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# Effect on $CO_2$-combining Power of Direct Irradiation of Blood in vivo.*

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In previously published papers, a method was described for direct irradiation, with a special carbon arc, of circulating blood in etherized dogs; also some effects on blood pressure[1] and various blood constituents and properties.[2, 3, 4] Since no adequate explanation has been found for most of the results reported, it has seemed advisable to investigate the possibility of other changes occurring, under the experimental conditions described, which might add to our understanding of photobiological effects.

It is the purpose of this paper to report the results of an investigation of the effect on carbon dioxide combining power of the blood of dogs subjected to the same technic as those used in the other investigations. C. Kroetz[5] has reported that ultra-violet and Roentgen irradiation produce immediately a temporary acidosis, with reversal of the effect after a few hours. It has been generally observed that ether anesthesia decreases the $CO_2$-combining power of the animal's blood.[6, 7]

It has also been noted that injection of medium doses of morphine, subsequent to complete ether anesthesia, will again increase this factor.[6, 8] It does not fall within the province of this paper to discuss the underlying causes of these changes, but to report our results for the sake of a complete picture of the immediate changes resulting from this method of irradiation.

A series of control experiments was made, in each of which a sample of blood was drawn from the saphenous vein, after which the animal was quickly etherized and subjected to all the operative technic previously described but without radiation. Further samples were drawn at varying intervals and the total amount of $CO_2$ in solution determined by the method of Van Slyke.[9] In all cases the blood was heparinized *in vivo*. Each determination was made in duplicate. The results are shown in Table I.

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TABLE I.

$CO_2$ per 100 cc. of blood. Control series. Time in five minute intervals.

| No. | Min. | 5 | 10 | 15 | 20 | 30 | 35 | 40 | 45 | 50 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 54.6 | | 46.2 | | | | | | | 44.6 | | 38.5 | | | 36.4 | | | 37.3 | | | 36.4 | 36.5 | |
| 2 | 42.4 | | 31.0 | | 31.4 | 35.1 | | 29.8 | | 29.9 | 31.0 | | 26.3 | | | | 29.6 | | | | 30.0 | | |
| 3 | 51.6 | 41.8 | 34.4 | | 34.4 | | | 34.7 | | 32.0 | | | | | | | | | | | | | |
| 4 | 51.0 | 45.5 | 47.9 | 47.1 | | | | | | 44.9 | | | | | | | 36.1 | | | | | | |
| 5 | 60.0 | 53.9 | 56.5 | 55.6 | | | | | | 53.3 | | | | | | | 43.6 | | | | | | |
| 6 | 44.0 | 36.8 | 36.8 | | 37.0 | | 40.5 | | | | 34.4 | | | | | | 37.3 | | | | | | |
| 7 | 51.1 | 39.8 | 39.9 | | | | | 40.2 | | | | | 39.8 | | 39.7 | 40.3 | | | | | | | |
| 8 | 40.8 | 36.5 | 36.5 | | | | | 36.5 | | | | 34.9 | | 36.2 | 35.0 | | 35.8 | | | | | | |
| 9 | 50.0 | | | | 43.1 | | | | | 34.4 | | | 30.3 | | | | 27.8 | | 28.2 | | 28.2 | | 28.2 |
| 10 | 53.1 | | | 46.5 | | | | | 54.7 | | | 42.4 | | 43.0 | | | | | | | | | |

TABLE II.

Experimental series. Irradiation begun at *.

