.8%	1.56	0.82, 2.97	1.6560	0.087
Monopolar + Harmonic	60	15.2%	336	84.8%	0.61	0.45, 0.84	9.5625	0.001
Bipolar + Harmonic	2		0		…	…	…	…

RR: Relative risk. IC: Confidence interval.

A Chi-Square test was performed, α of 0.05, and 1 degree of freedom (gdl), comparing hypocalcaemia with the type of electrosurgical energy. For this purpose, comparisons were made for each kind of electrosurgical energy separately (Table 4). For the variables bipolar alone and monopolar + harmonic, we obtained higher values than the theoretical value (3.8414). Therefore, when the theoretical value is inferior, there is a statistically significant relationship between hypocalcaemia and this type of electrosurgical energy, meaning that they are dependent variables. Regarding monopolar analysis alone and harmonic alone, no statistically significant association was found, meaning that they are independent variables.

Comparing groups, a statistically significant difference was found between monopolar (17.3%) and bipolar (52%), p= 0.000001418. No statistical significant difference was found between monopolar (17%) and harmonic + monopolar (15%), p= 0.3821. No statistically significant difference was found between harmonic (29%) and harmonic + monopolar (15%), p= 0.6865. These findings would indicate that the harmonic device does not confer additional protection.

Incidental parathyroid gland excision occurred in only 102 patients (15.6%). The number of parathyroid glands found at the pathological study was one in 64 patients, two in 26 patients, three in 6 patients, and four in 6 patients. A statistically significant difference in postopera- tive hypocalcaemia was obviously found between patients whose parathyroid glands were preserved and those with glands removed, p<0.0000001 (Table 5). But no statistically significant difference was observed between those patients with only one parathyroid gland removed and those with more than one parathyroid gland removed, p= 0.5945.

Table 5. Distribution of hypocalcaemia according to the number of parathyroid glands incidentally removed and reported at the pathological study.

Parathyroid glands	Hypocalcaemia			
	Yes		No	
Not removed	86	15.2%	477	84.8%
1 removed	27	42.1%	37	57.9%
+ 1 removed	14	36.8%	24	63.2%
Total	127 (18.8%)		538 (81.2%)	

p = 0.5945

DISCUSSION

Surgical intervention of the thyroid gland demands the surgeon's expertise, including careful and adequate identification and preservation of adjacent structures. Despite technological advances, lack of attention to these adjacent structures may cause substantial morbidity, such as

hypocalcaemia secondary to hypoparathyroidism. [12, 14]

In the present study, a significantly higher frequency of postoperative hypocalcaemia was found in patients aged between 26 and 35 years, and in patients with malignant tumors. Baldassarre et al., [4] emphasized that thyroidectomy extension was a predictive factor of hypocalcaemia, particularly after total thyroidectomy and lymph node dissection. In our study, gender was not a significant factor for hypocalcaemia. Del Rio et al., [10] described, however, an increased risk of hypocalcaemia in female patients and in those who underwent total thyroidectomy. Hypocalcaemia in females should be due to the sex steroid's effect on PTH secretion and the difference in cell signaling pathways, while hypocalcaemia after total thyroidectomy should be due to a greater area of dissection and edema, and a greater risk of vascular compromise of the parathyroid glands.

We tried to establish a relationship between the type of electrosurgical energy device and hypocalcaemia post thyroidectomy. Significant differences could be found when comparing monopolar and bipolar electrocoagulation, and the harmonic scalpel in terms of more significant collateral thermal damage of the parathyroid glands. In our study, patients in whom bipolar energy device was used had the highest frequency (52%) of hypocalcaemia. When analyzing the relative risk, the use of bipolar electrosurgical energy showed an increased risk of post-thyroidectomy hypocalcaemia. In contrast, the monopolar + harmonic energy is associated with a decreased risk, acting as a protective factor. However, no additional protection against hypocalcaemia was observed with harmonic scalpel. These results disagree with some studies in which the use of harmonic and bipolar energy was associated with a lower risk of hypocalcaemia. Fraga et al., [11] showed that the use of a harmonic scalpel or bipolar electrocoagulation was associated with a lower risk of hypocalcaemia compared with the help of monopolar energy. Some other studies also demonstrated a significant difference when comparing thermal damage to adjacent structures between bipolar electrocoagulation and harmonic scalpel. In the Garas et al., [20] meta-analysis and the Sutton et al., [21] study, it was shown that ultrasonic coagulation had a better safety profile regarding clinical complications such as hemorrhage and hypoparathyroidism. This was because the temperature and thermal lateral spread are lower than with the use of monopolar and bipolar electrocoagulation. On the other hand, the study carried out by Grajek et al., [22] suggested that bipolar electrocoagulation was associated with a lower thermal effect compared with the ultrasonic and monopolar scalpel. Therefore, depending on the temperature reached, there is a lower incidence of damage to the recurrent laryngeal nerve and parathyroid glands. Similarly, in Ecuador, the Padilla and Rueda study, [23] reported the use of bipolar electrosurgical energy as a protective factor regarding damage to adjacent structures after total thyroidectomy compared to monopolar and harmonic energy.

