

## Ultrasonographic thyroid nodular findings in Japanese children

Nobuyuki Taniguchi · Naomi Hayashida · Hiroki Shimura · Noriyuki Okubo · Yasushi Asari · Takeshi Nigawara · Sanae Midorikawa · Kazuhiko Kotani · Shige-yuki Nakaji · Misa Imaizumi · Akira Ohtsuru · Takashi Akamizu · Masafumi Kitaoka · Shinichi Suzuki · Shunichi Yamashita · Noboru Takamura · The Investigation Committee for the Proportion of Thyroid Ultrasound Findings

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### Abstract

**Purpose** The Fukushima Health Management Survey conducted after the accident at the Fukushima Nuclear Power Plant included thyroid ultrasound examinations for children aged  $\leq 18$  years at the time of the accident. The purpose of this study was to investigate the frequency of thyroid nodular lesions detected using high-quality ultrasonography in a general population of Japanese children, in whom such data have not been previously characterized. **Methods** The current study investigated 4,365 free-living children aged between 3 and 18 years in three Japanese prefectures (Aomori, Yamanashi and Nagasaki). The same ultrasonography equipment as that used in the Fukushima

Survey was employed to observe thyroid nodular lesions. The following categories of findings were used—‘A’, further examinations are not necessary; ‘B’, the presence of thyroid nodules with a diameter of  $\geq 5.1$  mm or thyroid cysts with a diameter of  $\geq 20.1$  mm; and ‘C’, immediate further examinations are required. As a sub-category of ‘A’, ‘A1’ was defined as the absence of nodules or cysts, and ‘A2’ was defined as the presence of thyroid nodules with a diameter of  $\leq 5.0$  mm or thyroid cysts with a diameter of  $\leq 20.0$  mm.

**Results** Overall, 4,321 (99 %) of the total participants were classified with a status of ‘A’ and 44 (1 %) were classified with a status of ‘B’. No participants were classified with a status of ‘C’. A total of 56.5 % of the total participants was classified with a status of ‘A2’. Thyroid nodules were identified in 1.6 % of the total participants and thyroid cysts were identified in 56.9 % of the participants.

**Conclusion** The current study provides data regarding the actual frequency of ultrasonographically detected thyroid nodular lesions among the Japanese children. These results would be useful for evaluating thyroid findings in Japanese children, although careful interpretation is required.

The current study is based on the project conducted by the Japan Association of Breast and Thyroid Sonology that was approved by the Ministry of Environment of Japan. The current paper is an English translation of part of a report written in Japanese by the Ministry of Environment of Japan (the summary is presently accessible: <http://www.env.go.jp/press/press.php?serial=16520> [on March 29, 2013] with its English version: <http://www.env.go.jp/en/headline/headline.php?serial=1933>). This paper is based on crude descriptive data only, and has been published in consideration of rapidly widespread social needs.

N. Taniguchi (✉) · K. Kotani  
Department of Clinical Laboratory Medicine,  
Jichi Medical University, 3311-1 Yakushiji, Shimotsuke,  
Tochigi 329-0498, Japan  
e-mail: taniguch@jichi.ac.jp

N. Hayashida · N. Takamura  
Department of Global Health, Medicine and Welfare, Atomic  
Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

H. Shimura  
Department of Environmental Internal Medicine,  
Interdisciplinary Graduate School of Medicine and Engineering,  
University of Yamanashi, Yamanashi, Japan

N. Okubo · S. Nakaji  
Department of Social Medicine, Hirosaki University Graduate  
School of Medicine, Aomori, Japan

Y. Asari  
Department of Emergency and Disaster Medicine, Hirosaki  
University Graduate School of Medicine, Aomori, Japan

T. Nigawara  
Department of Endocrinology and Metabolism, Hirosaki  
University Graduate School of Medicine, Aomori, Japan

**Keywords** Thyroid ultrasonography · Children · Thyroid cyst · Thyroid nodule · Nodular thyroid lesion

## Introduction

On March 11, 2011, the Fukushima Dai-ichi Nuclear Power Plant in Fukushima Prefecture was damaged by the Great East Japan Earthquake and a radioactive plume was dispersed into the atmosphere. After the accident, the Fukushima prefectural government started conducting the Fukushima Health Management Survey to evaluate the initial external dose of radiation exposure and to monitor the health conditions of local residents who were likely to have been heavily influenced by the accident [1]. One of the detailed surveys conducted in Fukushima included thyroid ultrasound examinations targeting all prefectural inhabitants aged between 0 and 18 years on March 11, 2011 (approximately 360,000 inhabitants) [1]. The findings of thyroid ultrasonography performed in approximately 38,000 inhabitants until March 2012 showed that about 40 % of the children had small cysts with a diameter of  $\leq 2.0$  mm [1].

