

Impact of the use of vessel sealing or harmonic scalpel on intra-hospital outcomes and the cost of thyroidectomy procedures

Impacto do uso da pinça seladora ou do bisturi harmônico nos desfechos intra-hospitalares e no custo de procedimentos de tireoidectomia

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ABSTRACT

Objectives: To analyze the operative time, length of hospitalization and cost, as well as the bleeding and pain observed during the postoperative period, of thyroidectomy procedures using vessel sealing, harmonic scalpel or the conventional technique. **Methods:** Retrospective analysis of thyroidectomies performed between 2007 and 2010 using either the conventional technique or minimally invasive techniques involving vessel sealing or a harmonic scalpel. Gender, age, primary diagnosis and procedure type were analyzed. The outcomes analyzed included the length of the procedure, length of hospital stay, need for blood product transfusions, pain and cost of hospitalization. The findings were based on a significance level of 5%, and statistical analyses were performed using the *R* software. **Results:** The use of the vessel sealing increased the duration of the surgery by approximately 47 minutes compared to the conventional technique ($p < 0.001$), and the use of the harmonic scalpel decreased the duration of the surgery by approximately 32 minutes compared to the conventional technique ($p < 0.001$). No statistically significant difference was found between the groups regarding the use of blood products and pain score. Procedures involving vessel sealing or a harmonic scalpel cost more than those using the conventional technique. **Conclusion:** The use of harmonic scalpel was favorable in terms of reducing the surgical time, but there was no reduction in hospitalization time. The cost of the procedure was higher than that of the conventional technique. The use of vessel sealing offered no advantages in terms of the outcomes assessed, and the cost of the procedure was greater than that of the conventional technique.

Keywords: Thyroidectomy; Health economics; Cost-effectiveness evaluation; Technology, high-cost

RESUMO

Objetivos: Analisar tempo cirúrgico, tempo de internação, sangramento, escore de dor no período pós-operatório e custo referente aos procedimentos de tireoidectomia com utilização de pinça seladora ou bisturi harmônico, comparando-os à técnica convencional. **Métodos:** Análise retrospectiva das tireoidectomias, realizadas entre 2007 e 2010, pela técnica convencional e com uso de pinça seladora ou bisturi harmônico. Foram analisados: gênero, idade, diagnóstico principal e tipo de procedimento. Os desfechos analisados foram: duração do procedimento, tempo de permanência hospitalar, necessidade de transfusão de hemoderivados, dor e custo da internação. As conclusões foram baseadas em um nível de significância de 5%, e as análises estatísticas foram realizadas utilizando o *software R*. **Resultados:** Para o desfecho “duração da cirurgia”, o uso da pinça seladora resultou em aumento médio de, aproximadamente, 47 minutos, quando comparado à técnica convencional ($p < 0,001$) e o uso do bisturi harmônico levou à redução média de, aproximadamente, 32 minutos, quando comparado à técnica convencional ($p < 0,001$). Não houve diferença estatisticamente significativa entre os grupos quanto ao uso de hemoderivados e escore de dor. Procedimentos que utilizaram pinça seladora ou bisturi harmônico apresentaram custo superior quando comparados àqueles com a técnica convencional. **Conclusão:** O uso do bisturi harmônico mostrou-se favorável na redução do tempo cirúrgico, porém não foi observada redução no tempo de hospitalização. O custo do procedimento foi mais alto em relação à técnica convencional. O uso da pinça seladora não trouxe vantagens com relação aos desfechos, e o custo do procedimento foi maior quando comparado à técnica convencional.

Descritores: Tireoidectomia; Economia da saúde; Avaliação de custo-efetividade; Tecnologia de alto custo

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INTRODUCTION

Thyroidectomy surgery was standardized by Kocher during the mid-20th century. He was awarded the Nobel Prize in Medicine in 1909 for his advances in the physiology and diseases of the thyroid, and his surgical techniques are still used today⁽¹⁾.

