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Validating CT characteristics of the thymus in healthy Indian adult population

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ABSTRACT

Aim: The research aimed to appraise the properties of healthy thymus in Indian adult population on computed tomography. *Background:* On cross sectional imaging assessments of the chest, the thymus is frequently spotted in a variety of appearances aging in a dynamic way. Although the structure and composition of the healthy thymus on CT varies from person to person, with absence of systematic documentation defining properties of the healthy thymus in the Indian adult population in the event of diseases, knowing the imaging properties of the normal thymus will aid precise radio graphic diagnosis. When in doubt, this will prevent unneeded imaging and action. *Material & Methods:* Review of Computed tomography of 154 adults aged 20–60 years was carried out. For 46 individuals with some solid tissue intact, the density, volume, form and preferred aspect of the thymus were measured and statistically analyzed based on the patient's age and gender. *Results:* The density and volume of the thymus diminished as the patient grew older. In our selection of sample group of individuals above the age of 54, there was absence of any solid element in thymus. The thymus in the proportion of patients had an arrowhead form with a midway location. However, there was a lot of variation in thymic form and boundary. The link between density and age of the patient was significantly substantial (p 0.0001). *Conclusion:* Strong association between age and thymic density was seen along with age and capacity. No relation was observed between volume and density with gender.

Keywords: Computed tomography, Indian population, thymus and mediastinum.

1. INTRODUCTION

The thymus continues to be an "organ of mystery" throughout medicine's 2000-year history (Nishino et al., 2006). The thymus achieves its greatest weight around adolescence and then undergoes involution, thus it's not a particularly noticeable structure in imaging examinations of healthy people. However, once the thymus is involved in pathology it exhibits a wide range of symptoms necessitating a thorough study of each entity (Simanovsky et al., 2012). Furthermore, radiologists should be aware with and comprehend the latest WHO classification for epithelial cancers of thymus based on histology,

including clinical pathologic, radiologic and prognostic characteristics (Nishino et al., 2017).

Individuals' thymuses differ in various dimensions. With age, it undergoes intricateness and is replaced with adipose tissue (Ge and Zhao, 2013; Jacobs et al., 1999). Gland diminishes in size after extremes of morbidity, with a return in dimensions after the stimulant has been eliminated. The radiologist analysing chest CT scans may be perplexed by the variety in the normal advents of the thymus (Jacobs et al., 1999; Goldstein et al., 2015).

Anatomy and Development of the Thymus

T-lymphocyte maturation takes place mostly in the thymus. During the sixth week of pregnancy, it emerges via the 3rd-4th pharyngeal pouches, together with the parathyroid glands (Jacobs et al., 1999; Baron et al., 1982). Migration of these cells takes place inferomedially through the thymo pharyngeal duct (extending far down to the sternocleido mastoid muscle) to the mediastinum anteriorly over the following few weeks. Lymphocytes from the liver and marrow of bone then travel to the thymus, where they develop into a cortex and medulla. Thymic lesions and ectopic thymic tissue can arise at multiple places alongside the thymo pharyngeal duct (Nishino et al., 2017). The healthy thymus is found in the mediastinum anteriorly; nevertheless, also spotted everywhere from the thyroid to the diaphragm (Leonidas et al., 1998). The thymus is normally bilobed and formed like an arrow head or quadrilateral however it can also be shaped differently, with slightly bulging or concave outlines (Nasseri and Eftekhari, 2010). The thymus might resemble big lesion in the mediastinum in neonates. It primarily exhibits soft tissue attenuation during early years of life and with age, it shows intricacies in the form of fibrous and adipose replacement. This fat replacement is thought to happen quickly in young adult males than in females (Nishino et al., 2006).

The thymus is divided as several lobules that are structured into a peripheral cortex and central medulla on histologic inspection. T cell lymphocytes of immature type and epithelial cells of thymus make up outer cortex, while mature lymphocytes and epithelial cells of spindle shape arranged in whorls make up the medulla, resulting in Hassall corpuscles with keratinized cores (Leonidas et al., 1998; Taub and Longo, 2005). Because the thymus varies in shape and size, radiologists should be conversant with a wide range of radiological findings of the normal thymus to reduce the number of invasive operations (Moore et al., 1983). The thymus appears large on chest Xrays in AP projection in new born and toddlers, although it becomes grueling to differentiate from the heart shadow (Lele et al., 2001). The thymus has clean boundaries and can be seen on Xrays till upto three years (Nasseri and Eftekhari, 2010).