Clinically, small cysts without solid components do not require further examination and/or treatment. However, affected inhabitants generally worry because it is well known that the rate of childhood thyroid cancer increased for 4–5 years after the Chernobyl Nuclear Power Plant accident in 1986 [2–4].

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S. Midorikawa · A. Ohtsuru  
Department of Radiation Health Management, Fukushima Medical University, Fukushima, Japan

M. Imaizumi  
Department of Clinical Studies, Radiation Effects Research Foundation, Nagasaki, Japan

T. Akamizu  
The First Department of Medicine, Wakayama Medical University, Wakayama, Japan

M. Kitaoka  
Division of Endocrinology and Metabolism, Showa General Hospital, Tokyo, Japan

S. Suzuki  
Department of Organ Regulator Surgery, Fukushima Medical University, Fukushima, Japan

S. Yamashita  
Department of Radiation Medical Sciences, Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan

S. Yamashita  
Radiation Science Center for Fukushima Health Management Survey, Fukushima Medical University, Fukushima, Japan

No large-scale ultrasound examinations of the thyroid in the general population of children in particular have been carried out until recently. Therefore, the frequency of thyroid nodular lesions, such as small cysts, on high-quality ultrasonography has remained unknown. We conducted ultrasound examinations of the thyroid among Japanese children in the general population of three Japanese prefectures (Aomori, Yamanashi and Nagasaki Prefectures) in order to investigate the frequency of thyroid nodular lesions using the same ultrasound procedures as those used in the Fukushima Health Management Survey.

## Subjects and methods

### Study areas

The study was conducted in Aomori Prefecture, Yamanashi Prefecture and Nagasaki Prefecture by Hirosaki University, Yamanashi University and Nagasaki University, respectively. These areas were chosen because they are geographically dispersed throughout the Eastern, Middle and Western regions of Japan and are thought to have been unaffected by radioactive material from the Fukushima Nuclear Power Plant accident. Additional reasons for choosing these areas were that these prefectures had thyroid ultrasound specialists and medical facilities equipped for further examinations.

### Participants

One kindergarten, one elementary school, one junior high school and one high school in each prefecture were contracted for this study, and all of the Japanese children aged between 3 and 18 years at each kindergarten and school were invited to participate in the study. Children for whom their parents refused the examinations were excluded from the study.

### Ethics statements

The study was approved by the ethical committees of Hirosaki University, Yamanashi University and Nagasaki University, respectively. It was conducted in accordance with guidelines expressed in the Declaration of Helsinki. Written informed consent was obtained from the parents of all children examined.

### Ultrasound examinations

The ultrasound examinations were performed between November 2012 and January 2013. For all examinations, we used the 7.75-MHz probe [12L-RS (GE Healthcare,

Japan) and LOGIQ e Expert (GE Healthcare, Japan)], the same ultrasonography equipment used in the Fukushima Health Management Survey [5]. The examination protocol was also the same as that used in the Fukushima Health Management Survey.

Ultrasound findings

We identified nodules and cysts in the thyroid. Cysts with solid components were defined as nodules. We classified the thyroid findings of all participants into three categories—‘A’ (‘A1’ and ‘A2’), ‘B’ or ‘C’, according to the same criteria used in the Fukushima Survey [1, 5] based on the guidelines of the Japan Association of Breast and Thyroid Sonology. ‘A’ indicated that no further examinations were required, and ‘B’ indicated the presence of nodules with a diameter of  $\geq 5.1$  mm or cysts with a diameter of  $\geq 20.1$  mm. ‘C’ indicated the presence of thyroid findings that required immediate further examinations in a hospital. We further classified the category ‘A’ into sub-categories ‘A1’ and ‘A2’. ‘A1’ was defined as the absence of nodules or cysts, and ‘A2’ was defined as the presence of nodules with a diameter of  $\leq 5.0$  mm or cysts with a diameter of  $\leq 20.0$  mm. Unclear findings were evaluated by an expert working group who made the final diagnosis.