| No. | Min. | 10 | 15 | 20 | 25 | 30 | 40 | 45 | 50 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 | 120 | 125 | 130 | 135 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 55.4 | 37.0 | * | | | | | | 40.5 | | | | | 40.5 | | | 40.5 | | 39.8 | | | | | | | |
| 2 | 47.1 | | | 42.8 | * | | 40.1 | | 40.1 | | | | | 40.0 | | | | | | 38.4 | | 38.8 | | | | |
| 3 | 59.1 | | 45.7 | | | | * | | 45.5 | | | | | 45.9 | | | | | | 43.0 | | | 42.9 | | 34.7 | |
| 4 | 48.9 | | 40.8 | | | | * | 43.1 | | | | | 42.6 | | | | | | 34.9 | | 30.5 | | 34.6 | | |
| 5 | 52.1 | | 46.1 | | | | | * | | 36.6 | | | | | | 34.9 | | | | | 34.3 | | | 28.2 | |
| 6 | 54.7 | | | | | 42.8 | * | | | | 42.8 | | | | | | 47.9 | | | 47.6 | | | 46.6 | | | |
| 7 | 56.3 | 45.2 | * | | * | | 36.9 | | | | | 34.9 | | | | | | 32.2 | | | 27.5 | | | | | |
| 8 | 50.6 | | | | 38.3 | | | | | | | | | | | 37.3 | | | 36.8 | 37.5 | 36.7 | 29.4 | | | | |
| 9 | 48.4 | | 41.1 | * | | 40.9 | | | | | | | 37.1 | | 33.6 | | | 31.5 | | | 29.6 | | | | | |
| 10 | 55.5 | | | 41.4 | * | | | 33.6 | | | | | 33.7 | | | 30.4 | | | 29.2 | | | | | | | |

* Irradiation begun.

TABLE III.

Control series. Morphine injection at m.

| No. | Min. | 10 | 15 | 20 | 30 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 85 | 90 | 95 | 100 | 110 | 115 | 120 | 130 | 135 | 150 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 61.7 | | 38.2 | m | | 40.2 | | | | | | 41.9 | | 42.1 | | | 42.2 | | 41.0 | | 43.0 | | |
| 2 | 55.9 | | 43.0 | m | 52.4 | | 54.2 | | | 54.5 | | | | | 51.4 | | | 47.7 | | 50.7 | | | |
| 3 | — | | 38.5 | m | | | 35.0 | | 35.2 | | 35.0 | | 35.7 | 36.4 | | 34.5 | | 34.6 | | | | | |
| 4 | 55.9 | m | 44.8 | | | | | 46.8 | | | | | 45.8 | | 48.1 | | 48.9 | 48.5 | | 48.2 | | | |
| 5 | 47.9 | m | 44.3 | | | | | 43.7 | | | | | 43.2 | | 39.9 | | 39.3 | 39.0 | | 39.2 | | | |
| 6 | 55.8 | | 41.3 | | | | | | | 41.6 | | | 31.3 | | 31.6 | | 31.5 | m | | | | 31.5 | 31.0 |

TABLE IV.

Experimental series. Morphine at m. Irradiation at *.

| No. | Min. | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 75 | 85 | 90 | 100 | 105 | 110 | 115 | 120 | 125 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 52.8 | | m | 38.9 | | | | * | | | 42.1 | | | 38.4 | | | | | | | 27.3 |
| 2 | 58.1 | | 41.2 | m | | * | | | 40.8 | | | 40.1 | 37.4 | | 35.4 | | 35.2 | | | 38.4 | |
| 3 | 49.2 | | 39.3 | | m | * | | | | 37.8 | | | 39.8 | | | | 42.1 | | 40.3 | | 42.6 |
| 4 | 51.9 | m | 44.0 | | * | | | | | 50.4 | | | 52.1 | | 57.0 | 56.9 | | 54.5 | | 55.3 | |
| 5 | 54.6 | m | 38.4 | * | | | | | | 25.8 | | | 23.6 | | 26.7 | | | | | | |
| 6 | 53.3 | m | 42.7 | * | | | | | | 43.6 | | | 43.9 | | 43.7 | 44.1 | | 43.2 | | 37.2 | |
| 7 | 55.5 | m | 49.7 | * | | | 35.6 | | | | | | 47.1 | | 45.5 | 47.9 | | 50.4 | | 50.7 | |
| 8 | 47.5 | m | 36.2 | * | | | | | | 36.9 | | | 38.9 | | 33.6 | 35.6 | | 28.0 | | 32.0 | |

In a second series, similarly managed, the blood was irradiated *in vivo*. For the sake of comparison with the results already reported, blood pressure was recorded in all series. No correlation was found possible between changes in blood pressure level and $CO_2$-combining power. .The results of this series are shown in Table II.

