Childhood and adolescent thyroid cancer after the Fukushima NPP accident

Department of Thyroid and Endocrinology, Fukushima Medical University, School of Medicine

Shinichi Suzuki
Introduction

• After the Fukushima Daiichi Nuclear Power Plant accident that followed the Great East Japan Earthquake and tsunami on March 11, 2011, residents in Fukushima Prefecture faced the problem of health effects caused by low-dose radiation exposure.
Thyroid Ultrasound Examination (TUE) Schedule

A large-scale thyroid ultrasound examination (TUE) decided to perform for people aged 18 years or younger at the time of the disaster.

• **Preliminary Baseline Survey (PBLS) subjects:** 368,000
  ① 1st survey: FY2011, from October 2011 to March 2012
  ② 2nd survey: FY2012, from April 2012 to March 2013

• **Full scale survey (FSS) subjects:** 380,000
  ① 1st survey: FY2014, from April 2014 to March 2015
  ② 2nd survey: FY2015, from April 2015 to March 2016

The full-scale survey will then continue every two years for each subject until the age of 20, then every five years thereafter for the remainder of each subject’s life.

TUE was performed first on those who were living in high-exposure areas at the time of the accident.

S Suzuki Clinical Oncol 2016 in press
Primary examination of TUE from Oct 9, 2011 at Fukushima Medical University Hospital

S. Suzuki, FMU
Summary of the results of TUE

**Preliminary baseline survey (PBLS)** 2011/10/09–2014/03/31
2015/4/30 finished (primary exam)
2016/3/31 collected (confirmatory exam)

- No. of primary exam. 300,476 subjects
  - participation rate: 81.7%
- Category B; 2293 (0.8%)
- Category C; 1 (0.0%)
- Confirmatory exam.
  - participation rate: 92.8%
- Malignant or suspected malignancy
  - 116 subjects
- Surgical treatment
  - 102 subjects
  - 101 thyroid cancer
  - 1 benign tumor

**Full scale survey (FSS)** 2014/04/01–2016/03/31

- No. of primary exam. 267,769 subjects
  - participation rate: 70.2%
- Category B; 2,061 (0.8%)
- Category C; 0 (0.0%)
- Confirmatory exam.
  - participation rate: 65.3%
- Malignant or suspected malignancy
  - 57 subjects
- Surgical treatment
  - 30 subjects
  - 30 thyroid cancer

S. Suzuki, FMU
Treatment of childhood thyroid cancer in Fukushima
Outcome of suspicious or malignant cases

Suspicious or malignant: 172

IC

Surgery completed: 132

Waiting for surgical Treatment

Nonsurgical Observation

cT1acN0cM0 without extrathyroidal invasion: 40

11 cases
Hope

S. Suzuki, FMU
Operation cases of Fukushima TUE from August 2012 to March 2016

Total number 132

Fukushima Medical University 125
  1 benign thyroid nodule
  124 thyroid cancers

Other institutions 7 thyroid cancers
Characteristics of 125 thyroid cancers in Fukushima Medical University from August 2012 to April 2016

- M:F 44:81 (1:1.8)
- Mean age at disaster $14.8 \pm 2.7$ (5–18)
- Mean age at diagnosis $17.8 \pm 3.1$ (9–23)
- Tumor location
  - Ipsilateral* 121 (96.8%)
  - Bilateral 4 (3.2%)

*:R 67  L 53  Isthmus 1  S. Suzuki, FMU
Preoperative findings  n=125

- Tumor size (largest measurement) 14.0±8.5 mm (5–53)

- cT
  - 1a  44 (35.2%)
  - 1b  57 (45.6%)
  - 2   12 (9.6%)
  - 3   12 (9.6%)

- cN
  - 0   97 (77.6%)
  - 1a  5 (4.0%)
  - 1b  23 (18.4%)

- M
  - 0   122 (97.6%)
  - 1   3 (2.4%)

S. Suzuki, FMU
## Preoperative findings  n=125

<table>
<thead>
<tr>
<th></th>
<th>1a</th>
<th>44 (35.2%)</th>
<th>1b</th>
<th>57 (45.6%)</th>
<th>2</th>
<th>12 (9.6%)</th>
<th>3</th>
<th>12 (9.6%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cN</td>
<td>0</td>
<td>97 (77.6%)</td>
<td>1a</td>
<td>5 (4.0%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cEx</td>
<td>0</td>
<td>106 (74.8%)</td>
<td>1</td>
<td>19 (15.2%)</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>0</td>
<td>122 (97.6%)</td>
<td>1</td>
<td>3 (2.4%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **cT1a (< 10mm) cN0M0 44 (35.2%)**

