

XXXIII. *Contributions to the Chemistry of the Urine.*—Paper III.PART IV. *On the Variations of the Sulphates and Phosphates in Disease.*By HENRY BENICE JONES, *M.D., M.A. Cantab., F.R.S., Physician to St. George's Hospital.*

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THE object of the following experiments was to determine whether the sulphates in the urine were increased or diminished in any class of diseases. The total amount of phosphates in the urine in the same diseases was at the same time made the subject of experiment, partly to see whether the deductions made in a paper published in the *Philosophical Transactions* for 1846 would be confirmed, and partly to determine whether the same disease produced the same or a different effect on the phosphates as on the sulphates; whether, in diseases in which the phosphates were increased the sulphates would be also increased in the same proportion; and whether, in those diseases in which the phosphates were diminished, the sulphates also would be found to be below the average amount.

Most of the following experiments were made on the urine first passed in the morning before food. When this could not be obtained, the afternoon or night urine was taken. Almost all the cases were in St. George's Hospital, and therefore under nearly the same circumstances as regards exercise. The diet usually varied with the state of the patient.

In two papers in the *Philosophical Transactions* for 1845 and 1849, I have shown that in the healthy state on full diet the total amount of sulphates and phosphates in the urine varies as regards sulphates—

|   |                       |
|---|-----------------------|
| After food from 11·85 grs. of sulphate of baryta per 1000 grs. of urine . | Spec. grav.<br>1033·9 |
| Before food to 7·93 grs. of sulphate of baryta per 1000 grs. of urine .   | 1026·5                |

As regards the total phosphates—

|   |        |
|---|--------|
| After food from 7·22 grs. of phosphate of lime per 1000 grs. of urine . | 1030·0 |
| Before food to 7·96 grs. of phosphate of lime per 1000 grs. of urine .  | 1027·9 |

In the following paper I shall give the amount of the sulphates and the total amount of the phosphates in the urine:—

1. In acute and chronic diseases in which the muscular structures are chiefly affected.
2. In some functional diseases of the brain, as delirium tremens and some other forms of delirium.
3. In acute inflammatory disease of the nervous structures.
4. In chronic diseases of the nervous structures.

5. In *acute* diseases in which neither the nervous nor the muscular structures are chiefly affected.

6. In *chronic* diseases in which neither the muscular nor nervous structures are chiefly affected.

TABLE I.—On the amount of Sulphates and the total amount of Earthy and Alkaline Phosphates in those diseases in which the muscular structures are chiefly affected.

|                                     | Sulphate of baryta<br>per 1000 grs. of urine. | Specific<br>gravity. | Total phosphates<br>per 1000 grs. of urine. |
|-------------------------------------|---|----------------------|---|
| Case 1. Acute chorea after salts.   |   |                      |   |
| 5th day .....                       | 25.09   | 1032.3               | 0.68  |
| 5th day .....                       | 21.73   | 1035.2               |   |
| 8th day .....                       | 7.28  | 1030.0               | 7.34  |
| 9th day .....                       | 2.56  | 1013.1               | 4.70  |
| Case 2. Acute chorea. Boy, æt. 8.   |   |                      |   |
| 6th day .....                       | 11.25   | 1030.6               | 3.29  |
| 7th day .....                       | 10.66   | 1031.8               | 2.52  |
| 8th day .....                       | 11.15   | 1031.2               | 2.54  |
| 10th day .....                      | 7.39  | 1028.4               | 3.50  |
| 11th day .....                      | 3.92  | 1018.6               | 1.57  |
| 102nd day .....                     | 8.01  | 1030.6               |   |
| Case 3. Acute chorea. Girl, æt. 22. |   |                      |   |
| 3rd day .....                       | 19.88   | 1036.0               |   |
| 5th day .....                       | 15.86   | 1033.8               |   |
| 6th day .....                       | 13.80   | 1028.4               | 6.51  |
| 7th day .....                       | 9.36  | 1026.8               |   |
| 8th day .....                       | 6.08  | 1025.4               |   |
| 13th day .....                      | 4.72  | 1016.4               |   |
| Case 4. Chronic chorea .....        | 1.86  | 1008.2               |   |
| Case 5. Chronic chorea .....        | 3.49  | 1014.7               | 1.61  |
|                                     | 1.91  | 1014.3               | 1.12  |
|                                     | 2.66  | 1013.0               | 4.05  |
| Case 6. Chronic tetanus .....       | 1.58  | 1009.9               | 2.47  |
|                                     | 2.95  | 1015.5               | 2.75  |

