Phosphate Partition in the Erythrocytes of Normal Newborn Infants and Infants with Erythroblastosis Fetalis. III. P\textsuperscript{32} Uptake and Incorporation

By Tibor J. Greenwalt, V. E. Ayers and S. A. Morell

Differences between the red cells in the perinatal period and those of adults have been reported. The enzyme activities in the erythrocytes of the newborn vary in some respects from those in adults. Jones and McCance\textsuperscript{1} found cholinesterase, glyoxalase, carbonic anhydrase and catalase diminished in cord blood. Stevenson\textsuperscript{2} reported low carbonic anhydrase levels in the erythrocytes of the newborn and Day and Du Pan\textsuperscript{3} found it decreased in premature infants. Lonn and Motulsky\textsuperscript{4} presented evidence that the methemoglobin reductase level in cord blood erythrocytes is reduced. Ross and Desforges\textsuperscript{5,6} demonstrated reduction in the ability of erythrocytes from cord blood to reduce methemoglobin in the presence of substrates which generate reduced diphosphopyridine nucleotide (DPNH), suggesting a transient deficiency of either DPNH-dependent methemoglobin reductase or one of the enzymes of the Embden-Meyerhof pathway responsible for the generation of DPNH. Gross and Hurwitz\textsuperscript{7} found increased values for G-6-PD,\textsuperscript{8} 6-PGD and aldolase in the erythrocytes of the newborn. The intermediate products of glycolysis have received less attention. Kutas and Stuetzel\textsuperscript{8} observed reduced amounts of phosphoglycerate in the red cells of newborn dogs, rabbits, pigs and guinea pigs. Greenwalt and Ayers\textsuperscript{9} reported that the low values of 2,3-DPG in the erythrocytes of rabbit pups rose fivefold to adult levels during the first three weeks of life. Partition of the intraerythrocytic acid-soluble phosphates in cord blood from normal and erythroblastotic infants (anti-D) and adults by paper chromatography revealed greater quantities of 2,3-DPG in the adults and erythroblastotic newborn.\textsuperscript{10} On incubation the drop in 2,3-DPG concentration was greater in the normal and erythroblastotic infants than in the adults. Zipursky, LaRue and Israels\textsuperscript{11} reported similar findings and also a slower uptake of P\textsuperscript{32} by cord blood erythrocytes. The permeability of the red cell membrane has been a subject of continuing interest, but comparative studies of the uptake, turnover and distribution of inorganic phosphate by the erythrocytes of the newborn and the adult are essentially lacking.

The purpose of this paper is to present studies of the uptake and incorporation of P\textsuperscript{32}O\textsubscript{4} into the intraerythrocytic acid-soluble phosphates of newborns.
and adults based on the results of quantitative paper chromatography reported in an earlier publication.  

**MATERIALS AND METHODS**

The collection of the blood samples, preparation of the perchloric acid filtrates and the solvent systems used for paper chromatography have been previously described. Each sample of whole blood, collected in ACD formula A, was equilibrated at 37 ± 0.5°C in a water bath for 15 minutes before the addition of 2.5 μc of P³²/ml as NaH₂P³²O₄. After thorough mixing, an aliquot was removed immediately to determine the initial plasma P³² counts per minute. Incubation was continued with shaking in air at 92 cycles per minute. Samples were removed at 20 minute intervals for the first two hours and then hourly up to four hours. Each aliquot was chilled at once in an ice bath and subsequent manipulations were performed in a cold room at 4°C. Very slight or no hemolysis was noted on gross inspection of each plasma specimen.

Duplicate 25 μl samples of each aliquot of plasma were plated on aluminum planchets and dried under an infrared lamp. Each planchet was counted to a total of 25,600 counts using a halogen-quenched Geiger-Mueller tube with a 1.4 mg/cm² mica window.

The paper chromatograms of the perchloric acid extracts of the once washed cells from the one, two and four hour incubation samples were cut into strips 1 to 1/8 inches in width and spliced end to end. They were run through a model C100A Actigraph II* system using the same Geiger-Mueller tube, and the radioactivity in each spot was recorded on a rectilinear chart operated synchronously.† The area under each peak was determined by planimetry and converted to c.p.m. The identity of the spots corresponding to the peaks of radioactivity was determined as previously outlined. The inorganic phosphate spot was located by scanning with a Geiger-Mueller tube. The relative specific activities of the compounds isolated were determined by using the quantitative data obtained by eluting each spot, making a correction for decay. The r.s.a. of ATP and 2,3-DPG were calculated on the basis of two labile phosphates for the former and one for the latter. These were reported in a previous publication but the essential data are reproduced in table 1.