- **Suspect of**
  - EX 1 or 2  20
  - N1a  3
  - RLN invasion  10
  - trachea invasion  7
  - Graves disease  1
  - GGO (lung)  1

- **Hope  11**

S. Suzuki, FMU
Surgical treatment is indicated for papillary microcarcinoma patients with clinical lymph node metastasis on palpation or imaging studies, distant metastasis, or significant extrathyroidal extension. Patients without these features can be candidates for observation after extensive explanation and obtaining informed consent.

Close to trachea, nearby recurrent nerve, suspect of extrathyroidal Invasion or lymph node metastasis

Recommended FNAC or surgery

S. Suzuki, FMU
Active surveillance (AS) for micropapillary thyroid cancer

• Indication; for adult only
• No evidence for children and AYA* generation
• Because under 40 years cases were increasing dropout due to increasing tumor size during AS

*:Adolescent and young adult
## Operation method

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total thyroidectomy</td>
<td>11</td>
<td>8.8%</td>
</tr>
<tr>
<td>Hemi-thyroidectomy (Lobectomy)</td>
<td>114</td>
<td>91.2%</td>
</tr>
</tbody>
</table>

*skin incision 4-5cm, **skin incision 3cm

### Lymph node dissection

<table>
<thead>
<tr>
<th>Node</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>103</td>
<td>82.4%</td>
</tr>
<tr>
<td>D2a</td>
<td>2</td>
<td>1.6%</td>
</tr>
<tr>
<td>D2b</td>
<td>20</td>
<td>16.0%</td>
</tr>
<tr>
<td>D3b</td>
<td>2</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

Central node 82.4%
Lateral node 17.6%

S. Suzuki, FMU
### Postoperative findings

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pT</strong></td>
<td>1a</td>
<td>43</td>
<td>34.4%</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>31</td>
<td>24.8%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>1.6%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>49</td>
<td>39.2%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>pEx</strong></td>
<td>0</td>
<td>75</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>49</td>
<td>39.2%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>1</td>
<td>0.8%</td>
</tr>
<tr>
<td><strong>pN</strong></td>
<td>0</td>
<td>28</td>
<td>22.4%</td>
</tr>
<tr>
<td></td>
<td>1a</td>
<td>76</td>
<td>60.8%</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>21</td>
<td>16.8%</td>
</tr>
</tbody>
</table>

- **pT1** 74 (59.2%)
- **pEx+** 49 (40%)
- **pN1** 97 (77.6%)

S. Suzuki, FMU
cT1a (< 10mm) cN0M0
44 (35.2%)

- Suspect of
  EX 1 or 2  20
  N1a         3
  RLN invasion 10
  trachea invasion 7
  Graves disease 1
  GGO (lung)    1

- Hope        11

Postoperative findings

pT1apN0pEx0  5/44 (11%)
pT1apN0pEx0  3/33
pT1apN0pEx0  2/11
Algorithms for diagnosis and treatment of papillary thyroid carcinoma

1) **N1**: larger than 3cm, invasion to the carotid vein, carotid artery, major nerves (such as the recurrent nerve), anterior vertebral fascia, or with large multiple lymph node metastases
2) **T4(EX2)**: extends beyond mucosal layer of the trachea or esophagus, involving recurrent nerve or trachea

*Note: Lymph node dissection (LND*)

- **Low-risk**
  - T1N0M0
  - Lobectomy (+LND*)
- **High-risk**
  - T>5cm
  - N1 1)
  - EX2 2)
  - M1
  - Total thyroidectomy (+LND*)
  - Postoperative treatment: Ablation, RAI, TSH suppression therapy

Treatment of Thyroid Tumor  Japanese Clinical Guidelines

S. Suzuki, FMU
**Prognostic factors of papillary thyroid cancer.**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Scores</th>
<th>AGES</th>
<th>AMES</th>
<th>MACIS</th>
<th>EORTC</th>
<th>TNM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td>≧40</td>
<td>M&gt;40</td>
<td>≧40</td>
<td></td>
<td>≧45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F&gt;50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td>-</td>
<td>M</td>
<td>-</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Tumor size</td>
<td></td>
<td>+</td>
<td>≧5cm</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Grading</td>
<td></td>
<td>3,4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EX</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Radicality</td>
<td></td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*: significant  - : not significant


