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ORIGINAL ARTICLE

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Should total thyroidectomies be performed by high-volume endocrine surgeons? A cost-effectiveness analysis

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Abstract

Purpose The increased experience of a thyroid surgeon reduces the risk of postoperative complications. However, whether it is also cost-effective is currently unknown. The aim of the present study was to compare cost-effectiveness of high-volume (HVS) with low-volume surgeons (LVS) when performing a total thyroidectomy.

Methods This was a retrospective study, comparing the mean cost of a total thyroidectomy per patient, between HVS and LVS. This included the cost of surgical procedure and pre- and post-operative inpatient hospitalization. A threshold of 25 thyroidectomies/year was used to discriminate between HVS and LVS.

Results Four-hundred and forty-one patients were classified into HVS and 342 into the LVS group. With regard to surgical complications, higher rates of temporary hypoparathyroidism and endangered airway were observed in the LVS than in the HVS group. The estimated total cost per patient was higher in the LVS compared with the HVS group [€1721 ± 396 ($1910 ± 439) versus €979 ± 68 ($1086 ± 487); $p < 0.0001$]. This cost remained higher when sub-analysis was performed for each surgical stage, involving either surgical procedure or pre- and post-operative inpatient hospitalization. Differences between LVS and HVS mainly involved the cost in surgical procedure (23% attributed to occupation of the operating room) and postoperative inpatient hospitalization (45% of the total thyroidectomy cost).

Conclusion Total thyroidectomy performed by a HVS seems to be cost-effective compared with the one conducted by LVS. This is mostly attributed to the lower rates of surgical complications, such as postoperative hypoparathyroidism and airway obstruction.

Keywords Thyroidectomy · High-volume surgeon · Low-volume surgeon · Cost-effectiveness

Introduction

Total thyroidectomy is a widely accepted operation characterized by low morbidity and, virtually, no mortality. The major aim of the modern thyroid surgeon is to provide surgery with the lowest possible complication rate [1]. Surgical experience is mandatory for the surgeon to achieve anatomic identification and preservation of the recurrent laryngeal nerves and parathyroid glands [2]. Complications still occur as a result of several factors. However, the most important factor seems to be the high-volume of operations [3]. A recent study by Adam et al. [4]. defined as "high-volume surgeons (HVS)" those performing more than 25 thyroidectomies/year and as "low-volume surgeons (LVS)" those performing less than 25.

Until recently, the expense or cost of a surgical procedure was a secondary consideration to all parties involved. However, recent global finance constraints have forced a shift in thinking [5]. In the surgical literature, a few metrics to measure cost-comparative analysis for specific operations and technologies, have been developed. This is probably due to the fact that the economics of surgical interventions are extremely complicated and not straightforward, since hospitals are complex economic environments that interact

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with multiple vendors, levels of staff, administration, policy etc.

The aim of the present study was to compare the cost-effectiveness of high-volume (HVS) with low-volume surgeons (LVS) when performing a total thyroidectomy, in an attempt to estimate the economic impact of sub-specialization on everyday practice.

Patients and methods

Inclusion and exclusion criteria

The study was approved by the ethics committee of AHEPA University Hospital and was performed over a 3-year period. The requirement to obtain a specific informed consent was waived because of the retrospective nature of the study and its aim. However, a written informed consent was obtained from each subject before the operation after explanation of the purpose and the nature of the procedure used. The study was performed in accordance with relevant guidelines and regulations.

During the last three years, from January 2016 to December 2018, 871 patients underwent thyroidectomy. Inclusion criteria for the study were: (i) age older than 18 years, (ii) written informed consent for total thyroidectomy and (iii) written informed consent for the patient to be included into the prospectively formed databank. Exclusion criteria were: (i) lymph node dissection (prophylactic or therapeutic), (ii) retrosternal goiter (defined as >30% of the gland under the level of the clavicle), (iii) transoral endoscopic thyroidectomy vestibular approach (TOETVA), (iv) reoperation, (v) more than one concomitant operation and (vi) lobectomy. A flow diagram of the study population is presented in Fig. 1. A threshold of 25 thyroidectomies/year was used to discriminate between HVS and LVS.

