Difference in Calcium Metabolism Following Billroth-I and Billroth-II Procedures for Gastric and Duodenal Ulcers

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ABSTRACT: There have been 7 patients with postoperative osteomalacia in our series of 500 patients who had a gastrectomy for gastric or duodenal ulcers. All seven of these patients had a Billroth-II type gastrojejunostomy or esophagojejunostomy which caused food to bypass the duodenum and the upper part of the jejunum, and six of these patients showed milk intolerance and had diarrhea on food other than cow's milk. From this finding, it may be surmised that patients are predisposed to osteopenia after gastrectomy due to disorder in the process of calcium absorption and they develop osteomalacia when treated with the Billroth-II procedure, showing milk intolerance and diarrhea on food other than cow's milk.

KEY WORDS: milk intolerance, calcium, phosphorus, osteoporosis, osteomalacia and Index Bone Area.

INTRODUCTION

A previous paper reports that milk intolerance, or the inability to take cow's milk was found in 30% of patients after a gastrectomy, often in association with postoperative hypocalcemia.[3] Furthermore, it has been recently found that patients treated with the Billroth-II procedure tend to develop hypocalcemia. In the present study we investigated postgastrectomy milk intolerance and osteomalacia in relation to the difference in calcium metabolism following two surgical procedures, the Billroth-I (B-I) and Billroth-II (B-II).

SUBJECTS AND METHODS

Five-hundred patients for whom we could follow up the postoperative state were selected from the 900 patients who had a gastrectomy for gastric or duodenal ulcers at the Niigata University Hospital in the period between 1960 and 1974; postoperative complaints were checked in all and absorption tests, including a ^{131}I-triolein absorption test,[5] were carried out in selected cases. Pre- and post-operative data on serum calcium, phosphate and alkaline phosphatase available were chosen from those on whom a gastrectomy had been performed more than one year previously; they were investigated for serum calcium, phosphate and alkaline phosphatase in relation to both the postoperative status of taking cow's milk and the operative procedure.

In each case suspected of osteomalacia, a bone biopsy was performed from the left 11th rib under the double labelling technique with tetracycline using a non-decalcified

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Table 1. Complaints after gastrectomy

Operative procedure	Milk Intolerance	Diarrhea	Early Dumping syndrom
B-I (181)	30%	20%	8%
B-II(177)	28%	20%	12%

specimen, and measurement was made of various parameters.[2,19]

Diagnosis of osteomalacia

For diagnosis of osteomalacia, we have employed the following laboratory tests in the outpatient clinic.

a) Blood biochemical examination
   1) Serum calcium and phosphate concentration (normal or slightly low even within normal ranges)
   2) Serum alkaline phosphatase activity (confirm release from bone tissue)

b) Bone x-ray examination
   1) Measurement of I.B.A.
   2) Findings of the head of femur (classification of Singh)[17]

c) Bone biopsy

In about 30 patients who were treated with a gastrectomy by the same surgeon five to six years ago, measurement was made of the I.B.A. (Index Bone Area) by the method of Virtama et al.[21] and these data were compared with those of 240 healthy subjects. The incidence of osteopenia after gastrectomy was examined and studies were made concerning whether or not there was any difference between the effects of the B-I and B-II procedures.

Results

When patients in whom ingestion 180 ml of cow's milk after a gastrectomy developed gastrointestinal symptoms such as diarrhea, abdominal pain, fullness in the abdomen, borborygus and nausea with consequent inability to take milk, they were considered to exhibit postgastrectomy milk intolerance; 30% of the gastrectomized patients were found to have this disorder, 20% of these patients complained of diarrhea after taking food other than cow's and 10% suffered from the early dumping syndrome. But there was no significant difference between the effects of the two surgical procedures, B-I and B-II (Table 1).

In a further study, 63 patients who received gastrectomies more than one year previously provided us with data on pre- and post-operative serum calcium and were investigated for serum calcium in relation to the postoperative status of taking cow's milk (Fig. 1). A group of patients for whom the intake of cow's milk had to be restricted because of the development of the above-mentioned symptoms postoperatively exhibited serum calcium levels significantly lower than those prior to operation. In contrast, another group of patients who took cow's milk every day regardless of the presence or absence of the symptoms showed no significant postoperative decrease in serum calcium as compared with preoperative levels.

