

# The Ascorbic Acid Content of Human Pituitary, Cerebral Cortex, Heart, and Skeletal Muscle and Its Relation to Age

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ACCORDING to most investigators, studies of the effect of age on blood ascorbic acid levels have shown that the ascorbic acid blood concentration in old individuals tends to be lower than in the younger age groups.<sup>1-3</sup> A recent study supports this correlation at least as far as institutionalized men are concerned, whereas no significant change in blood ascorbic acid level with age was observed in women.<sup>4</sup>

A decrease with age of tissue ascorbic acid concentration in humans has been reported by several authors.<sup>5-11</sup> Their studies have not always been based on a significant number of samples, and the analyses have sometimes been carried out with methods now considered less accurate. A more extensive investigation of the variation with age of the ascorbic acid content of human tissues therefore seemed desirable.

The present study was undertaken to examine the change with age in the total ascorbic acid (reduced ascorbic acid and dehydroascorbic acid) content of four representative human tissues (pituitary gland, cerebral cortex, myocardium, and pectoral muscle).

## EXPERIMENTAL

Sixty-nine samples of human pituitary gland, 71 samples of human brain (frontal lobe), 67 samples of human myocardium, and 63 samples of human pectoral muscle were ob-

tained fresh at autopsy at the St. Louis City Morgue and immediately placed in sterile beakers immersed in crushed ice. The ages of the individuals from whom the samples were derived ranged between 7 days and 88 years. The subjects had died from miscellaneous causes, and information about their ascorbic acid intake during the period preceding death was not available. The pituitary glands, ranging in weight from 0.10 to 0.70 g, were each processed as a whole. Portions of cerebral cortex weighing from 0.50 to 0.90 g were carefully dissected from the underlying white matter. From 0.50 to 0.80 g of macroscopically normal portions of myocardium (left ventricle) and of pectoral muscle were homogenized with 10 per cent trichloroacetic acid. The ascorbic acid analyses were carried out on the filtrates by the procedure of Roe and Kuether.<sup>12</sup> This method includes both reduced ascorbic acid and dehydroascorbic acid in the same determination. In most instances, the nitrogen content of the samples of brain, heart, and muscle was determined by subjecting the total protein precipitate collected on the filter paper to conventional Kjeldahl analysis. It was ascertained that storage of the tissues at 4° C for 24 hours did not result in any loss of tissue ascorbic acid.

## Results

The results of the tissue ascorbic acid analyses are presented in Table I. It will be seen from the table that average ascorbic acid concentrations of 0.617 mg, 0.184 mg, 0.042 mg, and 0.033 mg/g wet tissue were found for the pituitary, cerebral cortex, myocardium, and skeletal muscle, respectively.

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TABLE I

The Mean Ascorbic Acid Concentration in Human Pituitary, Cerebral Cortex, Myocardium, and Pectoral Muscle

Age Group	Pituitary		Cerebral cortex				Myocardium				Pectoral muscle			
	N*	mg/g wet weight.	N	mg/g wet weight.	N	mg/g tissue nitrogen.	N	mg/g wet weight.	N	mg/g tissue nitrogen.	N	mg/g wet weight.	N	mg/g tissue nitrogen.
0-9 years	6	0.889	7	0.452	7	40.9	6	0.073	6	3.2	5	0.047	4	1.5
10-19	3	0.950	3	0.223	3	17.0	3	0.042	3	1.7	3	0.044	3	1.6
20-29	6	0.770	6	0.181	5	13.6	6	0.034	6	1.4	6	0.031	5	1.1
30-39	6	0.988	6	0.180	6	14.1	5	0.055	5	1.8	4	0.043	4	1.6
40-49	4	0.447	5	0.122	5	10.4	5	0.038	5	1.5	5	0.028	5	1.1
50-59	15	0.521	16	0.140	14	11.1	13	0.030	12	1.3	14	0.030	13	1.2
60-69	17	0.511	16	0.153	16	11.4	14	0.040	14	1.6	13	0.033	13	1.0
70-79	4	0.497	11	0.149	11	11.9	11	0.039	10	1.6	10	0.031	10	1.2
80-89	1	0.455	1	0.103	1	8.0	4	0.049	2	2.1	3	0.019	1	0.4
Grand Mean		0.617		0.184		15.0		0.042		1.7		0.033		1.2

\* N = number of specimens.

