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ORIGINAL ARTICLE

Robot-assisted transaxillary thyroid surgery—retrospective analysis of anthropometric features

Dan Damian Axente [1] · **Nicolae Augustin Constantea** [1]

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Abstract
Purpose The vast majority of studies published on robot-assisted thyroid surgery are South Korean. This study aims to assess the impact of certain anthropometric parameters on performing robot-assisted thyroid surgery on Caucasian patients.
Materials and methods A total of 91 patients underwent robot-assisted surgery by the axillary approach in the Fifth Surgical Clinic, City Hospital Cluj-Napoca, between 2010 and 2015. Besides the specific clinical and pathological parameters, a series of anthropometric parameters and the postoperative occurrence of skin disorders in the cervical or subclavicular region were determined for each patient.
Results There was an increase in dissection time and console time, which was directly proportional to the patients' body mass index. There were no statistically significant differences in the incidence of postoperative complications in patients with different body mass indices. The postoperative drainage volume was significantly higher in overweight or obese patients. The time needed to visualize the thyroid lodge was longer in patients with wider shoulders, and there was a negative correlation between neck length and console time. A statistically significant direct correlation was found between the clavicle length–neck length ratio and the duration of the entire intervention. There was no significant influence of any of these parameters on the duration of hospitalization or the occurrence of other postoperative complications.
Conclusions The nutritional status of the patients and the other anthropometric parameters influenced the duration and difficulty of the intervention, without affecting its safety in terms of intra- and postoperative- complications.

Keywords Robotic surgery · Thyroid · Caucasian · Anthropometric parameters

Introduction

Currently, there are numerous endoscopic or video-assisted thyroid surgery techniques which, beside quick recovery, aim to obtain more esthetic results, generally by reducing the incision size and/or by placing the incision further away from the cervical region [1, 2].

Robot-assisted thyroid surgery by the axillary approach (RATS) was introduced in medical practice in order to overcome several technical shortcomings of endoscopic surgery [3–5]. The technique has been refined and standardized in robotic surgery centers in South Korea. The experience of these centers is by far the widest in the world [6, 7]. The conclusions of these studies certify the safety and feasibility of robot-assisted thyroid surgery [8].

The number of patients who undergo RATS is still limited in Europe and the USA. Moreover, after an initial increase in the number of patients undergoing RATS in the USA, there was a decrease after 2011 [9]. There are even surgeons from centers experienced in thyroid surgery who discarded the robotic axillary approach [10]. One of the most common causes for this situation lies in the anthropometric and weight status-related differences that exist between South Korean and Caucasian patients [9–11].

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✉ Dan Damian Axente
d_axente@yahoo.com

[1] Fifth Surgical Clinic, "Iuliu Hatieganu" University of Medicine and Pharmacy, 8 Victor Babes Street, 400012 Cluj-Napoca, Romania

In December 2012, Lee et al. published the results of a study carried out on 352 patients who had undergone RATS, which aimed to assess the impact of the body mass index (BMI) and other anthropometric parameters on postoperative results [12]. The research study concluded that robot-assisted endoscopic surgery was safe and feasible in overweight or obese Korean patients. However, the intervention lasted longer.

Apart from the anthropometric differences in terms of height or shoulder width, the prevalence of obese and overweight patients is significantly higher in the Caucasian population than in South Koreans [13].

The purpose of this study was to determine whether BMI or other anthropometric parameters had any impact on RATS and on the postoperative results in a selected group of Caucasian patients.

Materials and methods

The study group included 91 patients from the Fifth Surgical Clinic, Cluj-Napoca City Hospital. These patients underwent robot-assisted axillary surgery between 2010 and 2015.

For this technique, the main patient selection criteria were the presence of lesions (nodules, nodule conglomerates) or a lobe size of less than 60 mm, and the absence of any clinical, imaging, biochemical , or fine-needle aspiration biopsies suspicious for malignancy.

The da Vinci SI HD surgical system (Sunnyvale, CA) was used for all robot-assisted interventions. Moreover, the same protocol for surgical positioning was used in all patients. This was done to ensure optimum access to the armpit in order to obtain the minimum distance between the axilla and the anterior cervical region, to avoid the collision between the robotic arms during surgery and, mainly, to avoid postoperative functional disorders in the upper limb by vicious position and elongation of the brachial plexus [14].

During surgery, the functions of the brachial plexus were assessed by continuous neurophysiologic monitoring using the somatosensory evoked potentials generated by the electrical stimulation of peripheral nerves.