Concerning the treatment for milk intolerance, we examined the effects of a lactase preparation in 98 patients with milk intolerance. Administration of 0.5 gr of the lactase preparation at the time of milk intake revealed a statistically significant decrease in fre-

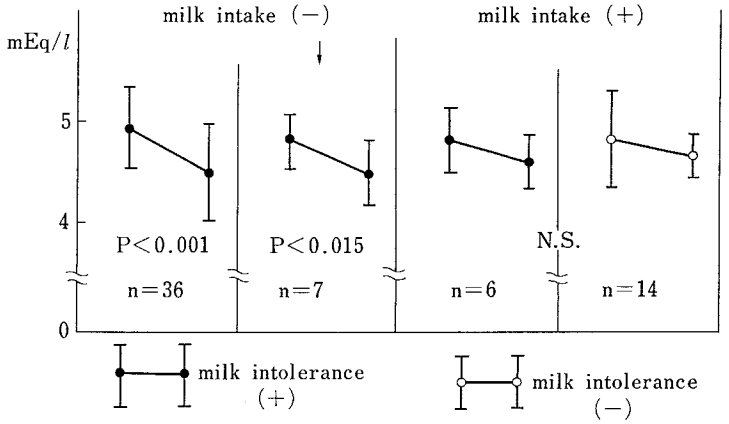

Fig. 1. Milk Intolerance and Serum Ca *Concentration after Gastrectomy
*Ca: serum calcium
(−): patients who have taken no cow's milk after surgery
(+): patients who have restricted cow's milk because of the developent of symptoms of postoperative milk intolerance
↓: patients who have taken little cow's milk after surgery

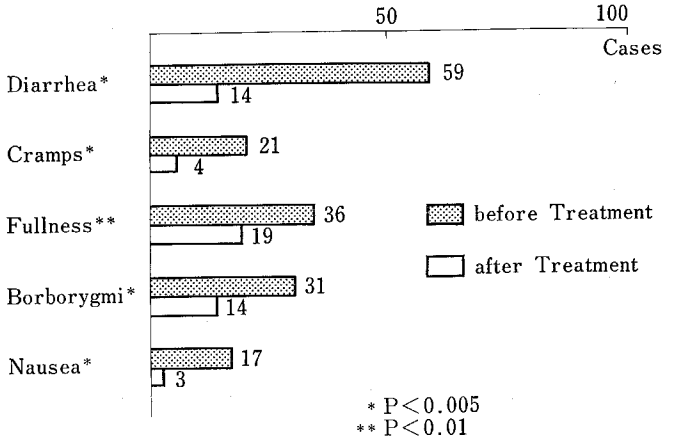

Fig. 2. Effects of Lactase Preparation

quency of the symptoms (Fig. 2). During outpatient treatment for patients who had been gastrectomized for ulcer, we found 7 cases with osteomalacia during the period 1974 to 1977 (Table 2). Three characteristics were recognized in these patients:

1) The diet goes into the jejunum, bypassing the duodenum and the upper part of the jejunum, with the B-II type gastrectomy.

Table 2. Post-gastrectomy osteomalacia

Case	Age	Sex	Yrs. after surg.	ope.	Milk intolerance	Diarrhea	I.B.A.	Ca*	P**	Al-*** pase
No.1	43	M	11(8.9.10)	B-II	+	##	↓	4.3	3.5	10.4
2	61	M	7(4.6)	B-II	+	+	→	4.4	2.0	8.8
3	72	M	9	B-II	+	−	↓	4.4	2.5	10.8
4	57	F	7	B-II	+	+		4.3	2.2	16.6
5	68	M	11	T.G.	−	+	↓	4.3	2.2	12.3
6	62	M	5	T.G.	+	+	↓	4.3	2.7	12.7
7	51	M	30(28.30)	T.G.	+	#	↓	4.3	3.0	10.2

B-II: Partial gastrectomy Billroth II
T.G.: Total gastrectomy Billroth II loop type

* mEq/l
** mg/dl
*** K.A.Unit.