The r.s.a. of the plasma P₁ was corrected to a constant hematocrit of 40 per cent and a standard addition of 10⁵ c.p.m./100 ml of whole blood.

These formulae were used:

\[
\text{r.s.a. of plasma } P_1 = \frac{\text{c.p.m./ml plasma}}{\text{mg. P}_1/\text{ml plasma}} \times \frac{10^5 \text{ c.p.m.}}{\text{c.p.m./100 ml whole blood}} \times \frac{\text{observed hematocrit}}{40}
\]

\[
\text{r.s.a. of compound} = \frac{\text{c.p.m. in area}}{\mu g. \text{ P in area}} \times \frac{1}{\text{ml. RBC in area}} \times \frac{10^5 \text{ c.p.m.}}{\text{c.p.m./ml whole blood}}
\]

**RESULTS**

**Plasma Phosphorus Turnover Studies**

a. **Percentage of added P³²O₄ entering erythrocytes in ACD blood at 37°C.** The results corrected to a constant hematocrit of 40 per cent are given in table 2. The uptake of P³² from plasma is similar for the erythrocytes of normal and erythroblastotic infants, but lags behind that of the erythrocytes of adults.

b. **Half-value times and turnover rates.** The r.s.a. of the plasma inorganic phosphate, corrected to a constant addition of 10⁵ c.p.m. of P³² per 100 ml of whole blood and a hematocrit of 40 per cent, was plotted against time on a semilogarithmic scale. The data for the four normal infants are presented in

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* Nuclear-Chicago Corp.
† Recti-riter, Texas Instruments Corp.
Table 1.—Partition of the Acid-Soluble Phosphate Compounds in Human Erythrocytes During Incubation

<table>
<thead>
<tr>
<th>Source</th>
<th>No. in group</th>
<th>Hours incubated</th>
<th>P/100 ml. red cells*</th>
<th>2,3-DPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>4</td>
<td>0</td>
<td>89</td>
<td>317</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>126</td>
<td>340</td>
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<td></td>
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<td>125</td>
<td>341</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>148</td>
<td>329</td>
</tr>
<tr>
<td>Normal infants</td>
<td>4</td>
<td>0</td>
<td>137</td>
<td>274</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>213</td>
<td>269</td>
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<tr>
<td></td>
<td></td>
<td>2</td>
<td>249</td>
<td>284</td>
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<tr>
<td></td>
<td></td>
<td>4</td>
<td>337</td>
<td>281</td>
</tr>
<tr>
<td>Hemolytic newborn</td>
<td>4</td>
<td>0</td>
<td>153</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>201</td>
<td>298</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>232</td>
<td>303</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>325</td>
<td>282</td>
</tr>
</tbody>
</table>

*Average values.

Figure 1. The rapid decrease in the r.s.a. of the plasma inorganic phosphate during the first 60 minutes, in contrast to the subsequent slow rate of fall observed with every specimen, suggests the interaction of two or more mechanisms of phosphorus uptake by the erythrocytes. The method of least squares was used to plot each point and the "slow" phase was extrapolated to zero time. The corrected "fast" component was estimated by subtracting the initial portion of the extrapolated "slow" phase from the observed initial "fast" phase. The half-
value times for the “slow” and “fast” portions of the plasma phosphorus uptake curves were thus obtained and are given in table 3 with the plasma turnover rates calculated using the equation \( k = \frac{0.693}{t} \). The turnover rate expressed as per cent of plasma phosphate per minute was greater in adults than in infants. The half-value time was approximately four hours for the slow phase of phosphorus uptake by the red cells of adults as compared to five hours for the infants. No difference in these values was demonstrable for cord blood erythrocytes from infants with anti-D hemolytic disease and for normal infants.

