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PREOPERATIVE CT-BASED PREDICTORS OF MEDIAN STERNOTOMY REQUIREMENT IN RETROSTERNAL GOITER SURGERY: A RETROSPECTIVE COHORT STUDY

Abdul Baseer[1], Nosheen Noor[*2], Shabana Ashiq[3], Anum Dilawar[4]

[1]*Associate Professor, FCPS Thoracic Surgery, Thoracic Surgery Department, LRH-MTI, Peshawar*
[*2]*Assistant Professor, FCPS Radiology, Lady Reading Hospital, Medical Teaching Institute, Peshawar*
[3,4]*MBBS, Resident FCPS-2, Lady Reading Hospital, Medical Teaching Institute, Peshawar*

[1]drabdulbaseer@hotmail.com, [*2]noshyyn@gmail.com , [3]sashiq8899@gmail.com, [4]danumdilawar@gmail.com

[1]ORCID: 0009-0008-2865-0853, [*2]ORCID: 0000-0002-0992-7887

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Corresponding Author: *
Nosheen Noor

Abstract

Background: *Retrosternal goiter (RSG) is a clinically important entity which may be encountered in 3-20% of thyroidectomy procedures, of which 5-15% require median sternotomy for safe resection. Unanticipated sternotomy may be associated with an increased operative time, blood loss and postoperative morbidity. Preoperative contrast-enhanced computed tomography (CECT) is an important tool for anatomical information but does not have any definitive criteria defined for prediction of sternotomy need from a CT point of view.*

Objectives: *To evaluate the association between preoperative CT findings and the requirement for sternotomy in patients undergoing surgery for retrosternal goiter.*

Methods: *This was a retrospective cohort study of 62 patients with retrosternal goiter (RSG), who were subjected to thyroidectomy from 2022-2024, at the Lady reading Hospital Peshawar,Pakistan. CECT images were reviewed for tracheal deviation/compression, vascular involvement and extension into the mediastinal spaces. Independent sternotomy predictors were determined using binary logistic regression.*

Results: *Of the 62 patients, 54 (87.1%) were managed through a cervical approach, while 8 (12.9%) required sternotomy. There was no statistically significant difference between tracheal deviation/compression or vascular involvement and sternotomy requirement (p=0.141 and p=0.258, respectively). Groups were comparable with regard to demographic characteristics.*

Conclusion: *In this regional cohort, common CT findings like compression of the trachea and vascular involvement were not individually associated with sternotomy. This provides an insight into the need for extensible, multiparametric, CT scoring system validated in resource-limited environments.*

INTRODUCTION

The subclinical mediastinal extension of the thyroid disease inferiorly through thoracic outlet is termed retrosternal goiter (RSG) and is a clinically and surgically important subset of thyroid disease. Historically included in the first

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description by Albrecht von Haller in 1749, the definition of RSG has varied somewhat over the years defined as, a goiter falling below the plane of the thoracic inlet or a goiter of over 50% of the mass below the sternal notch. Its incidence in general surgical thyroid series ranges from 3% to 20%, depending on the definition used in various centers.[1,2,3]

RSG represents a significant surgical challenge. While most of them can be resected via a regular cervical collar incision, about 5 to 15% of patients will need to have surgery extended to the partially- or totally- median sternotomy or thoracotomy, respectively.[4] Operative time, blood loss, complications, as well as hospital stay, are significantly longer for patients who require sternotomy.[5] Such a procedure places extra stress on logistical and psychological services for both the patient and the surgical team.

Modern computed tomography (CT) scans of the neck and thorax (CECT) yield detailed anatomical information regarding the local extent of the goiter, its proximity to mediastinal vascular structures and the extent of tracheal compression. Multiple CT parameters have been suggested to predict the need for sternotomy: extension of the goiter into the posterior mediastinum, involvement of the posterior mediastinum, total goiter volume, and craniocaudal length of intrathoracic extension.[6,7]

A recent systematic review and meta-analysis, published in 2025 and encompassing 46 studies, identified goiter extension below the aortic arch (RR: 5.36, $p<0.00001$), posterior mediastinal extension (RR: 9.33, $p<0.00001$), and extension below the carina (RR: 8.08, $p=0.005$) as the strongest CT-based predictors of sternotomy.[8] Although there is an increasing amount of evidence to aid in CT-based preoperative risk stratification for RSG surgery, there is no standardized, commonly accepted CT scoring system. The discrepancies in healthcare settings are particularly acute in countries of the South Asian region where large volume goiters with prolonged duration of symptoms are common.[9,10]

Lady Reading Hospital (LRH) in Peshawar, Pakistan, is a major tertiary referral center for a large population from Khyber Pakhtunkhwa Province and adjoining tribal areas that have been recognized as a high goiter endemic region. The Thoracic Surgery (TS) Unit at LRH treats a significant and growing number of patients with RSG and the majority of these are present late when the disease is more advanced and confined to the mediastinum. This is an institutional environment, which can be used to reveal an under represented perspective on CT-surgical correlations in the management of RSG.

