研 究 業 績

東南アジアにおける米粒中に含有する重金属、とくにカドミウム(Cd)について

Osteoamalacia and Cadmium: A Study of Reported Causal Connections

富山県農村医学研究所　末永良治
荒田栄次
豊田文一

第２次世界大戦後、日本の工業の発展はめざましいものがあります。その反面国土はそれによって、もたらさせる環境汚染は、いろいろな面に影響を及ぼしていることは事実である。従って現在日本においてあらゆる防止施策が講ぜられているが、未だ完璧とはいえない。この中で特殊な疾病といわれる「イタイイタイ病」と名付られる奇異な疾病があり私どもはその原因究明に多年従事してきた。

この疾病は中年以降の女性において全身の各部の骨の変形をきたし、臨床的に管状骨の骨折をみることが多く、身体の動揺により激痛を訴え、歩行困難で臥床を余儀なくされるという、きわめて悲惨な病状を呈することが特徴で、病理組織学的には Osteomalacia（骨軟化症）である。本疾患は私どもの居住する富山県神通川流域にのみ発生している特殊なもので、多数の学者によりその発生原因について探究され、数年前土壌に存在するカドミウムによるものであろうとの一応の結論に達した。この理由として神通川上流に存在する神岡鉱山の採堀鉱より流出されるカドミウムが下流の土壌に蓄積し、その土壌に生育する穀物中に吸収され、これを主食とする農民の体内に入り、カドミウムの作用により骨病変を起すものであろうとの見解がもたれた。しかしその後研究が進められ、カドミウム主因説に対し多数の学者により否定的な見解がもたれ、その原因について再検討の時期にあるといえる。しかしこの発生地域における米粒中のカドミウム含有量は他の地区に比較して極めて多く、私どもはその分析を行うとともに、日本のみならず、東南アジア地域の米粒の分析をも行い、比較検討を行った。

実験方法及び考察

試料10ｇ（湿重）を磁皿にとり、濃硝酸80 mℓと60%過塩素酸５mℓを加え、砂溶上で加熱し白煙がでるまで分解する。冷却後ＤＤＴＣ—クロロフォルム溶液で同時抽出し、原子吸光光度法により定量した。金属はカドミウム、亜鉛、銅である。なお分析値は乾物重当り、100万分率(ppm）で示した。（別表）

以上の分析成績よりみて、東南アジア産米粒中の重金属含有量は日本における重金属汚染のない地域の精白米中の重金属含有量とはほとんど差は認めなかった。一方前述の神通川流域の米粒中のカドミウム含有量は東南アジア地域のそれに比較して、カドミウム含有量は遙かに高かった。ただ私どもはカドミウム含有食物は「イタイイタイ病」の発生に関連を有するか否かの実験的研究を行った。すなわちビーグル犬６頭に約３年間 1,000ppm の硝酸カドミウム溶液を飲料水として飼育したが、骨の異常は認められなかった。

また兎、マウスでも骨折や骨の異常が認められなかった。ただマウスの一部では骨皮質比が多少変化したが、骨線維の異常は全く見

別　表　（単位：ppm）

No.	産　出　地　域	Cd	Zn	Cu	水　分
1	東ジャワ East Java	0.02	34.3	2.6	13.9
2	〃	0.07	25.3	2.7	13.1
3	北スマトウ North Sumatra	0.05	18.7	1.8	12.1
4	〃	0.09	27.8	1.6	12.3
5	〃	0.05	19.1	2.7	12.5
6	サルセラタン Sul-Selatan	0.03	28.0	3.1	13.4
7	西マレーシアトケダールーサネタト West Malyecr Kadal Stato	0.03	22.5	1.5	14.3
8—1	カンボジア（バタンバング地方） Canbodea（Barsnbarg liatiut）	0.03	20.1	2.2	13.8
8—2	〃	0.02	23.4	2.2	14.5
9	オーストラリア Australia	0.03	14.5	2.1	11.7
10	パキスタン Pakistan	0.04	19.0	2.1	12.2
11	コントロールルゴン Control Lugon	0.05	21.0	3.1	13.8
12—1	ビエンホア Bien-Hoa	0.11	20.3	1.8	12.6
12—2	ミト My-Tho	0.03	30.6	2.1	21.3
12—3	バクエン Ba-Xuyiu	0.04	21.5	1.7	13.6
13	イラワディ Irraudy	0.05	26.9	3.2	11.2
14	ラオス Laos　ラオス	0.11	25.1	2.1	10.8

られなかった。この事実より「イタイイタイ病」発生原因としてのカドミウム起因に対して多大の疑問をいだかざるをえない結論に到達した。私どもはかつて「イタイイタイ病」患者の治療を行った経験があり、栄養の改善とくに高蛋白療法、ビタミンD、Aの高単位療法により、約一年間の治療で著しい改善をみたことにより、神通川流域地区農民の「イタイイタイ病」の発生には、第2次大戦後の農村における栄養摂取の低下と栄養素の不均衡も重大な関連性をもつものであろうと推論した。なおカドミウムの大量摂取により、腎臓に障害を及ぼすことは多数の学者によって認められたことであり、私ども農村医学の研究を行うものとしても、農産物内のカドミウムの健康に及ぼす影響について看過することができない。今後も研究を続けたい。

本文は昭和50年4月、イランのテヘランで開催された第2回アジア農業農村医学会議において講演した。

Osteoamalacia and Cadmium: A Study of Reported Causal Connections

Ryoji Matsue, M.D. The Laboratory of Rural Medicine, Toyama Prefecture Japan.
Bunichi Toyota, M.D. President, Kanazawa University, Japan.

