

NORMAL BORON EXCRETION LEVELS AND BORATES RELATED GASTROENTERITIS CASES IN SINGAPORE

T C Chao, M L Ho, H K Cheng, D S T Lo, B Chen Bloodworth

ABSTRACT

Urinary borates calculated as boric acid were found to span 0 to 54 microgramme per ml urine for both Singaporean adults (population size: 507) and children (population size: 162). The normal dietary boron intake could account for the urinary boric acid levels observed.

Of the hundred and fifty-three children who suffered from gastroenteritis in Singapore over the period from Jan to May 1989, two were found to have urinary boric acid exceeding 54 μg per ml urine. One of them was said to have consumed fish balls, bean curds and noodles prior to the onset of illness. These food items were among those likely to have added borates. Unfortunately, the dietary intake prior to the onset of illness of the other child was not recorded.

Of the hundred and twelve adults affected by gastroenteritis in Dec 1988 in the Tiong Bahru area, one was found to have boric acid level of 117 μg per ml urine, indicative of added borates in the diet.

The present study showed that borates related gastroenteritis incidents in Singapore over the time-period of our study at least, were few and far in between. With the on-going surveillance for the presence of added borates in both locally manufactured and imported food and the continued tight control over the importation and sale of borates, future incidents are likely to be minimal.

Keywords: Borate related gastroenteritis, Urinary Boron excretion

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Institute of Science and Forensic Medicine
Outram Road
Singapore 0316

T C Chao, PPA, FRCPath, FCAP, FCLM, FRCPA, AM
Director

Ministry of Health Headquarters
College of Medicine Building
Singapore 0316

M L Ho, MBBS, MSc (Public Health), AM
Director (Professional Standards/Disease Control)

Department of Paediatrics
Tan Tock Seng Hospital
Moulmein Road
Singapore 1130

H K Cheng, M MED(Paed), FRACP, FRCPE, AM
Head of Department

Toxicology Department
Institute of Science and Forensic Medicine

D S T Lo, BSc(Hons), PhD, MSNIC, AMIC
Head of Toxicology Laboratory

Food Laboratory
Institute of Science and Forensic Medicine

B Chen Bloodworth, BSc, MSc, PhD, MSNIC
Head of Food Laboratory

Correspondence to: Professor T C Chao

1. INTRODUCTION

This paper is based on the findings of a special committee comprising Prof Chao Tzee Cheng et al, set up in Dec 1988 by the Ministry of Health, Singapore, to elucidate whether or not borates are causative agents towards gastroenteritis in Singapore. The gastroenteritis causing ability of these chemicals is well known (1,2). The committee's findings, together with the relevant experimental data, were previously summarized in a report (3) to the Ministry (Medical Research Grant Centre No. 2081001).

Borates, traditionally used as a preservative and texture enhancer, are in fact prohibited food additives. Borates as a toxin were well publicised as these chemicals were implicated together with aflatoxin in the tragic Perak (West Malaysia) mass poisoning (4) which took place in Oct 1988. The incidents touched a tender note in that all the thirteen deaths were children aged two and a half to eleven years old (eight males and five females, all Chinese).

To establish whether or not borates are causative agents towards gastroenteritis in Singapore, it is necessary to compare the urinary borates levels (expressed as boric acid) of gastroenteritis patients to the corresponding urinary levels of healthy people. Thus, the establishment of a 'norm' urinary boric acid range of healthy people for comparison purposes, became our primary task. Healthy people are defined as those who had not suffered from gastroenteritis in the immediate past (seven days at least) and whose dietary intake prior to urine procurement (past twenty-four hours) was well defined. The normal dietary boron intake could account for the urinary boric acid levels observed (5).

While the project was underway, two cases of oral consumption of borates by adults in an attempt to commit suicide came to our attention. These two cases provided valuable toxic urinary boric acid levels for adults.

2. LABORATORY METHODS

2.1 Procurement of Urine Samples

Healthy adults' urine samples came from two sources: one from the staff of Department of Scientific Services and the other from ex-addicts who are currently undergoing medical supervision. The urine samples of healthy children were collected over a period from Jan to May 1989 by Still Road Polyclinic and Queenstown Polyclinic. Samples pertaining to children suffering from gastroenteritis were collected at the same period by paediatric wards of the Singapore General Hospital, Alexandra Hospital and Tan Tock Seng Hospital. Urine samples of adults affected by gastroenteritis in Dec 1988 at Tiong Bahru area were collected by accident and emergency wards of the Singapore General Hospital and Alexandra Hospital.

In all cases, urine samples of gastroenteritis patients were procured within six hours after the onset of illness.

2.2 Sample Management

Samples were submitted to Toxicology Laboratory, Department of Scientific Services for analysis. Each sample was accompanied by a form stating the particulars of the volunteer or patient.

Samples were kept in a refrigerator at 4°C for up to five days before subjecting them to analysis. Prolonged storage of selected samples (up to two weeks) showed no detectable effect on the borate level.

