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Research Article

MORPHOLOGICAL VARIATIONS OF THE FETAL THYROID GLAND: A COMPREHENSIVE STUDY ON DIMENSIONS AND DEVELOPMENTAL ANOMALIES

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ABSTRACT

The thyroid gland plays a crucial role in endocrine function and metabolic regulation, with its development beginning early in gestation. This study aimed to measure the dimensions of the fetal thyroid gland and investigate its morphological variations across different gestational ages. A total of fifty intact fetuses, ranging from 10 to 36 weeks of gestation, were examined. The fetuses were grouped into three categories: 10-18 weeks, 19-27 weeks, and 28-36 weeks. Thyroid glands were carefully dissected, measured, and preserved for detailed morphometric analysis. The study found that the thyroid gland was consistently related to the 1st through 6th tracheal rings. In 12% of cases, the isthmus, which connects the two lobes of the thyroid gland, was absent. This absence was equally distributed between male and female fetuses. A pyramidal lobe, an additional lobe extending from the thyroid isthmus, was observed in 16% of cases, with 62.5% of these cases occurring in male fetuses. The pyramidal lobe was always associated with the Levator glandulae thyroideae, a fibromuscular structure extending to the hyoid bone. The study also noted that 62.5% of the pyramidal lobes arose from the left side of the isthmus.The findings underscore the importance of recognizing these anatomical variations, which can have significant clinical implications, particularly in surgical and radiological practices. Awareness of such variations is essential for avoiding complications during thyroid surgeries, such as incomplete removal of thyroid tissue in cases involving the pyramidal lobe, which can lead to recurrence of conditions like carcinoma and Graves' disease. This study establishes baseline data on the incidence of thyroid variations in fetuses, contributing valuable information to the field of pediatric surgery and radiology.

Keywords:- Fetal thyroid gland, Anatomical Variations, Isthmus Agenesis, Pyramidal Lobe.

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INTRODUCTION

The thyroid gland is an essential organ in the human body, playing a vital role in endocrine function and metabolic regulation. It is one of the earliest endocrine glands to differentiate, beginning its function as early as the 11th week of gestation [1]. The term "thyroid" is derived from the Greek word "thyreos," meaning shield, which aptly describes the gland's shape and its critical role in protecting various bodily functions [2]. The organogenesis of the thyroid gland is a complex process that starts when the median endodermal cells thicken and form a diverticulum in the primitive pharynx floor. By the 7th week of gestation, this structure descends to the level of the cervical spine, establishing the gland's position in the neck [3].

Anatomically, the thyroid gland is composed of two lobes connected by a narrow isthmus. However, variations in this typical structure are not uncommon. One such variation is the pyramidal lobe, which is a

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conical extension of the thyroid tissue that ascends towards the hyoid bone from the isthmus or adjacent parts of the lobes. This lobe is often connected to the hyoid bone by a fibromuscular band known as the levator glandulae thyroideae, which further illustrates the variability in thyroid anatomy [4, 5]. Additionally, accessory thyroid glands, which are small, detached masses of thyroid tissue, may be found in the vicinity of the lobes or above the isthmus [6]. These anatomical variations, while often incidental findings, can have clinical significance, especially during surgical procedures or imaging studies.The thyroid gland's primary function is to produce and secrete thyroid hormones, including thyroxine (T4) and triiodothyronine (T3), which are crucial for regulating the metabolic rate of nearly all cells in the body. These hormones ensure that cellular processes occur at an optimal rate, which is particularly important during periods of rapid growth and development. The role of thyroid hormones in brain development during fetal life and the early years of postnatal life is especially critical. Thyroid hormone deficiency during these stages can lead to significant neurodevelopmental impairments [7]. One of the most well-known consequences of iodine deficiency, which impairs thyroid hormone production, is preventable mental retardation and brain damage. Indeed, iodine deficiency remains the leading cause of preventable cognitive impairment globally [7].