In interpreting these data it is helpful to know whether the trend of phosphorus movement was in or out of the cells. The rates at which phosphorus entered and left the erythrocytes were calculated by applying the equations employed by Mueller and Hastings and are presented in table 4. The formulae used in the calculations are given in the legend to this table. Since \( p'' \) represents the rate of phosphorus transfer from red cells to plasma and \( p' \) the flow of phosphorus in the opposite direction, the balance of phosphorus movement is out of the cells when the ratio \( \frac{p''}{p'} \) exceeds unity. The prevailing movement of phosphorus was from cells to plasma.

**c. Incorporation of \( \text{P}^{32} \) into the intraerythrocyte phosphate compounds.** The relative specific activities of the intraerythrocytic P, ATP and 2,3-DPG after incubating for one, two and four hours with \( \text{P}^{32} \) are presented in table 5. The labeling of intraerythrocytic P, and 2,3-DPG proceeded at a much slower rate in the two groups of infants than in the adults. The overall rate of incorporation of \( \text{P}^{32} \) into the cells of all the newborn infants was depressed, but the rate of labeling of the intraerythrocytic phosphates in the infants with erythroblastosis was faster than in the normal newborn. The r.s.a. of 2,3-DPG in the red cells of adults equalled or exceeded the r.s.a. of P, and ATP by the end of four hours of incubation. This was not observed with the erythrocytes of the newborn infants in whom labeling of 2,3-DPG trailed ATP after four hours.

**DISCUSSION**

The experimental conditions used for studying the metabolism of erythrocytes have varied greatly. The anticoagulant most commonly employed has been heparin, but citrate, ACD and defibrination have also been used. Most frequently the blood-anticoagulant mixtures have been incubated as collected but some have used washed cells suspended in artificial media such as oxygen saturated phosphate Locke’s solution. Five per cent \( \text{CO}_2 - 95 \text{ per cent } \text{O}_2 \) has been bubbled through the cell suspensions by some, but air has been considered satisfactory by others. The effect of such variable environments on the results is not predictable. The initial and subsequent pH levels have been shown to be important. Murphy found a 50 per cent reduction in the glucose utilization of erythrocytes at pH 7.1 as compared to pH 7.5 and a 50 per cent increase at pH 7.8. The effect of pH is on the Embden-Meyerhof pathway. At lower pH a higher proportion of glucose is metabolized through the phosphogluconic shunt, which is not sensitive to changes in pH. Increasing concentrations of oxygen result in decreased total glucose utilization. Incubation above pH 7.3 favors esterification of inorganic phosphorus in the erythro-
cytes, whereas lower pH values have the opposite influence. This is in keeping with the observation by Kashket, Rubinstein and Denstedt18 that the pH maxima of glycerate-2, 3-diphosphatase are at 7.0 and 8.1 and are separated by a broad minimum between 7.2 and 7.8. The activity of erythrocyte hexokinase is depressed when the pH is below 7.4. Mollison19 has shown that the concentration of non-penetrating anions in the incubation mixture is critical in determining the rate of labeling of erythrocytes with P32. Chloride and sulfate apparently compete with phosphate and when they are replaced by citrate, ethylenediamine tetraacetate, or sucrose, the penetration of phosphate is remarkably enhanced. Our observations are in agreement, for as the proportion of ACD used was progressively increased, diluting the plasma chlorides, increasing citrate concentration and lowering pH from 7.11 to 6.91 and to 6.44, the percentage of P32 uptake increased, from 41 per cent, to 48 and 58 per cent respectively. The initial pH values of aliquots of a sample collected with heparin and ACD were 7.70 and 7.11 in that order; aeration at 37 C. for four hours produced pH readings of 7.97 and 7.30. The erythrocyte P32 uptake at the end of one hour at 37 C. was 28 per cent in the heparinized aliquot and 39 per cent in ACD. Certainly other differences between heparinized and ACD blood exist. In fresh ACD blood, Bartlett20 found no trace of fructose-1, 6-diphosphate which was demonstrable in heparinized blood. At low temperatures, phosphate exchange is negligible.19, 21, 22 The concentration of phosphate in the plasma was not considered to have any measurable effect by Hevesy21 or Gourley.23 Recently Zipursky24 has found an almost linear relationship between the external concentration of orthophosphate and its rate of entry into red cells. It should be noted that the latter observations were made with washed red cells suspended in veronal acetate buffer.

The erythrocytes of infants and adults cleared an average of 40 to 45 per cent of added radioactive phosphate from the plasma during the first hour (see table 2). This relatively rapid rate compared to the 20 per cent and 35 per cent clearance in one hour estimated from the graphs of Prankerd and Altman,25 and Gourley,23 for heparinized whole blood, can be explained by the lower pH and the presence of citrate.

