

## Vitamin A reserve of liver in health and coronary heart disease among ethnic groups in Singapore

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1. The vitamin A content of human liver tissue was determined in 363 autopsy samples. The sample comprised a total of 181 subjects dying after accidents and 182 dying from coronary heart disease among Singapore ethnic groups of both sexes.
2. The medium vitamin A reserve was 146 mg/kg in accident victims and 141 mg/kg in those who had died of coronary heart disease. Of all the samples 16% contained less than 40 mg/kg, 45% had 100-300 mg/kg, while 9% contained more than 500 mg/kg liver.
3. Among the accident victims, Indians had the lowest median liver vitamin A reserve (118 mg/kg) compared with that in other ethnic groups (137 mg/kg in Chinese, 191 mg/kg in Malays, 155 mg/kg in Caucasians).
4. The ethnic distribution of vitamin A reserve in coronary deaths was similar to that in accident victims.
5. There was no significant difference between the sexes in hepatic vitamin A reserve.
6. The distribution of vitamin A reserve in all the groups was skewed to the right.

About 90% of the body's total vitamin A reserve is stored in the liver (Moore, 1957; Raica *et al.* 1972). In this respect, the vitamin A content of the liver provides a convenient and reliable index of the vitamin A status of the individual (McLaren, 1967). Unfortunately the drawback of this approach is that there is a limit to the size of group that can be studied at any time, for samples have to be collected during autopsies. As for the scope of using liver biopsies, due to ethical reasons analysis can be carried out on only a limited number of cases (Meyer *et al.* 1942). It can be expected, therefore, that the number in such studies would be small. To date, the highest number of subjects in a liver vitamin survey on autopsy samples is 517 (Flores & Araujo, 1984).

The vitamin A concentration is significantly higher in the right lobe than that in the left lobe (McLaren *et al.* 1979). Most of the studies in the past have been undertaken to assess the vitamin A reserves in humans of different countries using autopsy samples of liver. Moore (1957) has reviewed the early studies on vitamin A reserves in man. Since then many other studies have been reported in Western countries: Smith & Malthus (1962) in New Zealand, Hoppner *et al.* (1969) in Canada, Underwood *et al.* (1970) and Mitchell *et al.* (1973) again in the United States.

Similar studies were performed in Bangladesh (Abedin *et al.* 1976), Brazil (Flores & Araujo, 1984) and Ghana (Dagadu, 1967). However, only one survey of liver vitamin A appears to have been conducted in the Far East, in Thailand (Suthutvoravoot & Olson, 1974). The lack of information in the Far-Eastern region motivated the present study to examine the vitamin A status in Singaporean ethnic groups who had died after accidents or from coronary heart disease.

## SUBJECTS AND METHODS

Liver samples (363) obtained during autopsies of victims of accidents (181) or coronary heart disease (182) were sealed in plastic containers and immediately frozen at  $-20^{\circ}\text{C}$ . A section of about 25 g of the tissue from the middle of the upper part of the right lobe was collected during post-mortem examination. Relevant information such as the cause and time of death, age, sex and race were recorded in every case.

Portions (1 g) of liver from the centre were weighed to the nearest 10 mg, ground with 5 g anhydrous sodium sulphate and extracted with diethyl ether. Portions of diethyl-ether extract were evaporated to dryness in a warm water-bath and the residue redissolved in chloroform. The vitamin A was assayed by the trifluoroacetic acid procedure according to Neeld & Pearson (1963), using a Beckman spectrophotometer. The absorbance of the solution was measured at 620 nm.

The vitamin A contents of liver (mg/kg) are presented as medians (range), arithmetic means, geometric means and coefficients of variation. The significance of difference between the populations was calculated using the Mann-Whitney U test (two-tailed). Only the median values for the vitamin A reserve have been given in the text.

