MEASUREMENT OF INTERNAL CONTAMINATION WITH RADIOACTIVE CESIUM RELEASED FROM THE CHERNOBYL ACCIDENT AND ENHANCED ELIMINATION BY PRUSSIAN BLUE

Tang Ming-hua Gong Yi-fen Shen Cheng-yao
Ye Chang-qing Wu De-chang

Institute of Radiation Medicine
Beijing, China

A serious accident was occurred in No.4 reactor of the Chernobyl Nuclear Power Station on April 26, as a result of which considerable quantities of radioactive materials were released to the environment. Fifteen members of a Chinese Foreign Trade Exhibition Group were working at Sofia and Profdef, Bulgaria from April 19 to May 23, 1986. During May 5-10 they occasionally found a rise in γ-background dose rate with a FD-301 dosimeter, which indicated that it might be contaminated with radioactive material released from the Chernobyl-4 reactor. Fifteen internally contaminated Chinese persons were monitored from June 12-21 in Beijing. This paper describes the results of measurements and of the effect of Prussian Blue on the rate of elimination of radiocesium.

The γ-activities of radionuclides in the 15 subjects were measured with the low background whole body counter developed in our laboratory [1] . The measurements were performed in two ways: a single crystal measurement at the sits of the thyroid, and a single, constant scanning speed detector moving along the length of the body. The counts were obtained by subtracting the counts in noncontaminated cases from the countes obtained from contaminated ones. The activities of radionuclides in the body was calculated by a matrix inversion method using calibration factors.

The results show that the activity of ^{131}I in the thyroid of these persons was lower than the minimun detectable level (10 Bq).

The activities of radiocesium at the moment of measurement are shown in Table 1. It express that radiocesium can be measured in vivo by a whole body counter for a relatively long time after contamination and may serve as a late marker of contamination of fission products released from a nuclear reactor accident. The initial intake was estimated on the supposition of: (1) A single intake at the middle of the exposure period i.e. May 11 (exposure period May 1-23), (2) The retention equation for cesium recommended by ICRP publication No.30 [2] was used in the estimation. Table 1 shows that the range of activity measured was 68-840 Bq (^{137}Cs) and 110-630 Bq (^{134}Cs). The range of the estimated initial intake was 95-1200 Bq (^{137}Cs) and 170-900 Bq (^{134}Cs).

The initial intake of ^{134}Cs and ^{137}Cs estimated here may be of significance in evaluating the levels of internal con-

tamination level of people who lived in Sofia and Profdef, Bulgaria, 6-30 days after the Chernobyl accident.

Table 1
Internal Contamination of 15 Chinese Subjects, Resident in Bulgaria at the Time of the Chernobyl Nuclear Reactor Accident

NAME	Date of Measurement	Activity in Body/Bq*		Intake Estimated/Bq	
		^{137}Cs	^{134}Cs	^{137}CS	^{134}Cs
ZN	86.6.12.	700	360	950	500
FU	6.19.	470	370	660	550
GO	6.17.	600	340	850	500
MU	6.18.	470	380	660	560
CE	6.20.	440	300	640	450
HO	6.21.	430	330	620	490
CN	6.19.	340	300	490	440
YU	6.18.	390	300	550	430
YN	6.20.	840	630	1200	930
HU	6.18.	280	170	390	260
EI	6.19.	350	240	500	350
SO	6.19.	440	250	620	270
WE	6.19.	320	210	460	300
JA	6.18.	370	260	530	380
LI	6.17.	68	110	95	170

* The relative error of all the measured values, except LI are in the range of 5-12%, while for LI the figures are 30% for ^{137}Cs and 31% for ^{134}Cs.

Activity of radiocesium was regularly measured in the 3 volunteers during a period of more than two months. The activities of ^{137}Cs and ^{134}Cs decreased with time after contamination with a single exponential function. The biological half-time of the radiocesium ranged from 42-71 days for ^{137}Cs and 42-51 days for ^{134}Cs.