In the present study, no statistically significant difference in hypocalcaemia was observed between individual and combined use of harmonic scalpel. Similarly, Smith et al., [24] described no considerable difference in terms of thermal lateral spread to the thyroid parenchyma between ultrasonic dissection. On the other hand, Ciftci et al. [14] and the Cannizzaro et al., [25] meta-analysis compared the use of the harmonic scalpel and the bipolar LigaSure and its relationship with post-thyroidectomy parathyroid dysfunction, finding no statistically significant difference.

The operative time seems to be shorter with the ultrasonic or bipolar scalpel when compared to the electric scalpel. [11]

This study has shown that bipolar electrosurgical energy has behaved as a risk factor, which may be due to the small number of patients analyzed in this group compared to the monopolar and harmonic group, either individually or combined. The surgical technique and the surgeon's skills may have an essential influence in the adequate preservation of the parathyroid glands and lower risk of hypocalcaemia. [22, 26] Therefore, these results cannot be generalized to the entire

population, and more studies with a more significant number of cases using bipolar electrosurgical energy are required.

Discrepancy in definitions of hypocalcaemia does not allow us to analyze the true risk of this complication post-thyroidectomy. [4]

Regarding the incidental excision of one or more parathyroid glands, no statistical significance of hypocalcaemia was observed between those patients in whom these glands were preserved or not. According to Mordojovich et al., this could be explained by the fact that normal function can be maintained by preserving at least one parathyroid gland. Even if its function decreases, there is always a possibility of recovery. [27]

Among the limitations in this study, we have that as thyroidectomies were performed by different teams of surgeons, variability in the surgical technique was expected.

CONCLUSIONS

A significantly higher frequency of hypocalcaemia post total thyroidectomy was observed patients with thyroid malignancies and those aged between 26 and 35 years, while no difference regarding sex. Bipolar electrosurgical device appeared to be a risk factor for hypocalcaemia, while monopolar + harmonic appeared as a protective factor.

REFERENCES

[1] Aschebrook-Kilfoy B, Ward M, Sabra M & Devesa S.. Thyroid Cancer Incidence Patterns in the United States by Histologic Type. 1992-2006. Thyroid; 2011:21(2):125-134. DOI: 10.1089/thy.2010.0021

[2] Instituto Ecuatoriano de Estadísticas y Censos. Camas y Egresos Hospitalarios. 2017. Recuperados el 16 de abril de 2020, de Egresos Hospitalarios. website: https://www.ecuadorencifras.gob.ec/camas-y-egresos-hospitalarios/

[3] Corral-Cordero F, Cueva-Ayala P, Yépez-Maldonado J, Tarupi- Montenegro W. Trends in cancer incidence and mortality over three decades in Quito – Ecuador. Colombia Médica 2018;49 (1):35-41. DOI: 10.25100/cm.v49i1.3785

[4] Baldassarre RL, Chang DC, Brumund KT & Bouvet M. Predictors of Hypocalcemia after Thyroidectomy: Results from Nationwide Inpatient Sample. ISRN Surgery. 2012;2012:838614. DOI: 10.5402/2012/838614

[5] Falch C, Hornig J, Senne M, Braun M, Konigsrainer A, Kirschniak A & Muller S. Factors predicting hypocalcemia after total thyroidectomy – A retrospective cohort analysis. International Journal of Surgery. 2018;55:46-50. DOI: 10.1016/j.ijsu.2018.05.014

[6] González JH & Piedrahita DL. Hipocalcemia postiroidectomía total: incidencia, control y tratamiento. Acta Otorrinolaringol Esp. 2013;64 (2):102-107. DOI: 10.1016/j.otorri.2012.09.001

[7] Kadhim J & Majeed H. Total thyroidectomy: Conventional Suture Ligation technique versus sutureless techniques using Harmonic Scalpel or Maxium. Ann Med Surg (Lond). 2016.;5:29–34. DOI: 10.1016/j.amsu.2015.11.010

[8] Kadem S & Alabbood M. Safety and Efficacy of Bipolar Radiofrequency Ablation Device in Hemostasis during Thyroidectomy in Comparison with Ultrasonic Scalpel: A Comparative Study. Indian J Endocrinol Metab. 2019;23(1):76-80. DOI: 10.4103/ijem.IJEM_519_18

[9] Orloff LA, Wiseman SM, Bernet VJ at al. American Thyroid Association Statement on Postoperative Hypoparathyroidism: Diagnosis, Prevention and Management in Adults. THYROID. 2018;28(7): 830-841. DOI: 10.1089/thy.2017.0309

[10] Del Rio P, Rossini M, Montana C, Viani L, Pedrazzi G, Loderer T & Cozzani F. Postoperative hypocalcemia: analysis of factors influencing early hipocalcemia development following thyroid surgery. BMC Surgery. 2019;18:25. https://doi.org/10.1186/s12893-019-0483-y