2.3 Treatment

To a 10 ml urine previously equilibrated to room temperature, was added one drop of concentrated hydrochloric acid (37%, E. Merck). The resultant mixture was centrifuged at 2500 rpm for 15 mins and the supernatant analysed for boron and hence boric acid content by inductively coupled plasma emission spectroscopy (ICP).

2.4 Instrumentation and Analysis

ICP analysis was carried out using a Perkin-Elmer plasma 40 emission spectrometer. The instrumental parameters are as follows:

Rf operating frequency : 40 MHz
 Gas flow rates (approx.) : Plasma argon:
 12 L/min
 Aux. argon:
 0.6 L/min
 Aspiration rate : Sample:
 1 ml/min
 Washing:
 4ml/min

The instrument was calibrated at 249.77 nm (characteristic emission line of boron) immediately before urine samples were analysed, with aqueous standards containing 0 µg, 5 µg, 10 µg, 20 µg, 40 µg boric acid per ml solution. Urine samples containing higher boric acid

concentrations were diluted with distilled water to 0-40 µg range before quantifications were carried out. The presence of boric acid was confirmed at 208.89 nm (another characteristic emission line of boron) with the instrument calibrated at this wavelength.

Two types of quality controls were instituted: one consisting of negative urine spiked with 10 and 20 µg boric acid per ml urine to check on the possibility of matrix effect and, the other consisting of aqueous standard of 10 µg boric acid per ml solution to be analysed after each batch of 10 urine samples was analysed, to check on instrument drift.

Throughout the course of this project, matrix effect was found to be absent and instrument drifts were countered by re-calibrations.

3. RESULTS

The urinary levels of the following groups of people:

- (i) healthy children;
- (ii) normal adults;
- (iii) children suffering from gastroenteritis over the period from Jan to May 1989 and;
- (iv) adults affected by gastroenteritis in Dec 1988 in the Tiong Bahru area.

are given in Tables I to IV and presented in Fig 1 respectively. For the sake of simplicity and clarity, populations which fell within a given range of boric acid levels (in quantum increase of 3 µg boric acid per ml urine) were grouped together.

The analytical results of the two borate overdose cases are given in 3.5 .

3.1 Healthy Children

Population size: 162 (75.3% Chinese, 24.7% Others)

Age Range : See Appendix 1

Table I

Urinary Boric Acid (µg per ml urine)	Population
0-2	22 (13.6%)
3-5	24 (14.8%)
6-8	67 (41.4%)
9-11	21 (13.0%)
12-14	9 (5.5%)
15-17	5 (3.1%)
18-20	10 (6.2%)
21-23	3 (1.8%)
24-26	0 (0 %)
27-29	0 (0 %)
30-32	0 (0 %)
33-35	0 (0 %)
36-38	1 (0.6%)
39-41	0 (0 %)

3.2 Healthy Adults

Population Size: 507 (88.0% Chinese, 12.0 % Others)

Table II

Urinary Boric Acid (µg per ml urine)	Population
0-2	245 (48.3%)
3-5	125 (24.7%)
6-8	65 (12.8%)
9-11	34 (6.7%)
12-14	14 (2.8%)
15-17	6 (1.2%)
18-20	7 (1.4%)
21-23	4 (0.8%)
24-26	2 (0.4%)
27-29	2 (0.4%)
30-32	1 (0.2%)
33-35	1 (0.2%)
36-38	1 (0.2%)

3.3 Children Suffering From Gastroenteritis

Population Size: 153 (80.4% Chinese, 19.6% Others)

Age Range: See Appendix 2

Table III

Urinary Boric Acid (ug per ml urine)	Population
0-2	59 (38.6%)
3-5	22 (14.4%)
6-8	39 (25.4%)
9-11	15 (9.8%)
12-14	7 (4.6%)
15-17	3 (2.0%)
18-20	2 (1.4%)
21-23	2 (1.4%)
24-26	1 (0.6%)
27-29	0 (0 %)
30-32	0 (0 %)
33-35	0 (0 %)
36-38	1 (0.6%)
.	.
66-68	1 (0.6%)
.	.
72-74	1 (0.6%)