Results

The overall participation rate was 85.0 %. In total, 4,365 children (1,630 children in Aomori, 1,366 in Yamanashi and 1,369 in Nagasaki) underwent ultrasound examinations. The characteristics of the participants are shown in Table 1. In total, 2,075 participants (47.5 %) were male and 2,290 (52.5 %) were female. One hundred and eighty-

nine (4.3 %), 1,275 (29.2 %), 1,995 (45.7 %) and 906 (20.8 %) of the participants were aged 3–5, 6–10, 11–15 and 16–18 years, respectively.

Table 2 shows the numbers of participants classified according to the thyroid findings. Overall, 4,321 participants were classified with a status of ‘A’ (99.0 %), consisting of 1,853 participants with a status of ‘A1’ (42.5 %) and 2,468 participants with a status of ‘A2’ (56.5 %). Forty-four participants were classified with a status of ‘B’ (1.0 %). No participants were classified with a status of ‘C’.

Table 3 shows the numbers of participants with thyroid nodules and cysts. Thyroid nodules were identified in 72 participants (1.6 %; size range 1.9–23.5 mm, median size 5.9 mm) and thyroid cysts were identified in 2,483 participants (56.9 %; size range 0.8–12.1 mm, median size 3.1 mm). Thyroid nodules with a maximum diameter of  $\geq 5.1$  mm were identified in 44 participants (1.0 %) and those with a maximum diameter of  $\leq 5.0$  mm were identified in 28 participants (0.6 %). No thyroid cysts with a maximum diameter of  $\geq 20.1$  mm were identified (0.0 %), while thyroid cysts with a maximum diameter of  $\leq 20.0$  mm were identified in 2,483 participants (56.9 %).

Table 4 shows the numbers of participants by age and gender classified according to the thyroid findings. The figure shows the percentage of participants with each thyroid finding. Among the males (Fig. 1a) aged 3–5 years, 69.8, 29.2 and 1.0 % were classified with a status of ‘A1’, ‘A2’ and ‘B’, respectively. Among the males aged 6–10 years, 45.7, 54.1 and 0.2 % were classified with a status of ‘A1’, ‘A2’ and ‘B’, respectively. Among the males aged 11–15 years, 44.6, 54.7 and 0.7 % were classified with a status of ‘A1’, ‘A2’ and ‘B’, respectively. Among the males aged 16–18 years, 44.5, 54.7 and 0.8 % were classified with a status of ‘A1’, ‘A2’ and ‘B’, respectively. Among the females (Fig. 1b) aged 3–5 years, 71.0, 29.0 and 0.0 % were classified with a status of ‘A1’,

**Table 1** Characteristics of the participants in the three examination areas

	Area	Age (years)				Total
		3–5	6–10	11–15	16–18	
Male	Aomori	26	223	388	146	783
	Yamanashi	18	178	309	93	598
	Nagasaki	52	220	308	114	694
	All areas	96 (2.2)	621 (14.2)	1,005 (23.0)	353 (8.1)	2,075 (47.5)
Female	Aomori	25	221	360	241	847
	Yamanashi	16	201	329	222	768
	Nagasaki	52	232	301	90	675
	All areas	93 (2.1)	654 (15.0)	990 (22.7)	553 (12.7)	2,290 (52.5)
Total		189 (4.3)	1275 (29.2)	1,995 (45.7)	906 (20.8)	4,365 (100)

The numbers in parentheses indicate the percentage of the total participants

**Table 2** Number of participants in the three examination areas classified according to the thyroid findings

Categories	Aomori	Yamanashi	Nagasaki	All areas
A	1,609	1,351	1,361	4,321 (99.0)
A1	670	404	779	1,853 (42.5)
A2	939	947	582	2,468 (56.5)
B	21	15	8	44 (1.0)
C	0	0	0	0 (0.0)

