Studies on Blood and Plasma Catalase

The 4th Report

The Blood and Plasma Catalase Content in Various Experimental Anemias

By

Syoiti Yamagata and **Sukehiko Seino**

(山形 徹一)

(清野 祐彦)

(From the Medical Clinic of Prof. T. Kurokawa,
Tohoku University, Sendai)

(Received for publication, July 30, 1952)

From our former report¹⁾, it is presumed that the blood catalase content changes in the close connection with erythrocytes and hemoglobin, but the plasma catalase content is influenced not only by the hemopoietic function, but also by the hemolysis in a living body and the hemoclastic function of the spleen.

Therefore, we made an attempt to measure the blood and plasma catalase content in various experimental anemias to make clear its significance.

EXPERIMENTAL

Results

1. Anemia caused by artificial bleeding

In our former report²⁾ we confirmed that there is no evident diurnal variation of the blood and plasma catalase content as the control test of normal rabbits.

In order to make an artificial anemia, 10 cc. of the blood was taken out from rabbits for 7 days by heart puncture. Data presented in Table I show that the blood catalase content decreases in company with erythrocytes and hemoglobin in anemia caused by artificial bleeding, but the recovery of the blood catalase content after stopping the bleeding precedes that of erythrocytes and hemoglobin, while the variation of the plasma catalase content is not remarkable. Moreover, the catalase index, hemoglobin-catalase index and plasma-blood catalase ratio tend to increase temporarily.

2. Anemia caused by phenylhydrazine

After subcutaneous injection of phenylhydrazine hydrochloride in doses of 2 cc. per kg. body weight of 1% solution for 3 days, the blood

TABLE I
Blood and Plasma Catalase Content by Artificial Bleeding

	No.	Before bleed- ing	1st day after bleed- ing	2nd " "	3rd " "	4th " "	5th " "	6th " "	7th " "	8th " "	9th " "	11th " "	13th " "	15th " "
Erythrocytes	1	614	592	407	336	348	471	445	443	420	420	481	534	608
	2	518	474	411	330	342	312	242	287	303	336	346	486	580
Hb.	1	86	70	55	58	51	50	50	45	44	59	65	72	81
	2	88	82	75	55	58	55	53	53	55	52	57	68	77
Hb-index	1	0.70	0.59	0.68	0.86	0.73	0.53	0.56	0.51	0.52	0.71	0.68	0.68	0.67
	2	0.85	0.86	0.92	0.83	0.85	0.88	1.09	0.92	0.91	0.77	0.82	0.70	0.66
Blood catalase	1	5.64	5.10	4.86	3.91	3.91	4.93	5.81	4.25	4.01	4.79	4.79	7.14	6.09
	2	7.21	4.69	3.74	4.35	4.01	3.20	3.84	3.60	4.42	3.81	4.96	5.10	5.27
Plasma catalase	1	25.16	13.60	17.00	29.24	13.60	5.44	23.46	25.16	11.56	10.40	4.76	30.60	34.68
	2	26.52	10.20	12.24	8.84	23.80	12.24	19.04	29.92	16.64	17.68	27.20	8.16	25.84
Catalase index	1	0.92	0.86	1.19	1.16	1.12	1.05	1.31	0.96	0.96	1.14	1.00	1.33	1.00
	2	1.39	0.99	0.91	1.32	1.17	1.02	1.58	1.26	1.46	1.13	1.43	1.05	0.91
Hb-catalase index	1	0.38	0.43	0.51	0.39	0.44	0.59	0.67	0.55	0.53	0.47	0.43	0.57	0.44
	2	0.48	0.33	0.29	0.46	0.40	0.34	0.42	0.40	0.46	0.43	0.51	0.44	0.40
Plasma-blood catalase ratio	1	4.46	2.67	3.49	7.47	3.47	1.11	4.03	5.91	2.88	2.12	0.99	4.29	5.71
	2	3.68	2.18	3.27	2.03	5.94	3.81	4.96	8.27	3.76	4.63	5.52	1.60	4.90

catalase content decreased rapidly together with erythrocytes and hemoglobin, but their recovery differed as presented in Table II. On the contrary, the plasma catalase content increased immediately after phenylhydrazine as well as reflected image in the mirror, and returned to a normal extent very slowly after stopping the injection.