A major advance in surgical procedures took place in the 1990s with the so-called laparoscopic revolution, in which many operations were adapted from traditional open surgery to minimally invasive techniques. Minimally invasive surgeries cause less surgical trauma and less pain and may result in a shorter hospital stay. The technique has become particularly attractive for thyroidectomy procedures because it produces better cosmetic results without increasing the incidence of postoperative complications^(1,2).

With the improvement of minimally invasive surgical techniques, new technologies have been introduced, among them the harmonic scalpel (UltraCision®) and the vessel sealing device (LigaSure®). The harmonic scalpel is an instrument that uses ultrasonic energy to achieve protein denaturation of the muscle layers and the endothelium of blood vessels. This technique has been recommended and is a well-accepted method for soft tissue incisions when the aim is to control bleeding and minimize thermal injury (complementing or replacing electrocautery, laser or even the cold scalpel), and it allows simultaneous cutting and coagulation. Because this method does not use an electrical current, the harmonic scalpel eliminates the risk of burns and it is easy to install and handle, leading to decreased surgical time⁽¹⁻⁵⁾. The vessel sealing device seals vessels by fusing the inner layers of the vessel wall with minimal levels of thermal dispersion, burning and tissue friction, thereby reducing the incidence of accidental burns⁽⁶⁾. Because of these benefits, the use of the harmonic scalpel or the vessel sealing device has grown in popularity with head and neck surgeons, especially for thyroid surgeries.

These technologies offer potential clinical benefits but also lead to increased costs, making it important to consider an economic evaluation that addresses these two dimensions⁽⁷⁾. Furthermore, no data have been published in Brazil on the cost and clinical outcomes associated with usage of the harmonic scalpel or the vessel sealing device for thyroidectomy procedures.

OBJECTIVE

The aim of the present study was to analyze the operative time, length of hospitalization, need for blood product

transfusions, pain score during the postoperative period and costs associated with thyroidectomy procedures using either a vessel sealing device, a harmonic scalpel or the conventional technique and subsequently compare the analysis results among these surgery methods. The present study analyzed thyroidectomies that took place from 2007 to 2010 at the *Hospital Israelita Albert Einstein* (HIAE).

METHODS

Using the HIAE billing system, thyroidectomy procedures performed between 2007 and 2010 were selected according to the technique used (the conventional technique or a minimally invasive technique using a vessel sealing device or a harmonic scalpel).

The medical records and hospital patient accounts were analyzed retrospectively. Gender, age and the primary diagnosis of patients undergoing thyroidectomy were analyzed. In addition, the year that the procedure was performed and the doctor responsible were registered. The procedures analyzed included total thyroidectomy and partial thyroidectomy, both with or without lymphadenectomy.

The outcomes analyzed included the following: the duration of the surgery (from the beginning to the end of surgery, ignoring the start of the anesthesia procedure), the length of hospital stay, the need for blood product transfusions, any postoperative blood counts requests, the pain score (using a numeric pain scale in which 0 represents no pain and 10 represents the worst pain imaginable) on the morning of the first postoperative day, the pain score before discharge and the total cost of the procedure.

To analyze the cost of the procedure for a particular patient, the unit cost of each resource used by the patient was updated based on the December 2010 cost table. This update was performed to account for the effects of inflation and cost increases over time. The costs of various techniques were compared against a reference value. The value chosen was the cost of the partial thyroidectomy procedure using the conventional technique. This cost benchmark was defined as the mean cost of partial thyroidectomy procedures using the conventional technique over the previous 3 years (n=53). The other procedures were subsequently compared to this reference and described as percentages of the reference value.

Statistical analyses were performed to evaluate the statistical significance of differences among the groups of interest. For the quantitative variables, the analysis of variance (ANOVA) was used to identify significant differences between the means and determine whether a

given factor exerts an influence on any of the dependent variables. For the qualitative variables, the χ^2 test was used to analyze the frequency of a certain event or to verify that all conditions are equally likely to occur.

A multiple linear regression model was used to evaluate the performance of the three procedure types (conventional technique, vessel sealing or harmonic scalpel) in terms of the “duration of surgery,” “length of hospital stay” and “total cost” outcomes. This model considers and evaluates the combined effect of the variables that are potentially related to the outcomes.

