Sacroccygeal Dysplasia and its Heredity A Case Report

by

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Sacroccygeal dysplasia is a rare teratism, and since Hohl reported on this disease in 1852 for the first time, some 150 cases had been reported up to 1980 (Peng and Hoffman, 1980)¹⁵⁾ in Europe and the USA, while in Japan only twenty-nine cases have been reported.

Among these cases, five cases in three families in Japan were originated from consanguineous marriages, and two cases in a sibship in a family, though not from an intermarriage of parents, were reported in Japan. In overseas countries there were three cases in a family reported by Robert et al¹⁶⁾, and the cases of a father and a son reported by Pouzet¹⁴⁾. Thus, a possibility of genetic factors is considered in the occurrences of this malformation.

The authors have reported on a case that originated from parents of a marriage between cousins, and discussions of the literature are presented in this paper about the genetic factors of these cases.

CASE REPORT

The patient is a fourteen-year-old girl. There were no particular abnormalities when her mother was pregnant or during the perinatal period. When the patient was two and a half years, she began to walk, but her legs were too slender to walk steadily and she easily fell. Urinary incontinence persisted from infancy and when she was seven, a neurogenic bladder was diagnosed. As the patients grew, lower limb length grew out of proportion to trunk length. At present the shape of her body indicates a figure as shown in Fig. 1, with the shortened neck and posterior curvature of thoracic spine.

Other characteristics are knee valgus, bilateral clubfeet, and shallow gluteal cleft. Mild sensory disturbances are noted in her buttocks and lower limbs, and her muscle power of lower limbs is slightly decreased so that she is unable to run. However, she can walk without much trouble. Currently she weighs twenty-three kilograms and is 124 centimeters tall, smaller and lighter than ordinary children.

RADIOGRAPHIC FINDINGS: The sacroccyx in the lateral view is small; a trace of sacroccyx, about 4.0 centimeters in length from the upper edge of the sacral vertebra

Fig. 1. The whole body picture.

The upper limb on both sides is longer, as compared with her body length. The lower limb demonstrates genu valgum, and clubfoot deformity is noted on both sides. The legs show muscular atrophy.

to the end of the coccyx still remains (Fig. 2-a). The sacroiliac joints are so close that the inner cavity of the pelvis is narrowed and lengthened like a hourglass. The ischium itself is completely defective (Fig. 2-b). The body of the thoracic vertebra looks like a butterfly, indicating an anterior spina bifida. The size of the vertebra is larger in the tho-

Fig. 2-a

Fig. 2-b

Fig. 2—c. X-ray findings.

- a) Lateral view, the small trace of sacrococcyx (arrow mark).
- b) Anteroposterior view, the small sacrococcyx. The lengthened vertical deformity on the inner cavity of the pelvis is noted.
- c) The anterior spina bifida at the thoracic and lumbar vertebrae. The small, deformed lumbar vertebrae and oar-like ribs are seen.

racic vertebra than that in the lumbar vertebra, and the pedicles and the lamina are not clearly defined. The ribs look like oars (Fig. 2-c).

CT FINDINGS: Fig. 3-a shows the 6th thoracic vertebra. The body of the thoracic vertebra is far from a normal circle, being flat in shape in the anteroposterior direction. Enlargement and deformation of the vertebral canal are conspicuous, and especially the posterior region of the spinal canal narrows towards the spinal process. Twisting due to the posterolateral curvature is also observed. Fig. 3-b, show the fifth lumbar vertebra. The body of the vertebra looks like a crescent, with the defect in the middle, indicating the rupture of the vertebral body. Enlargement and deformation of the spinal canal is remarkable, similar to that of the thoracic vertebra.

BIOCHEMICAL FINDINGS AND OBSERVATION OF THE CHROMOSOMES: No abnormalities were noted.

THE PEDIGREE (Fig. 4): Her parents are cousins (III, 4.5). Although five siblings of the father are healthy and alive, two natural abortions were experienced among them (III, 2.3). The six siblings of the mother are all healthy and alive. There were two siblings of the proband (IV, 3), and one natural abortion was experienced (IV, 2).

DISCUSSION

1. Occurrences in the same family

About 180 cases of congenital sacrococcygeal dysplasia have been reported in Japan and in Western countries. Among these reported cases, those suggesting hereditary oc-

Fig. 3. CT findings.

- a) The sixth thoracic vertebra. The body of the vertebra is long and slender, and the invasion of the vertebral canal towards the posterior region is noted.
- b) The fifth lumbar vertebra. Deformation and expansion of the vertebral canal are similar to those of the thoracic vertebrae.

Fig. 4. The pedigree.

The proband (IV-3) was born from parents married between cousins. One abortion was experienced in the siblings (IV-2).

currences are in three families in France, and five families including our own in Japan.