3. Anemia caused by saponin

When 1% saponin was intravenously injected in doses of 1 cc. per kg. on the first day, 1.5 cc. on the second day and 2 cc. on the third day, the blood catalase content decreased in a slight degree in company with erythrocytes and hemoglobin, contrary to the markedly increased content of plasma catalase, and then the recovery of the blood catalase content and hemoglobin preceded that of erythrocytes (Table III).

4. Anemia caused by colloidal silver

The results presented in Table IV show that 1% colloidal silver used intravenously in doses of 2 cc. per kg. for 20 days lowers little by little the blood catalase content, erythrocytes and hemoglobin, but the decrease of the blood catalase content takes place newly later after stopping the injection. In particular, it is notable that the plasma catalase content increases in the first stage, but decreases afterwards preceding that of the blood catalase.

5. Intoxication by sodium nitrite

When 0.5 cc. per kg. of 10% sodium nitrite which produces methemo-

TABLE II
Blood and Plasma Catalase Content by Phenylhydrazine Injection

	No.	Before injec- tion	1st day		2nd day		3rd day		4th day after injec- tion	5th	7th	9th	13th	17th	21th	28th	35th
			Be- fore injec- tion	3h after injec- tion	Be- fore injec- tion	3h after injec- tion	Be- fore injec- tion	3h after injec- tion									
Erythrocytes	1	609	735	597	552	514	394	350	272	179	308	393	536	537	635	554	670
	2	706	671	631	634	579	425	397	232	149	139	240	467	560	553	659	604
Hb.	1	86	85	83	80	70	48	40	32	44	60	76	88	95	96	87	96
	2	100	100	93	75	68	55	45	23	23	30	51	80	85	112	105	107
Hb-index	1	0.71	0.58	0.69	0.73	0.68	0.62	0.57	0.61	1.23	0.97	0.97	0.82	0.88	0.76	0.78	0.72
	2	0.71	0.75	0.74	0.59	0.59	0.65	0.56	0.50	0.77	1.11	1.06	0.86	0.71	1.01	0.80	0.88
Blood catalase	1	4.91	4.25	4.52	4.42	4.28	3.57	3.50	2.72	3.88	6.05	7.75	7.58	7.69	7.17	6.94	7.04
	2	4.91	4.62	4.86	5.13	4.08	3.13	2.92	2.18	1.94	2.79	5.30	7.14	6.66	7.24	6.80	6.73
Plasma catalase	1	12.35	8.16	10.20	68.68	95.88	74.46	102.68	127.84	58.48	36.72	16.32	17.00	11.56	4.76	10.88	17.68
	2	21.86	13.94	27.52	40.80	40.80	44.88	73.44	74.80	69.02	68.68	40.80	21.76	10.20	17.68	4.08	12.92
Catalase index	1	0.80	0.58	0.71	0.80	0.83	0.90	1.00	1.00	2.16	1.97	1.97	1.41	1.43	1.13	1.25	1.05
	2	0.69	0.67	0.77	0.81	0.70	0.74	0.74	0.94	1.31	2.01	2.21	1.53	1.19	1.31	1.03	1.11
Hb-catalase index	1	0.33	0.29	0.32	0.32	0.36	0.43	0.51	0.49	0.51	0.59	0.59	0.50	0.47	0.43	0.46	0.43
	2	0.28	0.27	0.31	0.40	0.34	0.33	0.38	0.54	0.49	0.54	0.63	0.52	0.46	0.37	0.37	0.37
Plasma-blood catalase ratio	1	2.52	1.92	2.26	15.51	22.40	20.82	29.30	46.80	15.08	6.07	2.11	2.24	1.50	0.66	1.57	2.51
	2	4.46	3.02	5.65	7.94	10.00	14.34	25.10	34.30	35.50	24.60	7.71	3.05	1.53	2.44	0.60	1.92