In many circumstances, determining whether an adult's anterior mediastinal soft tissue density indicates healthy thymus, abnormalities of thymus or a SOL might be challenging (Jacobs et al., 1999). We have occasionally lacked the diagnostic confidence to label a thymus typical for age. As a result, patients frequently end up undergoing radiological investigations and even interventions to rule out any abnormality (Nasseri and Eftekhari, 2010). The way in which normal thymus appears on CT has been appraised in previous studies; in spite of which, latest ventures to describe the properties of thymus on computed tomography, particularly in the Indian population, date from few tens to hundred years back from previous generation of machines (Moore et al., 1983). Due to thin, multi planar and continuous acquisitions and the ability to quantify in three dimensions, CT scanners can now show the thymus in greater detail.

Using contemporary CT techniques, we should be familiar with the vast range of normal thymus appearance. In order to avoid unnecessary scans and procedures, this is critical. The goal of this research was to look at the characteristics of normal thymus in a huge sample in Indians thus providing radiologists tools to tell the difference between a normal thymus and an aberrant mediastinal mass, most usually anterior.

Aims and Objectives

To characterize the thymus gland on CT in a large group of Indian population

To avoid unnecessary interventions in instances of dilemma

2. MATERIAL AND METHODS

Methods of Measurement

Imaging Protocol

We examined the Computed Tomography scans of Thorax of patients in our institute between January and April 2021, in this retrospective analysis. Our local institutional review board accepted the research protocol and informed consent was not required.

Study Instrument/Data Collection Tools

All chest CT scans were done on 16 slice TOSHIBA CT scanner.

Sample Size

As per study done by (Simanovsky et al., 2012), sample size for this study will be taken as 154, calculated using software epi info version 7

Selection Criteria

Exclusion criteria

Patient who underwent sternotomy (including all the indications) if there is any previous history of an oncological condition or lung lesions which require follow up in the present scan. In the setting of severe trauma that infiltrates the lungs, resulting in a mediastinal hematoma. Patients with air within mediastinum, pressure pneumothorax also, inability to clearly visualize the region of regard due to any issues of technicality, such as artefact was eliminated.

Inclusion criteria

We included 154 patients who were healthy and matched all our criteria. These included 89 men and 65 women ranging from the age of 20- to 60-year-old.

3. OBSERVATION AND RESULTS

Since the eldest patient having thymus residual soft tissue was 53 years of age, data on density and volume were obtained from people aged 20 to 53. Six individuals aged 40–53 years old had a residual solid tissue element in the gland, but the gland was quite small in these patients. All four are included in Group 4, with said soft tissue element featuring a scattered reticular pattern and up to 75% fat content. Patients in groups 1, 2, 3 and 4 were between the ages of 20.3 ± 2 and 42.3 ± 8.7 years in group 4 and 53 ± 12 years in group 5 (Table 2, p 0.0001). There was high inter observer agreement when allocating participants to categories based on the amount of fat replenishment with in gland.

Density decreased significantly with patient age in categories 1, 2, 3 and 4 (p = 0.0031). There was a strong link among density and age of the patient throughout the overall research sample (p 0.0001). The relationship across patient age with thymic density is shown in Table 2 and Figure 1 (Relationship between density and age is shown). In this research, fatty tissue had restored 50 percent or more of soft tissue in 90 percent of persons aged 20–60 (1a through 1e are diagrams). The average volume of thymic soft tissue in groups 1–4 was 5.9 ± 4.4 cm3, with values in the range between 7.3 ± 5.3 cm3 in group 1 to 3.0 ± 2.4 cm3 in group 4. Although there was a considerable association between age and volume in the whole research sample, no significant differences were found between groups in this study (Figure 2 Relationship between volume and age is shown, Table 2).

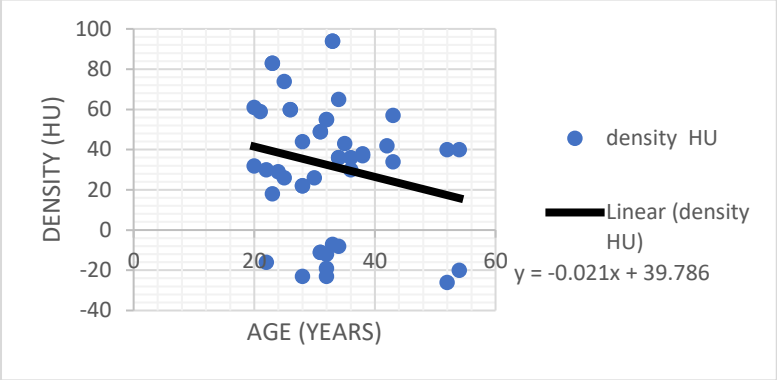
The form of the thymus was difficult to categorize. The glandular organ had a complicated shape in several cases, that can only be defined as arrowhead, bilobal, or spherical in the broadest sense of these terms. The primary configuration of the gland, however, was agreed upon in all cases. (Figures 2 (a-c) Axial CT images at the level of the thymus demonstrating typical shapes of the thymus. 2(a) Arrowhead shape, 2 (b) bilobal and 2(c) rounded shapes). In group 5, side predominance was only noticed in individuals with some solid tissue in the gland because the morphology of the totally fatty thymus was difficult to distinguish from the surrounding mediastinal fat. In 36 of the six cases, the thymus looked like an arrowhead (64.3 percent). In groups 1–4, it was found in the midline in 32 patients (57%) and exhibited left sided prevalence in 21 patients (37%) and right-side prevalence in just three people (6 percent).