Hence in three cases of acute chorea the most remarkable increase was observed in the amount of sulphates in the urine. That this did not arise from the small quantity of urine passed is evident from the small amount of the total phosphates in the urine. Moreover the actual quantity passed, when it could be determined by measure, was found occasionally to be above thirty ounces in twenty-four hours. It is worthy of notice that the amount of urea was also very greatly increased in these cases; so much so, that on the addition of nitric acid to the urine without any evaporation, nitrate of urea immediately crystallized out.

A very small quantity of food was taken by these patients, whilst the muscular action was most severe; and the contrast between the amount of sulphates when they were recovering and taking full diet, and the amount when they took little food, but were in a state of violent muscular action, is very remarkable.

The general conclusion is, that in acute chorea the amount of sulphates in the urine is increased, whilst the phosphates are in some cases as remarkably diminished.

TABLE II.—On the amount of Sulphates and the total amount of Earthy and Alkaline Phosphates in some functional diseases of the brain, as delirium tremens and some other forms of delirium.

|  | Sulphate of baryta<br>per 1000 grs. of urine. | Specific<br>gravity. | Total phosphates. |
|--|---|----------------------|-------------------|
| Case 1. Delirium tremens.                                    |   |                      |                   |
| 6th day .....  | 5.74  | 1017.9               |                   |
| 6th night. Death.  |   |                      |                   |
| Case 2. Delirium tremens.                                    |   |                      |                   |
| 5th day .....  | 13.34   | 1018.0               |                   |
| Case 3. Delirium tremens.                                    |   |                      |                   |
| 3rd day .....  | 10.60   | 1023.94              | 5.29              |
| Case 4. Delirium tremens.                                    |   |                      |                   |
| 10th day .....   | 17.31   | 1024.74              | 0.87              |
| Case 5. Delirium tremens. Chloroform.                        |   |                      |                   |
| 8th day .....  | 8.51  | 1026.8               |                   |
| Case 6. Delirium tremens.                                    |   |                      |                   |
| 5th day .....  | 20.77   | 1037.8               | 2.14              |
| 5th night .....  | 37.07 pink.                                   | 1041.2               | 5.95              |
| 6th died.  |   |                      |                   |
| Case 7. Delirium tremens.                                    |   |                      |                   |
| Uncertain day .....  | 2.96  | 1013.2               | 1.18              |
| Uncertain day .....  | 7.83  | 1021.6               | 7.24              |
| Uncertain day .....  | 8.61  | 1022.0               | 7.43              |
| Case 8. Delirium tremens.                                    |   |                      |                   |
| 13th day .....   | 13.10   | 1037.4               | 9.83              |
| 14th day .....   | 12.95   | 1034.6               | 8.89              |
| Case 9. Traumatic delirium tremens.                          |   |                      |                   |
| 3rd day .....  | .....   | 1014.8               | 1.97              |
| 5th day .....  | 8.45  | 1028.0               | 3.11              |
| 6th day .....  | 8.77  | 1026.2               | 6.23              |
| Case 10. Poisoned by laudanum, with delirium and excitement. |   |                      |                   |
| 2nd day .....  | 7.83  | 1026.8               | 7.53              |
| 3rd day .....  | 6.78  | 1023.0               | 1.11              |
| Re-admitted again poisoned.                                  |   |                      |                   |
| 1st day.....   | 6.35  | 1029.2               | 8.88              |
| 2nd day .....  | 6.38  | 1024.0               | 8.24              |
| 3rd day .....  | 15.89   | 1028.0               | 4.22              |
| 4th day .....  | 13.01   | 1026.0               | 4.81              |
| 6th day .....  | 7.55  | 1025.0               | 4.42              |
| 7th day .....  | 8.22  | 1026.3               | 5.88              |
| Case 11. Delirium, with phthisis.                            |   |                      |                   |
| 4th day .....  | 10.84   | 1027.34              | 1.44              |
| 4th night .....  | 6.97  | 1024.2               | 0.72              |
| 7th day .....  | 4.45  | 1018.3               | 1.51              |