The numbers in parentheses indicate the percentage of the total participants. Categories: 'A', no further thyroid examinations were required; 'B', the presence of nodules with a diameter of  $\geq 5.1$  mm or cysts with a diameter of  $\geq 20.1$  mm; 'C', the presence of thyroid findings requiring immediate further examinations in a hospital. Sub-categories: 'A1', no nodules or cysts; 'A2', the presence of nodules with a diameter of  $\leq 5.0$  mm or cysts with a diameter of  $\leq 20.0$  mm

**Table 3** Number of participants with thyroid nodules and cysts in the three examination areas

Findings	Aomori	Yamanashi	Nagasaki	All areas
<b>Nodule</b>				
All	35	27	10	72 (1.6)
$\geq 5.1$ mm	21	15	8	44 (1.0)
$\leq 5.0$ mm	14	12	2	28 (0.6)
<b>Cyst</b>				
All	946	955	582	2,483 (56.9)
$\geq 20.1$ mm	0	0	0	0 (0.0)
$\leq 20.0$ mm	946	955	582	2,483 (56.9)

The numbers in parentheses indicate the percentage of the total participants

**Table 4** Number of participants by age and gender classified according to the thyroid findings

Age (years)	A									B			C			Total		
	A1			A2			A1+A2											
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
3–5	67	66	133	28	27	55	95	93	188	1	0	1	0	0	0	96	93	189
6–10	284	283	567	336	369	705	620	652	1,272	1	2	3	0	0	0	621	654	1,275
11–15	448	339	787	550	635	1,185	998	974	1,972	7	16	23	0	0	0	1,005	990	1,995
16–18	157	209	366	193	330	523	350	539	889	3	14	17	0	0	0	353	553	906
Total	956	897	1,853	1,107	1,361	2,468	2,063	2,258	4,321	12	32	44	0	0	0	2,075	2,290	4,365

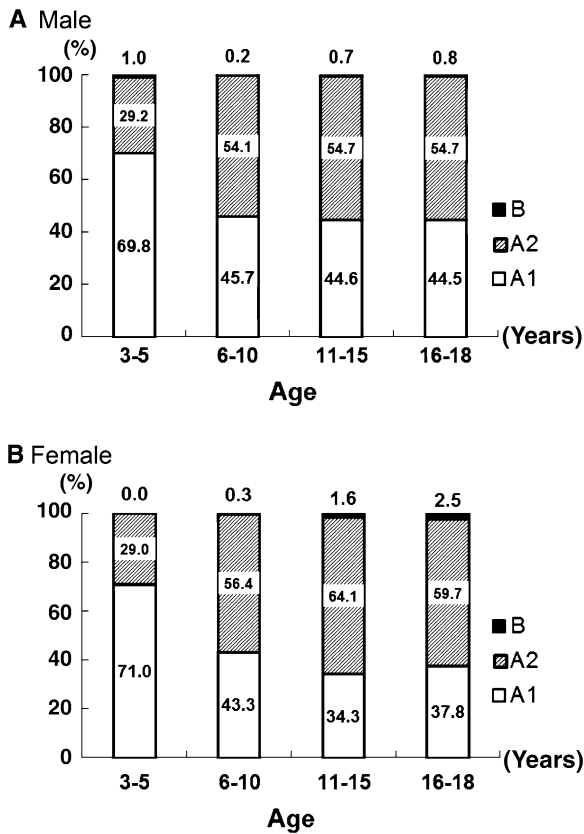
Categories: 'A', no further thyroid examinations were required; 'B', the presence of nodules with a diameter of  $\geq 5.1$  mm or cysts with a diameter of  $\geq 20.1$  mm; 'C', the presence of thyroid findings requiring immediate further examinations in a hospital. Sub-categories: 'A1', no nodules or cysts; 'A2', the presence of nodules with a diameter of  $\leq 5.0$  mm or cysts with a diameter of  $\leq 20.0$  mm

M, male; F, female

'A2' and 'B', respectively. Among the females aged 6–10 years, 43.3, 56.4 and 0.3 % were classified with a status of 'A1', 'A2' and 'B', respectively. Among the females aged 11–15 years, 34.3, 64.1 and 1.6 % were classified with a status of 'A1', 'A2' and 'B', respectively. Among the females aged 16–18 years, 37.8, 59.7 and 2.5 % were classified with a status of 'A1', 'A2' and 'B', respectively.

