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Expense of Robotic Thyroidectomy

A Cost Analysis at a Single Institution

James T. Broome, MD; Sharon Pomeroy, RN, BS, MHA; Carmen C. Solorzano, MD

Hypothesis: The cost of robotic thyroidectomy (RT) is significantly higher than that of standard open thyroidectomy (ST).

Design: A retrospective cost analysis of ST was compared with a projected cost analysis of RT using institution-specific data.

Setting: Endocrine surgery division at an academic center.

Participants: Standard open thyroidectomy data from 2 high-volume endocrine surgeons vs published variables from high-volume RT surgeons.

Main Outcome Measures: A cost analysis was performed for ST (Current Procedural Technology code 60240). The cost of RT was estimated as operative time plus anesthesia fees plus consumables plus the robotic system (da Vinci Surgical System; Intuitive Surgical, Inc). Institution-specific data were collected for ST, and only those costs that varied between ST and RT were included in the analysis. The mean operative time for ST was based on data from 2 high-volume endocrine surgeons at our institution. The RT operative data were extracted from published series of high-volume RT surgeons.

Results: The relative costs calculated were $2668 for ST vs $5795 for RT. This represents a 217% increased cost of RT compared with ST. The mean operative times were 113 minutes for ST vs 137 minutes for RT.

Conclusions: Technologic advances are paramount in providing the best medical care for patients. This progress must be tempered by a rational, open discussion about the costs of these advancements. Only then can the proposed benefits of a new technology be weighed accurately against the overall societal cost. Surgeons need to be aware of the cost of their technologic choices and the burdens that those place on limited resources.

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In the early part of the 20th century, our surgical forebears converted a once reviled procedure into a common, low-risk endeavor.[1] Thyroidectomy has become exceptionally safe, with a rate of permanent hypoparathyroidism of less than 2%, the frequency of recurrent laryngeal nerve injury at approximately 1%, and mortality well less than 1% in high-volume surgical practices.[2] Little has fundamentally changed during this time for the surgical approach and techniques used in thyroidectomy. Because technology has progressed and techniques have been refined, modern thyroidectomy can often be safely completed through small 3- to 6-cm collar incisions. Standard open thyroidectomy (ST) is the benchmark for treatment of benign and malignant thyroid disease.

Robot-assisted surgery has undergone an explosion of use, mostly driven by its near ubiquitous use in the removal of prostate cancer and the subsequent patient interest and demand. The use of a robotic system (da Vinci Surgical System; Intuitive Surgical, Inc) has been applied across several surgical fields, including urology, gynecology, cardiac surgery, and general surgery.[3-6] The robotic revolution has recently extended to the treatment of thyroid disease. Through the pioneering work of South Korean surgeons,[7-13] robotic thyroidectomy (RT) has been shown to be a safe and effective procedure for the removal of a range of pathologic conditions of the thyroid. Large-cases series[8,9,12,14,15] demonstrated equivalent rates of hypoparathyroidism, recurrent laryngeal nerve injury, and postoperative hematoma formation following RT compared with open surgery. Although concerns have been raised about potential injury to the brachial plexus, this "new"

Author Affiliations: Division of Surgical Oncology and Endocrine Surgery, Department of Surgical Sciences, Vanderbilt University, Nashville, Tennessee.

complication has proven to be rare when appropriate precautions are implemented.[8,11,14]

Robotic thyroidectomy has not demonstrated superiority in any comparison with ST for length of procedure, complication rates, or oncologic outcomes.[7,11,12,15] The sole demonstrable benefit seems to be the cosmetic effect of moving the incision, but often enlarging it in the process, to a "hidden" location within the axilla or around the areola.[2,7,11,13] However, RT carries a significant learning curve of approximately 45 to 50 cases, as well as relative contraindications to its use in a wide range of patients with thyroid disease.[9] This includes patients with large lesions, substernal goiter, and thyroiditis from severe Hashimoto disease and Graves disease, as well as restrictions based on the body mass index of the patient.[9,13] In a proactive attempt to safely introduce this technology to the field of endocrine surgery, an expert panel was convened to provide a framework for the safe implementation of new technologies, specifically for RT.[16] As elucidated by this panel, the first and likely the greatest drawback to this technology is the cost of its implementation. However, despite this concern, no analysis has yet been published to quantify and compare the cost differences between ST and RT. Therefore, we conducted a cost analysis at our institution to examine the cost differences between ST performed by 2 high-volume endocrine surgeons (J.T.B. and C.C.S.) compared with the calculated costs using published variables from high-volume RT surgeons.