The surgical technique that was used in our study required the axillary approach, either on the lesion side or on the dominant lobe. The robotic arms (1 and 2) and the 30^0 telescope were introduced through a 5 cm axillary incision. The trocar for the third robotic arm was inserted through an additional 8 mm incision on the same side, lateral to the sternum. The technique was described by Chung in 2009 in the first procedure guide [14, 15].

A suction drainage for the thyroid lodge was used in all situations, which was externalized through the armpit. It was suppressed when it reached a volume of 30 ml a day.

Apart from clinical and laboratory data, as well as other parameters related to the surgery itself and the immediate postoperative evolution, there were a series of anthropometric measurements taken from each patient, such as height, weight, clavicle length (CL), neck length (NL), clavicle length–neck length ratio (CL/NL).

The BMI was calculated and, according to the World Health Organization classification, patients were grouped into normal weight patients (BMI <25 kg/m^2), overweight patients (BMI 25–30 kg/m^2), and obese patients (BMI ≥30 kg/m^2).

Neck length was defined by the distance between the thyroid cartilage (the laryngeal prominence) and the superior border of the manubrium of the sternum (the jugular notch). Clavicle length was measured by direct palpation of its extremities. NL was measured in a standing position, by palpation of the anatomical parts described above, with the cephalic extremity in neutral position and with the eyes focused on the horizon.

Sensory disorders in the anterior cervical and prepectoral (subclavicular) region were assessed 3 months after surgery by using a questionnaire based on a 5-step scale. Each patient was asked to fill this 5-step questionnaire in order to assess the presence of hypoesthesia and paresthesia in the neck and anterior chest.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 20. Normality of quantitative data was tested using the Kolmogorov-Smirnov test. Quantitative data were described as mean and standard deviation, and qualitative data as frequency and percentage. Differences in frequency of a qualitative variable between two or more groups were tested using the chi-square test. ANOVA was used to determine the differences between the means of two or more groups. The Spearman rank correlation coefficient determined correlations between two quantitative variables. The degree of association between two random variables was measured using partial correlation. Differences were statistically significant for a p value of ≤0.05.

Results

Clinical and body habitus parameters

Demographic data of patients in the robot group are shown in Table 1 based on their inclusion in the specific BMI group. Most patients were overweight or obese. The mean age was significantly higher in obese or overweight patients ($p = 0.003$). Only three of the 91 patients were males (3.29 %).

Patients were assessed based on BMI and anthropometric parameters. NL was significantly lower in obese or overweight patients ($p = 0.005$). CL/NL ratio was inferior in the same groups of patients ($p = 0.002$).

Table 1 Demographic variables, anthropometric, and resected gland volume according to the patient's BMI and type of operation

		BMI <25	25 < BMI < 30	BMI >30	*p* value
Number		35 (38.46 %)	33 (36.26 %)	23 (25.27 %)	
Age (SD)		40.36 ± 17.48	51.48 ± 12.69	51.64 ± 11.17	0.003
Sex	Males	2 (5.71 %)	1 (3.03 %)	–	0.4
	Females	33 (94.28 %)	32 (96.96 %)	23 (100 %)	
CL (SD)		13.85 ± 1.56	13.88 ± 1.69	14.75 ± 1.44	0.1
NL (SD)		6.25 ± 1.59	5.09 ± 1.23	5.35 ± 1.46	0.005
CL/NL (SD)		2.32 ± 0.51	2.86 ± 0.72	2.99 ± 0.96	0.002
Type of operation					
TL					
Resected gland volume (SD)		15.07 ± 6.28	19.44 ± 7.68	21.17 ± 14.85	0.1
TLSTL					
Resected gland volume (SD)		25.93 ± 21.92	20.52 ± 7.91	21.29 ± 9.44	0.1
TT					
Resected gland volume (SD)		39.32 ± 13.95	30.87 ± 13.93	44.86 ± 22.86	0.3

TL total lobectomy, *TLSTL* total lobectomy with subtotal contralateral lobectomy, *TT* total thyroidectomy, *SD* standard deviation

The volume of the resected gland was correlated with the BMI groups. There were no significant differences. Therefore, the three groups were comparable in this respect.

In what concerns the type of surgery, total lobectomy (TL) was performed in 50 patients (54.94 %), total thyroidectomy (TT) in 22 patients (24.17 %), and total lobectomy with contralateral subtotal lobectomy (TLSTL) in 19 patients (20.87 %).

The influence of BMI on operative time

Robotic-assisted surgery comprised three operative time indicators: dissection or access time; namely, the dissection time necessary from skin incision to the thyroid lodge and mounting of the autostatic retractor, robot docking time; and console time; i.e., the effective time for the robotic removal of the thyroid.