An analysis of the mean ascorbic acid tissue value for the various decades revealed that the ascorbic acid concentration of the pituitary decreased from 0.889 mg/g wet tissue for the 0 to 9 year age group to 0.455 mg/g wet tissue for the 70 to 79 year group. Calculation of the coefficient of correlation age/pituitary ascorbic acid concentration showed an  $r$  value of  $-0.50$  ( $t = 4.72$ ,  $N = 69$ ). A similar reduction in the ascorbic acid content with age was observed in the case of the cerebral cortex, in which a decrease from 0.452 mg/g wet tissue (0 to 9 year group) to 0.103 mg/g wet tissue (70 to 79 year group) was recorded. Calculation of the coefficient of correlation age/cerebral cortex ascorbic acid concentration gave an  $r$  value of  $-0.60$  ( $t = 6.23$ ,  $N = 71$ ) when the calculation was based on the concentration found in the wet tissue, whereas the coefficient was found to be  $-0.57$  ( $t = 5.70$ ,  $N = 68$ ) when the concentration in cerebral tissue per g tissue nitrogen was considered. It will be seen from the table that the values for the ascorbic acid concentration in the myocardium and in the pectoral muscle were relatively high in the younger age groups, and that no decrease in the older age groups could be demonstrated after the second decade for the myocardium and after the fourth decade for the pectoral muscle.

The rate of decrease of the tissue ascorbic acid content with age was of the same degree in the males and in the females of the present

series. A comparative study of the tissue ascorbic acid concentration in the males and in the females of the total series disclosed higher values for the females in the case of the pituitary (55 per cent) and of the myocardium (24 per cent). No significant difference was found for the cerebral cortex and the pectoral muscle.

#### DISCUSSION

The results of this study have shown a decrease of the tissue ascorbic acid concentration with age in man. The decrease was statistically significant in the pituitary gland and in the cerebral cortex. After an initial fall, no such tendency could be demonstrated in the heart and in the pectoral muscle during the later decades. An unequivocal conclusion as to the lack of change of ascorbic acid content in human muscular tissue in old age can, however, not be drawn from the present data. The high ascorbic acid content of the pituitary gland reported by previous workers<sup>13,14</sup> was confirmed in the present investigation.

A decrease in the ascorbic acid concentration of the pituitary with age was observed by Diehl and Neumann.<sup>5</sup> While the general tendency of their findings is of interest, the ascorbic acid values reported by these authors are, however, not directly comparable with those observed in the present study, since they were obtained with the methylene blue method. The same applies to the few analyses reported by Melka.<sup>6</sup> A histochemical study of the

ascorbic acid content of the pituitary gland was carried out by Gough,<sup>7</sup> who applied the Szent-Györgyi silver reaction for ascorbic acid to histologic sections of 100 human pituitaries. The reactions, which were classified into strong, moderate, slight, and negative, were found to be less intense in the aged than in the younger subjects. Plaut and Bülow<sup>8,9</sup> examined 43 samples of brain tissue derived from foeti, infants, and adults of various ages with the 2,4-dichlorophenolindophenol method. Their mean values are in good agreement with those found in the present study and likewise show that in young subjects the concentration of ascorbic acid in the brain is higher than in old individuals.

Yavorsky, Almaden, and King,<sup>10</sup> using the 2,4-dichlorophenolindophenol procedure, investigated the adrenal gland, brain, pancreas, liver, spleen, kidney, lung, heart, and thymus in 67 human subjects of different ages. Their results are similar to those obtained by other workers and show a definite decrease in ascorbic acid tissue concentration with age. The same relationship is suggested by the data of Bessey and King,<sup>11</sup> who examined the adrenals and livers of four human subjects with the 2,4-dichlorophenolindophenol method.

An evaluation of the significance of the observed decrease in total tissue ascorbic acid concentration with age will not be attempted at the present stage.

#### SUMMARY

A study was made with the method of Roe and Kuether of the total ascorbic acid concentration in 69 samples of human pituitary gland, 71 samples of human cerebral cortex, 67 samples of human myocardium, and 63 samples of human pectoral muscle, derived from individuals ranging in age between 7 days and 88 years. Average values, respectively, of 0.617, 0.184, 0.042, and 0.033 mg/g fresh tissue were found.

A statistically significant decrease of ascorbic acid concentration with age was observed in the pituitary gland ( $r = -0.50$ ,  $t = 4.72$ ,  $N = 69$ ) and in the cerebral cortex ( $r = -0.60$ ,  $t = 6.23$ ,  $N = 71$ ). After an initial fall, no further decrease with age could

be demonstrated in the ascorbic acid concentration in the myocardium after the second decade and in the pectoral muscle after the fourth decade.

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