Journal of Pediatric Surgery (2013) **48**, 776–781

ELSEVIER

Journal of Pediatric Surgery

www.elsevier.com/locate/jpedsurg

Sacrococcygeal yolk sac tumor developing after teratoma: A clinicopathological study of pediatric sacrococcygeal germ cell tumors and a proposal of the pathogenesis of sacrococcygeal yolk sac tumors

Mariko Yoshida[a,b,*], Kentaro Matsuoka[c], Atsuko Nakazawa[c], Makiko Yoshida[d], Takeshi Inoue[e], Hiroshi Kishimoto[f], Masahiro Nakayama[g], Emi Takaba[h], Minoru Hamazaki[h], Shigeaki Yokoyama[i], Hiroshi Horie[j], Mio Tanaka[a], Kiyoshi Gomi[a], Youkatsu Ohama[k], Hisato Kigasawa[l], Yoshihiro Kitano[m], Hiroo Uchida[n], Yutaka Kanamori[o], Tadashi Iwanaka[b], Yukichi Tanaka[a]

[a]*Division of Diagnostic Pathology, Kanagawa Children's Medical Center, Yokohama, 232-8555, Japan*
[b]*Department of Pediatric Surgery, The University of Tokyo, Tokyo, 113-8656, Japan*
[c]*Department of Pathology, National Center for Child Health and Development, Tokyo, 157-8535, Japan*
[d]*Division of Pathology, Kobe Children's Hospital, Hyogo 654-0081, Japan*
[e]*Department of Pathology, Osaka City General Hospital, Osaka 534-0021, Japan*
[f]*Division of Pathology, Saitama Children's Medical Center, Saitama 339-8551, Japan*
[g]*Department of Clinical Laboratory Medicine and Anatomic Pathology, Osaka Medical Center and Research Institute for Maternal and Child Health, Osaka 594-1101, Japan*
[h]*Department of Pathology, Shizuoka Children's Hospital, Shizuoka 420-8660, Japan*
[i]*Department of Pathology and Laboratory Medicine, Hokkaido Medical Center for Child Health and Rehabilitation, Hokkaido 006-0041, Japan*
[j]*Division of Pathology, Chiba Children's Hospital, Chiba 266-0007, Japan*
[k]*Division of Surgery, Kanagawa Children's Medical Center, Yokohama 232-8555, Japan*
[l]*Division of Oncology, Kanagawa Children's Medical Center, Yokohama 232-8555, Japan*
[m]*Kitano Clinic, Tokyo 157-0071, Japan*
[n]*Division of Pediatric Surgery, Saitama Children's Medical Center, Saitama 339-8551, Japan*
[o]*Department of Pediatric Surgery, National Center for Child Health and Development, Tokyo, 157-8535, Japan*

Received 28 May 2012; revised 22 August 2012; accepted 23 August 2012

* Corresponding author. Division of Diagnostic Pathology, Kanagawa Children's Medical Center, Mutsukawa 2-138-4, Minami-ku, Yokohama 232-8555, Japan. Tel.: +81 45 711 2351; fax: +81 45 742 7821.
E-mail address: mariko_yo_shi_da@ybb.ne.jp (M. Yoshida).