As we gained more experience, the duration of the entire RATS intervention was reduced. After the first 30 robot-assisted interventions, there was a clear decrease in the total duration of robot-assisted procedures ($p = 0.02$).

We investigated the influence that BMI distribution had on surgery duration and on each operative time for all procedures and for each type of surgery separately (Table 2). Due to the small sample size for each type of surgery established based on the BMI, there was an increase in statistical significance when adding up all the interventions, therefore achieving the threshold for statistical significance. Thus, RATS lasted more in obese and overweight patients ($p < 0.001$) as a result of a significant increase in access time ($p < 0.001$) and console time ($p = 0.002$).

We studied the possible association between the incidence of postoperative complications, patient BMI, and the type of surgery (Table 3). There were three cases (3.29 %) who required a switch to classical surgery due to hemorrhage. Five patients (5.49 %) developed postoperative transient hypocalcemia. These patients required 1 to 3 days of intravenous treatment with calcium gluconate, followed by 7 to 21 days of oral administration of calcium supplements and vitamin D. Outpatient follow-up was performed by the endocrinologist. Two patients (2.19 %) suffered from temporary postoperative vocal cord paresis, with remission under treatment with nonsteroidal anti-inflammatory drugs after 14 and 28 days.

The occurrence of these complications together with local complications related to the surgical wound or the intraoperative position of the upper limb on the side of the incision were not influenced by the presence of obesity or overweight ($p > 0.4$).

The amount of discharge drained after surgery depended on the BMI. Overweight or obese patients showed a greater volume of fluid ($p = 0.03$), but there was no impact on the number of days required to maintain surgical drains ($p = 0.07$).

Thyroid access involved the dissection of the fascial layer of the pectoralis major muscle up to the level of the sternal insertion of the sternocleidomastoid muscle. We approached the thyroid between the sternal and clavicular heads of the sternocleidomastoid muscle, beneath the subhyoid muscles up to the thyroid capsule. There were no injuries or ischemic lesions of the dissected musculocutaneous flap.

There was no statistically significant association between the occurrence of cervical or subclavian skin sensory disorders 3 months after surgery and the patient's BMI (Table 3).

Table 2 Correlation between the surgical times in the BMI groups depending on the type of surgery

	BMI <25	25 < BMI < 30	BMI >30	*p*
All interventions	35	33	23	
Total duration of intervention	138 ± 26.86	164.26 ± 48.6	185.29 ± 41.21	<0.001
Dissection/access time	62.42 ± 11.09	69.35 ± 21.32	83.1 ± 16.99	<0.001
Robot docking time	8.48 ± 2.08	9.19 ± 3.51	9.71 ± 2.41	0.2
Console time	58.06 ± 20,31	75.65 ± 31.45	86.67 ± 31.63	0.002
TL *n* = 50				
Total duration of the intervention	131 ± 21.3	153.72 ± 53.79	153 ± 39.39	0.1
Dissection/access time	62.17 ± 11.56	71.11 ± 24.28	80 ± 20.61	0.05
Robot docking time	8.22 ± 2.06	9.44 ± 3.98	10.14 ± 2.67	0.2
Console time	50.87 ± 12.67	63.61 ± 30.13	59.29 ± 23.35	0.1
TLSTL *n* = 19				
Total duration of the intervention	152.5 ± 39.47	174 ± 49.8	190.71 ± 27.75	0.3
Dissection/access time	62.5 ± 6.45	65 ± 16.20	85.71 ± 14.26	0.02
Robot docking time	9.25 ± 2.63	9.60 ± 3.36	10.86 ± 1.86	0.5
Console time	83.75 ± 31.45	96 ± 32.86	90.71 ± 20.08	0.8
TT *n* = 22				
Total duration of the intervention	163.75 ± 28.1	181.88 ± 31.16	212.14 ± 35.33	0.06
Dissection/access time	63.75 ± 14.36	68.13 ± 18.50	83.57 ± 17.72	0.04
Robot docking time	9.25 ± 1.7	8.38 ± 2.61	8.14 ± 2.03	0.7
Console time	73.75 ± 18.87	90 ± 22.67	110 ± 29.29	0.08

Table 3 Correlation between the incidence of complications and postoperative evolution by BMI groups