## RESULTS AND DISCUSSION

*Frequency distribution*

Table 1 shows the frequency distribution of liver vitamin A in different ethnic groups. The distribution was skewed to the right, a common finding in other studies on liver vitamin A (Smith & Malthus, 1962; Suthutvoravoot & Olson, 1974). Of all the samples examined, 16% contained less than 40 mg vitamin A/kg and approximately 45% contained between 100 and 300 mg vitamin A/kg. At the extreme end of the range, 9% of the subjects had concentrations above 500 mg/kg and 1% of the subjects had concentrations above 1000 mg vitamin A/kg in the liver. These values are in concordance with the findings of Huque (1982) for a survey of human liver reserves of retinol in London. On the other hand, studies in the United States and Canada showed that a much higher percentage of the samples (22–35%) had less than 40 mg vitamin A/kg (Hoppner *et al.* 1969; Underwood *et al.* 1970; Raica *et al.* 1972; Mitchell *et al.* 1973). Studies in developing countries (Ghana, Thailand) showed a lower percentage of samples having a vitamin A content of less than 40 mg/kg (Dagadu, 1967; Suthutvoravoot & Olson, 1974). However, these two previously mentioned studies cannot be taken as representative of the vitamin A status of developing countries in general. Palm oil, rich in provitamin A, is commonly used in Ghana (Dagadu, 1967) while it was emphasized (Suthutvoravoot & Olson, 1974) that the Bangkok study was not representative of the Thai population as a whole.

*Ethnic and sex differences*

Liver vitamin A concentrations relative to ethnic groups are presented in Table 2. Among males, the Caucasians and Eurasians had the highest median liver vitamin A store of 247 mg/kg, followed by the Malays (182 mg/kg). The Chinese had 154 mg vitamin A/kg liver, while the Indians had the lowest liver reserve (120 mg/kg). Statistical analysis revealed that the Caucasians and Eurasians had a significantly higher liver vitamin A store than the Indians ( $P < 0.01$ ) and Chinese ( $P < 0.05$ ). Also the Malays had significantly higher values than the Indians ( $P < 0.01$ ).

The mean vitamin A reserve of the Caucasians in the present study (294 mg/kg) was higher than that found in the UK (252 mg/kg), United States (146–223 mg/kg) and

Table 1. Frequency distribution of liver vitamin A (retinol) reserves in ethnic groups of Singapore

Vitamin A (mg/kg liver)	Chinese		Indian		Malay		Total*	
	n	(%) of total	n	(%) of total	n	(%) of total	n	(%) of total
0-39	24	16.6	23	20.9	9	10.8	59	16.3
40-99	29	20.0	21	19.1	14	16.9	67	18.5
100-149	21	14.5	24	21.8	14	16.9	62	17.1
150-199	18	12.4	11	10.0	9	10.8	41	11.3
200-249	11	7.6	11	10.0	10	12.0	33	9.1
250-299	14	9.7	5	4.5	7	8.4	28	7.7
300-399	11	7.6	6	5.5	6	7.2	25	6.9
400-499	9	6.2	2	1.8	3	3.6	16	4.4
500-699	3	2.1	7	6.4	5	6.0	20	5.5
700-999	4	2.8	0	—	3	3.6	8	2.2
1000-1499	1	0.7	0	—	3	3.6	4	1.1
—	145	—	110	—	83	—	363	—

\* Includes twenty-five Caucasians and Eurasians.

Table 2. Liver vitamin A (retinol) reserves in ethnic groups of Singapore  
(Median, range, mean values and coefficients of variation)

Ethnic group	Sex	n	Age (years)		Vitamin A (mg/kg liver)			
			Mean	SD	Mean		Coefficient of variation	
			Median (range)	Arithmetic	Geometric			
Chinese	♂	111	46.8	22.4	154* (0-1040)	198	118	100
	♀	34	47.8	26.5	138* (1-766)	195	80	99
Indian	♂	96	50.8	18.2	120** (0-679)	165	92	92
	♀	14	51.6	21.2	60** (2-623)	122	50	141
Malay	♂	77	41.5	18.4	182†† (1-1492)	254	144	106
	♀	6	41.3	20.4	175†† (46-578)	217	158	89
Caucasian and Eurasian	♂	25	48.6	23.4	247 (7-773)	294	198	77

Median value was significantly different from that for Caucasian and Eurasian group (two-tailed Mann-Whitney U test): \*  $P < 0.05$ , \*\*  $P < 0.01$ . Median values were significantly different from those for Indian group (two-tailed Mann-Whitney U test): ††  $P < 0.01$ .

Table 3. *Liver vitamin A (retinol) reserves in relation to age in ethnic groups of Singapore (both sexes)*

(Median, range, mean values and coefficients of variation)

Age group (years)	n	Vitamin A (mg/kg liver)			
		Median (range)	Mean		Coefficient of variation
			Arithmetic	Geometric	
0-19	32	104 (11-650)	170	105	96
20-39	113	162 (1-1492)	217	129	103
40-59	103	146 (0-773)	195	107	91
60-79	92	137 (0-1040)	226	114	103
80-87	13	125 (14-958)	217	71	130

Table 4. *Liver vitamin A (retinol) reserves in accident (previously healthy) and coronary heart disease victims in all ethnic groups of Singapore*

(Median, range, mean values and coefficients of variation)

	n	Vitamin A (mg/kg liver)					
		Age (years)		Median (range)	Mean		Coefficient of variation
		Mean	SD		Arithmetic	Geometric	
Accident	181	38.4**	20.9	146(0-1492)	200	109	103
Coronary heart disease	182	55.7	17.5	141(0-1040)	209	115	100

Mean value was significantly different from that for coronary heart disease victims (two-tailed Mann-Whitney U test): \*\*  $P < 0.01$ .