METHODS

A cost analysis was performed for 12 consecutive STs (Current Procedural Technology code 60240) performed by 2 high-volume endocrine surgeons at our institution. The cost of ST was calculated as operative time plus anesthesia fees plus consumables. The operative time was the base fee plus the fee for each 30 minutes. The anesthesia fees were the base anesthesia relative value units plus the fee for each 15 minutes. Consumables were the harmonic scalpels. The cost of RT was estimated as operative time plus anesthesia fees plus consumables plus the robotic system. The operative time and anesthesia fees were estimated in the same manner as for ST. Consumables for RT were the robotic arms (each used 10 times) plus the trocar plus the robot drapes plus the special retractor (cases used per year) plus the harmonic scalpels. The cost of the robotic system was calculated as the total robot cost with yearly depreciation divided by the total number of robot-assisted cases per year.

Institution-specific data were collected on fees, charges, and the billing level for operating room (OR) time. Only those costs that varied between ST vs RT were included in the analysis. Examples of costs that are identical between ST and RT include analgesics, postoperative visits, inpatient room and board, surgeon professional fees, salaries of the necessary OR staff (assistant, scrub, and circulator), and standard surgical instruments and items used in each procedure (sutures, nerve monitoring, and basic instruments, including forceps, needle drivers, etc), as well as the physical costs of equipping the OR to perform surgery (operating table, overhead lights, etc). By excluding these items, a more direct comparison can be made between the cost structures of each procedure. The robotic system already exists at many institutions and would not be a new cost of RT implementation but would be included in the ongoing costs of owning and operating the system at that facility. By defraying the costs of the robot over all procedures conducted at an institution, the cost attributable to RT could be estimated. The mean operative time for ST was based on data from 2 high-volume endocrine surgeons (>250 thyroidectomies per year combined) at our institution who also teach surgical residents during the performance of the procedure. The RT operative data were extracted from published series[9,11] of high-volume RT surgeons.

Table 1. Operative Costs of Standard Open Thyroidectomy by 2 Surgeons

	Cost, $	
Variable	**Surgeon 1**	**Surgeon 2**
Operative time[a]	513	630
Anesthesia	1378	1590
Consumables	612	612
Total cost[b]	**2503**	**2832**

[a] The mean operative times were 103 minutes for surgeon 1 and 123 minutes for surgeon 2.
[b] The mean cost between the 2 surgeons was $2668.

RESULTS

STANDARD OPEN THYROIDECTOMY

The mean operative times for ST (from skin incision to skin closure) were 103 minutes for surgeon 1 and 123 minutes for surgeon 2 (**Table 1**). The cost of the operative time (a level 3b case) represents a base fee ($162) for the first 30 minutes and an additional $117 for each 30 minutes (or portion thereof) after that initial time. The level of a case is an estimation of the complexity and resources committed to a particular operation. It is chosen internally at each institution in an attempt to account for the resources used in various procedures. Professional fees for anesthesia are also calculated on a per-time basis. The anesthesia fees are based on anesthesia relative value units ($636) plus an additional $106 for each 15 minutes (or portion thereof) in the OR. The only consumable used routinely in ST that would not be used in RT is the handheld harmonic scalpel, with a 2011 market cost of $612 per disposable hand piece. Using these values, the total costs of ST were $2503 for surgeon 1 and $2832 for surgeon 2. This results in a mean relative cost of ST at our institution of $2668 (**Figure**).

ROBOTIC THYROIDECTOMY

The mean operative times for RT (from skin incision to skin closure) in 2 large published series[9,11] were 129 minutes and 144 minutes. The same calculations and assumptions as those for ST were used to determine the cost of the operative time and the anesthesia fees. The consumables that would differ from those for ST include the robot-use harmonic scalpel, a 12-mm bladeless trocar used in the case, special drapes used to cover the robotic arms, each robotic arm (defrayed over the 10 uses allowed per arm), and a special retractor described for creation and maintenance of the operative space

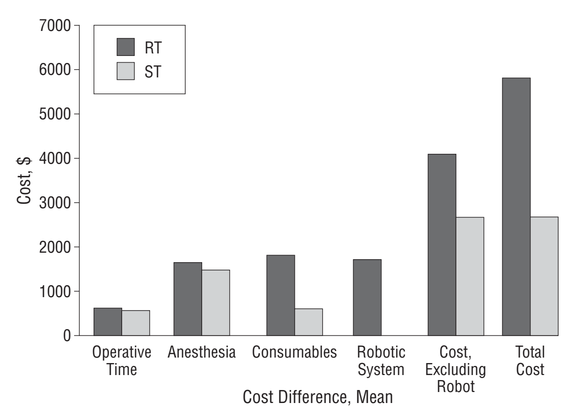

Figure. Mean cost differences between robotic thyroidectomy (RT) and standard open thyroidectomy (ST) by major contributors to the costs of the procedures. The mean values represent a combination of the relative costs of short and long cases.