Economic methodologies

Distinction between charge and cost is essential for an analysis to have any utility. Charge is the price paid by the consumer (patient-health insurance) needed for the institution (hospital) to break even and to be solvent. On the other hand, cost is the price paid by the producer (institution—hospital) for resources consumed during the production [6]. Moreover, a distinction must be made between fixed versus variable costs, and direct versus indirect costs. A direct cost reflects the price of resources that are directly attributable to the project, whereas indirect costs are not directly attributable to the completion of the studied activity [7]. In the present paper, we measured all direct unit costs by identifying and analyzing the resources consumed in each phase of hospitalization. This cost evaluation is meant to provide health institutions and

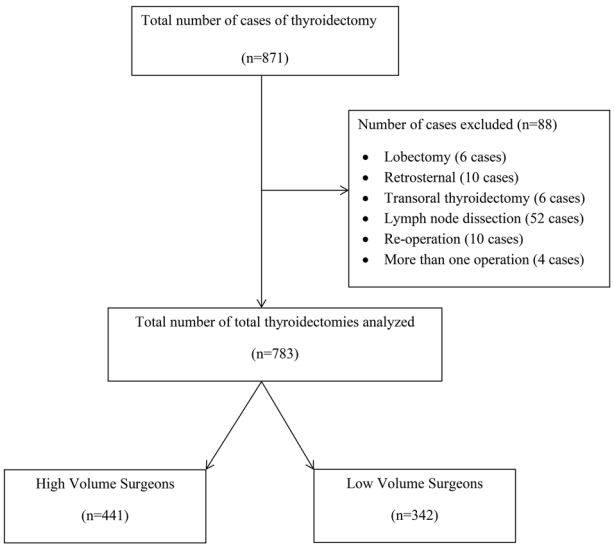

Fig. 1 Flow diagram of the study population

managers with detailed information on whether an operating team or a followed strategy can optimize surgery cost.

The direct costs of total thyroidectomy were divided into three categories: (i) preoperative inpatient hospitalization, (ii) surgical procedure and (iii) postoperative inpatient hospitalization.

Preoperative inpatient hospitalization

During this phase the direct costs include: (i) administrative, (ii) healthcare professionals, (iii) laboratory and imaging testing.

Surgical procedure

During this phase the direct costs include: (i) occupation of operating room (OR), (ii) healthcare professionals, (iii) pharmaceuticals, (iv) consumables and (v) pathology. The cost of occupation of OR was the mean cost of the OR per hour [which is €250 ($277.5)] for total thyroidectomy multiplied by the duration of the operation (time of exit–time of entry in the OR). The cost of health professionals (other than surgeons and anesthetists), which is fixed and the administrative cost, was also included in the cost of OR occupation. Pathology included both frozen and paraffin sections. Intraoperative costs of consumables include everything disposable after the operation starting from gauges and going up to neuromonitoring and specialized disposable instruments. The healthcare professionals cost includes surgical team and anesthetist cost. To calculate the cost, we divided the monthly salary of both anesthetists and surgeons by the number of working days (25) and by the number of working hours (8). In this way, we calculated the cost of surgeons and anesthetists at €7 ($7.8) per hour each.

Postoperative inpatient hospitalization

During this phase the direct cost includes: (i) ward stay, (ii) healthcare professionals, (iii) pharmaceutical, (iv) laboratory and (v) imaging testing. Ward stay costs include also the administrative cost, calculated per day of hospitalization, as a unit value of €310 ($344).

Medical and surgical data

The present retrospective study had no intention to evaluate the different practices employed by HVS and LVS. LVS usually have no standard protocol of treatment and the low number of operations does not permit comparisons and analysis. However, the number of complications was recorded by the use of two definitions: (i) postoperative hypoparathyroidism, defined as parathyroid hormone (PTH) levels <15 pg/ml, 24 h post surgery [8], (ii) endangered airway, considered in any patient that had to undergo emergency tracheostomy at any point of his hospitalization. The etiology of the endangered airway from an economic point of view is pointless with regard to the direct hospitalization costs.

Statistical analysis

The normality of distribution of continuous variables was tested with the Kolmogorov–Smirnov test. Data for continuous variables are presented as mean ± standard deviation (SD) (in cases of normal distribution), whereas data for categorical variables are presented as numbers or percentages. Repeated measures analysis of variance (ANOVA) was used to test for differences within the levels of continuous variables and the chi square test for categorical variables. A p value < 0.05 (two-tailed) was considered statistically significant. Statistical analysis was performed using SPSS for Windows version 13 (SPSS Inc., Chicago, IL, USA).