Prophylactic RAI without high risk cases;
In Japan, RAI for children; conservative
Problem of Levothyroxine supplement after total thyroidectomy

S. Suzuki, FMU
Algorithms for diagnosis and treatment of papillary thyroid carcinoma

PTC

TNM classification

T1N0M0

Gray Zone

T>5cm

1) N1: larger than 3cm, invasion to the carotid vein, carotid artery, major nerves (such as the recurrent nerve), anterior vertebral fascia, or with large multiple lymph node metastases

2) T4(EX2): extends beyond mucosal layer of the trachea or esophagus, involving recurrent nerve or trachea

Low-risk

Lobectomy (+LND*)

*: Lymph node dissection

Mid-risk

Total thyroidectomy (+LND*)

High-risk

Postoperative Treatment

Ablation, RAI, TSH suppresion therapy

1) N1: larger than 3cm, invasion to the carotid vein, carotid artery, major nerves (such as the recurrent nerve), anterior vertebral fascia, or with large multiple lymph node metastases

2) T4(EX2): extends beyond mucosal layer of the trachea or esophagus, involving recurrent nerve or trachea

Postoperative observation

S. Suzuki, FMU
Comparison of operation method between Belarus after Chernobyl accident and Fukushima after the accident

Belarus

- n=740
- Mean age 11.7 (range, 4.2–14.9)

Fukushima

- N=125
- Mean age 17.8 (range, 9–23)

Demidchik YE, et al.
Ann Surg 2006;243:525-532

S. Suzuki, FMU
### Histopathological type of 125 thyroid cancers

<table>
<thead>
<tr>
<th>Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papillary thyroid carcinoma</td>
<td>121</td>
</tr>
<tr>
<td>classical type</td>
<td>110</td>
</tr>
<tr>
<td>follicular variant</td>
<td>4</td>
</tr>
<tr>
<td>diffuse sclerosing variant</td>
<td>3</td>
</tr>
<tr>
<td>solid variant</td>
<td>0</td>
</tr>
<tr>
<td>cribriform-morular variant</td>
<td>4</td>
</tr>
<tr>
<td>Poorly differentiated thyroid carcinoma</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
</tr>
</tbody>
</table>
Histopathological type of 125 thyroid cancers

• Papillary thyroid carcinoma 121
  classical type 110
  follicular variant 4
  diffuse sclerosing variant 3
  solid variant 0
  cribriform-morular variant 4

• Poorly differentiated thyroid carcinoma 3

• Others 1

S. Suzuki, FMU
### Mutation profile in different groups

<table>
<thead>
<tr>
<th>mutation</th>
<th>Sporadic, adults</th>
<th>Sporadic, children</th>
<th>Post-Chernobyl, children</th>
<th>our data Ja adults</th>
<th>Fukushima n=52</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAF</td>
<td>40–50%</td>
<td>3–6%</td>
<td>0 * 4–16% **</td>
<td>60–80%</td>
<td>63.2%</td>
</tr>
<tr>
<td>RAS</td>
<td>10–15%</td>
<td>0</td>
<td>0</td>
<td>5%</td>
<td>0</td>
</tr>
<tr>
<td>RET/PTC</td>
<td>20–30%</td>
<td>50–60%</td>
<td>64–86% * 50–60% **</td>
<td>5–10%</td>
<td>10.3%</td>
</tr>
<tr>
<td>AKAP9/BR AF</td>
<td>1%</td>
<td></td>
<td>11% * 0 **</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TRK fusion</td>
<td>0–10%</td>
<td></td>
<td>3–7%</td>
<td>4%</td>
<td>8.8%</td>
</tr>
</tbody>
</table>

*In tumors developed after short latency (< 7-10 yr)

**In tumors developed after long latency (> 9-10 yr)

**BRAFV600E** mutation is highly prevalent in thyroid carcinomas in the young population in Fukushima: a different oncogenic profile from Chernobyl

Mitsutake, et al.