Table 2. Cost of Consumables Used to Perform Robotic Thyroidectomy

Variable	Cost, $	No. of Uses	Cost per Case[a]
Robotic arms			
Maryland dissector	4600	10	460
Grasper attachment	2200	10	220
Harmonic shears	1100	10	110
Maryland bipolar	2100	10	210
Robot drapes for 4 arms	260	1	260
12-mm Bladeless trocar	49	1	49
Harmonic shears	430	1	430
Special retractor	10 000	125	80

[a] The total cost of consumables was $1819.

Table 3. Projected Operative Costs of Robotic Thyroidectomy

Variable	Cost, $ Short Case	Cost, $ Long Case
Operative time[a]	630	630
Anesthesia	1590	1696
Consumables	1819	1819
Robotic system	1703	1703
Total cost[b]	**5742**	**5848**

[a] The mean operative times were 129 minutes for short cases and 144 minutes for long cases.
[b] The mean cost was $5795.

(**Table 2**). An assumption was made that approximately 20% of our present ST volume (about 250 cases per year) would be eligible for a robotic approach (50 cases). The cost of the robotic system varies by individual contract with each institution. As a high-volume institution, a lower figure could be expected; therefore, the cost of the robot was estimated at $1.5 million. The depreciated cost of the robotic system was based on 5 years, with the total institutional use of 831 robotic cases per year plus the addition of the estimated 50 RT cases to be completed. This is then divided among the 5 robotic systems in use at our institution. This meant that the relative cost of the robot was $1703 per case. Using these values, the relative costs of RT were $5742 for a short case and $5848 for a long case (**Table 3**). Together, the mean projected relative cost of RT at our institution was $5795 (Figure).

COMMENT

The surgical robot is at the vanguard of surgical technology, with surgeons aptly applying this system across a wide range of procedures.[3-6] A recent consensus article[16] set forth a framework for the assessment of new technology and its safe implementation. In doing so, the authors correctly identified the major potential drawback to this technology, namely, the high cost associated with its use in the OR. Now that several large series[9,11,14,15] have demonstrated the comparable safety and efficacy of RT compared with ST, we sought to address the expense of RT with a detailed cost analysis of the procedure. When looking only at those aspects of the procedure that would differ between RT and ST, we see a 2.2 times (217%) increase in costs related to the use of the robotic system to perform thyroidectomy.

The method used to perform this cost analysis has been adapted from previous evaluations of the cost differences between laparoscopic and robotic urologic procedures.[17] The comparison is simplified by looking only at those costs that would be different between the 2 procedures. The costs determined do not translate into actual charges to the patient or third-party payers. This analysis was intended to explore the costs incurred by the system as a whole rather than look at charges passed along to the health care consumer. In doing this type of analysis, several assumptions are made that must be addressed to truly understand the scope of this difference. As described in the "Methods" section, several costs are shared between ST and RT. By excluding costs that are identical to both procedures, a more direct comparison can be made between the cost structures of each procedure. A review of the current literature demonstrates no significant difference between the 2 procedures in the length of hospital stay, amount of postoperative pain, or time needed before return to work that would need to be taken into account in the overall expense of the operations.[9,11,12,14]

Other assumptions made in this analysis affect the conclusions. Every effort was made to give the benefit of the doubt to the RT approach. The operative times used herein were drawn from high-volume, robotic-experienced surgeons who have long plateaued on the learning curve for the procedure.[9,11] A recent American series[18] that reports operative times for RT, including lobectomy and total thyroidectomy, demonstrates significant increases in operative times (mean [SD], 232 [66] minutes) compared with those of our high-volume South Korean colleagues. An estimated learning curve of approximately 40 to 45 cases has been described,[9] which would undoubtedly increase the initial costs of RT at an institution. When we examined the costs of the procedure at different time points along the reported learning curve, a limited effect on cost based on the longer operative times (approximately $223 per case) was found earlier in the curve.[9] These reported times include a mixture of thyroid cases reported, including total thyroidectomy and thyroid lobectomy.[9,11] Certainly, the inclusion of anything less than total thyroidectomy in the mean operative times would be expected to lower the true operative time for total thyroidectomy.

The exclusion criteria for RT are also an important factor in the implementation of this technique in the United States. These criteria include patients with large lesions, substernal goiter, or thyroiditis from severe Hashimoto disease and Graves disease, as well as restrictions based on the body mass index of the patient. In our present practice, the 2 surgeons described herein perform on average 250 to 300 thyroid operations per fiscal year. Many of these operations are performed for large goiters with or without substernal extension or Graves disease and in patients with body mass indexes that would be prohibitive to the robotic approach. Assuming that 20% of the procedures would be performed robotically is likely another significant overestimation in favor of the cost of RT. One must also consider that some patients eligible for RT would elect to undergo ST when given the option and full informed consent was obtained.