[11] Fraga TS, Köhler HF, Chulam TC & Kowalski LP. Impact of scalpel type on operative time and acute complications in thyroidectomies. Braz J Otorhinolaryngol. 2019;822:1-6. DOI: 10.1016/j.bjorl.2019.08.004

[12] Aires F, De Matos L, Dedivitis R, Cernea C. Effectiveness of harmonic scalpel in patients submitted to total thyroidectomy systematic review with meta-analysis. Rev Assoc Med Bras 2018;64(7):649-657. DOI: 10.1590/1806-9282.64.07.649

[13] Brzezinski J, Kaluzna-Markowska K, Naze M, Strozyk G & Dedecjus M. Comparison of Lateral Thermal Spread Using Monopolar and Bipolar Diathermy, and the Bipolar Vessel Sealing System ThermoStapler During Thyroidectomy. Polish Journal of Surgery. 2011;83(7): 355-360. DOI:10.2478/v10035-011-0056-y

[14] Ciftci F, Sakalli E, Abdurrahman I & Guler, B. Parathyroid function following total thyroidectomy using energy devices. European Archives of Otorhinolaryngology. 2015;273(7), 1905-1911. https://doi.org/10.1007/s00405-015-3704-8

[15] Balagué, C. Hemostasia y tecnología. Energía. Desarrollo de las nuevas tecnologías. Cirugía Española. 2009:85(1):15-22. https://doi.org/10.1016/S0009-139X(09)71623-9

[16] Adamczewski Z, Król A, Kałużna-Markowska K, Brzeziński J, Lewiński A & Dedecjus M. Lateral spread of heat during thyroidectomy using different haemostatic devices. Ann Agric Environ Med. 2015.;22(3):491–494. DOI: 10.5604/12321966.1167721

[17] Al-Dhahiry J & Hameed H. Total Thyroidectomy: Conventional Suture Ligation technique versus sutureless techniques using Harmonic Scalpel or Maxium. Ann Med Surg (Lond). 2016;5:29-34. DOI: 10.1016/j.amsu.2015.11.010

[18] Manouras A, Markogiannakis HE, Kekis PB, Lagoudianakis EE & Fleming B. Novel hemostatic devices in thyroid surgery: electrothermal bipolar vessel sealing system and harmonic scalpel. Expert Review of Medical Devices. 2008;5(4):447-466. DOI: 10.1586/17434440.5.4.447

[19] Tucker, M. Surgeons Performing Over 25 Thyroidectomies/Year Get Best Outcomes. 2016. Recovered April 16 2020, from https://www.medscape.com/viewarticle/860737

[20] Garas G, Okabayashi K, Ashrafian H, Shetty K, Palazzo F, Tolley N, et al. Which Hemostatic Device in Thyroid Surgery? A Network Meta-Analysis of Surgical Technologies. Thyroid. 2013; 23(9):1138-1150. DOI: 10.1089/thy.2012. 0588

[21] Sutton PA, Awad S, Perkins AC & Lobo DN. Comparison of lateral thermal spread using monopolar and bipolar diathermy, the Harmonic Scalpel and the LigaSure. Br J Surg. 2010;97(3):428–433. DOI: 10.1002/bjs.6901

[22] Grajek ZW, Dadan J, Ładny JR & Opolski M. The assessment of the influence of the method for obtaining hemostasis on the occurrence of postoperative complications after thyroid surgery. Adv Clin Exp Med. 2015;24:275–278. DOI: 10.17219/acem/40464

[23] Padilla H, Rueda M. Factores de riesgo para disfonía en pacientes sometidos a tiroidectomía total en el Hospital Metropolitano de Quito, Enero 2016-Julio 2019. Disertación de médico especia- lista en Cirugía General y Laparoscópica, Uni- versidad Católica del Ecuador. 2019. Website: http://repositorio.puce.edu.ec/handle/2000/17485

[24] Smith CT, Zarebczan B, Alhefdhi A & Chen H. Infrared Thermographic Profiles of Vessel Sealing Devices on Thyroid Parenchyma. Journal of Surgical Research. 2011;170(1):64-68. DOI: 10.1016/j.jss.2011.03.005

[25] Cannizzaro M, Borzí L, Lo Bianco S, Oketyeva V, Cavallaro A & Buffone A. Comparison between Focus Harmonic Scalpel and other hemostatic techniques in open thyroidectomy: A systematic review and meta-analysis. Head & Neck. 2016; 38(10):1571-1578. DOI: 10.1002/hed.244 49

[26] Bakkar S, Papavramidis TS, Aljarrah Q, Materazzi G & Miccoli P. Energy-based devices in thyroid surgery – an overview. Gland Surg. 2020;(1):S14-S17. DOI: 10.21037/gs.2019.08.05

[27] Mordojovich R G, Lavín G M, Ávalos J N. Medición de niveles de paratohormona como predictor de hipocalcemia sintomática en el post-operatorio precoz de tiroidectomía total. Revista chilena de cirugía. 2015;67(2):147–52. http://dx.doi.org/10.4067/S0718402620150002000006.