Given the importance of the thyroid gland in both development and metabolic regulation, it is crucial for healthcare professionals, including surgeons, radiologists, and pathologists, to be aware of the possible variations in thyroid anatomy. While much of the literature focuses on thyroid variations in adults, it is equally important to recognize these variations in fetuses. Knowledge of these anatomical differences is essential for accurate diagnosis and intervention, particularly in cases involving thyroid disorders or surgeries.

In summary, the thyroid gland plays a pivotal role in the body's endocrine system, supporting both metabolic regulation and developmental processes. Its early differentiation during gestation underscores its importance in fetal development, particularly in the brain. Anatomical variations in the thyroid gland, such as the presence of a pyramidal lobe or accessory thyroid tissue, highlight the need for awareness among medical professionals. By understanding these variations and their potential implications, healthcare providers can ensure better outcomes for their patients, from the earliest stages of life through adulthood.

Aims and Objectives

The study was conducted with the following aims and objectives:

1. **To measure the various dimensions of the fetal thyroid gland.**
   - This objective focuses on quantifying the size and shape of the fetal thyroid gland at different stages of gestation. By measuring the length, breadth, and thickness of the thyroid gland, the study aims to establish normative data on fetal thyroid gland dimensions that could serve as a reference for future research and clinical practice.
2. **To study the morphology of the fetal thyroid gland and its variations, if any.**
   - This objective is to investigate the structural characteristics and any anatomical variations of the fetal thyroid gland. The study particularly aims to identify the presence of common variations such as the pyramidal lobe, Levator glandulae thyroideae, and the absence of the isthmus. Understanding these variations is crucial for both anatomical education and clinical interventions.

MATERIAL AND METHODS

The study was conducted on a total of fifty intact fetuses of varying gestational ages, ranging from 10 to 36 weeks. These fetuses were procured from the Department of Anatomy at Sri Lakshmi Narayana Institute of Medical Sciences, Pondichery, India. The selection of fetuses was based on strict inclusion and exclusion criteria to ensure the accuracy and relevance of the findings.

Grouping of Fetuses:

- **Group 1:** 10-18 weeks of gestation
- **Group 2:** 19-27 weeks of gestation
- **Group 3:** 28-36 weeks of gestation

The fetuses were labeled numerically from 1 to 50 and categorized into the three groups according to their gestational age. Fetuses exhibiting gross developmental anomalies or any abnormality in the neck, such as scars or swellings, were excluded from the study. This exclusion was necessary to ensure that the observations and measurements were based on anatomically normal specimens.

Exposure of the Thyroid Gland:

The thyroid gland was exposed following the dissection method outlined by Romanes (2016 reprint). This involved careful dissection to preserve the gland and its surrounding structures. During the dissection, certain findings were recorded in situ, including:

- The anatomical level of the thyroid gland in relation to the neck structures.

- The presence or absence of the isthmus in relation to the tracheal rings.

Morphometric Measurements:

Once exposed, the thyroid gland was excised from the body and preserved in 10% formalin solution to maintain its structure for detailed study. The following morphometric measurements were taken:

1. **Length of the Isthmus:** The length was measured as the distance between two horizontal planes, one passing along the upper border of the isthmus and the other along its lower border. A digital vernier caliper was used for precision in measurement.
2. **Breadth of the Isthmus:** The breadth was measured between two vertical points, each passing along the medial surfaces of the right and left lobes where the isthmus connected to them.
3. **Length, Breadth, and Thickness of Each Lobe:** The length of each lobe was measured from the highest point of the lobe, while the breadth and thickness were measured from corresponding dimensions. These measurements aimed to provide a comprehensive understanding of the gland's morphology.

Observations of Variations:

In addition to the standard measurements, the study also carefully documented any morphological variations observed in the thyroid gland. This included:

- The presence of a pyramidal lobe, which is an anatomical variant where an additional lobe extends superiorly from the thyroid isthmus or one of the lobes.
- The presence of the Levator glandulae thyroideae, a fibromuscular structure that connects the thyroid gland to the hyoid bone.
- The absence of the isthmus, a condition where the isthmus is either underdeveloped or completely absent, leaving the two lobes disconnected.