Canada (117 mg/kg). Indians in Singapore are mostly vegetarians which may account for their lower vitamin A reserve compared with other groups.

In general the hepatic vitamin A reserve was found to be lower in female subjects than in male subjects, though the difference was not significant. However, the number of female subjects investigated was rather small.

The liver vitamin A reserves relative to age in the entire sample, regardless of the cause of death and ethnic origin, are presented in Table 3. A low, median liver vitamin A level (104 mg/kg) was noted in the age group 0-19 years. The median values for liver vitamin A rose markedly within the age group 20-39 years, followed by a decrease in the age group 80-87 years (125 mg/kg). However, none of the differences was significant ( $P > 0.05$ ). A similar pattern of hepatic vitamin A reserves was observed by Raica *et al.* (1972) in the United States.

#### *Cause of death*

The frequency distribution of vitamin A reserves in accident and coronary heart disease victims was very similar. The relation between the cause of death and liver vitamin A is presented in Table 4. For this purpose the 363 subjects were grouped into two categories. The first category, which comprised subjects dying of sudden causes of a violent nature

Table 5. Liver vitamin A (retinol) reserves in accident victims (previously healthy subjects) in ethnic groups of Singapore

(Median, range, mean values and coefficients of variation)

Ethnic group	n	Vitamin A (mg/kg liver)					
		Age (years)		Median (range)	Mean		Coefficient of variation
		Mean	SD		Arithmetic	Geometric	
Chinese	88	38.8	21.9	137(0-958)	188	102	94
Indian	41	40.2	19.9	118*(0-564)	151*	84*	93
Malay	41	35.5	17.6	191(2-1492)	263*	151*	109
Caucasian and Eurasian	11	39.8	28.5	155(7-773)	253	148	96
All	181	38.4	20.9	146(0-1492)	200	109	103

Median value was significantly different from that for Malay group (two-tailed Mann-Whitney U test): \*  $P < 0.05$ .

Table 6. Liver vitamin A (retinol) reserves in coronary heart disease victims in ethnic groups of Singapore

(Median, range, mean values and coefficients of variation)

Ethnic group	n	Vitamin A (mg/kg liver)					
		Age (years)		Median (range)	Mean		Coefficient of variation
		Mean	SD		Arithmetic	Geometric	
Chinese	57	59.7	19.7	161(0-1040)	213	118	105
Indian	69	57.3	14.4	115(0-679)	165	86	99
Malay	42	47.5	17.5	165(1-1033)	240	139	102
Caucasian and Eurasian	14	55.6	16.5	318**(58-689)	325	249	65
All	182	55.7	17.5	142(0-1040)	209	115	100

Median value was significantly different from that for Indian group: \*\*  $P < 0.01$ .

(drowning, traffic accident, hanging, stabbing), had a median liver vitamin A value of 146 mg/kg. The other category, classified as subjects dying of coronary heart disease, had a median liver vitamin A value of 141 mg/kg, which was not significantly different from the former. In contrast, Huque (1982) had observed a lower median value for vitamin A reserves in heart disease victims compared with that in accident victims.

Table 5 shows that the median liver vitamin A reserve of 181 accident victims who died was 146 mg/kg for the entire group. When grouped according to ethnic background, the Indians exhibited the lowest level (118 mg/kg). The Malays were found to have the highest median liver vitamin A store (191 mg/kg), which was significantly different from that of the Indians ( $P < 0.05$ ). No other significant difference could be established between the other races. In a group of 182 who died from coronary heart diseases, the pattern of lowest liver vitamin A store persisted in the Indians (Table 6). No significant difference could be established between the ethnic groups in the case of coronary heart disease victims, except

that the Caucasians and Eurasians had significantly higher values than the Indians ( $P < 0.01$ ). It may be concluded that the vitamin A status of all Singaporean ethnic groups is reasonably satisfactory, although vitamin A deficiency is not uncommon in the neighbouring populations. This may be due to the better socio-economic status of Singaporeans.

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