S. Suzuki, FMU


[www.nature.com/scientificreports](http://www.nature.com/scientificreports)
Age distribution of childhood thyroid cancer patients in Ukraine after Chernobyl and in Fukushima after the NPP accident.

Tronko MD, Saenko VA, Shpak VM, Bogdanova TI, Suzuki S, Yamashita S.
Age Distribution of Childhood Thyroid Cancer Patients in Ukraine After Chernobyl and in Fukushima After the TEPCO-Fukushima Daiichi NPP Accident. Thyroid 2014,
FIG. 4. Distribution of the estimated four-month (March 11 to July 11, 2011) cumulative effective dose in children and adolescents from 0 to 18 years of age at the time of the accident. The numbers in parentheses indicate those with records of residence/action for less than four months. Of the 63 patients diagnosed with or suspected for carcinoma, 45 (71.4%), including five whose record of residence/action did not extend to four months, were exposed to a cumulative effective dose of <1 mSv.
Prevalence of thyroid cancer or suspected thyroid cancer diagnosed by FNAC in Fukushima Prefecture

*S Suzuki*  *Clinical Oncol* 2016, 28(4):263-271

<table>
<thead>
<tr>
<th>Area</th>
<th>Level of radiation exposure</th>
<th>Implementation fiscal year</th>
<th>No. subjects screened</th>
<th>Suspicious or malignant cases*</th>
<th>Proportion of suspicious or malignant cases (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>①</td>
<td>High</td>
<td>FY2011</td>
<td>41,810</td>
<td>15</td>
<td>0.036</td>
</tr>
<tr>
<td>②</td>
<td>Medium</td>
<td>FY2012</td>
<td>139,338</td>
<td>56</td>
<td>0.039</td>
</tr>
<tr>
<td>③</td>
<td>Low</td>
<td>FY2013</td>
<td>119,328</td>
<td>42</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>300,476</td>
<td>113</td>
<td>0.038</td>
</tr>
</tbody>
</table>

* Excluding one suspected case found benign after surgery

Heat map of the radiation dose

Since Oct.9, 2011
FIG. 1. (a) Map of Japan and Fukushima prefecture. Green area denotes Fukushima prefecture. (b) Schematic map of baseline survey for thyroid disease by ultrasonography in four areas, including the evacuation zone (1; 13 municipalities, survey performed between October 2011 and March 2012); Nakadori (2; 27 municipalities, survey performed between April 2012 and March 2014); Iwaki and Soma (3; 3 municipalities, survey performed between April 2013 and March 2014); and Aizu (4; 16 municipalities, survey performed between April 2013 and June 2014).
The overall prevalence of childhood thyroid cancer in Fukushima was determined to be 37.3 per 100,000 with no significant differences between evacuated and non-evacuated areas.

<table>
<thead>
<tr>
<th></th>
<th>1 Evacuation zone</th>
<th>2 Nakadori</th>
<th>3 Iwaki and Soma</th>
<th>4 Aizu</th>
<th>Overall Fukushima</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible population</td>
<td>47,768</td>
<td>199,451</td>
<td>70,539</td>
<td>49,927</td>
<td>367,686</td>
</tr>
<tr>
<td>Number screened</td>
<td>41,810</td>
<td>169,158</td>
<td>55,788</td>
<td>32,720</td>
<td>300,476</td>
</tr>
<tr>
<td>Average age in years at the time of screening (standard deviation)</td>
<td>10.4 (5.3)</td>
<td>10.7 (5.1)</td>
<td>11.2 (5.0)</td>
<td>11.2 (4.6)</td>
<td>10.7 (5.0)</td>
</tr>
<tr>
<td>Sex (% female)</td>
<td>49.6</td>
<td>49.3</td>
<td>49.9</td>
<td>49.7</td>
<td>49.5</td>
</tr>
<tr>
<td>External radiation doses during 4 months</td>
<td>1.1%</td>
<td>0.007%</td>
<td>0.004%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Proportion of doses &gt;5 mSv\textsuperscript{a} Arithmetic mean\textsuperscript{a} (mSv)</td>
<td>0.8</td>
<td>1.0</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Patients needing confirmatory testing</td>
<td>221</td>
<td>1230</td>
<td>509</td>
<td>334</td>
<td>2294</td>
</tr>
<tr>
<td>Number of confirmatory tests performed (%)</td>
<td>197 (89.1)</td>
<td>1111 (90.3)</td>
<td>459 (90.2)</td>
<td>289 (86.5)</td>
<td>2056 (89.6)</td>
</tr>
<tr>
<td>Diagnosed or suspected cancer cases\textsuperscript{b}</td>
<td>14</td>
<td>63</td>
<td>24</td>
<td>11</td>
<td>112\textsuperscript{c}</td>
</tr>
<tr>
<td>Diagnosed or suspected cancer per 100,000</td>
<td>33.5</td>
<td>37.2</td>
<td>43.0</td>
<td>32.6</td>
<td>37.3</td>
</tr>
<tr>
<td>Odds ratio compared with Aizu</td>
<td>1.223</td>
<td>1.212</td>
<td>1.189</td>
<td>1.0 (reference)</td>
<td></td>
</tr>
<tr>
<td>[confidence interval]</td>
<td>[0.554–2.699]</td>
<td>[0.638–2.300]</td>
<td>[0.582–2.429]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a}External radiation doses (effective dose) individually estimated for respondents to the Basic Survey. Background (natural) radiation dose was subtracted in the estimation (14).