Results

Among the screened patients, 783 where included in the analysis and were classified into either HVS ($n = 441$) or LVS group ($n = 342$). Patients having undergone thyroidectomy by an HVS tended to be older, with a higher male-to-female ratio compared with those operated by an LVS. Of note, a greater proportion of patients presented with a malignant pathology in the former than in the latter group. With regard to surgical complications, higher rates of temporary hypoparathyroidism and endangered airway were observed in the LVS than in the HVS group. The duration of hospitalization and mean OR use was longer in the latter compared with the former group. Of note, patients in the HVS were more frequently operated on for a benign pathology than those in the LVS group. These data are presented in detail in Table 1.

Table 1 Patients' descriptive characteristics according to the group of surgeons

	HVS ($n = 441$)	LVS ($n = 342$)	p value
Age (years)[a]	49 ± 15	47 ± 13	0.05
Female-to-male ratio	3.46	3.89	<0.0001
Benign-to-malignant ratio	0.70	6.17	<0.0001
Temporary hypoparathyroidism (%)	91 (20.63)	216 (63.16)	<0.0001
Endangered airway (%)	0 (0)	5 (1.46)	<0.0001
Mean hospitalization time (days)[a]	0.96 ± 0.025	1.72 ± 0.708	<0.0001
Mean OR use (min)[a]	47 ± 9	97 ± 23	<0.0001

HVS high-volume surgeon, *LVS* low-volume surgeon, *OR* operation room

[a]Data are presented in mean ± SD

The estimated total cost per patient was higher in the LVS compared with the HVS group [€1721 ± 396 ($1910 ± 439) versus €979 ± 68 ($1086 ± 487)]. This cost remained higher when sub-analysis was performed for each surgical stage, involving either the preoperative inpatient hospitalization, surgical procedure or postoperative inpatient hospitalization. Differences between LVS and HVS mainly involved the cost in surgical procedure (23% attributed to occupation of OR) and postoperative inpatient hospitalization (45% of the total cost for thyroidectomy). Detailed data are presented in Table 2.

Discussion

The present study showed that thyroidectomies performed by an HVS are not only associated with a lower risk of surgical complications, but they are also cost-effective, compared with those performed by an LVS. This cost-effectiveness involves namely the postoperative period (almost half of the total cost), highlighting the contribution of the complications occurring during this period (i.e., hypoparthyroidism and endangered airway, leading to emergency tracheostomy) in the total thyroidectomy cost.

The surgeon's experience, illustrated by the number of thyroidectomies performed per year, seems to significantly contribute to a reduced total cost, mainly due to the reduced rates of postoperative complications. In general, the surgeon caseload is inversely associated with the risk of complications and, in consequence, with the length of stay in hospital and total charges [4, 9]. Some authors, using data from a large surgical series ($n = 16{,}954$), set a threshold of 25 total thyroidectomies/year to improve patient's outcomes [4]. The odds ratio for inhospital complications between LVS

Table 2 Estimated mean cost for each group of surgeons in Euros and dollars

	HVS	LVS	*p* value
1. Preoperative inpatient hospitalization			
A. Administrative	€7 (0) $7.8 (0)	€7 (0) $7.8 (0)	1
B. Healthcare professionals	€70 (0) $78 (0)	€70 (0) $78 (0)	1
C. Laboratory and imaging testing	€59 (6) $65.5 (6.6)	€97 (9) $107.7 (10)	<0.0001
2. Surgical procedure cost			
A. Occupation of operating room	€196 (38) $217.5 (42)	€404 (96) $448.4 (106.5)	<0.0001
B. Healthcare professionals	€11 (2) $12.2 (2.2)	€23 (5) $25.5 (5.5)	<0.0001
C. Pharmaceuticals	€37 (2) $41.1 (2.2)	€54 (16) $ 59.9 (17.6)	<0.0001
D. Consumables	€62 (12) $68.8 (13.3)	€140 (31) $154 (34)	<0.0001
E. Pathology	€130 (5) $144.3 (5.5)	€140 (13) $154 (14.4)	<0.0001
3. Postoperative inpatient hospitalization			
A. Ward stay	€298 (7) $330.8 (7.8)	€533 (219) $591.63 (243)	<0.0001
B. Healthcare professionals	€70 (0) $78(0)	€120 (49) $133.2 (54.4)	<0.0001
C. Pharmaceuticals	€18 (8) $20 (9)	€54 (6) $60 (6.6)	<0.0001
D. Laboratory and imaging testing	€21 (3) $23.3 (3.3)	€79 (2) $87.7 (2.2)	<0.0001
Total cost of total thyroidectomy	**€979 (68) $1086.7 (75.5)**	**€1721 (396) $1910 (439.5)**	**<0.0001**