All measurements and observations were conducted with precision tools such as digital vernier calipers to ensure the accuracy and reliability of the data. The detailed morphometric analysis of the fetal thyroid gland, along with the identification of anatomical variations, provides valuable insights that can inform clinical practice, particularly in pediatric surgery and radiology.

RESULTS

In this study, the thyroid gland was consistently found to be related to the 1st through 6th tracheal rings across all fetal specimens examined. The gland displayed a typical butterfly shape in the majority of the fetuses, except in 6 cases (12%) where the isthmus was absent. This absence of the isthmus was equally distributed between male and female fetuses, with 3 cases (50%) being male and 3 cases (50%) being female. The absence of the isthmus, a key anatomical feature connecting the two lobes of the thyroid gland, highlights a significant variation in fetal thyroid morphology.

The mean dimensions of the length, breadth, and width of each lobe of the thyroid gland are presented in Table 1 (Note: Ensure to reference the actual table in the final report). These measurements provide a quantitative baseline for the normal development of the thyroid gland during fetal growth.

In 8 cases (16%), a pyramidal lobe was observed. The pyramidal lobe is a common anatomical variation where an additional lobe extends superiorly from the thyroid isthmus or one of the lobes. Interestingly, in all 8 cases where the pyramidal lobe was present, it was also associated with the Levator glandulae thyroideae, a fibromuscular structure that connects the pyramidal lobe to the hyoid bone. This anatomical variation was observed more frequently in male fetuses, with 5 out of the 8 cases being male and the remaining 3 cases being female.

Further analysis revealed that in 5 out of the 8 cases with a pyramidal lobe, the lobe arose from the left side of the isthmus. This lateralized origin of the pyramidal lobe may have implications for surgical approaches and diagnostic imaging, particularly in the accurate localization of thyroid tissue during medical procedures.

Additionally, as depicted in Figure 5 (Note: Ensure to reference the actual figure in the final report), there was a clear increase in the size of the fetal thyroid gland with advancing gestational age. This growth pattern aligns with the overall development of the fetus and reflects the gland's increasing functional demands as the fetus matures.

In conclusion, this study not only confirms the typical anatomical relationships of the thyroid gland with the tracheal rings in fetuses but also highlights several significant variations, including the absence of the isthmus and the presence of the pyramidal lobe with associated Levator glandulae thyroideae. These findings contribute valuable information to the understanding of fetal thyroid development and its potential variations, which is essential for clinical practices involving fetal and neonatal care.

Table1: Mean Dimensions of Thyroid Gland.

Gestational Age(weeks)/No.	Right Lobe(mm)			Left Lobe(mm)			Isthmus(mm)	
	L	B	W	L	B	W	L	B

Gr1(10-18)/15	5.8	3.1	1.2	5.6	3.0	1.3	3.9	3.7
Gr2(19-27)/15	9.9	4.5	1.4	9.8	4.4	1.5	4.6	4.5
Gr3(28-36)/20	13.1	6.9	1.7	12.9	7.0	1.7	8.9	8.8

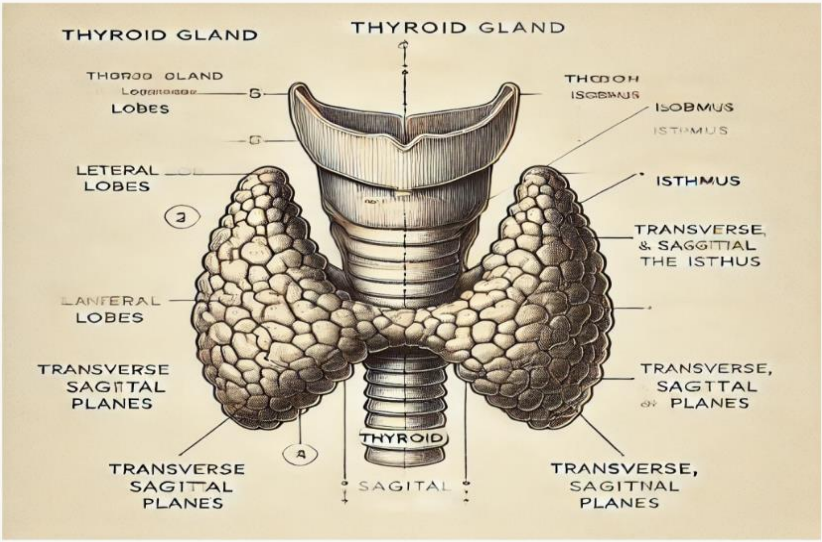
Table 2: Showing incidence of agenesis of isthmus.