In this study the biological half-times of radiocesium are shorter than the 110 days for the 0.9 of retention recommended by ICRP. As we know that age, sex, hormone and potassium content in food etc. may influence the turnover of radiocesium in body. So in the case of dose estimation, it is preferable to use the subject's own biological half-time instead of the recommended biological half-time of 2 days for 0.1 of retention, 110 days for 0.9 of retention.

The annual effective dose equivalent was estimated on the basis of the highest initial intake (YN), which was $1.1X10^{-2}$ mSv for ^{137}Cs, $1.2X10^{-2}$ mSv for ^{134}Cs. The above values were only around 2% of the ICRP annual dose equivalent limit for the public (1 mSv). For the other 14 cases the annual effective dose equivalent should be much lower.

Prussian blue(PB) was given to the 3 volunteers to investigate the effect on cesium excretion. 1.0g of Prussian Blue

was given 3 times per day, for a six days course. Three courses were given with a time interval of 6 days between each subsequent course. During the investigation period of 114-141 days after contamination, the biological half-time of radiocesium ranged from, 29 to 48 days for ^{137}Cs and 23 to 33 days for ^{134}Cs. From the biological half-time it can be seen that the body retention of radiocesiums declined more rapidly following Prussian Blue administration than in those of controls.

It is evident that shortening of biological half-time results in a more pronounced decrease of cumulative activity of radiocesium in the body. The percentage excess decrease of cumulative activity during the period of 114-141 days after internal contamination was calculated by using each subjects own biological half-time. The results in Table 2 indicate that the cumulative

Table 2
Diminution of Radiocesium Body-Burden in Man by Prussian Blue (PB)

Persons	Radiocesium	Cumulative Activity/Bq.d		Activity
		No PB	PB Admin.	Decreased(%)
YN	^{134}Cs	4400	3600	18
	^{137}Cs	9900	9100	8
ZN	^{134}Cs	2100	2000	5
	^{137}Cs	5700	5600	2
MU	^{137}Cs	4200	3500	17

activities decrease significantly ($P<0.05$), showing that Prussian Blue treatment can enhance the excretion of radiocesium.

Many studies have demonstrated that ferric ferrocyanide is an effective agent for accelerating the turnover of internally deposited radiocesium in animals and humans. Ferric ferrocyanide is not absorbed into the body, it preferentially binds cesium ions in the lumen of the gut, thereby interrupting the enteric circulation and preventing reabsorption and deposition in tissues. The shortening of biological half-time has been used as an indicator of effectiveness. Some works appears that the effectiveness of Prussian Blue is not strongly dependent on the time when treatment begins, but is proportional to the duration treatment[3-6].

Whole body ^{40}K measurements were also made on the same 3 volunteers. The results indicate that the difference of ^{40}K content between the control and PB administration period is not statistically significant. Body potassium and sodium burdens do not appear to be affected by treatment[5], so it is non-toxic and well tolerated.

REFERENCES

1. Shen Cheng-yao., et al., "Performance and application of a low-background whole body counter", in "Assessment of radioactive contamination in man", IAEA-SM-276/58 Proc. of an International Symposium held at Paris, 19-23 November 1984,

P.123
2. International Commission on Radiological Protection, 1979. Limits for Intakes of Radionuclides by Workers. Publication 30, Annals of the ICRP, 2(3/4)
3. Ye Gen-yao., et al., 1981. "Enhancement of elimination of ^{137}Cs from 3 subjects by Prussian Blue", Chinese Journal of Radiological Medicine and Protection (Chinese), Vol.1(3):6
4. Ma Ru-wei., et al., 1983. "The retention and excretion of ^{137}Cs by five subjects with internal contamination", Radiation Protection, (Chinese) Vol. 3(4):284
5. C.R. Richmand, Accelerating the turnover of internally deposited radiocesium, in "Diagnosis and treatment of deposited radionuclides", Proc. of a symposium held at Richland, Washington U.S.A 15-17 May 1967, P.315. Excerpta Medica Foundation.
6. Madshus K., 1966. "Diminution of radiocesium Body-burden in dogs and human begins by Prussian Blue", Int. J. Radiat. Biol. 10,519.