POTASSIUM LEVELS IN EXCHANGE TRANSFUSION*

BY
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In the Royal Maternity Hospital, Belfast, in common with other centres treating haemolytic disease of the newborn, the number of infants requiring exchange transfusion has been increasing steadily in the past few years. In 1950 there were seven live-born affected infants, of whom five were treated, all successfully, by exchange transfusion, in 1954 there were 42 live-born affected infants of whom 34 were treated by exchange transfusion, 31 surviving.

At the end of 1952 and the beginning of 1953 there were two deaths during the actual transfusion in infants who were comparatively mildly affected. The deaths were sudden and unexpected, and it occurred to us that they might have resulted from an excess of potassium in the bottles of blood used for the exchange. The plasma from several random bottles was therefore analysed, and it was found that levels of 40 mg. % were not uncommon, even though none of the blood had been more than one week in store.

In an attempt to determine whether hyperpotassaemia might in fact be the cause of death in these infants, an investigation was planned on the following lines:—

In every case where it was decided to treat the baby by exchange transfusion, samples of blood were taken from the umbilical vein at the beginning of the transfusion and after every 100 ml. of the exchange. These samples were taken into heparinized tubes and the plasma separated within four hours. Similar samples were taken from the bottles of stored blood used for the exchange. In general, the criteria for transfusion were those suggested by Mollison (1952), and an exchange of 60 ml. of packed cells per lb. weight was aimed at.

When data had been obtained from 20 infants (21 transfusions) they were examined; the potassium levels for this control group are shown in Fig. 1. It will be seen that 13 of the 104 samples had potassium levels of 28 mg. % or above, and that three of the four deaths in this group had potassium levels above 32 mg. %. (The fourth death was of a premature infant, weighing 4 lb. 6 oz., with a cord blood haemoglobin of 42 % (6.2 g.).)

To attempt to correlate the potassium level in the bottles used with the levels reached in the infants, the cases were grouped according to the greatest level in the bottles used, and the maximum level in the babies charted. These results are shown in Table 1.

<table>
<thead>
<tr>
<th>Maximum in Bottle</th>
<th>Mean in Bottle</th>
<th>Maximum in Child</th>
<th>Mean of Maximum Levels in Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 26</td>
<td>22-34</td>
<td>1</td>
<td>2*)</td>
</tr>
<tr>
<td>26-32</td>
<td>29-66</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Over 32</td>
<td>45-80</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

* Indicates deaths.

In such a group of cases, with many variable factors such as birth weight, cord blood haemoglobin, birth order, maturity, etc., it is impossible to make any valid statistical analysis. It does not appear, however, from the figures shown in this table that there is any simple relation between the potassium level in the bottle of blood used for exchange and the maximum level reached in the child. In this we were unable to confirm the work of Miller, McCord, Joos and Clausen (1952), who found that in a small series of eight cases there was a direct relation between the potassium level in the stored blood and that reached in the child.

Although the results obtained in this control group do not prove that the high potassium levels were the actual cause of death, rather than a coincidental result of some other process in the disease itself or the transfusion, it was felt that an attempt should be made to guard against the rise. It is generally accepted that the most rapid way to remove potassium from the extracellular to the intracellular fluid is to give glucose and insulin.

* Based on a paper read to the Ulster Paediatric Society on May 7, 1955.
intravenously. In the absence of any previous reports on this technique as applied to the newborn infant, it was decided in the first instance to give 2 g. of glucose and 2 units of insulin into the umbilical vein after the first 100 ml. of blood had been exchanged. When the first few transfusions had been carried out it was found that the blood sugar levels were high, and as the 50% glucose used tended to make the syringe sticky and thus added baby with very intense jaundice, who died during a second transfusion, with clinical evidence of kernicterus. (Consent was unfortunately not obtained for a necropsy.) The group of six rather high readings (32 mg. per 100 ml. and above) was examined to see whether any reason could be found for the apparent failure to respond to the insulin.

One was the specimen only 100 ml. after giving the insulin, then the subsequent samples having normal

slightly to the technical difficulty, it was decided to give the insulin alone. (It should be mentioned that the standard anticoagulant solution used by the Northern Ireland Blood Transfusion Service contains glucose, so that the plasma glucose level of stored blood is generally about 700-800 mg. per 100 ml.)

The potassium levels from 16 infants (17 transfusions) are shown in Fig. 2.