The aim of the current study was to identify specific CECT findings that may predict the need for median sternotomy in RSG surgery, with particular emphasis on tracheal deviation/compression and vascular involvement, and to describe the distribution of surgical approaches used in our institution.

MATERIALS AND METHODS

Study Design and Setting

This is a retrospective cohort study conducted in the Thoracic Surgery Unit, LRH, Peshawar, Pakistan, as it is a tertiary care referral hospital providing tertiary care in our local region of Khyber Pakhtunkhwa and adjoining areas. The study comprised patients with a diagnosis of retrosternal goiter with surgical treatment between January 2022 and December 2024. This study was carried out after obtaining ethical clearance from the Institutional Review Board (IRB) of Medical Teaching Institution (MTI), Lady Reading Hospital.

Study Population

The study consisted of adult patients (age ≥18 years) with radiologically confirmed goiter in the retrosternal space. On preoperative contrast-enhanced computed tomography (CECT), retrosternal goiters were diagnosed if the thyroid had extended below the thoracic inlet into the mediastinum.

Inclusion Criteria

Patients were included if they:

- Were aged 18 years or older.
- Had goiters with retrosternal extension found on CECT preoperatively.

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- Surgical management of the condition conducted during the study period.
- Available complete data on demographics, radiological and surgical approach.

Exclusion Criteria

Patients were not included if they:

- Had recurrent retrosternal goiter.
- Any ectopic mediastinal thyroid tissue, without a cervical-thyroid connection.
- Did not have complete clinical and/or radiological information.

Sampling Technique and Sample Size

Consecutive sampling technique was employed, which is a non-probability sampling. All patients meeting the inclusion criteria within the study period, were included. A total of 62 patients were analyzed.

Data Collection

Patient data were collected using structured data collection forms from patients medical records, operative records and radiology reports in a retrospective manner. Demographic variables included age (years) and gender. Preoperatove radiological assessment included contrast enhanced CT Neck and Chest reviewd by consultant radiologist. The following radiologic features were recorded such as presence of retrosternal extension, deviation and/or compression of the airway through the trachea and vascular involvement. The main outcome variable was the surgical technique used for goiter removal i.e. cervical approach or sternotomy (partial, median, extended or midline). For regression analysis, patients were grouped into cervical approach and sternotomy required.

Statistical Analysis

The collected data was entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Data for continuous variables were reported as mean ± SD, and frequencies and percentages were used for categorical variables. Values of continuous variables were compared between the two groups (cervical and sternotomy) with the independent samples t-test and values of categorical variables were compared with Fisher's exact test. Binary logistic regression analysis was conducted to examine the relationship between CT findings and need for sternotomy. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined. P-value < 0.05 was set as statistically significant.

Ethical Considerations

All information collected was anonymized prior to analysis and no personal identifiers were documented. Ethical approval was granted by the Institutional Review Board (IRB) of MTI – Lady Reading Hospital before the beginning of the study.

RESULTS

A total of 62 patients who had a confirmed diagnosis of RSG and were surgically treated were included in this study as shown in table 1. Most of the participants were female (50/62, 80.6%) as expected, since goiter is a disease prevalent in females. The mean age was comparable between the cervical and sternotomy groups (51.8 ± 13.1 vs. 51.0 ± 13.6 years; p=0.880). Due to the anatomical selection criterion for study inclusion, retrosternal extension was indicated in 50 (92.6%) of cervical cases and 8 (100%) with sternotomy (p=1.000).

Table 1

Baseline Demographic and Clinical Characteristics of the Study Population (n=62)

Variable	Cervical (n=54)	Sternotomy (n=8)	p-value
Age (years), mean ± SD	51.8 ± 13.1	51.0 ± 13.6	0.880
Female sex, n (%)	43 (79.6%)	7 (87.5%)	1.000
Male sex, n (%)	11 (20.4%)	1 (12.5%)	
Retrosternal extension, n (%)	50 (92.6%)	8 (100%)	1.000

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† Independent samples t-test for continuous variables; Fisher's exact test for categorical variables. p<0.05 considered significant.