3.4 Adults Affected by Gastroenteritis in Dec 1988 in the Tiong Bahru Area

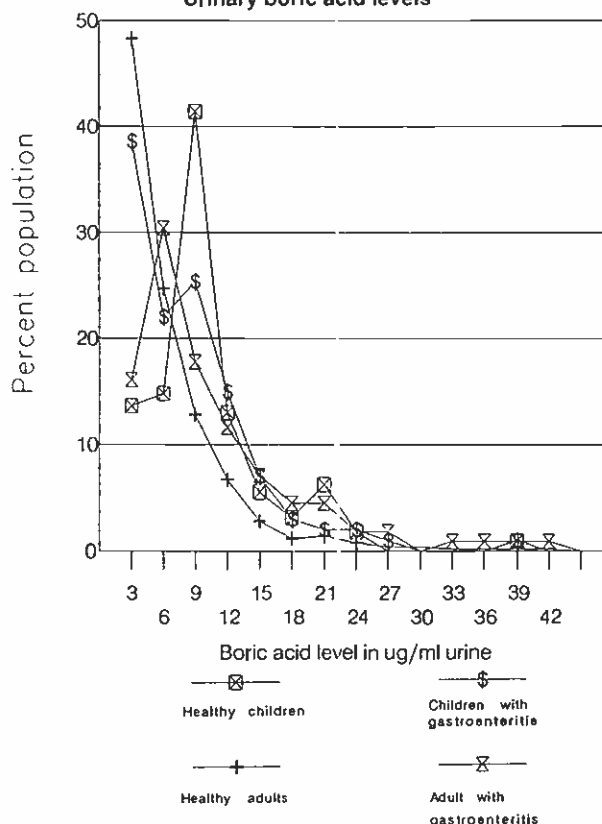
Population size: 112 (89.1% Chinese, 10.9% Others)

Table IV

Urinary Boric Acid (µg per ml urine)	Population
0-2	18 (16.1%)
3-5	34 (30.4%)
6-8	20 (17.8%)
9-11	13 (11.6%)
12-14	8 (7.1%)
15-17	5 (4.5%)
18-20	5 (4.5%)
21-22	2 (1.8%)
24-26	2 (1.8%)
27-29	0 (0 %)
30-32	1 (0.9%)
33-35	1 (0.9%)
36-38	1 (0.9%)
39-41	1 (0.9%)
.	.
.	.
117-119	1 (0.9%)

Fig 1

Urinary boric acid levels



3.5 Borates Overdose Among Adults

Two cases of self-poisoning with borates were recently handled by the Toxicology Laboratory, Department of Scientific Services. The particulars together with the analytical results are given below:

Case 1

Patient: 50-year old Chinese female
Analytical results:
Stomach washout: 37 mg boric acid per ml washout.
Urine: 4800 µg boric acid per ml urine.

Case 2

Patient: 33-year old Chinese female
Analytical results:
Stomach washout: 17 mg boric acid per ml washout.
Urine: 2530 µg boric acid per ml urine.

In both cases, samples were procured within ten hours after the act of consumption.

4. DISCUSSION

4.1 Urinary Boric Acid Range of Healthy People

Based on the results listed in Tables I and II, the urinary boric acid was found to span 0-54 µg boric acid per ml urine for both healthy adults (population size: 507) and children (population size: 162). This range, though somewhat higher than that of 0-20 µg boric acid per ml urine reported elsewhere (4), is consistent with the estimated dietary boron intake of Singaporeans (5).

The urinary boric acid levels of 10.0 to 54.9 µg per ml urine were established elsewhere for five of the Perak mass poisoning victims (4).

4.2 Urinary Boric Acid Range of Gastroenteritis Patients

Of the 153 children who suffered from gastroenteritis over the period from Jan to May 1989, 98.8% were found to have boric acid below 54 µg per ml urine. 1.2%, the equivalence of two children, were found to have boric acid above 54 µg per ml urine (Table III). Both were male Malays aged 1 1/2 years and 3 years. The dietary intake of the 3-year old prior to the onset of gastroenteritis consisted of fish balls, bean curds, and

noodles, items likely to have added borates. The dietary data of the 1 1/2-year old were not available.

Of the 112 adults affected by a gastroenteritis outbreak in Dec 1988 in the Tiong Bahru area, 99.2% were found to have boric acid below 54 µg per ml urine. One male Chinese among the affected adults showed a boric acid level of 117 µg per ml urine (Table IV), indicative of added borates in the diet.

4.3 Toxic Urinary Boric Acid Levels

The toxic urinary boric acid levels of 2530 to 4800 µg per ml encountered by the Toxicology Laboratory as recorded in paragraph 3.5, were found to be at least 46 times greater than the highest normal range of 54 µg boric acid per ml urine.

5. CONCLUSION

From the foregoing discussion, it is clear that the occurrences of borates related gastroenteritis incidents in Singapore over the time-period of our study at least, were minimal. We are tremendously relieved by the findings and are confident that future occurrences would be kept to a minimum, with the on-going control over the importation, sale and use of borates in Singapore (6).

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Appendix 1
Age-range of
healthy children

Age-Range	Population
0+ year	19
1+ year	30
2+ years	29
3+ years	46
4+ years	21
5+ years	15
6+ years	1
7+ years	0
8+ years	0
9+ years	1
Total	162

Appendix 2
Age-range of children
suffering from gastroenteritis

Age-Range	Population
0+ year	29
1+ year	16
2+ years	27
3+ years	17
4+ years	14
5+ years	10
6+ years	9
7+ years	10
8+ years	7
9+ years	7
10+ years	3
11+ years	4
Total	153

Appendix 1 and Appendix 2 of 'Normal Boron excretion levels and borates related gastroenteritis cases in Singapore'

CONTRIBUTIONS TO OBSTETRICS & GYNAECOLOGY

by

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National University of Singapore

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