Our data suggest the existence of an early fast phase of inorganic phosphate transport across the red cell membrane. This phase dominates during the first hour of incubation and may represent passive diffusion overshadowing an active transport mechanism. The active transport mechanism which may be responsible for the slow phase is dependent on the maintenance of the metabolic integrity of the cell. These observations closely resemble those of Gourley and Matschner12 but Prankerd and Altman25 were unable to demonstrate the early fast component. Active transport has been thought to be linked to the anaerobic glycolytic metabolism,25, 26 but recently Zipursky24 published data which indicate that it continues even though glycolysis has been completely inhibited by iodoacetic acid if adenosine is present. He therefore suggested linkage to the hexose monophosphate shunt.

The more rapid uptake of P32 by the erythrocytes of adults than by those of normal and erythroblastotic newborns became clearly apparent after the first hour of incubation (table 2). In keeping with these findings the percentage of
inorganic phosphorus turned over by the cells of the adults was higher than for the infants and agreed with the values obtained by Gourley. The uptake and turnover rates of phosphorus by the erythrocytes of erythroblastotic and normal infants were similar (Table 3). The antibody coating and the higher percentage of young cells in the infants with hemolytic disease had no influence on these functions.

When the amount of phosphate moving in and out of the erythrocytes was calculated and expressed as $\mu$M per cent per minute, the total exchange across the cell membrane appeared to be greater in the red cells of the infants than in those of the adults (Table 4). The balance of the phosphate exchange was always from the cells to the plasma. During the first 20 minutes of incubation, the average rate of turnover by erythroblastotic (anti-D) infants was twice that of the others and there was no overlapping of the results of individual experiments.
### Table 4.—Rate of Transfer of Phosphorus Across the Red Cell Membrane in ACD Blood

<table>
<thead>
<tr>
<th>Group</th>
<th>Interval, minutes, inc., at 37 C.</th>
<th>Average mM per L. plasma</th>
<th>$\mu$M P\textsubscript{i} transferred per minute</th>
<th>$p^*$</th>
<th>$p^\prime$</th>
<th>$p^\prime/p^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 adults</td>
<td>0–20</td>
<td>0.790</td>
<td>20.70</td>
<td>34.61</td>
<td>1.67</td>
<td></td>
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<tr>
<td></td>
<td>20–40</td>
<td>0.981</td>
<td>9.51</td>
<td>14.64</td>
<td>1.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40–60</td>
<td>1.081</td>
<td>6.90</td>
<td>11.80</td>
<td>1.71</td>
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<tr>
<td></td>
<td>60–80</td>
<td>1.178</td>
<td>6.39</td>
<td>9.95</td>
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<tr>
<td></td>
<td>80–100</td>
<td>1.241</td>
<td>4.84</td>
<td>6.61</td>
<td>1.37</td>
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</tr>
<tr>
<td></td>
<td>100–120</td>
<td>1.313</td>
<td>5.78</td>
<td>12.74</td>
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<tr>
<td></td>
<td>120–180</td>
<td>1.479</td>
<td>3.81</td>
<td>7.38</td>
<td>1.94</td>
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<tr>
<td></td>
<td>180–240</td>
<td>1.749</td>
<td>1.62</td>
<td>7.21</td>
<td>4.45</td>
<td></td>
</tr>
<tr>
<td>4 normal infants</td>
<td>0–20</td>
<td>1.083</td>
<td>21.28</td>
<td>34.16</td>
<td>1.61</td>
<td></td>
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<tr>
<td></td>
<td>20–40</td>
<td>1.381</td>
<td>13.54</td>
<td>30.29</td>
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<tr>
<td></td>
<td>40–60</td>
<td>1.614</td>
<td>13.77</td>
<td>20.42</td>
<td>1.48</td>
<td></td>
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<tr>
<td></td>
<td>60–80</td>
<td>1.752</td>
<td>7.21</td>
<td>13.08</td>
<td>1.81</td>
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<tr>
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<td>80–100</td>
<td>1.881</td>
<td>6.57</td>
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<td>3.46</td>
<td>12.42</td>
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<td>120–180</td>
<td>2.376</td>
<td>2.47</td>
<td>12.68</td>
<td>5.13</td>
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<tr>
<td></td>
<td>180–240</td>
<td>2.871</td>
<td>1.09</td>
<td>9.11</td>
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<tr>
<td>4 hemolytic newborn</td>
<td>0–20</td>
<td>1.320</td>
<td>37.58</td>
<td>61.56</td>
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<td>2.387</td>
<td>3.09</td>
<td>13.34</td>
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<td>120–180</td>
<td>2.676</td>
<td>4.21</td>
<td>10.50</td>
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<tr>
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<td>180–240</td>
<td>3.088</td>
<td>0.34</td>
<td>11.79</td>
<td>34.68</td>
<td></td>
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</table>