A description of the distribution of surgical approaches is provided in Table 2. The cervical approach was used in 54 patients (87.1%) which included 41 total thyroidectomies, 13 subtotal thyroidectomy . 8 patients (12.9%) required sternotomy: 6 had median sternotomy, 1 had partial sternotomy. In one patient (1.6%), thoracotomy with right posterolateral dissection was required due to anomalous posterior mediastinal positioning.

Table 2.
Distribution of Surgical Approaches in Retrosternal Goiter Patients (n = 62)

Surgical Approach	N	Percentage (%)
Cervical Approach (Total)	**54**	**87.1%**
Total Thyroidectomy	41	66.1%
Sub-total Thyroidectomy	13	21.0%
Sternotomy (Total)	**8**	**12.9%**
Median Sternotomy	6	9.7%
Partial Sternotomy	1	1.6%
Thoracotomy	1	1.6%

Percentages are calculated using the total study population (n = 62).

In this cohort, tracheal deviation or compression was found in a higher proportion of the cervical group (30/54, 55.6%) than the sternotomy group (2/8, 25.0%), with an odds ratio of 0.27 (95% CI: 0.05–1.44; p=0.141). This inverse relationship that the sternotomy group paradoxically had less tracheal involvement was not statistically significant but is interesting and warrants exploration in larger groups. In 19 (35.2%) of the 54 patients who underwent a cervical approach, and 1 (12.5%) of the 8 patients who underwent sternotomy, vascular involvement was identified, with an OR of 0.26 (95% CI: 0.03–2.30; p=0.258). Tracheal deviation/compression and vascular involvement were not statistically significant predictors of sternotomy.

Table 3
Association of CT Features with Sternotomy Requirement (n=62)

CT Feature	Category	Cervical (n = 54) n (%)	Sternotomy (n = 8) n (%)	OR (95% CI)	p-value
Tracheal deviation/compression	Yes	30 (55.6%)	2 (25.0%)	0.27 (0.05–1.44)	0.141
	No	24 (44.4%)	6 (75.0%)		
Vascular involvement	Yes	19 (35.2%)	1 (12.5%)	0.26 (0.03–2.30)	0.258
	No	35 (64.8%)	7 (87.5%)		

** Fisher's exact test. OR = Odds Ratio; 95% CI = 95% Confidence Interval. Reference: Cervical approach. p<0.05 considered significant.*

Data for binary logistic regression, using the dependent variable sternotomy requirement and independent variables CT features (Table 4) were derived and analyzed. Tracheal deviation/compression (p=0.141, 95% CI; 0.05–1.44) and vascular involvement (p=0.258 95% CI; 0.03–2.30) were not shown to be statistically significant independent predictors. The number

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of participants in sternotomy group (n=8) is relatively small, thus reducing the power in regression modelling.

Table 4.

Binary Logistic Regression Analysis for Predictors of Sternotomy Requirement (n = 62)

Variable	B	S.E.	Wald	p-value	Adjusted OR	95% CI
Tracheal deviation/compression	-1.31	0.89	2.16	0.141	0.27	0.05–1.44
Vascular involvement	-1.35	1.08	1.28	0.258	0.26	0.03–2.30

Dependent variable: Sternotomy requirement (Yes/No). Reference category: Cervical approach. Model type: Binary logistic regression. $p < 0.05$ considered significant.

DISCUSSION

In this study, we examined the clinical and surgical outcomes of patients with RSG from a large thoracic surgery centre in Peshawar. A 12.9% (8/62 patients) sternotomy rate falls within the upper limit of the range of frequently reported in the literature (5-15%) and corresponds with the referral pattern, which included patients with large long-standing goiters at LRH. This is further supported by previous literature which suggested that pooled rates of sternotomy/extracervical access would be around 6–10% depending on the RSG definitions used.[11,14]

One of the interesting and somewhat paradoxical results of this study was that there were no statistically significant associations between tracheal deviation/compression, vascular involvement and sternotomy. Indeed, both of the aforementioned CT features were more common in the cervical approach group compared to the sternotomy group, a pattern that supports discussion. Though this institutional setting may have influenced the decision to use sternotomy, it might also have been impacted by other factors not recorded in the two CT variables analyzed here, such as the craniocaudal extent of mediastinal extension, the degree of posterior mediastinal involvement, and limited mobility of goiter during attempted transcervical delivery - could have influenced these decisions.[16,22]