(Figures 3 (a-c) - Axial CT images demonstrating side predominance of the thymus (a) Left side predominance, (b) midline position and (c) right side predominance). The pattern of thymic shape side predominance and soft tissue distribution in groups 1–4 is summarized in table. In regression models, there was no association between thymus density or volume and gender, while there was a significant correlation among patient age, density and volume (Graph 1: Relationship between density and age is shown and Graph 2: Relationship between volume and age is shown)

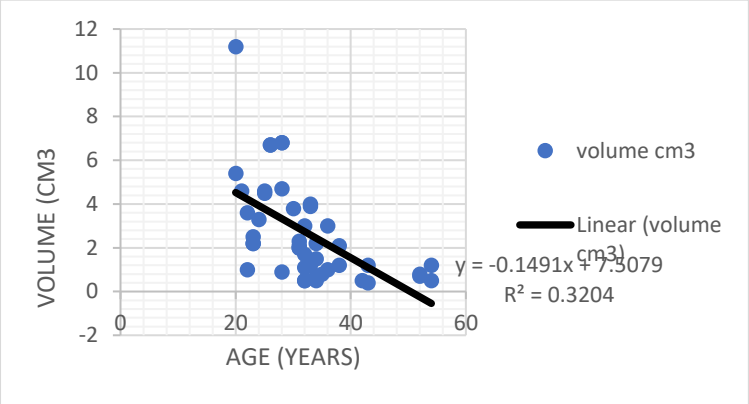
Table 1 Patient information, volume and density of thymus in groups 1-5

Group	1 100%softtissue	2 75%softtissue	3 50%softtissue	4 25%softtissue	5 100%fatreplaced
Total	3	12	8	23	108

Age(years)	24 ± 3.4	27.5± 5.2	28 ± 5.4	37.3 ± 8.6	47.2 ± 11.1
Female (%)	1 (33.3%)	6 (50%)	2 (25%)	18 (79.3%)	35 (32.4%)
Male (%)	2 (66.67%)	6 (50%)	6 (75%)	5 (21.7%)	73 (67.6%)
Density (HU)	60.3± 0.57	55.5± 28.9	33.1±11.2	28.4 ± 27.9	-
Volume (mm^3)	8.2 ± 2.5	4.2 ± 1.5	3.3 ± 2.8	1.1 ± 0.5	-



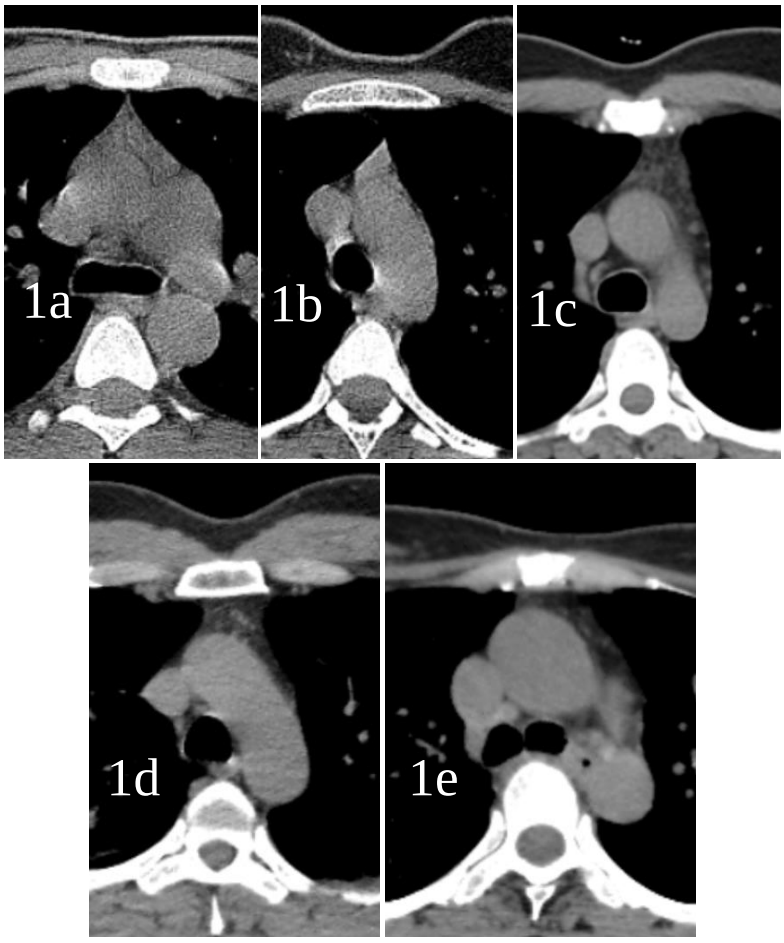
Graph 1 Relationship between density and age is shown