In the 2nd, 3rd, 4th, 6th and 8th cases of delirium tremens the sulphates were found to be above the average. In the 6th case the sulphates are in the greatest quantity ever observed in health or disease. Sulphate of magnesia had also been taken by this patient, so that the amount of sulphates is partly owing to the medicine; but that this is not the sole or chief cause of the increase is proved by the fact that many of the patients with other diseases took the same quantity of sulphate of magnesia, but the sulphates in the urine were never increased to the same amount.

The phosphates, in seven out of the nine cases of delirium tremens, were below the average. The same fact was stated in my previous paper, but from the diminution

of the phosphates in acute chorea, it becomes doubtful how far this result is owing to the action of alcohol in the system.

Further experiments are required; meanwhile excessive abstinence from food must be admitted as a cause of the diminution of the phosphates in the urine, provided there is no inflammatory action of the nervous structures.

In a case of restless excitement leading to self-destruction, the sulphates in the urine were found to be increased, and the same thing was also observed with a diminution of the phosphates in a case of delirium and phthisis.

In the 6th and 10th cases urea was found to be in great excess when the sulphates were increased. In the other cases the excess of urea was not looked for.

TABLE III.—On the amount of Sulphates and the total amount of Earthy and Alkaline Phosphates in acute inflammatory diseases of the nervous structures.

|  | Sulphate of baryta per<br>1000 grs. of urine. | Specific<br>gravity. | Total phosphates. |
|--|---|----------------------|-------------------|
| Case 1. Inflammation of the brain.<br>20th day .....   | 7.67  | 1031.8               |                   |
| Case 2. Inflammation of the brain.<br>12th day .....   | 3.96  | 1018.7               | 5.14              |
| 13th day .....   | 11.23   | 1027.26              | 11.13             |
| 14th day .....   | 2.91  | 1013.1               | 6.06              |
| 16th day .....   | 7.34 }<br>7.69 }                              | 1027.0               | { 10.75<br>11.04  |
| 16th night. Died.  |   |                      |                   |
| Case 3. Subacute hydrocephalus.<br>15th day .....  | 8.83  | 1030.0               | 9.41              |
| 16th day .....   | 10.69   | 1029.0               | 8.45              |
| 22nd day .....   | 8.83  | 1029.8               | 10.19             |
| 26th day .....   | 9.46  | 1031.4               | 9.01              |
| 28th day. Died.  |   |                      |                   |
| Case 4. Acute after chronic disease.<br>Uncertain .....  | 3.54<br>9.39                                  | 1024.9<br>1026.0     | 0.91<br>9.31      |
| Died.  |   |                      |                   |
| Case 5. Head symptoms, with tubercles in<br>cerebellum and lungs.<br>15th day .....                | 9.88  | 1031.6               | 8.72              |
| 15th night .....   | 10.07   | 1032.2               | 8.91              |
| 16th day .....   | 6.69  | 1016.4               | 4.72              |
| 16th night .....   | 8.25  | 1018.2               | 5.69              |
| 18th day. Died.  |   |                      |                   |
| Case 6. Inflammation of the lungs, with tu-<br>bercles and violent head symptoms.<br>4th day ..... | 8.55  | 1027.85              | 7.19              |
| 6th day .....  | 7.81  | 1026.1               | 6.43              |
| 8th day .....  | 11.63   | 1031.4               | 9.30              |
| 9th day .....  | 10.13   | 1026.2               | 7.99              |
| 9th night. Died.   |   |                      |                   |
| Case 7. Injury, with head symptoms not<br>violent.<br>2nd day .....                                | 7.34  | 1026.8               | 5.20              |
| 4th day .....  | 9.66  | 1028.6               | 7.52              |
| 5th day .....  | 13.74   | 1028.6               | 7.91              |
| 32nd day .....   | 2.11  | 1011.66              | 1.52              |
| Case 8. Injury of the head, slight.<br>7th day .....   | 6.59  | 1022.9               | 8.93              |