TABLE III
Blood and Plasma Catalase Content by Saponin Injection

	No.	Before injec- tion	1st day		2nd day		3rd day		4th day after injec- tion	5th " "	7th " "	10th " "	13th " "	16th " "
			Before injec- tion	3h after injec- tion	Before injec- tion	3h after injec- tion	Before injec- tion	3h after injec- tion						
Erythrocytes	1	597	593	617	452	424	494	461	392	407	413	463	424	479
	2	695	697	676	594	659	686	620	574	587	587	590	544	596
Hb.	1	79	83	94	85	78	64	52	58	55	58	75	72	65
	2	98	99	107	110	110	94	90	94	86	92	92	83	90
Hb-index	1	0.66	0.70	0.76	0.94	0.92	0.65	0.57	0.74	0.68	0.70	0.81	0.86	0.68
	2	0.70	0.72	0.79	0.93	0.84	0.64	0.73	0.82	0.73	0.79	0.78	0.76	0.76
Blood catalase	1	7.41	7.75	6.83	7.45	6.77	8.02	5.41	6.56	6.09	6.39	8.30	9.25	8.02
	2	7.41	7.41	6.49	7.92	6.97	8.19	7.58	7.31	6.66	6.80	7.58	9.09	8.19
Plasma catalase	1	17.68	8.16	12.24	10.20	47.60	61.24	53.04	40.12	36.04	21.08	12.92	21.76	13.60
	2	11.56	8.16	29.24	9.52	40.12	30.60	66.64	54.40	50.32	36.72	19.72	19.72	12.24
Catalase index	1	1.24	1.31	1.11	1.65	1.59	1.62	1.17	1.69	1.49	1.55	1.79	2.17	1.67
	2	1.06	1.06	0.96	1.33	1.06	1.19	1.22	1.27	1.13	1.16	1.28	1.67	1.38
Hb-catalase index	1	0.55	0.54	0.42	0.51	0.50	0.73	0.60	0.66	0.64	0.64	0.64	0.74	0.72
	2	0.44	0.44	0.35	0.42	0.37	0.51	0.49	0.45	0.45	0.43	0.48	0.64	0.53
Plasma-blood catalase ratio	1	2.39	1.05	1.79	1.39	7.03	7.63	9.81	6.61	5.92	3.30	1.56	2.36	1.70
	2	1.56	1.10	4.51	1.20	5.77	4.40	8.79	7.44	7.54	5.40	2.60	2.17	1.49