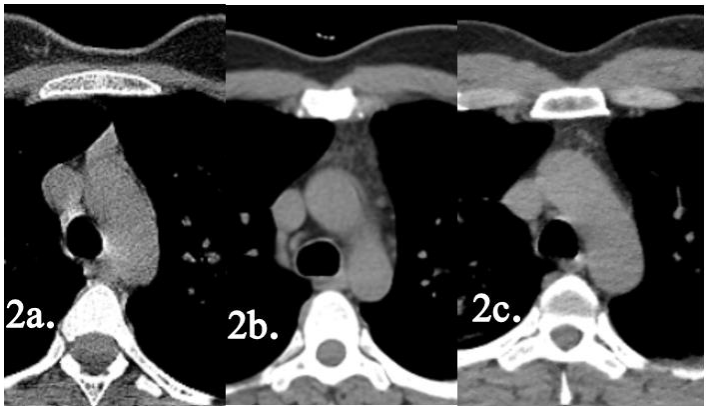
Graph 2 Relationship between volume and age is shown

Table 2 Thymic side predominance and shape in groups 1-4 (Total 46 patients)

Group	1 100%softtissue	2 75%softtissue	3 50%softtissue	4 25%softtissue
Total	3	12	8	23
Side predominance				
Left	0	4 (33.3%)	1 (12.5%)	12 (52.1%)
Middle	3 (100%)	7 (58.3%)	7 (87.5%)	10 (47.9%)
Right	0	1 (8.3%)	0	0
Shape				
Arrowhead	2 (33.3%)	10 (83.3%)	2 (25%)	2 (8.6%)
Bilobal	1 (76.7%)	1 (8.3%)	2 (25%)	11 (47.8%)
Quadrilateral	0	1 (8.3%)	4 (50%)	10 (43.6%)



Figures 1a-e Axial CT images of thymus showing characteristic thymic density in five groups of study participants1(a) Group 1, 100% solid tissue 1(b) Group 2, 50–75% solid tissue 1(c) Group 3, 25–50% solid tissue 1(d) Group 4, up to 25% solid tissue 1(e) Group 5, 100% fatty replacement.



Figures 2a-c Axial CT images at the level of the thymus demonstrating typical shapes of the thymus 2(a) Arrowhead shape, 2(b) bilobal and 2(c) rounded shapes.

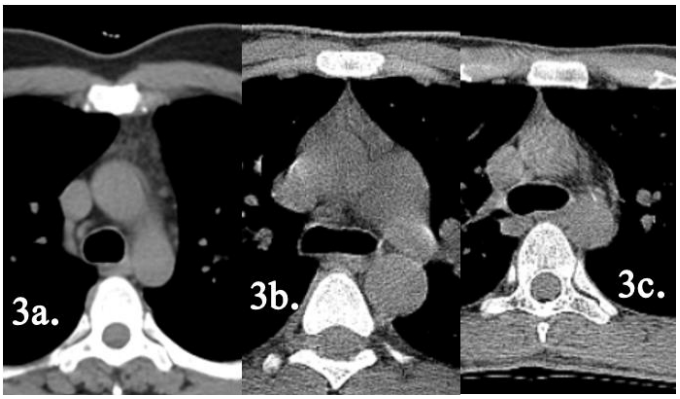


Figure 3 a-c Axial CT images demonstrating side predominance of the thymus (a) Left side predominance, (b) midline position and (c) right side predominance.