It will be seen that the general trend is lower in this 'insulin' group than in the 'control' group.

The only death in this treated series was a 6-lb. values, and the infant showing no clinical sign of distress. It is possible that in this case even higher and perhaps fatal potassium levels might have occurred had insulin not been given.

Two were the samples at the end of transfusion in infants showing some collapse, not sufficient to cut short the exchange, and the remaining three were from the one infant, who had intense jaundice and who died at the age of 2 months with evidence of kernicterus.

For comparison with the control group, the relation between the potassium levels in the bottles
used and the maximum levels reached in the infants is shown in Table 2. This shows little difference from Table 1.

<table>
<thead>
<tr>
<th>Maximum in Bottle</th>
<th>Maximum in Child</th>
<th>Mean of Maximum Levels in Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean in Bottle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 26 23-48</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>26-32</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Over 32</td>
<td>3</td>
<td>1*</td>
</tr>
</tbody>
</table>

* Indicates deaths.

In such small groups of cases, with many variable factors in the individual infants, one cannot make any detailed statistical analysis. Table 3 shows that as far as birth weight and cord blood haemoglobin were concerned there was no great difference between the two groups.

The actual mean levels of potassium at each stage of the transfusions are shown in Table 4. These are of much less practical importance than the individual readings shown in Figs. 1 and 2, since the occasional high value, associated clinically with collapse or death, does not make an appreciable difference to the mean reading. The mean blood sugar levels are also shown in Table 4, and also the mean cord blood potassium in a series of 16 normal infants. The latter was found to agree with the value given by Earle, Bakwin and Hirsch (1951) and not with the much higher values quoted by Smith (1951).

### Discussion

From the results obtained in this investigation it appears that hyperpotassaemia is not infrequent in the course of exchange transfusions for haemolytic disease of the newborn, and that the levels reached are potentially lethal. As has been stated, there is no proof that the high potassium content of the plasma has been the cause of death in those infants who died suddenly rather than a coincidental finding. Little work appears to have been done on this aspect of exchange transfusion; apart from a passing reference to one fatal case by Walker and Neligan (1955), the only article that I have been able to trace is that of Miller et al. (1952) already referred to. They relate the high potassium levels directly to the high content of the transfusion blood; our results do not confirm this, but it is difficult to offer any explanation for the apparent individual variation in the rate of accumulation of potassium. Although the series is too small to justify detailed subdivision into subgroups according to all the variable factors involved, there does not seem to have been any relation to the severity of the disease as measured by cord blood haemoglobin or bilirubin levels. As far as possible the actual technique of transfusion has been standardized to eliminate possible variations in such factors as rate of exchange, chilling of the baby, etc.

Gustafson (1951) has reported electrocardiographic changes suggesting hypocalcaemia during exchange transfusion, although the total calcium content of the blood did not show any significant change. The plasma calcium levels were estimated in the first few of our series, but as there was no apparent variation, this was discontinued and attention concentrated on the more striking potassium changes. We hope to be able to obtain a direct-reading electrocardiograph in order that a continual check may be kept on the action of the heart muscle during transfusion, as this may prove to be the most sensitive estimate of electrolyte changes and may show the need for appropriate treatment before serious harm can occur.

Our present opinion is that there is sufficient evidence to support the theory that hyperpotassaemia is a cause of death to justify the routine use of insulin in future transfusions. It might be advisable to give a slightly larger dose, e.g., 3 units, before giving the first 10 ml. replacement. (In this connexion, it has been found that a tuberculin syringe is essential for accurate measurement of dosage.)

It will necessarily take a year or more to obtain a really large series of cases, but it is hoped that other centres may consider similar investigations as a check on our findings.
Summary

An investigation has been carried out into the plasma potassium levels in newborn infants undergoing exchange transfusions for haemolytic disease. Toxic levels have been found in some infants, and it is suggested that this may be one factor in causing death. The potassium level in the child does not appear to bear a direct relationship to that in the stored blood used.

Intravenous insulin has been used in an attempt to reduce the potassium levels, with some success.

I am very grateful to my obstetric and paediatric colleagues in the Royal Maternity Hospital, Belfast, for much help both in planning and carrying out this trial. Mr. D. W. Neill, M.Sc., A.R.I.C., Senior Scientific Officer, Belfast Hospital Group, has given invaluable advice and much practical assistance at every stage.

REFERENCES