Table 1 describes the details, including the names of the authors, names of the journals, number of families, number of cases, and the consanguinity of the marriages.

- 1) The cases where vertical inheritance was demonstrated

This is an example of dominant inheritance from father to son. This is an irregular dominant inheritance reported by Robert et al. (1974)¹⁶⁾, occurring from the genetic carrier in the first family.

- 2) The cases where the disease occurred in the siblings

- (i) The cases where there were no consanguineous marriages of the parents or ance-

Table 1.

Reporters	Name of Journal	No. of Family	No. of the Case	Consanguineous Marriage	Remarks
1. Pouzet ¹⁴⁾	Lyon. Chir. 1938	1	2	—	father to son
2. Robert et al. ¹⁶⁾	J. Génét. hum. 1974	1	3	—	occurred from genetic-carrier
		1	3	—	occurred in the siblings
3. Yuki ¹⁹⁾	J. Jpn. Orthop. Ass. 1964	1	2	+	parents married between cousins
4. Maeda et al. ¹²⁾	Orthop. Surg. 1964	1	2	—	occurred in the siblings
5. Tasaka et al. ¹⁷⁾	J. Chubunihon Seisai 1967	1	1	+	grandparents married betw. cousins and parents married betw. half-pousins.
6. Kuba et al.		1	1	+	parents married betw. cousins.

but the disease occurred in the siblings of the offspring.

There were two families, and in one of them the disease occurred in all three siblings of the second family reported by Robert et al. (1974)¹⁶⁾. The other was reported by Maeda et al. (1966)¹²⁾ where the disease occurred in two sisters among seven siblings.

(ii) The cases where the parents of ancestors were married consanguineously, and the disease occurred.

There were two cases occurring in two male siblings reported by Yuki (1964)¹⁹⁾ and one case reported by us, on the basis of parents' intermarriages among cousins. There were also two cases of a brother and sister by the marriage between second cousins reported by Maeda et al. (1966)¹²⁾ and one case originated from the complicated intermarriage of the grandfather and grandmother between half-cousins, reported by Tasaka et al. (1967)¹⁷⁾.

II. Experimental occurrence of the disease

1) Hereditary occurrence

A similar condition with this disease was produced genetically in such model animals as Ishibashi rats⁷⁾, laboratory Swiss mice produced by Frye⁸⁾, and rumpless fowls described by Dunn (1925)⁴⁾.

(i) Ishibashi rats⁷⁾: The animals were produced by repeating the mating of a brother and sister, and their signs are very much similar with this disease.

Over the entire area of the vertebra, dysplasia of the body of the vertebra, rupture, partial defect and insufficient fusion, unilateral insufficient separation of the vertebrae constitute the cause for the kyphoscoliosis. In addition, an abnormal number of teeth, the appearance of the lumbar ribs, and dental caries, especially in the second mandibular molar,

are observed. Furthermore, biochemical abnormalities such as the decline in the serum alkaline phosphatase and excessive excretion of urinary phosphorus are noted in these experimental animals, and these are considered to be a syndrome due to pleiotropism.

(ii) Laboratory Swiss mice⁶⁾: By mating the offspring of next generation, or by mating among brothers and sisters to produce their offspring, signs similar to this disease such as short tails, complete defect of the caudal segment, defect of the caudal vertebrae and defect of the sacral segment, were produced (Frye, 1964)⁶⁾.

(iii) Rumpless fowl: There have been two formulas of the occurrence of rumplessness. Dunn (1925)⁴ suggested two causes as hypotheses: one is that it is caused by a monofactorial gene, and the other is that the germ of the caudal vertebra and the tail is formed at an early stage by an accident of embryogeny.

2) Non-hereditary occurrence.

The following are the results of animal experiments in which similar signs with those in this disease were developed due to the so-called environmental factors.

(i) Injection of insulin into the embryo of a fowl produced the rumpless fowl (Landauer, 1945, Duraiswami, 1955).

(ii) The embryo of fowl were subjected to changes in temperature, and rumpless fowl were produced (Danforth, 1932).

(iii) The eggs of a frog were irradiated with ultraviolet rays, and the spina bifida was produced (Baldwin, 1915).

(iv) Rats were kept in a state of alimentary deficiency, and the malformation of the limb and spine occurred in their offspring (Warkany, 1943).

Many authors have been considering that the real cause for the occurrence of this disease is unknown whereas Blumel et al. (1959) and Pang et al. (1980) presumed an association of genetic factors.

As has been mentioned before, there have been several clinical and experimental findings supporting the genetic occurrence theory, while on the other hand, there have been some experimental results suggesting the association of environmental factors. This contradiction may be interpreted in that this disease can be caused both by genetic and environmental factors. However, it may be rather difficult to demonstrate the influence of the environmental factors on humans.