This interpretation is supported by existing literature. A study conducted in Pakistan that concluded extension below the aortic arch and posterior mediastinal extension were more consistent and stronger predictors of sternotomy than was tracheal compression alone–the latter is a more common problem with large cervical and proximal retrosternal goiters and may be safely treated via the cervical approach, especially in experienced, trained thoracic surgeons with adequate intraoperative airway management.[8,15]

A study published from Northwest General Hospital, Peshawar a geographically and demographically similar suitable hospital introduced a new CT-based classification system that allowed for RSG management, this clarifying that CT parameters have the potential to be systematically employed for surgical approach stratification. After studying 511 thyroid surgeries, they came up with 68 cases of "retrosternal extension" of the thyroid (RSG), reinforcing the high regional prevalence of RSG in KP and validating the institutional experience at LRH as representative of the broader regional epidemiology.[10,17]

This study showed an overall predominance of females (80.6%) which is in line to the well documented of females in countries across the globe, and a mean age of around 51 years, which is consistent with that of RSG in other cohorts in South Asian and Middle Eastern countries. A retrospective study in Yemen regarding 69 cases of RSG for a period of 2024, reported a mean age of 51.0±13.6 years with 65.2% females, which was very similar to ours.[12,18]

There is a good overall correlation between the tracheal compression in the cervical group and with the already published literature. In 2024, researchers studied 32 patients with RSG and found that 43.8% had compression of the trachea

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and 62.5% had deviation of the trachea. Specifically, that study mentioned the relationship between involvement of the trachea and difficult intubation and the complications after the procedure; such as tracheomalacia which was also an anesthetic and perioperative concern when present in a CT scan but not a direct predictor for sternotomy.[13,19]

The variety of sternotomy types recorded (median, partial) in 8 cases is indicative of personalised decision-making according to anatomy of experienced thoracic units for surgery conducted by experienced teams using RSG.[19,20,23] The single thoracotomy case the right posterior one is a reminder of the rare but noteworthy presentation of primary posterior mediastinal goiters, which can be quite distinct in terms of their intrathoracic blood supply and therefore will need a thoracic operative corridor.[21,22]

CONCLUSIONS

The preoperative CT findings regarding tracheal deviation or compression and vascular involvement were not statistically significant with sternotomy requirement and failed to become independent predictors in logistic regression analyses. Therefore, it could be assumed that some other anatomical factors might have greater significance in predicting sternotomy needs in these cases. Larger prospective studies incorporating comprehensive CT-based parameters are required to develop reliable predictive models for preoperative surgical planning.

LIMITATIONS AND RECOMMENDATIONS

Several significant limitations can be discussed with this study. Firstly, due to the relatively small numbers within certain subgroups of the cross-sectional analysis (particularly the sternotomy group of just 8 patients) and the retrospective design, this study lacks sufficient levels of statistical power for the conclusions reached and holds questionable reliability when using multivariate analysis. Second, there was a limitation related to the different CT variables included in the analysis (tracheal compression and vascular involvement); indeed, other predictors, as could be craniocaudal extent below the aortic arch, the total volume of thyroid gland, or the mobility of the goiter, were not systematically included because of poor availability of data in this retrospective cohort. Thirdly, unlike the absence of any standard measurement by the study radiologists, CT imaging was assessed for variables reported from other publications. Finally, single-center design was performed in a high-volume tertiary referral center that may not be representative in smaller centres. One limitation of the present study was the exclusion of the size of retrotracheal extension from the analysis. This parameter could not be assessed reliably because nearly half of the patients had undergone imaging at external institutions, and only hard-copy films were available for review. The lack of digital imaging prevented accurate and standardized measurement of retrotracheal extension. Future studies incorporating complete digital imaging data will include this variable to better evaluate its clinical significance and potential association with study outcomes.

More future prospective studies in LRH and other regional centers with comprehensive CT measures such as CT volumetric analysis, aortic arch extension and goiter mobility scoring is required to create predictive model applicable to the patient population from South Asian RSGs. This information would allow surgeons to be better prepared for an operation, better counsel patients and minimize intra-operative complications arising from such unforeseen sternotomy.

AUTHORS CONTRIBUTION

1. AB; Conceived and designed the study, supervised data collection, drafted the manuscript, and performed critical analysis and review of the final manuscript.

2. NN; Contributed to manuscript writing, data collection, results compilation, and discussion writing.

3. SA; Participated in data collection and data management.

4. AD; Participated in data collection and data management.

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