*Corrected to 50% hematocrit.

\[
K = \frac{2.3}{t} \times \log \frac{C_0}{C_t}
\]

\[
p^\prime = \frac{KP \times 1000}{t}
\]

\[
p^\prime = \frac{(P_t - P_0) \times 1000}{t}
\]

\[
p^\prime = \mu \text{M P transferred/minute from plasma into L. of cells}
\]

\[
p^\prime = \mu \text{M P transferred/minute from L. of cells into plasma}
\]

\[
C_0 = \text{c.p.m./ml. plasma at 0 time}
\]

\[
C_t = \text{c.p.m./ml. plasma at t time}
\]

\[
t = \text{time in minutes}
\]

\[
K = \text{velocity constant}
\]

\[
P = \text{plasma phosphorus expressed in mM per L. plasma}
\]

The rate of labeling of intraerythrocytic P\textsubscript{i}, ATP and 2,3-DPG was slower in all the infants than in the adults, but was somewhat more rapid in the red cells of infants with erythroblastosis than in normal infants, possibly secondary to factors associated with the attachment of anti-D antibodies to the red cells and their increased destruction and production. It is difficult to correlate these observations with the decreased utilization of glucose by erythrocytes in erythroblastosis reported by Abrahamov and Diamond.\textsuperscript{29}

The relative rates at which P\textsubscript{i}, ATP and 2,3-DPG were labeled are significant.
Table 5.—Relative Specific Activities of Intraerythrocyte Phosphates During Incubation with $^32P$

<table>
<thead>
<tr>
<th>Hrs. incub.</th>
<th>Normal Adults</th>
<th>Normal Infants</th>
<th>Erythroblastotic Infants</th>
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<tbody>
<tr>
<td></td>
<td>ATP 2,3-DPG P</td>
<td>ATP 2,3-DPG P</td>
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<td>1</td>
<td>45094 12116 55834</td>
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<td>44016 8452 30038</td>
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<td>(26231- (10869- (32968-</td>
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<tr>
<td></td>
<td>75706)* 14480 82125)</td>
<td>38933 8246 33758)</td>
<td>64241 12130 42283)</td>
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<td>30880 12650 22370</td>
<td>39846 17625 30360</td>
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<td>58450) 81233) 48499)</td>
<td>33228) 25069) 25416)</td>
<td>56066) 40070) 37593</td>
</tr>
</tbody>
</table>

*Range.*

The r.s.a. of ATP was calculated on the basis of two active phosphate groups and that of 2,3-DPG in terms of one high energy phosphate. In the erythrocytes of adults, 2,3-DPG was labeled at a slower rate than either P, or ATP, but by the end of four hours of incubation, these three compounds appeared to be in equilibrium. These relationships are similar to those described by Gourley, Gerlach et al., Bartlett, and Tatibana et al. The latter reported measurable labeling of ATP and ADP 10 seconds after the addition of $^32P$. The possible precursor relationships involved in these reactions have been adequately discussed by others. More important to this discussion is the difference in the degree of labeling of P, and ATP encountered in the cells of both groups of infants and maintained during the entire period of study. The inorganic phosphates and ATP had reached or passed their maximum r.s.a. by the end of one hour. The retarded incorporation of $^32P$ by 2,3-DPG, along with its relatively rapid drop in concentration when the cord blood of normal and erythroblastotic infants was incubated, suggests decreased formation of this compound. This was also proposed by Zipursky, LaRue and Israels in a recent report.