( ): number of years after the operation at which patients developed spontaneous fractures due to postoperative osteomalacia

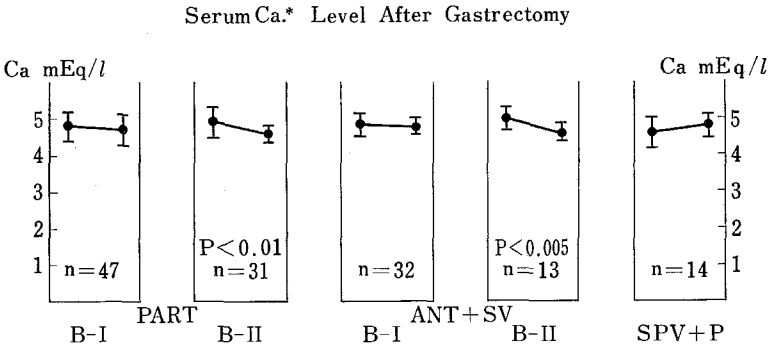

Fig. 3.

*Ca: serum calcium
PART.: partial gastrectomy
ANT+SV: antrectomy plus selective vagotomy
SPV+P: selective proxymal vagotomy plus pyloroplasty

2) Milk intolerance was observed in all except for Case 5, inhibiting cow's milk intake after surgery.
3) There were some types of diet other than milk which tended to cause diarrhea in all except for Case 3.

Small figures in parentheses of Table 2 indicate the number of years after the operation at which patients developed spontaneous fractures due to postoperative osteomalacia.

To determine whether or not the duodenum and the upper part of jejunum play an important role in the absorption of calcium, serum calcium levels were measued in each group of patients for whom preoperative values were available. In the group having B-I gastrectomies, no significant fall was observed in serum calcium levels after surgery while a significant fall was found in the B-II group. In contrast with the findings about the two groups, the level of serum calcium was found to be higher in the selective proximal vagotomy plus pyloroplasty (SPV+P) group (Fig. 3). Serum phosphorus levels failed to show

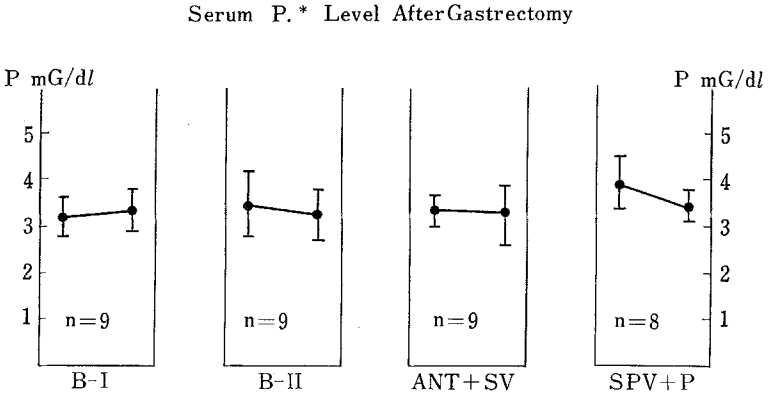

Fig. 4.
*P.: serum phosphate

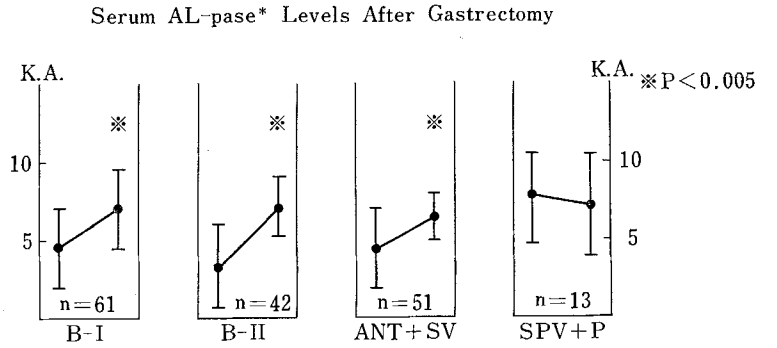

Fig. 5.
*AL-pase: Alkaline phosphatase

any constant tendency (Fig. 4). However, serum alkaline phosphatase levels revealed a statistically significant elevation in all groups except for the SPV+P group (Fig. 5).

Referring to the results of the measurement of the I.B.A., patients showing a normal I.B.A. were very small in number, 20% in the B-II and 50% in the B-I group, as shown in Figs. 6 and 7.

Inversely, a very high incidence of osteopenia was observed 5 to 6 years after surgery in 50% of the B-I and 80% of the B-II group. These patients included a total gastrectomy patient who is noted in Fig. 6 with an arrow. This person showed low serum calcium and phosphate values and a high alkaline phosphatase value and was diagnosed by bone biopsy as havig osteomalacia. Figure 8 shows a pattern of the rib biopsied from Case 6 in Table 1, the person marked with the arrow in Fig. 6. These patterns reveal increased osteoid tissue, poor uptake of tetracycline by the osteoid tissue and poor mineralization.