After the war Japan experienced rapid industrial development without adequate anti-environmental pollution safeguards. As a result, pollution-contamination of the environment has emerged as a serious problem. Although attempts have been made to deal with the issue, hitherto, they have achieved only moderate success. In this country many unusual or strange diseases have been attributed to the contamination problem, including, for example, the so-called 'Itai-Itai' disease.

Research into the origin of this disease dates back many years. The disease is characterized by malformation and fracture of the bones and appears to be prevalent only amoung elderly women. When clinically examined, tubular bones are often found to be broken; patients complain of acute pain whenever movement is attempted, find it difficult to walk and consequently are obliged to remain in bed. From the pathological point of view, this condition may be referred to as Osteomalacia.

This particular disease occurs only in the Zinzu River Basin where we (i.e. the co-authors of the present paper) live. A number of scholars inquired into the origins of this disease, and several years ago a tentative conclusion was reached, to the effect that the disease might be attributed to the cadmium deposits in the soil of this region. They reported that cadmium carried by the riverways from the excavation sites of the Kamioka Mines, located in the upper basin of the Zinzu River, had accumulated in the soil of the region around the lower reaches of the same river. Then, according to the theory, the rice crops in the Zinzu Basin absorbed this cadmium which consequently was passed on to the consumer population, rice being a staple food-stuff in Japan. This process was said to explain the cause of osteomalacia.

However a number of researchers were not satisfied with this one variable explanation which purported to demonstrate a causal connection between Os-

teomalacia and cadmium. On the basis of their research findings they have questioned the validity of the 'cadmium' theory. Given these circumstances, it may be said that we are now in a transitional period where it is necessary to reconsider the origins of the Itai-Itai disease.

However, I want to point out that the amount of cadmium present in the rice grains produced in this region where the Itai-Itain disease occurred is extremely high. In the present paper, we will attemt a comparative, analytical discussion of cadmium and other heavy metals which are present not only in the rice grains in Japan, but also in the grains produced in other parts of Southeast Asia.

(1) Method and Procedure

10g (wet weight) of sample were decomposed by 80 ml of conc. HNO_3 and 5 ml of 60% $HClO_4$ in beaker on sand-bath. After cooling, heavy metals were extracted from the decomposed solution by DDTC-chloroform solution. Heavy metals(Cd, Zn and Cu)were determined by the method of atomic absorption spectrum. Heavey metals were shown by ppm in dry weight of sample.

Table 1. Heavy Metals in Southeast Asia-grown rices

rice-growing district	Cd(ppm)	Zn(ppm)	Cu(ppm)	moisture %
1) East Java	0.02	34.3	2.6	13.9
2) East Java	0.07	25.3	2.7	13.1
3) North Sumatra	0.05	18.7	1.8	12.1
4) ibid	0.09	27.8	1.6	12.3
5) ibid	0.05	19.1	2.7	12.5
6) Sal-Salatan	0.03	28.0	3.1	13.4
7) West Malysir Kedal Stato	0.03	22.5	1.5	14.3
8-1) Cambodia (Batambang)	0.03	20.1	2.2	13.8
8-2) ibid	0.02	23.4	2.2	14.5
9) Australia	0.03	14.5	2.1	11.7
10) Pakistan	0.04	19.0	2.1	12.2
11) Control Lugon	0.05	21.0	3.1	13.8
12-1) Bien-Hoa	0.11	20.3	1.8	12.6
12-2) My-Tho	0.03	30.6	2.1	21.3
12-3) Ba-Xuyiu	0.04	21.5	1.7	13.6
13) Irrawady	0.05	26.9	3.2	11.2
14) Laos	0.11	25.1	2.1	10.8

(2) Table 1 which shows the results of our analysis indicates that the amount of heavy metals present in the rice grains of Southeast Asia is scarcely more than that present in the rice produced in various areas of Japan where there is no heavy metal pollution. On the other hand, the amount of cadmium contained in the rice grains grown in the Zinzu River Basin is higher than the level in their counterparts in Southeast Asia. However, there is one factor which distinguishes our research from many previous studies of the same problem. Our results are based upon a series of animal experiments which we shall now proceed to describe.

Over a period covering three years, six beegle dogs were regularly given drinking water which contained a 1000 ppm solution of nitric acid cadmium, but no abnormal condition or malformation of bones was observed. In the same kind of experiments, this time using rabbits and mice, once again no indication of osteomalacia was detected. Only a slight change was noticed in some mice, but no abnormal condition of bone tissue was present. Our results lead us to question and to challenge the reliability of the theory which attributes to cadmium principal responsibility for the origin of the so-called 'Itai-Itai' disease.

In addition to these experiments, we have in the past treated 'Itai-Itai' disease patients, by the prescription of high protein and V_D, V_A content aliment therapy over a year period; the patients responded remarkably well and we obtained a very noticeable improvement in their condition. In those days, we inferred that the occurrence of the Itai-Itain disease among the farmers of the Zinzu River Basin was partly due to malnutrition and the imbalance of nutrients in rural areas after World War II.

Of course, the fact that the absorption of a large amount of cadmium does give rise to kidney trouble has been pointed out by a number of scholars and so we need not refer to this aspect of the problem in the present paper. To be sure, however, we cannot overlook the negative effects which cadmium tends to produce. We are determined to continue research into this problem in the future.

By way of concluding remarks, I would like to add a few more words. The main purpose of our participating in the 2nd Asian Agricultural Medicine

Conference is to exchange our ideas in relation to the 'Itai-Itai' disease and other problems of mutual concern. Before returning to Japan we will pass through a number of Asian countries, and we hope to deepen our study by learning as much as possible about similar conditions in the mining communities of these areas. For this purpose, we want to collect samples of agricultural produce and soil. We would greatly appreciate your assistance in this endeavour. Thank you all very much for your kind attention.