Since there could be shown no evidence of any constant effect of irradiation, it was decided to determine whether any effect could be found after the application of morphine, since this would increase the $CO_2$, after it had been decreased by ether. A control series was undertaken in which each animal, after complete ether anesthesia, and after all details of operative technic were completed, received a subcutaneous injection of 25 mg. of morphine sulphate per kilo of body weight. The first sample of blood was drawn before anesthesia, the second, just before morphine was administered, and subsequent samples at varying intervals as shown in Table III.

Another series prepared as above was subjected to irradiation after morphine injection. (Table IV.) As in the case of the first procedure, it was not found possible to demonstrate any constant changes in the $CO_2$-combining power, during or after irradiation. Nor was it found possible to correlate any observed variations with any other factor, although blood pressure was invariably depressed to a marked degree in both series of irradiations, as already reported,[1] even though considerable depression had already resulted from the morphine.

The results shown in Tables I and III, in general, confirm the findings of others with regard to the effects of ether anesthesia, and, of morphine and ether combined. With the single exception of number 6, Table II, there was a progressive decrease throughout each experiment in series I and II, which was more rapid in the earlier stages. While subject to some fluctuations during later stages, in both control and experimental series, there were no significant variations that could be attributed to irradiation.

Dog number 5, Table IV, died suddenly at the end of 90 minutes and after 70 minutes of irradiation. Such a result was not uncommon, in the previously reported experiments, and, seemed to be due to irradiation of an animal that, for some reason not understood, was extraordinarily sensitive, since the degree of anesthesia was, in no case, such as to warrant expectation of any such results.

Administration of morphine usually, though not invariably, caused an increase of $CO_2$, but the failure to do so was as frequently

apparent in the control series as in the experimental series, so that this result does not appear to be due to irradiation.

In view of the frequently reported effects of various types of irradiation on general metabolism, the failure to find any constant changes in $CO_2$-combining power in these experiments is disappointing. But so far as our results are concerned, it can be said that irradiation of blood *in vivo*, by our technic, does not produce any constant effect on this factor, at least within relatively short periods.

[1] Reed, C. I., *Am. J. Physiol.*, 1925, lxxiv, 518, 525.

[2] Falk, I. S., and Reed, C. I., *Am. J. Physiol.*, 1926, lxxv, 600.

[3] Koch, F. C., and Reed, C. I., *Am. J. Physiol.*, 1926, lxxv, 351.

[4] Reed, C. I., and Tweedy, W. R., *Ibid.*, 1926, lxxvi, 54.

[5] Kroetz, C., *Biochem. Z.*, 1924, cli, 146.

[6] Beckman, E., *Deut. Arch. klin. Med.*, 1914, cxvii, 419.

[7] Van Slyke, D. D., Austin, J. H., and Cullen, G. E., *J. Biol. Chem.*, 1922, liii, 227.

[8] Holló, J., Patai, J. A., and Kolta, E., *Arch. exp. Path. and Pharmakol.*, 1925, cvii, 162-70.

[9] Van Slyke, D. D., *J. Biol. Chem.*, 1917, xxx, 360.

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## Accessory Etiologic Factors of Pneumonia in Rabbits. I: Effect of Putting Brilliant Green into Nasal Passages.

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A weak solution (from 0.1 to 0.3 per cent) of brilliant green dropped into the nostrils of rabbits carrying *B. lepisepticum* incites severe snuffles and pneumonia. In rabbits not carrying the organism naturally, the same effect can be obtained by putting a small amount of culture into the nostrils before the dye is given or 1 or 2 days afterwards. The dye alone has little or no visible effect.

Thirty-two rabbits having very slight serous discharges from the nose, and, a positive lepisepticum culture, were given 0.2 cc. of the solution (0.3 per cent) in each nostril. All of the rabbits developed very profuse nasal discharges, which often caused such obstruction of the nasal passages, that they were forced to breathe through the mouth. To all intents and purposes the rabbits had a very severe