Discussion

Postgastrectomy osteomalacia was originally reported by Sarasin in 1941.[15] There have been many reports of osteomalacia after gastric resection. Thompson et al.[20] went

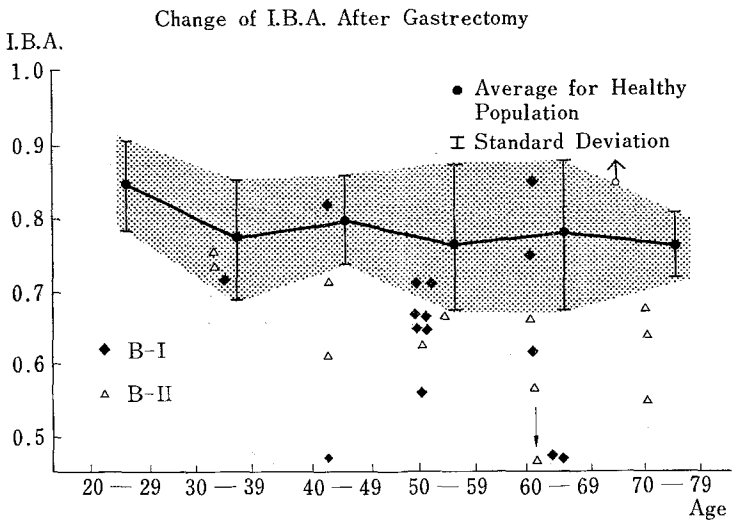

Fig. 6.
↓: Totalgastrectomized patient

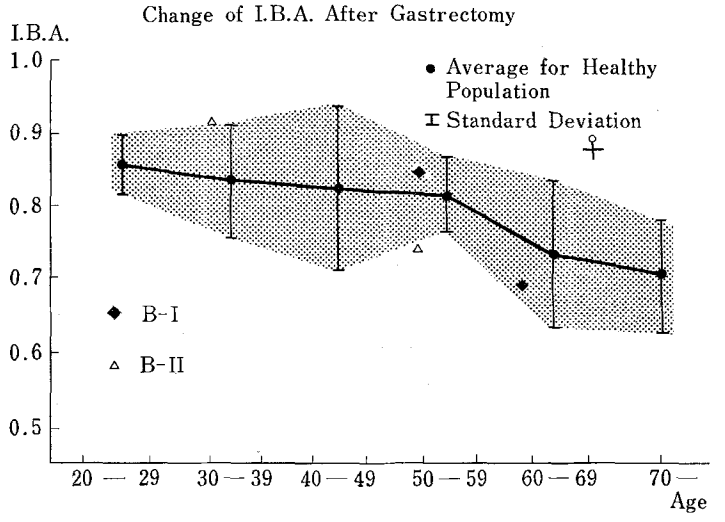

Fig. 7.

so far as to state that gastric resection ranks as the first cause of osteomalacia in Europe. Nilsson et al.[12] made the interesting point that the incidence of bone fracture 20 years after surgery in cases subjected to the B-II gastrectomy was about two times higher than the average for persons in the same age groups.

In Japan, meanwhile, Ikeda et al.[7] reported in 1951[9] about osteomalacia after total gastrectomy, and in 1967 Sakai[14] reported the first case in Japan of a bone lesion after distal gastric resection. Furthermore, Niwayama reported that osteomalacia and osteoporosis were found in 4.9% of patients treated with gastric resection.