TABLE III. (continued.)

|                           | Sulphate of baryta per<br>1000 grs. of urine. | Specific<br>gravity. | Total phosphates. |
|---------------------------|---|----------------------|-------------------|
| Case 9. Fractured spine.  |   |                      |                   |
| 5th day .....             | 3.75  | 1014.2               | 3.15              |
| 6th day .....             | 12.23   | 1030.2               | 10.68             |
| 7th day .....             | 9.91  | 1028.8               | 10.10             |
| 7th night. Died.          |   |                      |                   |
| Case 10. Fractured spine. |   |                      |                   |
| 4th day .....             | 14.57   | 1029.2               | 9.26              |
| 5th day .....             | 15.54   | 1029.2               | 8.16              |
| 6th day .....             | 13.00   | 1030.2               | 7.96              |
| 7th day .....             | 6.65  | 1021.6               | 4.30              |
| 8th day .....             | 8.80  | 1022.0               | 6.67              |
| 9th day .....             | 2.18  | 1007.3               | 1.58              |
| 10th day .....            | 2.37  | 1010.8               | 2.57              |
| Died.                     |   |                      |                   |
| Case 11. Fractured spine. |   |                      |                   |
| 1st day .....             | 5.59  | 1012.0               | 4.15              |
| 1st night. Died.          |   |                      |                   |
| Case 12. Fractured spine. |   |                      |                   |
| 1st day .....             | 5.90  | 1019.4               | 2.47              |
| 2nd day .....             | 6.45  | 1025.3               | 4.31              |
| 2nd night .....           | 3.37  | 1012.4               | 1.40              |
| 3rd day .....             | 5.87  | 1023.0               | 1.09              |
| 3rd night .....           | 10.32   | 1027.0               | 3.11              |
| 4th day .....             | 6.65  | 1022.6               | 5.77              |
| 4th night .....           | 7.61  | 1024.1               | 4.90              |
| 5th day .....             | 13.03   | 1027.8               | 4.08              |
| 6th day. Died.            |   |                      |                   |

In the first eight cases of inflammatory action in the brain, there is an increase in the amount of sulphates as well as in the total amount of phosphates in the urine. In the second and third cases this increase is most apparent. In the previous paper the phosphates in the urine were shown to be decidedly increased in inflammation of the brain, and from these experiments it is evident that the sulphates are increased also.

From the amount of albumen in the nervous structures, it is certain that the amount of sulphur present therein is but little if at all less than the amount of phosphorus which it contains.

TABLE IV.—On the amount of Sulphates and the total amount of Phosphates, Earthy and Alkaline, in some slight and chronic diseases of the nervous or neighbouring structures.

|  | Sulphate of baryta<br>per 1000 grs. urine. | Specific<br>gravity. | Total<br>phosphates. |
|--|--|----------------------|----------------------|
| Case 1. Pain in the head. After salts.     |  |                      |                      |
| 40th day .....                             | 9.98                                       | 1026.2               |                      |
| Case 2. Hemiplegia.                        |  |                      |                      |
| 7th day .....                              | 5.13                                       | 1021.6               | 5.22                 |
| 21st day .....                             | 2.60                                       | 1017.0               | 1.51                 |
| Case 3. Scalp wound. After salts.          |  |                      |                      |
| 6th day .....                              | 8.34                                       | 1023.7               | 4.63                 |
| 8th day .....                              | 4.84                                       | 1018.7               | 3.77                 |
| Case 4. Fracture of the skull. After salts | 11.97                                      | 1019.1               | 6.08                 |
| Case 5. Recent paraplegia .....            | 7.24                                       | 1021.6               | 4.50                 |

In these diseases no increase of sulphates was observed, except after sulphate of magnesia had been taken as a medicine. The quantity taken was usually two drachms; yet the amount in the urine never reached to what it was when there was excessive action of the muscular or nervous structures.