Sl.no	Authors	Year	% Incidence
1	Marshall	1895	10
2	Won & Chung	2002	3
3	Harjeet et al	2004	7.9
4	Ranade et al	2008	33
5	Anupriya A	2016	2.5
6	Present Study	2017	12

Table 3: Showing the incidence of Pyramidal Lobe

Sl. no	Authors	Year	% Incidence
1	Marshall C.F	1895	43
2	Hamilton WJ	1976	40
3	De Groot	2001	15
4	Harjeet et al	2004	28
5	Choudhary N	2015	19.23
6	Present Study	2017	16

Figure No.1: Diagram showing the length and breadth of the lobes and the Isthmus and various planes.



DISCUSSION

The thyroid gland is well known for its anatomical variations, which include agenesis of the isthmus, the presence of a persistent pyramidal lobe, Levator glandulae thyroideae, and lingual thyroid, among others. These variations have been extensively studied by various authors. For instance, Harjeet et al. reported different shapes of the thyroid gland, with 36.8% being horseshoe-shaped, 5% irregularly shaped, and 7.9% presenting with two separate lobes [8]. The occurrence of agenesis of the isthmus has been noted by Anupriya and Kalpana, who reported an incidence of 2.5% [9]. Agenesis of the isthmus is often associated with the absence of one lobe or the presence of ectopic thyroid tissue. When such conditions are diagnosed radiologically, differential diagnoses such as autonomous thyroid nodules or thyroiditis should be considered [9].

During thyroidectomy, surgeons must be aware of such variations. The precise dissection is critical due to the proximity of important nerves and vessels to the thyroid gland [10]. The development of two separate lobes is often attributed to a high division of the

thyroglossal duct, which may also be associated with dysorganogenesis, such as the absence of a lobe or the presence of ectopic thyroid tissue [11]. This highlights the importance of preoperative planning and intraoperative vigilance when encountering unusual thyroid anatomy.

The pyramidal lobe, which was found in 14% of cases in this study, likely represents the developmental remnants of the thyroglossal duct's caudal end [12]. This lobe can be a source of complications during surgery, as its preoperative diagnosis can be challenging, especially in scintigraphic imaging [13]. Incomplete removal of the pyramidal lobe, also known as Lalouette's lobe, during thyroid surgery can lead to significant postoperative complications, particularly in cases of carcinoma and Graves' disease [14].

According to Standring, the Levator glandulae thyroideae (LGT) typically extends from the pyramidal lobe or the upper border of the isthmus to the hyoid bone, usually on the left side (15). In this study, all cases with a pyramidal lobe were associated with the LGT, which extended up to the hyoid bone. Previous literature has described the LGT as either fibrous, muscular, or fibromuscular. Godart, based on a nitric oxide test, identified this structure as muscular (15), while Hamilton and Mossman suggested that it could be a fibrous or muscular remnant of the pyramidal lobe [16]. These variations underscore the need for careful examination and understanding of thyroid anatomy during both radiological and surgical procedures.

CONCLUSION

This study highlights various developmental anomalies of the thyroid gland across different gestational ages. It provides valuable insights into how the dimensions of the thyroid gland increase with gestational age and emphasizes the importance of recognizing anatomical variations, such as agenesis of the isthmus, the presence of the pyramidal lobe, and the Levator glandulae thyroideae. These variations are often overlooked during surgical and radiological procedures, yet they hold significant clinical relevance. The findings of this study aim to establish baseline data on the incidence of these variations and to inform surgeons, radiologists, and other interventionists of their potential implications. Awareness of these anomalies is crucial for avoiding complications during thyroid surgeries and improving patient outcomes

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