Our institution is a high-volume user of the robotic system. Current prices for various models of the robotic system range from $1.5 to $2.0 million, depending on the individual institutional contract. We chose to use the low end of this range to once again favor RT in terms of the cost analysis. The high volume of robot-assisted cases performed at our institution has another advantage in allowing the capital cost of the robot to be divided among many more procedures than simply the number of RT cases performed per year. Once again, this would favor the cost analysis of RT compared with ST. Excluded from the analysis is the cost of the service and maintenance package required to be purchased by the institution in addition to the capital cost of the robot. This contract can run from $250 000 to $400 000 per year based on the institutional contract. As shown in the Figure, even when one excludes the cost of purchasing the robotic system, the expense of RT still far exceeds that of ST.

Another cost to be considered but which is not counted against RT in this analysis is the up-front cost of training for the surgeon and the operative staff involved in the thyroid cases. Certainly, many institutions will have support staff already trained and competent in using the robotic system, which means that adding RT does not add personnel costs. However, the surgeon must pay approximately $3000 to undergo training, exclusive of travel, accommodations, and lost clinical revenue during that time, and many surgeons choose to pursue further training or mentorship before implementing the procedure. Over the lifetime of the surgeon, this is likely to be of minimal influence in the financial decision, which is why it was not factored into the present cost analysis. In addition, many surgeons implementing RT enlist the help of a second attending surgeon during the learning curve of the operation. This limits the ability of the second surgeon to have independent revenue and potentially decreases the productivity of the department.

Despite these assumptions, RT still demonstrates a significant increase in relative costs compared with ST. Our initial expectation was that the increased operative time of RT would account for the bulk of the cost increase between the techniques. In contrast, as shown in the Figure, most of the increased costs are accounted for by the cost of the robot arms and the capital cost of the robotic system. At this time, a monopoly exists for surgical robots that are available on the market. As time progresses, the price of the technology will invariably decline, just as the cost of computers has declined. However, no company is now in competition with the manufacturer of the robotic system. When the time comes that a competitor is introduced to the marketplace, another cost analysis could be performed to evaluate the influence of competition. In fact, it may provide a unique opportunity to explore the role of competition in the cost structure of the US health care system.

At this time, no difference exists in the payment system for RT vs ST in the United States. In South Korea, where RT was pioneered, a graduated reimbursement system is based on the procedure performed.[19] Standard open thyroidectomy has one base reimbursement, while endoscopic thyroidectomy and RT have increasing reimbursements.[19] This difference helps to defray the cost to the overall medical system that is inherent in the use of more expensive technologies for the different operations. Given the present data, the only demonstrable benefit of RT remains the cosmetic difference in the placement of the incision. As with other cosmetic procedures, perhaps a payment system that reflects the nature of the procedure should be proposed. Certainly, American coding systems must evolve to take into account the increased cost of the procedure to the system and attempt to offset that difference.

What is difficult to estimate is the relative value of the cosmetic benefits of RT. Data show that patients undergoing RT are more satisfied with their cosmetic outcomes compared with patients undergoing ST.[11] What is more difficult to define is the financial value of this satisfaction. In an open marketplace, traditional economic forces exist to set the cost of a product or service that consumers are willing to pay. Our health care system lacks the influence of traditional economic pressures to regulate costs. Although subjective and theoretical, a simple survey of all patients providing informed consent for thyroidectomy, asking what they would expect to pay for the use of the robotic system, could give an idea of what consumers might be willing to pay and provide an estimate of the value of cosmesis.

Surgeons should also be aware that, in October 2011, the Food and Drug Administration revoked approval for the use of the robotic system for thyroidectomy and parathyroidectomy. It is unclear what prompted this withdrawal by the Food and Drug Administration, but further use of the robotic system to conduct thyroidectomy must be considered off-label use of the technology. Therefore, RT would be most appropriately confined to the realm of clinical trials and responsible evaluation. Patients must be informed that RT is an off-label use of the technology in the United States, although good safety data exist internationally.

This analysis should not be construed as a rant against the use of technology to benefit our patients. One needs only to look at the significant positive effects that laparoscopic techniques have had on the lives of millions of patients worldwide. Shorter hospitalizations, less postoperative pain, and quicker returns to work are significant and demonstrable benefits in addition to the smaller cosmetic defects incurred with minimally invasive incisions. Instead, this study is meant to be a candid evaluation of the effect of that technology, balanced against the limited resources available to the United States health care system. Technologic advances are paramount in providing the best medical care for patients. However, this progress must be tempered by rational, open discussion about the costs of these advancements. Only then can the proposed benefits of a new technology be weighed accurately against the overall societal cost. Surgeons need to be aware of the price of their technologic choices and the burdens that those place on limited resources.

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Correspondence: James T. Broome, MD, Division of Surgical Oncology and Endocrine Surgery, Department of Surgical Sciences, Vanderbilt University, 2220 Pierce Ave, Nashville, TN 37232-6860 (james.broome@vanderbilt.edu).
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