TABLE V.—On the amount of Sulphates and the total amount of Earthy and Alkaline Phosphates in acute diseases, in which neither the nervous nor muscular structures are chiefly affected.

|   | Sulphate of baryta<br>per 1000 grs. of urine. | Specific<br>gravity. | Total phosphates. |
|---|---|----------------------|-------------------|
| Case 1. Petechial fever.                                      |   |                      |                   |
| 5th day .....   | 5.65  | 1014.6               | 2.62              |
| 6th day .....   | 3.79  | 1012.9               | 2.01              |
| 9th day .....   | 1.30  | 1010.0               | 0.73              |
| 13th day .....  | 0.93  | 1011.5               | 2.61              |
| 18th day .....  | 5.25  | 1016.2               | 0.73              |
| 19th day .....  | 10.06   | 1027.4               | 4.80              |
| 20th day .....  | 1.12  | 1010.94              | 2.10              |
| 22nd day .....  | 2.58  | 1020.80              | 2.68              |
| 55th day. Recovered.  |   |                      |                   |
| Case 2. The same patient with ague and                        |   |                      |                   |
| 28th day .....  | 5.71  | 1021.6               | 5.13              |
| 33rd day .....  | 4.86  | 1015.6               | 1.41              |
| afterwards with petechial fever.                              |   |                      |                   |
| 5th day .....   | 5.39  | 1027.0               | 4.32              |
| 8th day .....   | 6.56  | 1026.2               | 4.32              |
| 16th day .....  | 3.19  | 1014.2               | 3.09              |
| 21st day. Recovered.  |   |                      |                   |
| Case 3. Scarlet fever.  |   |                      |                   |
| 3rd day .....   | 8.27  | 1032.2               | 6.33              |
| 10th day .....  | 2.01  | 1012.0               | 2.90              |
| 19th day .....  | 4.14  | 1022.1               | 5.42              |
| Case 4. Inflammation of the lungs.                            |   |                      |                   |
| 7th day .....   | 6.21  | 1019.7               | 6.41              |
| 8th day .....   | 5.91  | 1021.5               | 6.98              |
| 9th day .....   | 6.59  | 1021.5               | 4.24              |
| 10th day .....  | 6.96  | 1025.4               | 6.96              |
| 11th day .....  | 8.13  | 1025.5               | 4.23              |
| 13th day .....  | 8.02  | 1027.1               | 2.86              |
| 16th day .....  | 4.16  | 1018.0               | 3.77              |
| Case 5. Petechial fever.                                      |   |                      |                   |
| 16th day .....  | 3.05  | 1013.7               | 4.08              |
| Case 6. Petechial fever.                                      |   |                      |                   |
| 10th day .....  | 3.35  | 1013.2               | 2.90              |
| 11th day .....  | 4.04  | 1013.7               | 3.94              |
| 14th day .....  | 3.73  | 1016.8               | 7.08              |
| Case 7. Inflammation of the lungs and membranes of the brain. |   |                      |                   |
| 7th day .....   | 4.05  | 1012.5               | 2.86              |
| Case 8. Acute rheumatism. After sulphur.                      |   |                      |                   |
| 9th day .....   | 11.75   | 1031.10              |                   |
| Case 9. Acute rheumatism.                                     |   |                      |                   |
| 11th day .....  | 6.96  | 1025.7               | 5.59              |
| Case 10. Acute rheumatism. After salts.                       |   |                      |                   |
| 5th day .....   | 11.89   | 1026.0               | 9.84              |
| 7th day. After salts .....                                    | 10.78   | 1029.1               | 5.53              |
| 20th day .....  | 6.94  | 1021.8               | 5.97              |
| Case 11. Acute rheumatism.                                    |   |                      |                   |
| 8th day .....   | 7.17  | 1023.2               | 5.60              |
| 17th day .....  | 5.68  | 1027.5               | 6.26              |

In these acute diseases, except after sulphate of magnesia, the amount of sulphates was not found above the average. The amount both of phosphates and sulphates appeared not to be influenced by these diseases.