	BMI < 25	25 < BMI < 30	BMI ≥ 30	*p*
Severe complications				
Intraoperative hemorrhage–conversion to open surgery	2 (5.71 %)	–	1 (4.5 %)	0.4
Minor complications				
Temporary vocal cords paresis	1 (2.85 %)	1 (3.03 %)	–	0.7
Transient hypocalcemia	2 (5.71 %)	3 (9.09 %)	–	0.3
Seroma	2 (5.71 %)	1 (3.03 %)	–	0.4
Hematoma	–	1 (3.03 %)	–	0.7
Wound suppuration	–	1 (3.03 %)	–	0.7
Brachial plexus neuropraxia	1 (2.85 %)	–	–	0.7
Total volume of drainage (ml)	116.27 ± 65.85	137.29 ± 70.4	165.68 ± 79.16	0.03
Number of drainage days	2.61 ± 0.99	2.71 ± 1.07	3.23 ± 0.86	0.07
Cervical skin sensitivity disorders				
Absent	28 (80 %)	28 (84.84 %)	16 (69.56 %)	0.7
Very low	3 (8.57 %)	2 (6.06 %)	3 (13.04 %)	
Average	2 (5.71 %)	2 (6.06 %)	4(17.39 %)	
Severe	2 (5.71 %)	1 (3.03 %)	0	
Very severe	0	0	0	
Subclavian skin sensitivity disorders				
Absent	25 (71.42 %)	17 (51.51 %)	13 (56.52 %)	0.3
Very low	4 (11.42 %)	7 (21.21 %)	7 (30.43 %)	
Average	4 (11.42 %)	5 (15.15 %)	3 (13.04 %)	
Severe	2 (5.71 %)	2 (6.06 %)	0	
Very severe	0	2 (6.06 %)	0	

The impact of anthropometric parameters on surgical outcomes

There were correlations between certain anthropometric data and certain operative times (Table 4). There was a significant direct correlation between access time and CL ($p = 0.005$) and between the total duration of the surgery and CL/NL ratio ($p = 0.04$). There was a significant negative correlation between console time and NL ($p = 0.04$). NL was also negatively correlated with the amount of surgical drains and the number of days required for the maintenance of surgical drains.

There was no correlation between anthropometric parameters and the occurrence of complications.

All these correlations were still present when considering the patient's BMI (partial correlation, $p < 0.05$).

No correlation was found between the intensity of cervical and subclavian skin sensory disorders and CL, NL, or the CL/NL ratio ($p > 0.4$).

Discussions

RATS is a new type of surgery. The current global experience in using this technique is extremely poor, except for surgery centers in South Korea [3, 15–18].

Overweight and obesity were important parameters in the group of patients undergoing RATS. The BMI was not an exclusion criterion for RATS. Thus, almost two thirds (61.53 %) of the patients in the study group were overweight or obese. Specific characteristics regarding the presence of obesity in such patients were also shown in studies on cases from South Korea, where this comorbidity is less frequent than in Caucasians [13].

Therefore, we tried to study the impact of obesity on RATS in our study.

Overweight and obesity had an obvious impact on the entire duration of all types of surgery performed and included in our study. Procedures performed in these patients lasted longer than in patients with normal weight, resulting in a highly significant difference ($p < 0.001$). The duration of each stage of the surgery was similarly influenced, except for docking time.

Thyroid access was more difficult in obese patients. In addition to dissection flap tension until reaching the thyroid lodge and inserting the autostatic retractor, there were difficulties in finding and recognizing different anatomical features, such as the small supraclavian fossa or the sternal insertion of the sternocleidomastoid muscle. Other hindrances were related to the dissection and creation of the space between the internal jugular vein and the outer margin of the subhyoid muscles, the need to section the omohyoid muscle, sometimes in order to have proper access to the upper pole of the thyroid gland, and the proper dissection of the tracheoesophageal groove.

Unlike the results published by Lee in his similar study carried out on 352 Korean patients who underwent RATS, the total console time for all procedures in our study was influenced by the presence of obesity ($p = 0.002$) [12]. When analyzing the console time for each type of surgery separately (TL, TLSTL, TT), there were no significant differences in relation to the BMI groups, probably because of the small number of patients for each type of surgery (Table 2).

Kandil reported similar results after 100 interventions using RATS performed on North American patients. The increase in the total duration of the surgery in patients with a BMI >30 kg/m^2 was caused by both a longer access time and an increase in console time [19].