4. DISCUSSION

We discovered that thymic tissue was maintained in many healthy adults in this study, accounting for 28% of the total population. In the vast majority of cases, the gland was located in the midline or on the left side of the body, with a bilobed or rounded shape. We found some retained soft tissue in physically healthy people over the age of 40, but the gland was predominantly fat replaced and the solid tissue pattern was diff use reticular. On chest radiographs, the normal and diseased appearance of the thymus in children (Lele et al., 2001) and adults (Strollo and Rosado de Christenson, 1999) has been reported. However, even within the same age group, the thymus gland has been demonstrated to vary greatly. Surprisingly, we discovered that the most recent CT investigations of the normal thymus in adults were conducted in the year 2016 (Araki et al., 2016). This research was also conducted in the context of a foreign population, with no studies conducted on an Indian population to date.

Myasthenia gravis or thymoma is the most prevalent reasons for resection of the thymus gland (Heiberg et al., 1982). The thymus gland's consistency and appearance make it difficult to distinguish from mediastinal fatty tissues at times. It is critical to have a thorough understanding of the architecture of the gland and its interaction to surrounding structures (Safieddine and Keshavjee, 2011). Conventional chest radiography and tomography were the principal ways of imaging a suspected thymic abnormality before the advent of computed tomography (CT), while arteriography, venography and pneumomediastinography were rarely utilized (Kreel etal., 1967; Sone et al., 1980; McLoud et al., 1979; Day and Gedgaudas, 1984).

Early thoracic computed tomography reports revealed the discovery of occult thymomas, but the age-related CT appearance of the normal thymus, particularly in the Indian population and surgical confirmation were not recorded (Lele et al., 2001; Francis et al., 1985). Few MRI based studies have described the function of chemical shift in magnetic resonance imaging in separating hyperplastic thymus from thymic malignancies and lymphoma (Ackman et al., 2012). An MRI examination of abnormal thymic tissue was also performed. Thymus, especially when it is posteriorly placed, can be difficult to diagnose. Once a mediastinal "lesion" has been defined on plain film, MRI is the most efficient and effective diagnostic tool for determining the nature of the mass and its relationship to other mediastinal structures (Slovis et al., 1992).

MDCT scans are now commonly available and can provide more precise data that can aid radiologist in distinguishing normal thymus from abnormality once the usual appearance has been characterized. These MDCT techniques can also be used to identify the tiniest soft tissue islands present in the thymic gland. Modern scanners make it easier to distinguish between involuting thymus and surrounding mediastinal fat, however the exact border of the mainly fatty replacement gland can be difficult to track in many situations. The normal thymus can be easily overlooked in cross sectional imaging scans of the chest. Understanding thymic evolution and architecture is crucial in distinguishing between typical variations and benign illnesses and cancers after a thymic aberration has been found. Thymic hyperplasia and discrete thymic masses are two kinds of thymic disease (Kissin et al., 1987; Livesay et al., 1979).

Thymic hyperplasia is defined by symmetrical development lacking invasion and thymic masses have specific demographic and radiological markers that assist restrict the differential diagnosis. Recognizing the thymus' shape and growth can also aid radiologists in making more accurate diagnoses, eliminating the need for unnecessary imaging exams and treatments. Participants with a mostly fatty thymus showed a widespread reticular form of solid tissue distribution in our research. Soft tissue was found in the thymus of six perfectly healthy persons aged 40–54, showing that soft tissue in an asymptomatic patient is rare but not unheard of. If the thymus seems to be exceptionally thick, has a focal noticeable solid area or demonstrates interval change with solid component development, a true thymic illness should be examined.

In this work, we show that healthy people can maintain small quantities of solid thymic tissue. The thymus is usually found near the midline or on the left side of the body. It has a spherical shape in most cases however the shape varies depending on the subject. We discovered a strong link amongst age with thymic density, as well as a strong relation between age and volume. Volume and density are unaffected by gender. Our research offers critical statistical information to the characterization of normal thymic appearance in adults, allowing us to avoid unnecessary and costly imaging tests as well as surgical intervention. Because of the small sample size and retrospective character of the study, our findings are constrained.

5. CONCLUSION

We discovered a strong link amongst years and thymic density and also a remarkable link amongst age, volume and density are unaffected by gender. Our research offers critical statistical information for classification of healthy thymic morphology in adults, allowing for the avoidance of unneeded and costly imaging examinations as well as surgical treatment.

Abbreviations

CT: Computed tomography
MRI: Magnetic resonance imaging
MDCT: Multi detector computed tomography
WHO: World health organization
SOL: Space occupying lesion
AP: Antero posterior

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Authors Contribution

All authors made substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Ethical Approval

The study was approved by Medical Ethics Committee of NKP Salve Institute of Medical Sciences and Research Centre with the letter number: (NKPSIMS & RC & LMH/IEC/ IEC: 14/2021).

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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