\textsuperscript{b}Number of diagnosed or suspected cancer cases by fine-needle aspiration cytology/number of children screened×100,000.

\textsuperscript{c}Excluding one patient with benign tumor confirmed after surgery.

The baseline survey for thyroid screening was performed in two and half years from October 2011 to March 2014 in four different areas as follows: October 2011 to March 2012 in the evacuation area, April 2012 to March 2013 in 83% of Nakadori and April 2013 to March 2014 in the remaining 17% of Nakadori, and April 2013 to June 2014 in Iwaki and Soma, and Aizu.
Did thyroid cancer occur in these patients as a result of radiation exposure after the Fukushima Daiichi NPP Accident?

Tentative answer: “No”.

• Exposure levels in Fukushima were extremely low. It is highly likely that no children have exceeded the maximum exposure level of 50mSv (intervention level).

• Symptoms of radiation-induced thyroid cancer will appear following a latency period of at least four to five years; however, only five years have passed since the Fukushima accident.

• The carcinogenic risk would be heightened if the subjects were young at the time of the accident, but the average age of these malignant or suspected malignant cases was 15 years old and the youngest age group (0–5) has shown no occurrence of cancer to date.

• There was no difference in the thyroid cancer discovery rate within the five-year period.

• Unlike Chernobyl, most cases were diagnosed with classical PTC, and there were no solid variant PTCs. Genetic alteration was also different between Chernobyl and Fukushima’ children.

The results of the FSS study were similar to those of the PBLS study.

S. Suzuki, FMU
Problems after US screening in Fukushima

S. Suzuki, FMU
Malignant or suspected malignancy cases by FNAC every held in Prefectural Oversight Committee Meeting (POCM) for Fukushima Health Management (FHM) Survey

These data was announced every held in POCM
Diagnostic rate
(No. of Malignant and suspected malignancy/ No. of primary examination subjects)

PBLS+FSS

S. Suzuki, FMU
High prevalence of thyroid cancer in Fukushima after NPP accident

- Radiation exposure due to the Fukushima Daiichi NPP accident
- Over-diagnosis/Over-treatment
- Watch & Follow to avoid over-diagnosis/treatment
- Anxiety
- Harmful rumor
- Screening bias
- Mass screening effect
- S. Suzuki, FMU
Screening cancer vs clinical cancer

Preclinical cancer

Asymptomatic cancer

Latent cancer

Incidental cancer

Screening cancer

Incidental cancer

Asymptomatic cancer

Clinical cancer

Symptomatic cancer

Guidelines

T >10mm
N+
Ex+
M+

S. Suzuki, FMU
### Changing trends in the management of well-differentiated thyroid carcinoma in Korea.

Percentages of respondents recommending FNAC as a function of thyroid tumor size compared to Fukushima HMS

<table>
<thead>
<tr>
<th>Size of tumor</th>
<th>2009 (n=90)</th>
<th>2014 (n=101)</th>
<th>Fukushima HMS (2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 mm</td>
<td>94.4 %</td>
<td>53.5 %</td>
<td>0%</td>
</tr>
<tr>
<td>5-10 mm</td>
<td>100 %</td>
<td>80.2 %</td>
<td>10.0%</td>
</tr>
<tr>
<td>&gt; 10 mm</td>
<td>-</td>
<td>-</td>
<td>60.8%</td>
</tr>
</tbody>
</table>

In Fukushima’s survey, diagnostic criteria is extremely conservative to avoid overdiagnosis. Comparison, therefore, cannot be made with the cases in Korea.

