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# Bone Mineral Analysis in Patients with Biliary Atresia after Successful Kasai Procedure

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Toki, A., Todani, T., Watanabe, Y., Sato, Y., Ogura, K., Yoshikawa, M., Yamamoto, S. and Wang, Z.-Q. *Bone Mineral Analysis in Patients with Biliary Atresia after Successful Kasai Procedure.* Tohoku J. Exp. Med., 1997, **181** (1), 213-216 —— Metabolism is probably disturbed in patients with abnormal liver function who have undergone a successful Kasai procedure. We examined bone mineral metabolism in patients who have successfully undergone Kasai procedure. Bone mineral metabolism was examined in 8 patients with biliary atresia after a successful Kasai procedure. Five patients were female and 3 were male. The ages at Kasai procedure ranged from 50 to 80 days, and the follow-up periods ranged from 3 to 27 years after the operation. All patients eat a normal oral diet. We examined plasma levels of 25-OH-$D_3$, 1, 25-$(OH)_2$-$D_3$, Ca and phosphorus (P). Bone mineral content of the lumbar spine ($L_2$-$L_4$) was assessed by dual energy x-ray absorptiometry (DEXA), and the data were expressed as a bone mineral density (BMD). Two patients showed abnormal levels on hepatic function tests. Plasma levels of 1, 25-$(OH)_2$-$D_3$, Ca, and P were normal in all patients. The level of 25-OH-$D_3$ was normal in 7 patients. BMD levels were normal in 6 patients, but low in 2 who had undergone partial splenic embolization and splenectomy, respectively, due to hypersplenism. In long-term survivors of Kasai procedure, measurement of BMD may detect bone mineral deficiency earlier than measurements of serum levels of 25-OH-D, 1, 25-$(OH)_2$-D, Ca and P. ———— biliary atresia; dual energy x-ray absorptiometry; bone mineral density; vitamin D

Vitamin D is hydroxylated to 25-hydroxy-vitamin D (25-OH-D) in the liver and converted to active metabolite 1, 25-dihydroxy-Vitamin D (1, 25-$(OH)_2$-D) in the kidney. Calcium (Ca) is the most abundant mineral in the body. Ca absorption in the intestine is facilitated by 1, 25-$(OH)_2$-D. Metabolism may be disturbed in long-term survivors of the Kasai procedure for biliary atresia who have slight hepatic dysfunction.

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## Patients and Methods

We examined bone mineral metabolism in 8 long-term survivors who successfully underwent a Kasai procedure for biliary atresia (Table 1). Five patients were female and 3 were male. The ages at the time of the Kasai procedure ranged from 50 to 80 days. The follow-up periods ranged from 3 to 27 years after surgery. All patients were able to eat a normal diet daily. We examined plasma levels of 25-OH-$D_3$, 1, 25-$(OH)_2$-$D_3$, Ca and phosphorus (P) and assessed bone mineral content of the lumbar spine ($L_2$-$L_4$) by dual energy x-ray absorptiometry (DEXA) (Lunar Exp-5000, Jeol Trading Co., Ltd., Madison, WI, USA), and the data were expressed as bone mineral density (BMD).

## Results

Weights and heights of all patients were within the normal ranges as evaluated by the growth chart. Hepatic functions in all patients were as follows: total bilirubin; 0.3–2.5 mg/100 ml, direct bilirubin; 0.2–1.7 mg/100 ml, GOT; 17–156

Table 1. *Physical characteristics of patients*

| Case | Sex | Age (years) | Age at operation (days) | Type of BA | Hypersplenism | Fracture |
|---|---|---|---|---|---|---|
| 1 | M | 3 | 64 | III-$b_1$-$\mu$ | +(PSE) | + |
| 2 | F | 5 | 50 | III-$b_1$-$\nu$ | − | − |
| 3 | M | 5 | 74 | III-$a_1$-$\nu$ | − | − |
| 4 | F | 9 | 57 | III-$b_1$-$\nu$ | +(PSE) | − |
| 5 | F | 17 | 70 | I cyst-$c_1$-$\beta$ | − | − |
| 6 | M | 23 | 80 | III-$c_1$-$\mu$ | +(PSE) | − |
| 7 | F | 25 | 64 | III-$a_1$-$\nu$ | − | − |
| 8 | F | 27 | 78 | II-$b_1$-$\beta$ | +(splenectomy) | + |

M, male; F, female; PSE, partial splenic embolization.