0022-3468/$ – see front matter
http://dx.doi.org/10.1016/j.jpedsurg.2012.08.028

Key words:
Sacrococcygeal teratoma;
Recurrence;
Germ cell tumor;
Yolk sac tumor

Abstract
Purpose: We evaluated the clinicopathological characteristics of pediatric sacrococcygeal germ cell tumors (SGCTs) and yolk sac tumors (YSTs) developing after sacrococcygeal teratoma (SCT) resection, and discussed the pathogenesis of sacrococcygeal YST.
Methods: We retrospectively analyzed pediatric SGCT patients attending 10 Japanese institutions.
Results: A total of 289 patients were eligible, of which 74.6% were girls. The mean age at surgery was 7.1 months. There were 194 mature and 47 immature teratomas, and 48 YSTs. YST developed after SCT resection in 13 patients (5.4% of SCTs), and was detected between 5 and 30 months after resection. At initial surgery, 9 of these 13 patients were neonates, 12 underwent gross complete resection with coccygectomy, and 9 had histologically mature teratoma without microscopic YST foci. Postoperative serum alpha-fetoprotein (AFP) levels were regularly examined in 11 patients. Intervals of AFP measurement ≤ 4 months helped to detect subclinical localized YSTs for resection.
Conclusions: The characteristics of SGCT in Japanese children were similar with those reported in Europe or the United States. YST developed after SCT resection not only in patients with previously reported risk factors. We recommend that patients undergo serum AFP monitoring every 3 months for ≥ 3 years after SCT resection.

Sacrococcygeal germ cell tumors (SGCTs), including mature (MTs) and immature (ITs) teratomas, yolk sac tumors (YSTs), and other malignant tumors, are quite rare with a reported incidence of 1 in 35,000 to 40,000 live births, mostly affecting neonates and infants [1-3]. MTs and ITs are histologically considered to be benign and are usually treated by gross complete resection. However, malignant germ cell tumors, such as YSTs, may occur at the same location after sacrococcygeal teratoma (SCT) resection [1].

Several retrospective and prospective multicenter studies of pediatric SGCTs in Europe and the United States have been reported [2-11]. By contrast, only a few case-series in Japan or other East-Asian countries have been reported [12,13]. These series generally involved a small number of patients, except for the study of prenatally diagnosed SCT reported by Usui et al. [14].

The present study is the first multicenter retrospective study in Japan that considers all pediatric SGCTs. Our aim was to better understand the clinicopathological characteristics of SGCT in Japanese children, particularly of YST occurring after SCT resection, and to discuss the possible pathogenesis of sacrococcygeal YSTs.

1. Methods

We retrospectively analyzed archival cases of pediatric SGCT treated between January 1960 and December 2010. Ten tertiary pediatric medical institutions in Japan, including eight children's hospitals, one general hospital, and one university hospital, participated in this study. We collected data on age, sex, pathological diagnosis, and recurrence/non-recurrence. Teratomas were classified as MTs or ITs as described by Gonzalez-Crussi [15]. Grade 0 or 1 teratomas (tumors containing no or few foci of embryonal tissue but not exceeding 10% of the tumor tissue) were considered to be MTs. For recurrent tumors, more detailed information was sought, and histopathological review was performed. This study was approved by the institutional review board of Kanagawa Children's Medical Center.

Categorical variables were analyzed using χ^2 tests by Microsoft Excel (Microsoft Corporation, Redmond, WA). Values of $P < .05$ were considered statistically significant.

2. Results

2.1. Characteristics of SGCT patients

A total of 289 pediatric SGCT patients were eligible for evaluation. There were 212 girls (74.6%) and 77 boys (25.4%). More than half of the patients were neonates, and approximately 80% were younger than 1 year (Table 1). The mean age at surgery was 7.1 months.

Histological examination showed that there were 194 MTs (67.1%), 47 ITs (16.3%), and 48 YSTs (16.6%; Table 1). The age distribution of MT patients was similar to that of all patients with SGCT, while all IT patients were < 1 year old, and 41 of 48 (85.4%) YST patients were ≥ 1 year old. The mean ages of MT, IT, and YST patients were 4.4, 0.4, and 24.9 months, respectively.

Three patients had mixed germ cell tumors consisting of YST and MT; these patients were included in the YST group. These 3 patients had tumors with different histological characteristics; 2 were neonates with a small YST (4 and 8 mm in diameter) inside or adjacent to a large MT, while a 2 year old girl had a 5 cm YST and a circumferential MT. Two of these patients underwent adjuvant chemotherapy, and no recurrence has been observed. The other patient had a small YST adjacent to an MT but did not undergo adjuvant