ORIGINAL ARTICLE

Ultrasound of the thyroid gland in the newborn: normative data

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Objective: To establish reference ranges for thyroid length, breadth, depth, and volume in healthy term Scottish infants.

Design: Prospective observational study of 100 (49 male) neonates. Length, breadth, and depth were measured, and the volume of each lobe was calculated using the formula for a prolate ellipsoid (volume = length × breadth × depth × π/6).

Results: All measurements showed gaussian distribution, with no significant differences between the right and the left lobes. Values (mean (SD) range) were: length (cm), 1.94 (0.24) 0.9–2.5; breadth (cm), 0.88 (0.16) 0.5–1.4; depth (cm), 0.96 (0.17) 0.6–2.0; volume (ml), 0.81 (0.24) 0.3–1.7; combined volume (ml), 1.62 (0.41) 0.7–3.3. Although there was no difference in mean volume between right and left lobes, there was considerable variation (−0.8 to + 0.7 ml) between the two lobes in individual babies.

Conclusions: Both lobes should be measured to give a combined volume. Our findings provide a reference against which thyroid hypoplasia or goitre can be evaluated.

Thyroid imaging has a role in the assessment of newborns with raised levels of thyroid stimulating hormone (TSH). In true congenital hypothyroidism, ultrasound may show no thyroid tissue in the neck because of either ectopia or agenesis. Alternatively the gland may be small in volume as the result of hypoplasia, or enlarged because of dyshormonogenesis, which is seen in 20% of our neonatal population with congenital hypothyroidism.[1] In transient TSH elevation, associated with prematurity, acute illness, and congenital malformations,[2] the thyroid gland should be of normal size.

It is recognised that newborn infants with congenital hypothyroidism due to a thyroid gland in situ show a higher diagnostic yield in terms of specific cause.[3] The discovery of the transcription factors PAX-8, TTF-1, and TTF-2[4 5] and the description of inactivating TSH receptor defects[6 7] suggest that accurate determination of thyroid anatomy will become increasingly important.

The current optimum method for thyroid imaging in babies and children with suspected congenital hypothyroidism is isotope scanning. Isotope scanning is also the only recognised method of reliably detecting an ectopic gland, although recent work reports successful ultrasound identification of lingual thyroid in eight out of eight patients scanned using midline sagittal and posterior coronal views of the floor of the mouth.[8] However, most isotope scanning is performed in adult units, and the results may be difficult to interpret in babies, especially if they have received iodine in the course of antiseptic procedures (as this may interfere with the uptake of isotope and give a misleading impression of thyroid agenesis). Moreover, it is not practical to carry out isotope scanning in sick, preterm infants.[9]

Thyroid ultrasound is a promising but relatively underused technique for thyroid imaging in newborn infants with congenital hypothyroidism.[10] As far as we are aware, no data exist to indicate whether thyroid size is best expressed in terms of linear measurements or volume.[11] However, in both the paediatric and adult literature, thyroid size is most commonly denoted in terms of volume. In the neonatal population, thyroid volume has been used to create normative data in both Germany[12–14] and Belgium.[15]

We have studied a sufficient number of healthy term neonates within the first week of life to allow normal ranges in thyroid volume and linear measurements to be established for babies born in the United Kingdom. These data have enabled us to determine whether thyroid volume is dependent on birth weight or sex.

STUDY DESIGN

After institutional ethical approval, infants were recruited from the postnatal wards of the Queen Mother's Hospital, Glasgow, Scotland during a six month period from February to August 1999. The criteria for inclusion were gestation between 37 and 42 weeks, birth weight between the 10th and 90th centiles on Gairdner and Pearson (0–2 year) growth charts,[16] and no clinical abnormality other than mild to moderate jaundice or minor problems such as superficial infection of the skin or umbilicus. Babies were excluded if they had any congenital malformations or abnormality of TSH either on venous or routine neonatal capillary screening. After written and informed consent had been obtained from the parents, birth weight, gestation, and sex of the infants were recorded and thyroid scanning was performed.

Infants were scanned by a single observer (ASH) in the X-ray Department of the Royal Hospital for Sick Children, Glasgow with the same ultrasound scanner, an Acuson 128XP 10 System (Acuson Mountain View, California, USA). Babies were examined in the supine position with the neck hyperextended without sedation. Using a linear 7.5 MHz probe with prewarmed coupling gel, transverse and longitudinal sections of both lobes of the thyroid gland were scanned. Measurements of the maximum length of the lobe from the sagittal images were recorded (fig 1). The maximum transverse diameter (breadth) and the maximum depth of each lobe were recorded from the transverse images (fig 1). To ensure that the probe was in the same position each time, anatomical landmarks were used. For measurement of thyroid length, the probe was placed longitudinally in the midline of the neck to obtain sagittal views of the larynx; the probe was then moved obliquely to find the maximum length of the thyroid gland, just medial to the carotid vessels. The transverse views were obtained by using the trachea and carotid vessels as landmarks. The thyroid volume was calculated using the formula for a prolate ellipsoid,[11] where thyroid volume = length × breadth × depth × π/6.