Clinically speaking, this disease has been found in babies born from diabetic mothers, and in Europe and the USA, 16 percent of the babies with this disease were born from diabetic mothers (Pang et al. 1980).

In Japan, there has been one case born from a diabetic mother (Nakamura et al., 1975).

In our case, the influence of environmental factors during the period from pregnancy to childbirth cannot be considered, and a strong possibility of its occurrence due to the homogeneous conjunction of recessive genes may be considered.

However, the occurrence of this disease by this genetic formula has not been found in Europe and the USA, but in Japan there have been six cases in four families, including our own.

SUMMARY

One case of sacrococcygeal dysplasia of a child from an intermarried of cousins has been presented. The authors consider this case to be suggestive of a possibility of hereditary occurrence.

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References

- 1) Baldwin, W. M.: The action of ultra-violet rays upon the frogs egg. I. The artificial production of spina bifida. *Anat. Rec.* 9: 365-381, 1915.
- 2) Blumel, J., Evans, E. B., and Eggers, G. W. N.: Partial and complete agenesis or malformation of the sacrum with associated anomalies. *J. Bone Joint Surg. (Am)*, 41A: 497-518, 1959.
- 3) Danforth, C. H.: Artificial and hereditary suppression of sacral vertebrae in the fowl. *Proc. Soc. Exp. Biol. Med.*, 30: 143-145, 1932.
- 4) Dunn, L. C.: The inheritance of rumplessness in the domestic fowl. *J. Hered.*, 16: 127-134, 1925.
- 5) Duraiswami, P. K.: Comparison of congenital defects induced in developing chickens by certain teratogenic agents with those caused by insulin. *J. Bone Joint Surg.*, 37: 277-294, 1955.
- 6) Frye, F. L., Mcfarland, L. Z., and Enricht, J. B.: Sacrococcygeal agenesis in Swiss mice. *Cornell Vet.*, 54: 487-495, 1964.
- 7) Ischibashi, M. Rat with congenital spinal dysplasia. heredity, 33 : 38-44, 1979. (Japanese)
- 8) Landauer, W.: The morphophology of intermediate rumplessness in the fowl with remarks concerning heredity and accidental rumplessness. *J. Hered.*, 19: 453-467, 1928.
- 9) Landauer, W.: Linkage test in poultry: II Linkage of the rumpless gene. *J. Hered.*, 24: 293-294, 1933.
- 10) Landauer, W. and Dunn, L. C.: Further data on genetic modification of rumplessness in the fowl. *J. Genetics.* 33: 401-405, 1936.
- 11) Landauer, W.: Rumplessness of chicken embryos produced by the injection of insulin and other chemicals. *J. Exp. Zool.*, 98: 65-77, 1945.
- 12) Maeda, S., Kisanuki, T., Uematsu, T., Kiyama, Y., and Kodama, K. Congenital absence of the sacrum. A report of six cases. *Orthop. Surg.* 17: 916-919, 1966. (Japanese)
- 13) Nakamura, M., Kawamura, J., and Hayashi, H. Congenital absence of lumbo-sacro-coccyx. A case report. *Clin. Orthop. Surg.* 10: 543-545, 1975. (Japanese)
- 14) Pouzet, F.: Les anomalies de developpement du sacrum. *Lyon. Chir.* 35: 371-373, 1938.
- 15) Pang, D., and Hoffman, H. J.: Sacral agenesis with progressive neurological defect.

- Neurosurgery. 7: 119-126, 1980.
- 16) Robert, J. M., Pernod, J., et Bonnet, R.: L'agenesis sacrococcygienne famial. A prop de 6 cas dans deux-familles. J. Génét. hum., 22: 45-60, 1974.
 - 17) Tasaka, K., Ueo, T. and Kobayashi, M.: Sacro-coccygeal agenesis. A report of two cases. Cent. Jap. J. Orthop. Traumat. 10: 406-409, 1967. (Japanese)
 - 18) Warkany, J., Nelson, R. C., and Schraffen beyer, E.: Congenital malformation induced in rats by inaternal nutritional deficiency. J. Bone Joint Surg., 25: 261-270, 1943.
 - 19) Yuki, E.: Analysis of chromosomes in systemic disease of bone and joints. J. Jpn. Orthop. Ass. 38 (9): 903-928, 1964. (Japanese)

和 文 抄 録

Sacrococcygeal dysplasia は環境因子の関与を示唆する実験的研究がみられるが、遺伝的発生を裏づける臨床的、実験的事実もある。この自験例は妊娠から出産までを通じて環境因子の影響を受けたとは考えられず、両親のいと結婚であることを考えれば劣性遺

伝子のホモ合接による発生の可能性がつよいと考えられた。この遺伝様式による発生は欧米の文献にはみられず本邦において自験例を含め4家系例6存在する。以上文的考察を加え本症例が遺伝的発生の可能性を示唆していることに関して報告した。