TABLE IV
Blood and Plasma Catalase Content by Colloidal Silver Injection

	No.	Be- fore injec- tion	1st day after injec- tion	3rd	5th	7th	9th	11th	13th	17th	21th	25th	29th	35th	40th	50th	60th	70th
Erythrocytes	1	616	729	468	530	522	516	532	486	507	446	430	458	518	570	540	556	560
	2	618	575	644	682	544	565	540	562	424	520	311	529	527	600	630	650	649
Hb.	1	80	98	63	68	75	65	66	64	55	63	57	63	74	80	80	82	84
	2	85	82	87	80	77	75	68	70	62	58	56	62	71	86	88	98	100
Hb-index	1	0.65	0.67	0.67	0.64	0.68	0.63	0.62	0.66	0.55	0.71	0.66	0.70	0.71	0.74	0.74	0.74	0.75
	2	0.69	0.71	0.68	0.59	0.71	0.65	0.63	0.62	0.73	0.56	0.90	0.59	0.62	0.72	0.70	0.75	0.77
Blood catalase	1	5.68	5.13	3.77	3.98	4.93	4.96	4.83	3.54	5.24	4.96	5.71	5.34	4.79	5.30	4.42	3.33	3.13
	2	5.61	5.51	4.59	5.75	5.51	5.00	4.90	4.69	4.86	5.20	5.30	4.83	5.07	5.61	5.10	3.88	3.94
Plasma	1	47.94	35.36	23.12	31.28	43.52	45.56	58.48	30.60	26.52	53.04	34.00	38.76	18.36	23.12	10.54	6.80	7.48
catalase	2	34.00	23.80	12.24	47.60	51.68	44.88	49.64	39.44	42.84	55.08	34.68	22.44	53.72	23.80	13.60	7.48	10.20
Catalase index	1	0.92	0.70	0.81	0.75	0.89	0.96	0.91	0.74	1.03	1.11	1.33	1.16	0.92	0.93	0.82	0.60	0.56
	2	0.99	0.89	0.71	0.84	1.01	0.89	0.91	0.83	1.14	1.00	1.70	0.91	0.96	0.93	0.81	0.60	0.61
Hb-catalase	1	0.41	0.30	0.35	0.34	0.38	0.44	0.43	0.32	0.53	0.46	0.58	0.49	0.38	0.38	0.32	0.24	0.22
index	2	0.38	0.39	0.31	0.42	0.41	0.39	0.42	0.39	0.45	0.52	0.55	0.45	0.41	0.38	0.34	0.23	0.23
Plasma-blood	1	8.29	6.88	8.64	7.85	8.82	9.17	12.08	8.67	5.07	10.70	5.96	7.24	3.82	4.34	2.38	2.04	2.39
catalase ratio	2	6.06	4.32	2.67	8.28	9.39	8.98	10.11	8.40	8.81	10.57	6.55	4.64	10.71	4.24	2.67	1.93	2.59

TABLE V
Blood and Plasma Catalase Content by Sodium
Nitrite Injection

	No.	Before injection	After injection (time in hours)						
			0.25	0.5	1	2	3	5	7
Erythrocytes	1	617	575	614	599	617	577	629	615
	2	621	618	623	598	624	608	628	619
Hb.	1	97	92	101	104	102	95	102	94
	2	90	90	91	95	98	92	101	91
Hb-index	1	0.78	0.80	0.82	0.87	0.83	0.82	0.81	0.76
	2	0.73	0.73	0.73	0.79	0.79	0.75	0.80	0.74
Blood catalase	1	8.87	8.84	8.53	7.75	7.99	8.60	8.06	7.99
	2	8.02	8.19	7.75	7.58	8.30	7.96	7.75	7.99
Plasma catalase	1	27.88	19.04	19.38	23.80	18.36	23.12	20.74	18.02
	2	13.60	12.24	12.58	17.68	11.56	14.62	12.92	11.22
Catalase index	1	1.44	1.54	1.38	1.29	1.29	1.47	1.28	1.30
	2	1.29	1.32	1.24	1.27	1.32	1.30	1.23	1.29
Hb-catalase index	1	0.53	0.56	0.49	0.43	0.46	0.52	0.46	0.49
	2	0.52	0.53	0.49	0.47	0.49	0.50	0.45	0.51
Plasma-blood catalase ratio	1	3.14	2.16	2.27	3.07	2.30	2.69	2.57	2.25
	2	1.70	1.40	1.62	2.33	1.39	1.84	1.67	1.40

globin in the blood, was intravenously injected, the change of the blood and plasma catalase content, erythrocytes and hemoglobin remained almost within a physiological variation (Table V).

DISCUSSION

It is generally accepted that the blood catalase content decreases in parallel with erythrocytes and hemoglobin in anemia caused by artificial bleeding (Bernstein³), Ochi⁴), Nozaki⁵), Takimoto and Kubo⁶), Bode⁷), v. Krüger⁸), Fujikawa⁹), but Kurokawa¹⁰) and Takisawa¹¹) recognize the plasma catalase content to be unchangeable. As for the catalase index of the above-stated anemia, Nozaki⁵), Takimoto⁶) and Fujikawa⁹) recognize the temporary increase, but Bode⁷), Nissen¹²), Bernstein³), Ochi⁴) and v. Krüger⁸) report it to be constant. The results obtained from our experiments show that the blood catalase content decreases in company with erythrocytes and hemoglobin, but the recovery of the former precedes that of erythrocytes and hemoglobin. Therefore, the catalase index, hemoglobin-catalase index and plasma-blood catalase ratio tend to increase temporarily, while the plasma catalase content is not so variable.