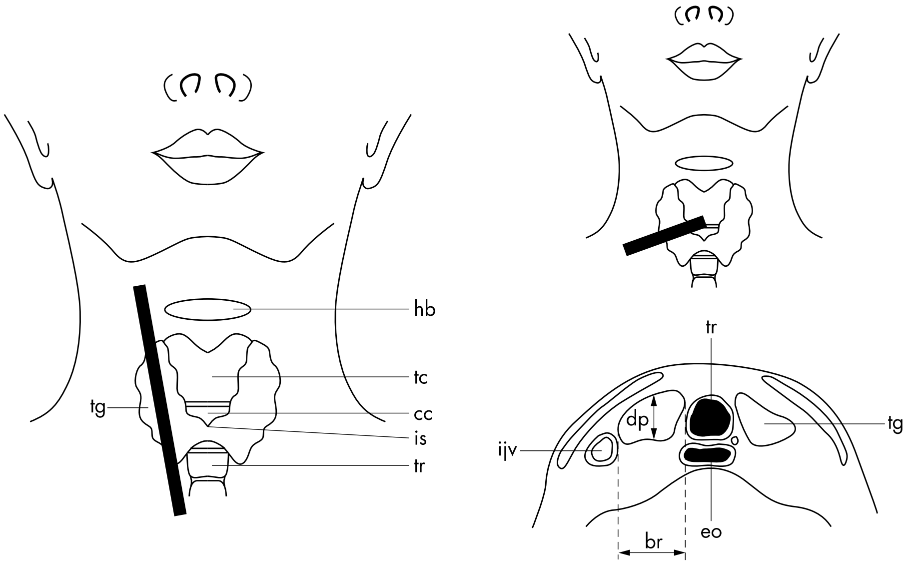

Figure 1 Diagram of thyroid gland (tg) showing the right and left lobes connected by the narrow isthmus (is). Each lobe is pear shaped with its apex directed upwards. The maximum length of each lobe was determined from sagittal sections on ultrasound, the maximum transverse diameter (br = breadth) from the transverse sections, and the maximum anteroposterior measurement (dp = depth) from the transverse images. tc, Thyroid cartilage; cc, cricoid cartilage; tr, trachea; hb, hyoid bone; ijv, internal jugular vein; eo, oesophagus.

Table 1 Ultrasound measurements of the thyroid gland in 100 healthy newborn infants within the first week of life

		Male infants (n=49)		Female infants (n=51)		All infants	
		Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Length (cm)	R	1.99 (0.22)	1.6–2.5	1.88 (0.26)	0.9–2.5	1.94 (0.24)	0.9–2.5
	L	1.96 (0.21)	1.6–2.4	1.92 (0.27)	0.9–2.4	1.94 (0.24)	0.9–2.4
Breadth (cm)	R	0.87 (0.17)	0.5–1.4	0.86 (0.13)	0.6–1.2	0.87 (0.15)	0.5–1.4
	L	0.89 (0.14)	0.6–1.3	0.88 (0.17)	0.6–1.4	0.89 (0.16)	0.6–1.4
Depth (cm)	R	0.96 (0.12)	0.7–1.3	0.97 (0.20)	0.6–2.0	0.97 (0.16)	0.6–2.0
	L	0.91 (0.13)	0.7–1.2	0.99 (0.20)	0.7–1.9	0.95 (0.17)	0.7–1.9
Volume (ml)	R	0.84 (0.24)	0.3–1.4	0.78 (0.22)	0.5–1.7	0.81 (0.23)	0.3–1.7
	L	0.79 (0.19)	0.4–1.3	0.84 (0.29)	0.4–1.7	0.82 (0.24)	0.4–1.7
Total volume (ml)		1.63 (0.37)	0.7–2.4	1.61 (0.44)	1.0–3.3	1.62 (0.41)	0.7–3.3

The length, breadth, depth, and volume are given for each lobe along with the combined volume of of the two lobes (R = right lobe; L = left lobe).

The data were entered into an Excel spreadsheet and imported into MINITAB for analysis. As the data were normally distributed, the paired *t* test was used to compare mean thyroid measurement between right and left lobes. An unpaired *t* test was used to compare mean values between boys and girls and between babies of different gestation. Correlation between variables was assessed using the Pearson test, and the Bland Altman test[17] was used to determine the predictive value of measuring one thyroid lobe.

RESULTS

One hundred infants were recruited and studied during the first week of life. Mean (range) birth weight and gestation were 3.46 (2.6–4.3) kg and 39.7 (37–42) weeks respectively. There were 51 girls and 49 boys.

Table 1 shows the descriptive statistics for the recorded data on length, breadth, depth, and calculated volume for right and left lobes, and the combined volume for boys, girls, and all infants. There was no significant correlation between either birth weight or gestation and thyroid dimensions.

The data obtained for each variable showed gaussian distribution (fig 2), enabling the paired *t* test to be used to compare the mean measurements of left and right lobes, including volume. There was no significant difference.