Table 2. *Liver function of patients*

| Case | GOT (U/liter) | GPT (U/liter) | Alp-ase (U/liter) | T-bil (mg/100 ml) | D-bil (mg/100 ml) |
|---|---|---|---|---|---|
| 1 | 69 | 72 | 959 | 0.5 | 0.2 |
| 2 | 23 | 22 | 504 | 0.3 | 0.2 |
| 3 | 31 | 14 | 512 | 1.4 | 0.3 |
| 4 | 69 | 54 | 780 | 0.6 | 0.2 |
| 5 | 46 | 39 | 207 | 1.6 | 0.6 |
| 6 | 27 | 27 | 334 | 1.4 | 0.5 |
| 7 | 17 | 9 | 155 | 0.6 | 0.2 |
| 8 | 156 | 152 | 1005 | 2.5 | 1.7 |

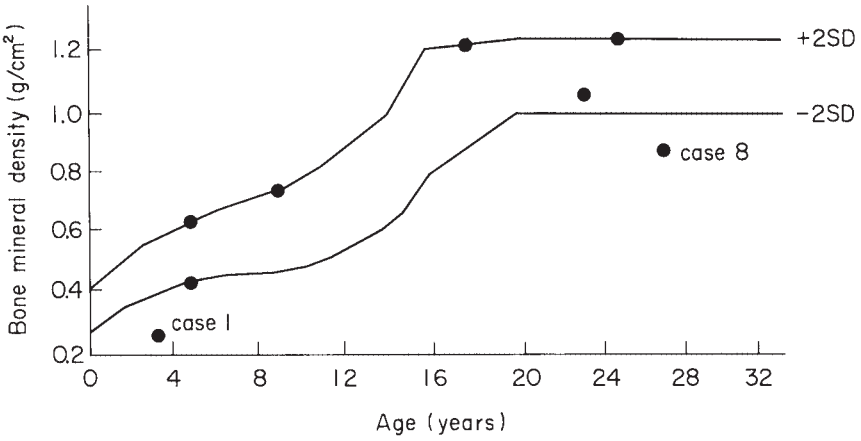


Fig. 1. Bone mineral density obtained by dual energy x-ray absorptiometry.

U/liter, and GPT; 9–152 U/liter. Cases 1 and 8 showed abnormal levels in hepatic function tests (Table 2). Plasma levels of Ca, P and 1, 25-$(OH)_2$-$D_3$ were normal in all patients. Levels of 25-OH-$D_3$ were normal in 7 patients, but not in case 8. BMD levels were normal in 6 patients, but low in cases 1 and 8 (Fig. 1).

## Discussion

In hepatic dysfunction in patients with biliary atresia, the intestinal absorption of Ca, P and vitamin D, which is facilitated by bile salts, appears to be impaired, and 25-hydroxylation of vitamin D in the liver is probably decreased. Vitamin D in humans is mainly composed of vitamin $D_2$ supplied from an oral diet and vitamin $D_3$. Provitamin $D_3$ is converted to previtamin $D_3$ through ultraviolet irradiation of the skin, and previtamin $D_3$ is isomerized to vitamin $D_3$ in the skin. Vitamin D transported to the liver is hydroxylated to 25-OH-D which is transported to the kidney where 1, 25-$(OH)_2$-D is produced. 1, 25-$(OH)_2$-D increases intestinal absorption of Ca and P, and mobilizes Ca and P from bone.

Bone mineral content consists mainly of Ca, P and Mg (magnesium). Ca is absorbed by active transport in the duodenum and passive diffusion in the ileum and jejunum (Venkataraman et al. 1985). P is absorbed in the jejunum and terminal ileum through active mechanisms (Harrison and Harrison 1961). The absorption of P is increased by the presence of vitamin D and decreased by a high Ca diet. On the contrary, Ca and Mg interact with the parathyroid hormone, calcitonin and 1, 25-$(OH)_2$-D. Ca and Mg are possibly absorbed in the intestine at a common site (Alcock and MacIntyre 1962). In the bone, low serum Mg concentrations are associated with decreased Mg-Ca exchange, and thus with decreased Ca release from bone. Therefore, hypocalcemia is accompanied by hypomagnesemia (Chase and Slatopolsky 1974). Consequently, serum Mg levels in our series may be assumed to be normal because of the normal Ca levels in plasma in our findings.

The bone is composed of both compact and trabecular bone tissue. The trabecular bone has abundant cell components, and supports active bone metabo-

lism (Yamada et al. 1992). Therefore, we examined the bone mineral content of the lumbar spine which is mostly composed of trabecular bone tissue using DEXA. Because of its low irradiation exposure, rapid scanning, and precision, DEXA is a less invasive method suitable for use with infants and children (Wahner et al. 1988; Glastre et al. 1990; McCormick et al. 1991).

We performed partial splenic embolization in cases 1, 4 and 6, and splenectomy in case 8, due to hypersplenism. Cases 1 and 8 developed bone fractures, probably due to disturbance of bone metabolism. However, serum Ca, P and 1, 25-$(OH)_2$-D levels were normal in all patients, and 25-OH-D was also normal in all except case 8. BMD levels were low in cases 1 and 8. Accordingly, our findings show that the measurement of BMD, as evaluated by DEXA, possibly detects the deficiency of bone mineral content earlier than measurement of serum 25-OH-D, 1, 25-$(OH)_2$-D, Ca, and P in long-term survivors after a Kasai procedure.

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