## Discussion

Before the popular usage of thyroid ultrasonography, most thyroid tumors were detected using thyroid palpation. A large-scale report of Japanese adults who underwent general health check-ups showed that the frequency of thyroid nodules detected on ultrasound examinations (18.55 %) was much higher than that detected on palpation (1.46 %)



**Fig. 1** Percentage of participants by age and gender classified according to the thyroid findings. **a** and **b** show the percentages of males and females, respectively. ‘A1’, no nodules or cysts; ‘A2’, the presence of nodules with a diameter of  $\leq 5.0$  mm or cysts with a diameter of  $\leq 20.0$  mm; ‘B’, the presence of nodules with a diameter of  $\geq 5.1$  mm or cysts with a diameter of  $\geq 20.1$  mm

and that the frequency of thyroid cysts with a diameter of  $\geq 3$  mm was 27.6 % [6]. However, no information regarding ultrasonographic thyroid nodular findings in a general population of children is available.

The current study conducted ultrasound examinations of the thyroid among general Japanese children aged between 3 and 18 years in order to investigate the frequency of thyroid nodules and cysts. We chose three examination areas distributed geographically throughout Japan, that are thought to have been unaffected by radioactive material from the Fukushima Nuclear Power Plant accident. The major findings of this study are that 99 % of the total participants were classified with a status of ‘A’, 1 % classified with a status of ‘B’, and no participants were classified with a status of ‘C’ (requiring immediate further examinations). In addition, 56.5 % of the total participants had a status of ‘A2’, having thyroid nodules with a diameter of  $\leq 5.0$  mm or thyroid cyst with a diameter of  $\leq 20.0$  mm. Most ‘A2’ cases involved thyroid cysts with a diameter of  $\leq 20.0$  mm. The results of the current study, thus, provide valuable information regarding the actual

frequency of ultrasonographically detected thyroid nodular lesions in the general population of Japanese children.

We paid particular attention to the accuracy of the ultrasound examinations. Due to recent advances in ultrasonographic technology, imaging quality has dramatically improved. We used the same high-quality ultrasonography equipment as that used in the Fukushima Health Management Survey. Thyroid ultrasound specialists, such as certified sonographers, conducted the examinations. We judged the thyroid findings according to the same classification as that used in the Fukushima Survey based on the guidelines of the Japan Association of Breast and Thyroid Sonology. These factors are strengths of the current study.

We do not think that the participation bias largely affected the frequency of thyroid nodules and cysts because the overall participation rate was relatively high. However, several limitations possibly exist in further applying these results to Japanese general populations aged  $< 18$  years. In our study population, the group aged between 3 and 5 years was much smaller than the other age groups, and there were slightly more females than males. Because the frequency of thyroid nodules and cysts is generally higher in females than in males and increases with age [7], the frequency found in this study might be higher than those seen in the similar populations. Inter-observer differences in the ultrasound examinations, iodine consumption, socio-ecological and educational backgrounds, and the lack of information regarding individual family and past histories must also be taken into consideration. Therefore, careful interpretation is required when comparing the frequency of thyroid nodular lesions between different populations. Further detailed analyses will be conducted in a future study.

**Conclusion**

In summary, the current study investigated the frequency of ultrasonographically detected thyroid nodular lesions in Japanese children aged between 3 and 18 years in the general population of three prefectures (Aomori, Yamanashi and Nagasaki). Of the 4,365 children, 4,321 participants (99 %) were classified with a status of ‘A’ (indicating that no further examinations were required) and 44 participants (1 %) were classified with a status of ‘B’ (indicating the presence of nodules with a diameter of  $\geq 5.1$  mm or cysts with a diameter of  $\geq 20.1$  mm). No participants were classified with a status of ‘C’ (indicating the presence of thyroid findings that required immediate further examinations). Although careful interpretation is required, these results would be useful for evaluating thyroid nodular findings on ultrasonography in Japanese children.

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