For the “length of hospital stay” outcome, the χ^2 test was applied; this test compares the ratio of the length of stay for each of the analyzed groups.

The conclusions were based on a significance level of 5%, and the statistical analyses were performed using the *R* software package.

Patients characteristics

Table 1 shows the characteristics of the patients who were included in the analysis.

No differences were observed among the groups in terms of age, gender or diagnosis of neoplasia. There were significant differences among the treated groups regarding the type of procedure performed. In the group that received treatment with the vessel sealing device, a higher percentage of the surgeries involved total thyroidectomy procedures with lymphadenectomy compared to the other two groups, suggesting that greater complexity was needed for this treatment.

Differences were also found in relation to the surgeon who performed the procedure. In the group who received treatment using the vessel sealing device,

Table 1. Characteristics of the patients included in the analysis

Characteristics	Conventional	Vessel sealing device	Harmonic scalpel	p value
n	331	58	71	-
Mean age	46	44	47	0.287
Males, n (%)	91 (27)	19 (33)	15 (21)	0.326
Grouped diagnosis				
Patients with neoplasia, n (%)	181 (55)	34 (59)	38 (54)	0.826
Procedure description				
Partial thyroidectomy, n (%)	53 (16)	2 (3)	4 (6)	
Total thyroidectomy, n (%)	237 (72)	25 (43)	54 (76)	< 0.001
Total thyroidectomy + lymphadenectomy, n (%)	41 (12)	31 (53)	13 (18)	
Surgeon				
Surgeon 1, n (%)	24 (7)	0 (0)	34 (48)	
Surgeon 2, n (%)	16 (5)	0 (0)	2 (3)	
Surgeon 3, n (%)	7 (2)	52 (90)	7 (10)	<0.001
Surgeon 4, n (%)	96 (29)	1 (2)	3 (4)	
Others, n (%)	188 (57)	5 (8)	25 (35)	

RESULTS

Between January 2007 and August 2010, 625 thyroidectomy procedures were documented in the billing system. The cases that involved associated surgery and partial thyroidectomy with lymphadenectomy, lymphadenectomy alone and substernal goiter procedures were excluded from the analysis.

After exclusion, 460 procedures were included in the analysis with 331 procedures in the conventional technique group and 129 procedures in the new technology groups (58 procedures using vessel sealing device and 71 using harmonic scalpel).

one doctor (Surgeon 3) was responsible for 90% of the procedures, and in the harmonic scalpel group, 58% of the procedures were performed by two physicians (Surgeon 1 and Surgeon 3).

Outcomes

The outcomes of the analysis are shown in table 2, as separated by treatment group and by type of procedure.

With respect to the analyzed outcomes, significant differences were found among the compared groups for

Table 2. Analysis of outcomes according to group and type of procedure

	Outcomes, mean (standard deviation)			p value
	Conventional	Vessel sealing device	Harmonic scalpel	
Duration of surgery (min)				
Partial thyroidectomy	112.45 (±47.20)	80.00 (±56.57)	47.50 (±8.66)	0.02
Total thyroidectomy	138.50 (±54.52)	179.20 (±43.84)	103.52 (±50.79)	0.00
Total thyroidectomy + lymphadenectomy	158.29 (±73.35)	215.00 (±63.03)	160.00 (±101.73)	0.01
Length of hospital stay (days)				
Partial thyroidectomy	1.38 (±0.66)	1.50 (±0.71)	1.00 (±0.00)	0.50
Total thyroidectomy	1.53 (±0.75)	2.48 (±0.77)	1.50 (±0.75)	0.00
Total thyroidectomy + lymphadenectomy	1.49 (±0.84)	2.58 (±0.56)	1.69 (±0.85)	0.00
Total cost				
Partial thyroidectomy	(Reference) (±24%)	99% (±5%)	113% (±16%)	0.59
Total thyroidectomy	107% (±24%)	133% (±25%)	141% (±23%)	0.00
Total thyroidectomy + lymphadenectomy	123% (±47%)	143% (±39%)	154% (±31%)	0.03
Pain score				
Morning of the first day postoperative				
Partial thyroidectomy	0.51 (±1.64)	3.00 (±4.24)	0.00 (±0.00)	0.11
Total thyroidectomy	0.47 (±1.65)	1.00 (±2.40)	0.87 (±2.24)	0.18
Total thyroidectomy + lymphadenectomy	0.78 (±1.96)	0.35 (±1.43)	0.62 (±1.33)	0.57
Last assessment before discharge				
Partial thyroidectomy	0.00 (±0.00)	0.00 (±0.00)	0.00 (±0.00)	-
Total thyroidectomy	0.40 (±1.57)	0.63 (±2.12)	0.34 (±1.39)	0.77
Total thyroidectomy + lymphadenectomy	0.29 (±1.20)	0.35 (±1.64)	0.00 (±0.00)	0.73