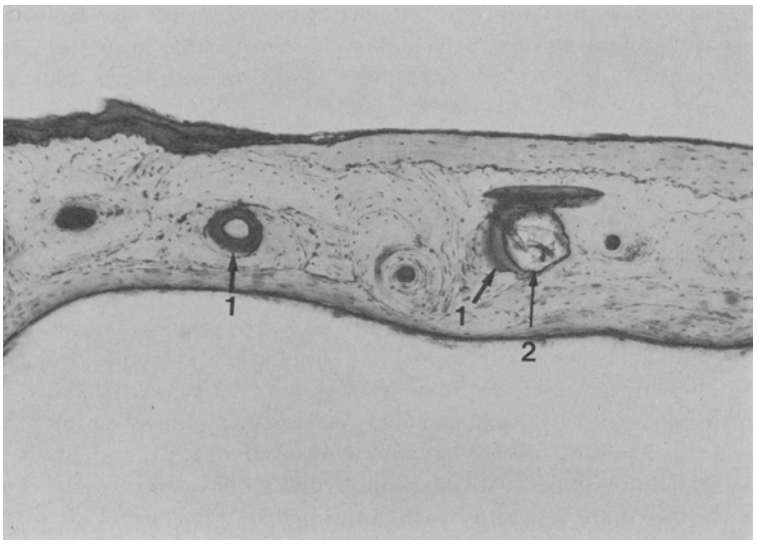

Fig. 8.
1) Osteoid seam
2) resorption cavity
Pattern of the rib biopsied from Case 6 in Table 1 and marked an arrow in Fig. 6.

Duodenum, upper part of jejunum and calcium absorption:

Since the report of Wasserman et al. in 1960,[22] many studies have been made on the active transport of calcium using an everted sack of an animal intestinal tract. Kocián[8] examined absorption of ^{47}Ca in patients undergoing gastric resection and reported that absorption of ^{47}Ca was lowered more in the B-II group than in the B-I group.

When the "calcium-binding protein" tests of Wasserman,[23] the concept of Schachter et al.[16] and our clinical data in this report are combined, it may be surmised that the duodenum and upper part of the jejunum are important regions for absorption of calcium.

Milk intolerance and Bone impairment after gastric resection:

The incidence of so-called postgastrectomy milk intolerance, or the inability to take milk due to abdominal symptoms such as diarrhea and abdominal pain following drinking milk, is varied according the several reports. However, it was shown to be 39% by Spencer et al.[18] and 30% by us.[3]

Regarding milk and absorption of calcium, Lengemann in 1959[10] reported that drinking milk was indispensable for growing animals. There are some reports indicating that not only lactose but other sugars and amino acids are important factors in absorption of calcium. We consider, however, that the lactose in the cow's milk most accelerates absorption of calcium from the intestine.

Diarrhea:

Six of seven patients were found to have diarrhea on taking foods other than milk. Suspecting that there might be a disorder in the digestion and absorption of fats and a further disorder of the absortion of vitamins D and K[6,13] (recently known to take part in mineralization of bone), following the B-I and B-II procedures. Disorders involving the digestion and absorption of fat are greater after the B-II procedure of gastrectomy than after B-I procedure as far as the literature is concerned. Lilienfeld-Toal[11] et al. stated

that cases undergoing the B-II procedure might cause a disorder of vitamin D absorption and, still more, hyperparathyroidism secondary to low plasma 25-OH-D and high urine CAMP. Regretably, however, they made no comparison with cases undergoing the B-I procedure.

I.B.A. (Index of Bone Area):

Osteopenia carries almost the same meaning as osteoporosis. Kocián[9] et al. measured the I.B.A. from the midpoint of left clavicle by the method of Virtama et al.[21] and, on investigating the values in patients who had gastrectomies, they reported that those restricting milk ingestion, i.e., cases of milk intolerance, showed low I.B.A. values and susceptibility to osteopenia.

Further, from the fact that a high incidence of osteopenia was observed in patients who had undergone B-II type gastrectomies five to six years previously, it may by surmised that patients following gastrectomy first develop osteopenia on the basis of a calcium absorption disturbance and eventually result in osteomalacia in association with a vitamin D absorption disturbance. In seven patients with osteomalacia, the I.B.A. was lowered abnormally in five of the six cases of which the I.B.A. could be measured. These findings, coupled with the fact that osteoporosis was confirmed by bone histology to be present in them, led us to the conclusion that the I.B.A. measurement could be useful data for establishing the diagnosis of postgastrectomy osteoporosis.

Prevention of osteomalacia after gastric resection:

Following gastric resection, we have been trying to improve postoperative digestion and absorption by administering lactase preparations and digestive enzyme preparation. For patients showing symptoms of osteomalacia, we administer VIT. D_3,[1] Dehydrotachysterol (D.H.T.)[4] and Vitamin K with satisfactory results. With this treatment, a patient who previously had three episodes of bone fractures never had a fracture for the subsequent four years. On the basis of these results, it seems desirable in general to perform physiological anastomosis (the B-I procedure) if possible. Since patients are predisposed to milk intolerance and diarrhea following a gastrectomy, careful postoperative treatment, including administration of digestives and lactase preparation, is necessary over a long postoperative period of time.

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