Our criteria to avoid overdiagnosis

Solid lesion

- ≤ 5 mm
  - Observational follow-up
- > 5 mm - ≤ 10 mm
  - Strongly suspicious for malignancy
- > 10 mm - ≤ 20 mm
  - Suspicious for malignancy
- > 20 mm
  - FNAC

Primary

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Edge definition and character of the border</td>
</tr>
<tr>
<td>Benign findings</td>
<td>regular</td>
</tr>
<tr>
<td>Malignant findings</td>
<td>irregular</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S. Suzuki Clinical Oncol. 2016
Our criteria to avoid overdiagnosis

<table>
<thead>
<tr>
<th>Solid lesion</th>
<th>≤ 5 mm</th>
<th>&gt; 5 mm-≤ 10 mm</th>
<th>&gt; 10 mm-≤ 20 mm</th>
<th>&gt; 20 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observational follow-up</td>
<td>Strongly suspicious for malignancy</td>
<td>Suspicious for malignancy</td>
<td>FNAC</td>
<td>FNAC</td>
</tr>
</tbody>
</table>

S. Suzuki Clinical Oncol. 2016
Conclusion

• This long-term, large-scale TUE began in Fukushima.
• At present, in the five years after the NPP accident, preliminary and full-scale TUE surveys have been performed on 300,476 and 267,769 children, respectively.
• Regarding those who underwent FNAC, 116 treated by PLBS and 57 treated by FSS were diagnosed with malignant or suspected malignant tumors.
• Of those subjects, 132 were confirmed as having thyroid cancer after thyroid surgery, and one was confirmed as having a benign nodule as of the end of March 2016.
• The increase of thyroid cancers in Fukushima after the accident seems to be due to a mass screening effect by the large-scale and highly sophisticated ultrasound examination, but not as epidemic due to direct linkage of radiation-induced.
• Causes of the observed thyroid cancers might not be associated with radiation exposure from the Fukushima nuclear accident.
• However, the TUE should be continued long-term to determine whether the risk of childhood and adolescent thyroid cancer due to radiation exposure increases or not.
• The present diagnostic criteria for ultrasound and FNAC as well as the guidelines for surgical treatment must be obeyed in order to avoid over-diagnosis or overtreatment.

S. Suzuki, FMU
# Acknowledgement

<table>
<thead>
<tr>
<th>FMU</th>
<th>Shinichi Kikuchi</th>
<th>Satoshi Suzuki</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seichi Takenoshita</td>
<td>Keiichi Nakano</td>
</tr>
<tr>
<td></td>
<td>Shunichi Yamashita</td>
<td>Mai Ashizawa</td>
</tr>
<tr>
<td></td>
<td>Hitoshi Ohto</td>
<td>Koji Kohno</td>
</tr>
<tr>
<td></td>
<td>Masafumi Abe</td>
<td>Dept. of Thyroid and Endocrinology</td>
</tr>
<tr>
<td></td>
<td>Koichi Tanigawa</td>
<td>Dept. of Organ Regulatory Surgery</td>
</tr>
<tr>
<td></td>
<td>Hiroki Shimura</td>
<td>Thyroid Team of FHM survey</td>
</tr>
<tr>
<td></td>
<td>Sator Suzuki</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toshihiko Fukushima</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Akira Otsur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Akira Sakai</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tetsuya Ohira</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Takashi Matsuzuka</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sanae Miorikawa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yuko Ito</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chiyo Okouchi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hiroshi Mizunuma</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Izumi Nakamura</td>
<td></td>
</tr>
<tr>
<td>Nagasaki Univ.</td>
<td>Shunichi Yamashita</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Noboru Takamura</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Naomi Hayashida</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Norisato Mitsutake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vladimir Saenko</td>
<td></td>
</tr>
<tr>
<td>Hiroshima Univ.</td>
<td>Kenji Kamaiya</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The panels of thyroid experts</td>
<td></td>
</tr>
</tbody>
</table>

Thank you for your attention

S. Suzuki, FMU