Values in parentheses are the SD value of the costs

and HVS with this cutoff in this study was 1.51 [95% confidence interval (CI) 1.16–1.97] [4]. This was confirmed by others using the threshold of 30 thyroidetomies/year for the definition of HVS, in comparison with an LVS (defined as those who perform 1–3 thyroidectomies/year) [10]. The lowest risk of surgical complications is achieved by surgeons who perform ≥100 operations/year, as shown by another study [9]. This seems to be independent of patient's comorbidities, economic factors and hospital-centric variables [9]. The increase in hospital length of stay and cost with a LVS is estimated at 12% and 2%, respectively [4].

In the present study, by using a micro-costing approach, the mean patient's cost was estimated at €979 ($1086) versus €1721 ($1910) for HVS and LVS, respectively. This cost was significantly lower than the one reported in Europe. For instance, in one study from Italy, the direct cost of surgery and hospitalization was €4956 ($5501), rising to €5812 ($6451), after incorporating the costs attributed to presurgical and postsurgical follow-up, as well as complication management through 12 months postoperatively) [11]. Few studies have focused on the cost-effectiveness of the surgeon's volume, with respect to thyroidectomy. In a large cross-sectional study from the USA ($n = 77{,}863$), the mean hospital cost associated with HVS (defined as those with ≥30 thyroidectomies/year) was $6662.69 (€6002.42) ± 409.31 (€368.74). This was significantly lower than the one assigned to an intermediate volume surgeon [4–29 thyroidectomies/year; $6912.41 ± 137.20 (€6227.39 ± 123.60)] or to an LVS [1–3 thyroidectomies/year; $10,396.21 ± 345.17 (€9365.95 ± 310.96); $p < 0.001$] [10].

In general, the parameter "cost effectiveness" should be taken under consideration during the patient's management for a specific thyroid pathology. Except for the surgeon volume, intraoperative neural monitoring of the recurrent laryngeal nerve further increases the cost-effectiveness of a thyroidectomy [12]. In specific situations, such as patients with papillary microcarcinoma, some groups are in favor of active surveillance rather than early surgical management, due to the low rates of tumor progression (<3%) [13, 14]. The former approach seems also to be cost-effective for 16 years and onwards, irrespective of the patient's age, based on the quality-adjusted life year gained policy [15].

Our study has certain limitations. First, its retrospective design constitutes a significant shortcoming compared with a randomized clinical trial. Second, selection and recall bias could not be ruled-out, taken also into account the patient's preference with regard to the surgeon. Third, the higher malignancy rates in the HVS group could have had an impact on the cost-effectiveness, due the potentially longer procedure times and higher risk of complication rates, such as temporary hypoparathyroidism, in this group. However, even in this case, this would be in favor of LVS's group performance.

Conclusions

A total thyroidectomy performed by an HVS seems to be a cost-effective strategy compared with operations conducted by an LVS. This is mostly attributed to the lower rates of surgical complications, such as postoperative hypoparathyroidism and airway obstruction, which necessitates the emergency tracheostomy. Almost half of the total surgical cost refers to the postoperative period, highlighting the

contribution of the surgeon's experience to the reduction of these risks. The key issue is to replicate these findings in future prospective randomized-controlled clinical trials.

Author contribution PA analyzed the data and wrote the first draft of the paper. IP and SP provided surgical data and searched the literature. AC was responsible for the statistical analysis and reviewed the manuscript. VS and AM reviewed the manuscript and provided critical scientific input. TSP conceived the idea of the study, provided critical scientific input and had the primary responsibility for the paper's final content.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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