Table 4 Correlation between CL, NL, the ratio CL/NL and the surgery times, the incidence of complications, the drainage volume, and the number of hospitalization days

	CL		NL		CL/NL	
	r	*p*	*r*	*p*	*r*	*p*
Total duration of the intervention	0.187	0.09	−0.149	0.1	0.203	0.04
Dissection/access time	0.301	0.005	0.007	0.9	0.135	0.2
Robot docking time	0.090	0.4	−0.002	0.9	0.04	0.6
Console time	0.112	0.3	−0.225	0.04	0.236	0.33
Total drainage volume	0.036	0.7	−0.248	0.03	0.240	0.02
Number of drainage days	−0.006	0.9	−0.224	0.03	0.195	0.05
Postoperative complications						
Total number of complications	−0.017	0.8	−0.036	0.7	0.001	0.9
Temporary vocal cords paresis	0.143	0.2	−0.81	0.4	0.124	0.2
Temporary hypercalcemia	−0.050	0.6	0.06	0.5	−0.115	0.3
Seroma	−0.053	0.6	−0.077	0.4	0.056	0.6
Hematoma	0.135	0.8	0.215	0.9	0.115	0.9
Wound suppuration	0.125	0.9	0.124	0.7	0.134	0.7

r Spearman's rank correlation coefficient

In what concerns postoperative complications, there were no significant differences between BMI groups, and the procedure was considered equally safe irrespective of the presence or absence of obesity. Moreover, two of the total five cases of transient hypocalcemia occurred in normal weight patients. There were three patients with intraoperative bleeding and we had to switch to an open surgery. This was caused by the fragmentation of the thyroid parenchyma when gripped or, in one case, by tangent lesion of the jugular vein [20]. Two of these three cases of hemorrhage were in patients with normal body weight.

Patients with a BMI >25 kg/m^2 required several days of surgical drains and the average amount of serosanguinous discharge was higher than in normal weight patients because of the more difficult dissection and more abundant subcutaneous tissue.

Apart from BMI, we also studied possible correlations with other anthropometric parameters. Thus, although the average duration of all robotic procedures was not significantly affected, a direct correlation was found between access time and CL, a longer clavicle actually means a longer distance between the armpit and the thyroid lodge.

The actual duration of robot-assisted gland removal was longer in patients with short neck. The explanation was simple and obvious from the very first RATS procedures. The subhyoid muscles are shorter and the space obtained after being retracted was significantly reduced. The dissection and approach of the various anatomical structures was difficult in patients with small NL. The access to the upper and lower vascular pedicles was more difficult, the lower pole being often located against the clavicle or slightly plunging in the retroclavicular region, therefore hindering the approach of the blood vessels at this level [14].

The total volume of postoperative drainage and the number of days of postoperative drainage were inversely correlated with NL. This result could be explained by a more difficult dissection and by access difficulties with regard to the sealing and sectioning of the blood vessels. However, there was a direct correlation between the CL/NL ratio and the volume of drainage and the number of days of drainage, respectively.

A statistically significant direct correlation was found between the CL/NL ratio and the total duration of the procedure. RATS took longer in patients with broader shoulder girdle and shorter neck. Postoperative complications were not influenced by the two parameters studied or by their ratio, and surgery was safe regardless of the breadth of the shoulder girdle or of the length of the neck [12].

Maintaining the operating space in the thyroid lodge by suspending the musculocutaneous flaps that are anterior to the gland on the autostatic retractor required a higher tension in obese patients.

On the other hand, the prepectoral fascia flap up to the sternoclavicular joint implies a higher theoretical risk of direct or ischemic suprajacent skin lesion in patients with low BMI, where the subcutaneous tissue is less thick. However, there were no significant differences regarding anterior cervical or subclavian postoperative cutaneous sensory disorders between normal weight, overweight, or obese patients [21].

Moreover, CL had no influence on the occurrence of postoperative complications, even if in patients with larger CL, the distance between the armpit and the small supraclavicular fossa was greater and the prepectoral dissection site was wider.

The limitations of the study consisted of the relatively small number of TT or TLSTL procedures. Thus, their distribution into BMI groups was not homogeneous, which could have influenced the statistical analysis of a type of surgery considered separately.

Another limitation was the fact that the group was not homogeneous in terms of gender; the entire group were including only three men. Features referring to tissue consistency, shoulder girdle width or the more significant muscle development could influence perioperative parameters studied in men.

The unicentric study was based on the robotic experience of only one surgical team.

Conclusions

The RATS approach was safe and feasible when performed on a group of selected Caucasian patients. This new technique seems to provide some benefits even for overweight or obese patients. Other anthropometric parameters also influenced the duration and difficulty of the procedure.

RATS is a new type of surgery that benefits from the technical advantages of robot-assisted surgery, but the overall experience when performed on Caucasians is currently still limited.

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Author contribution Study concept and design, data acquisition, data analysis and interpretation, manuscript drafting: D.D. Axente.

Critical revision of the manuscript: N.A. Constantea.

Compliance with ethical standards

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

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its additional amendments or comparable ethical standards.

Ethical standards/informed consent Informed consent was obtained from all patients prior to their inclusion in the study.

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