In anemia caused by phenylhydrazine which is compared to pernicious anemia, many workers, such as Nissen¹²), Bernstein³), Ochi⁴), Nozaki⁵), Takimoto and Kubo⁶), v. Krüger⁸) and Fujikawa⁹), recognize that the catalase index increases remarkably. Data presented in our experiments

show that the decrease of the blood catalase content precedes that of erythrocytes and hemoglobin and the increase of the plasma catalase content evidently continues for more than one week after the last injection. Therefore, the catalase index, hemoglobin-catalase index and plasma-blood catalase ratio increase remarkably, but the latter subsequently decreases to the subnormal degree.

Gaisböck and Bayer¹³⁾ as well as Kano¹⁴⁾ report that saponin, the hemolytic toxin, is accompanied by the disturbed function of the bone marrow. According to our results, it is presumed that the plasma catalase is produced by hemolysis in a living body, because it changes as reflected image in the mirror, compared with the blood catalase. Moreover, in the above-stated anemia as well as anemia caused by phenylhydrazine, the recovery of the blood catalase and hemoglobin is more marked than that of erythrocytes, therefore, it is accompanied by the excitement of the hemopoietic function.

As to the blood and plasma catalase of anemia caused by colloidal silver which is compared to aplastic anemia by Komiya¹⁵⁾, there is no report. Our results show that the decrease of the blood and plasma catalase content is still remarkable after the stopping of the injection, especially, the latter is more marked than the former.

Furthermore, we attempted to estimate the influence of the intoxication by sodium nitrite, which is recognized as a toxin to cause methemoglobin by Loewy¹⁶⁾. Our results show that the variation of the blood and plasma catalase content remains almost within a physiological change, and then the catalytic power of the blood and plasma can not be identified with hemoglobin.

Therefore, it is presumed that the variation of the blood and plasma catalase content in various experimental anemias is produced by functional or anatomical disorders of the hemopoietic organs.

SUMMARY

From these experiments with various experimental anemias caused by artificial bleeding, phenylhydrazine, saponin, colloidal silver and sodium nitrite, it can be concluded that the blood and plasma catalase is produced in the hemopoietic organs by different process from that of erythrocytes and hemoglobin, while a larger portion of the plasma catalase is produced by the hemolysis in a living body.

References

- 1) Yamagata and Seino, *Tohoku J. Exp. Med.*, 1952, **57**, 101.
- 2) Yamagata, Seino and Nakao, *ibid.*, 1952, **57**, 85.
- 3) Bernstein, *Biochem. Z.*, 1926, **179**, 304.

- 4) Ochi, Hokkaido Med. J. (Jap.), 1928, **6**, 693.
 - 5) Nozaki, J. Chōsen Med. Assoc. (Jap.), 1929, **19**, 1319.
 - 6) Takimoto and Kubo, J. Gastroenterology (Jap.), 1930, **5**, 868.
 - 7) Bode, Z. exp. Med., 1931, **77**, 558.
 - 8) v. Krüger, *ibid.*, 1933, **88**, 437.
 - 9) Fujikawa, Mitt. d. med. Ges. zu Okayama (Jap.), 1935, **47**, 3072.
 - 10) Kurokawa, Tohoku J. Exp. Med., 1930, **14**, 520.
 - 11) Takisawa, *ibid.*, 1931, **18**, 223.
 - 12) Nissen, Z. klin. Med., 1921, **92**, 1.
 - 13) Gaisböck and Bayer, Wien. klin. Wschr., 1924, 952.
 - 14) Kano, Mitt. d. Med. Ges. zu Nagoya (Jap.), 1934, **41**, 695.
 - 15) Komiya *et al.*, J. Kumamoto Med. Soc. (Jap.), 1928, **4**, 121.
 - 16) Loewy, Zbl. f.d. ges. inn. Med. u. Grenzgeb., 1937, **88**, 374.
-