the duration of surgery, the length of hospital stay and the total cost of hospitalization.

Duration of surgery

For patients undergoing partial thyroidectomy, the mean duration of surgery using the harmonic scalpel was lower than that of surgery using the conventional method ($p=0.0216$). Furthermore, for the patients who underwent total thyroidectomy, this difference was significant among the three groups, again with the harmonic scalpel group undergoing the shortest duration of surgery. For the total thyroidectomy with lymphadenectomy procedure, the mean duration of surgery was lowest for the conventional technique group. The difference was not significant related to the harmonic scalpel group but was significant related to the vessel sealing device group ($p=0.001$).

Length of hospital stay

With respect to the length of hospital stay, a difference in time was not observed among the groups for the partial thyroidectomy procedure. For the total thyroidectomy

and total thyroidectomy with lymphadenectomy procedures, the vessel sealing device group experienced longer hospital stays compared to the other two groups ($p<0.001$).

Cost

Partial thyroidectomy with the conventional technique was used as a reference value to analyze the cost of the procedure. In terms of the cost of the partial thyroidectomy procedure, no significant difference was found among the groups. The costs were also similar for the total thyroidectomy with lymphadenectomy procedure (according to significance tests conducted on two groups at a time). For the total thyroidectomy procedure, there was a significant difference among the conventional group and the other two groups ($p<0.001$), with higher costs being incurred when the harmonic scalpel or the vessel sealing device were used.

Because certain factors, such as the patient and surgical procedure complexity and the experience level of the surgeon with the technology, can independently influence the outcomes, it was decided to use multiple

linear regression to analyze the effect of using the vessel sealing device or the harmonic scalpel as described below.

Pain

The pain score varied according to the type of procedure and whether the new technologies were used. However, no clear pattern was identified and no significant differences were found among groups.

Bleeding

No records were found for blood transfusions performed in any of the groups. Furthermore, there were few requests for postoperative blood counts in the groups analyzed. Consequently, these outcomes were not included in the multivariate analysis.

Regression analysis

A multiple linear regression model was developed to evaluate the “duration of surgery,” “length of hospital stay” and “total cost” outcomes.

For the “duration of surgery” outcome, the following variables had a significant impact: the use of vessel sealing device, harmonic scalpel or conventional technique; the neoplasia diagnosis, the type of procedure, and gender (Table 3). The analysis revealed that the use of vessel sealing device increased the mean duration of operation by approximately 47 minutes compared to the conventional technique ($p < 0.001$); the use of harmonic scalpel reduced the mean duration of surgery by approximately 32 minutes compared to the conventional technique ($p < 0.001$). The surgeries for non-neoplastic diagnoses and the procedures involving partial thyroidectomy had shorter average durations ($p < 0.004$).

Table 3. Multivariate model for evaluating the “duration of surgery” outcome

Parameter	Coefficient	Standard error	p value
Conventional technique (reference)			
Vessel sealing device	46.678	8.71	<0.001
Harmonic scalpel	-31.604	7.623	<0.001
Cancer [Yes]	16.267	5.826	0.005
Partial thyroidectomy (reference)			
Total thyroidectomy	24.081	8.374	0.004
Total thyroidectomy + lymphadenectomy	48.791	11.034	<0.001
Gender [Male]	11.982	5.969	0.045

The percentage distribution in the length of stay category (Table 4) was not homogeneous in relation to the groups ($p < 0.001$), indicating that the group influenced the length of stay in the hospital. For the group of patients whose surgeries involved vessel sealing, 53% of the cases (95% confidence interval - 95%CI= 39.98%, 66.46%) experienced a longer hospital stay (3 days or more). The groups whose surgeries involved the conventional technique and the harmonic scalpel showed similar distributions related to one another in terms of the length of hospital stay.