Pearson correlation showed a highly significant association ($p < 0.001$) between right and left volumes for the group as a whole. The Bland and Altman test[17] was used to measure how useful the volume of one thyroid lobe would be to predict the volume of the other lobe. The test calculated that for a given individual the difference between volume of the right and left thyroid would be –0.52 to + 0.51 ml. Therefore the volume of one lobe could not be used to reliably predict that of the other lobe. The actual range of difference in individual babies was –0.8 to + 0.7 ml.

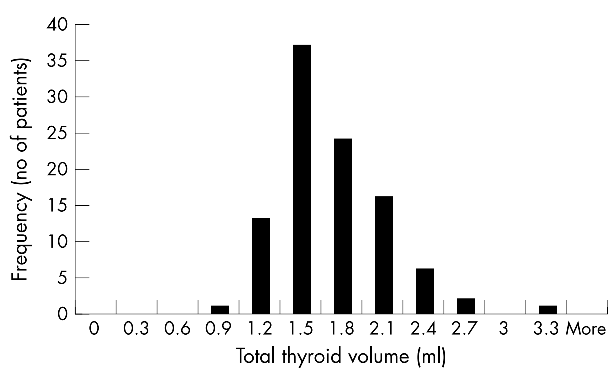

Figure 2 Histogram showing the gaussian distribution of total thyroid volume.

Comparison of the thyroid dimensions of boys and girls showed no difference except that the right lobe was longer in boys, and the depth of the left lobe was greater in girls. Although these differences reached significance ($p < 0.01$ and $p < 0.05$ respectively), they are unlikely to be of clinical importance.

DISCUSSION

This study of thyroid size in normal newborn babies provides reference data with which infants with suspected thyroid anomalies can be compared. Given that considerable discrepancy may exist between the size of right and left lobes in individual babies, we suggest that the length, breadth, and depth of each lobe be determined together with the volume of each lobe and hence the combined volume. These calculations do not take the size of the thyroid isthmus into account, but this structure contributes only a small part of the thyroid volume, and, if each lobe is considered as an ellipsoid, much of the contribution of the isthmus is included.

Clearly the most important role of the ultrasound examination is to determine whether or not there is thyroid tissue in the correct position in the neck. Establishing whether or not the thyroid is small, normal, or enlarged is also important and more difficult because the gland is a three dimensional structure, and therefore length, breadth, and area are each insufficient to describe size. The object of this study was not only to establish the normal volume of the thyroid in our newborn population, but also to compare our normative data with those reported in studies from other countries using the same volumetric calculations.

It is well recognised that ultrasound is an observer dependent technique and ideally we would have had two independent observers performing the scans. However, we were constrained by the practical and ethical difficulties of subjecting newborn babies to a prolonged examination purely in the interests of research. However, the narrow range of values obtained for thyroid size imply that there was a high degree of intraobserver accuracy in our study.

Our findings are somewhat at variance with the normative data described by Klingmuller *et al*[14] in 1992 in Gissen, Germany and by Chanoine *et al*[15] in 1990 in Belgium. Our mean (SD) volume of 1.62 (0.41) ml was higher than both the German value of 1.1 (0.6) ml and the Belgian value of 0.84 (0.38) ml.

Forty five neonates (21 female) were studied in Germany and 85 neonates (37 female) in Belgium during the first 6 days of life, although both study groups included older children. Thyroid volume was calculated using a slightly different formula by Klingmuller *et al*[14]; the equation used was length $\times$ breadth $\times$ depth $\times$ 0.479. In both studies, no individual dimensions were described and no significant sex difference was observed. However, Chanoine *et al* reported an asymmetric distribution of thyroid volume, which was skewed towards elevated values.

We are unable to explain the discrepancy between these two studies and our larger study which was performed solely on neonates. Using the Klingmuller group's constant of 0.479 rather than $\pi/6$ (0.52), our mean volume would only be slightly lower at 1.56 ml. Thyroid volume can be expected to vary from country to country in relation to iodine intake. As iodine deficiency would result in a larger thyroid volume in both mother and baby, this would not account for the slightly higher volumes observed in our cohort of infants, as traditionally Germany is iodine poor compared with Scotland.[18] However, current iodine status may have changed in the United Kingdom, as table salt is no longer iodinated. Also certain areas of Germany such as Berlin[19] and Leipzig[20] are now reported to be iodine replete.

Moreover in association with borderline iodine deficiency, thyroid volume may also be affected by other factors such as smoking and non-specific goitrogens in the environment. Barrere *et al*[21] reported a 25% increase in mean thyroid volume in healthy French adults who were current smokers compared with non-smokers. We did not record maternal smoking status in our study, but in view of the high prevalence of smoking[22] and the rising prevalence of smoking in young women in the West of Scotland,[23] this could in part explain our slightly higher thyroid volumes.

We hope that the data will be of value to other centres performing neonatal thyroid ultrasonography. However, as ultrasonography is a highly observer dependent technique and regional factors influence thyroid volume, we suggest that interested centres develop their own normative data for use in newborn assessment.

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