TABLE VI.—On the amount of Sulphates and the total amount of Earthy and Alkaline Phosphates in Chronic Diseases, in which neither the nervous nor muscular structures are chiefly affected.

|   | Sulphate of baryta<br>per 1000 grs. of urine. | Specific<br>gravity. | Total phosphates. |
|---|---|----------------------|-------------------|
| Case 1. Exostosis .....   | 1.75  | 1016.6               |                   |
| Case 2. Exostosis .....   | 7.09  | 1023.4               | 6.03              |
| Case 3. Exostosis .....   | 9.08  | 1026.4               | 11.58             |
| Case 4. Diabetes .....  | 7.45  | 1025.2               | 3.94              |
| Case 5. Diabetes .....  | 4.21  | 1030.2               | 0.91              |
| Case 6. Diuresis. Albumen .....   | 0.49  | 1003.6               | 1.09              |
|   | 0.89  | 1005.36              | 1.49              |
| Case 7. Obstruction of the œsophagus. Albumen .....                       | 1.38  | 1012.2               | 4.70              |
| Case 8. Aneurism of aorta? .....  | 6.03  | 1017.8               | 2.39              |
| Case 9. Obstruction of the bowels. Sulphate of magnesia.<br>8th day ..... | 22.55   | 1024.3               | 3.51              |
| 9th. Died.  |   |                      |                   |
| Case 10. Excessive oxalate of lime .....                                  | 7.89  | 1025.5               | 6.14              |
| Case 11. Indigestion. Alkaline from fixed alkali .....                    | 3.26  | 1024.7               | 3.65              |
| Case 12. Chronic rheumatism. After sulphur .....                          | 5.85  | 1011.82              | 4.86              |
| Case 13. Chronic rheumatism .....   | 7.93  | 1023.44              |                   |
| Case 14. Chronic gout. Vichy water.....                                   | 10.04   | 1025.8               | 5.26              |

In these chronic diseases nothing remarkable was observed as to the amount of sulphates or phosphates, excepting in case 3 of exostosis, in which the amount of sulphates and of phosphates was above the average.

In case 9, of total obstruction of the bowels, sulphate of magnesia was given frequently during the day in small doses: nothing passed through the intestine. The whole of the sulphate was absorbed, and hence the great increase in the sulphates in the urine.

In a patient, case 14, who was taking Vichy water, the sulphates were observed to be slightly above the average.

The conclusions I have drawn may be thus enumerated:—

Table I. In three cases of acute chorea the most remarkable increase was observed in the amount of sulphates in the urine. In the same cases the quantity of urea was very much increased. The quantity of urine made in twenty-four hours was not excessively diminished, and the total amount of earthy and alkaline phosphates was below the average amount.

The general conclusion was, that in acute chorea the amount of sulphates in the urine is increased, whilst sometimes the phosphates are as remarkably diminished.

Table II. In delirium tremens and in other delirium a remarkable increase in the amount of sulphates in the urine was frequently observed, and the total phosphates were in the same cases occasionally remarkably diminished; and the resemblance to

the state of chorea was still closer, inasmuch as occasionally a very great excess of urea was found in these cases also.

Table III. In acute inflammatory diseases of the nervous structures, during the most febrile symptoms, an increase was observed in the amount of sulphates in the urine, and the total amount of earthy and alkaline phosphates in these diseases appeared to be increased in the same proportion as the sulphates were increased.

Table IV. In some slight and chronic diseases of the nervous structures, no increase in the amount of sulphates in the urine was observed, excepting when sulphate of magnesia had been taken as a medicine.

Table V. In acute diseases, in which neither the nervous nor the muscular structures were chiefly affected, no increase in the sulphates or phosphates was observed, except after sulphate of magnesia.

Table VI. In chronic diseases, in which neither the nervous nor the muscular structures were chiefly affected, no decided increase in the sulphates or phosphates in the urine was observed, except after sulphate of magnesia. One case of exostosis may be regarded as a doubtful exception to this statement.

The general conclusions are—

1. That in acute chorea, in which the muscles are in excessive action, the sulphates and urea in the urine are greatly increased.
2. That in delirium tremens the same state of urine is frequently met with; that in these diseases the phosphates are not at all increased.
3. That in acute inflammation of the nervous structures, sulphates and phosphates are both increased in the urine.
4. That in chronic diseases of the brain, and that in other acute inflammations and diseases and in other chronic diseases, no increase in the total amount of sulphates is observed, excepting when sulphate of magnesia is taken as a medicine.

The result of this investigation is that—

Muscular action increases the sulphates in the urine without increasing the phosphates; whilst

Inflammation of the brain increases both the sulphates and phosphates in the urine.