Table 4. Ratios and confidence intervals for the “length of hospital stay” outcome

Group	Length of stay		
	Up to 1 day	1 to 2 days	3 days or more
Conventional (%)	59 (53.12- 64)	35 (29.57- 40.1)	7 (4.33- 10.09)
Vessel sealing device (%)	7 (2.23- 17.55)	40 (27.32- 53.36)	53 (39.98- 66.46)
Harmonic scalpel (%)	65 (52.47- 75.5)	20 (11.57- 31.2)	15 (8.35- 26.46)

χ^2 Test p value <0.001.

For the “total cost” outcome (Table 5), the variables with significant impact included the use of the vessel sealing device, the use of harmonic scalpel ($p < 0.001$), the age of the patient ($p = 0.006$) and the type of procedure. Surgeries involving the use of the vessel sealing device or the harmonic scalpel cost more than those that used the conventional technique. Increased patient age led to increased cost, and the total thyroidectomy procedures, with or without lymphadenectomy, were significantly more costly than the partial thyroidectomy procedures.

Table 5. Multivariate model for assessing the “total cost” outcome

Parameter	Coefficient * (%)	p value
Conventional technique (reference)		
Vessel sealing device	29	<0.001
Harmonic scalpel	39	<0.001
Partial thyroidectomy (reference)		
Total thyroidectomy	10	0.0318
Total thyroidectomy + lymphadenectomy	27	<0.001
Age	0.3	0.006

* In this case, the coefficients represent how much each factor affects the cost compared to the baseline, which is represented by the intercept.

DISCUSSION

The objective of the present study was to evaluate the impact of two new surgical techniques on the

intermediate clinical outcomes and hospital costs for patients undergoing thyroidectomy surgery at HIAE, between January 2007 and August 2010. The analysis allowed the correlation between the influence of each method on clinical outcomes and on the costs of the procedures.

With respect to the length of hospital stay, no significant difference was observed between the use of harmonic scalpel and the use of the conventional technique, which corroborates the results obtained by international studies⁽⁷⁻¹¹⁾.

In the group undergoing surgery using the vessel sealing device, an increase was observed in the duration of surgery and in the length of hospital stay; these results contradict other results reported in the literature⁽⁷⁻¹¹⁾. Given that 90% of the procedures that used the vessel sealing device were performed by a single surgeon, this result may be related to his surgical technique and not specifically to the use of the vessel sealing device.

The use of the harmonic scalpel reduced the mean duration of surgery by approximately 32 minutes compared to the conventional technique. International studies have shown significant reductions in the mean duration of the thyroidectomy procedure, with the use of harmonic scalpel leading to a 17- to 20-minute reduction in procedure time⁽⁷⁻¹¹⁾.

Considering the per-minute costs associated with using the operating room, this shortened duration should result in a 4% reduction in the total cost of procedures by using this technology. However, the incremental cost increase due to the use of the harmonic scalpel more than compensates for the savings achieved through a shorter period of time in the operating room. The use of the harmonic scalpel in surgical thyroidectomy reflected a mean increase of 28% in the total cost of the procedure.

No significant differences were found among the groups regarding the use of blood products and the postoperative pain score.

One limitation of the study is the fact that the physician chose which technology to use. It was therefore not possible to differentiate between the effect of the surgeon and the effect of the chosen technology in the evaluated outcomes.

CONCLUSION

The use of the harmonic scalpel was favorable in terms of reducing the duration of surgery, however, there was no effect on the length of hospital stay, and the cost of the procedure was significantly higher than that of other treatments. Regarding the use of the vessel sealing device, no favorable results were observed among the outcomes that were evaluated, and the cost increase was significant compared to the conventional technique.

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