The decreased rate of labeling of P, ATP and 2,3-DPG in cord red blood cells cannot be explained on the basis of deficient activity of the enzymes of the hexose monophosphate shunt because the erythrocytes of the newborn possess ample quantities of G-6-PD and 6-PGD. Löhrr and associates investigated alterations of the metabolism of human erythrocytes during aging in vivo and in vitro; of many enzymes studied, only GAPD and G-6-PD were significantly decreased. SH groups are known to be important in enzyme catalysis. Krimsky and Racker identified GSH as a firmly bound prosthetic group of GAPD. GAPD requires reduced SH groups for activity. GSH was not measured in these studies but alterations in its concentration are not likely to be the basis of the findings herein reported, because 300 mg. per cent of glucose were added initially to each blood specimen in the ACD solution. Zinkham observed no decrease of GSH in the red cells of a normal newborn infant following incubation for two hours in the presence of less than 10 mg. per cent of glucose. Gross and Hurwitz found high levels of aldolase in cord blood, indicating that the concentration of this enzyme is not a limiting factor.
Diminished activity of GAPD could explain the slower rate of labeling of the intraerythrocytic phosphates of cord blood. A block in the Embden-Meyerhof pathway at this point would prevent the formation of phosphoglycerates from the triose phosphates produced by the action of aldolase on fructose-1, 6-diphosphate.

**Summary**

The uptake and incorporation of P$^{32}$O$_4$ by the cord blood erythrocytes of normal and erythroblastotic infants and the erythrocytes of adults was studied by incubating specimens in ACD at 37 C. in air. The uptake of P$^{32}$ from the plasma was slower in the infants than in the adults. It was possible to demonstrate an initial “fast” phase followed by a “slow” phase in all the plasma P$^{32}$ uptake experiments. The half-value time and the percentage turnover per minute indicated greater activity in the adults compared to the infants. The balance of movement of phosphorus was from red cells to plasma in all the experiments. No striking differences in phosphate metabolism were demonstrated between the normal and erythroblastotic newborns, except for the large turnover in $\mu$M of P per minute by the red cells of the latter during the first 20 minutes of incubation.

Labeling of intraerythrocytic inorganic phosphorus (P$_1$), adenosine triphosphate (ATP) and 2,3-diphosphoglycerate (2,3-DPG) proceeded more slowly in the infants than in the adults. The labeling of the erythrocyte 2,3-DPG of all the infants lagged far behind P$_1$ and ATP whereas in the adults the r.s.a. of 2,3-DPG had equalled or exceeded the r.s.a. of P$_1$ and ATP in four hours. It is suggested that there is decreased synthesis of phosphoglycerates by the erythrocytes of the newborn which may be due to a lower level of glyceraldehyde-3-phosphate dehydrogenase activity.

**Summario in Interlingua**

Le acceptation e incorporacion de P$^{32}$O$_4$ per le erythrocytos in le sanguine umbilical de infantes normal e erythroblastotic e in le erythrocytos de adultos esseva studiate per medio de specimens incubate a 37 C in acido-citratodextrosa in aere. Le acceptation de P$^{32}$ ab le plasma esseva plus lente in le infants que in le adultos. Il esseva possibile demonstrar un phase initial “rapide” sequite per un phase “lente” in omne le experimentos del acceptation de P$^{32}$ in plasma. Le tempore de medie valor e le procentage de excambio per minuta indicava un plus alte activitate in le adultos in comparation con le infants. In omne le experimentos le balancia del movimento de phosphoro esseva ab le erythrocytos ad in le plasma. Nulle remarcabile differentias esseva demonstrate inter neonatos normal e neonatos erythroblastotic con respecto al metabolismo de phosphato, con le exception del alte excambiam—mesurate in $\mu$M de P per minuta—durante le prime 20 minutas in le erythrocytos del infants erythroblastotic.

Le marcase de intraerythrocytic phosphoro inorganic (P$_1$), de adenosina triphosphatic (ATP), e de 2,3-diphosphoglycerato (2,3-DPG) esseva plus lente in le infants que in le adultos. Le marcase del 2,3-DPG in le erythrocytos de omne le infants esseva muito plus lente que le marcase del P$_1$ e del ATP durante que in le adultos le relative activitate specific de 2,3-DPG
equalava o excedeva le relative activitate specific de P, o de ATP in quatro horas. Il es sugerite que in le erythrocytos del neonatos il existe un decrescite synthese de phosphoglyceratos, le qual es possibilemente debite a un plus basse nivello de activitate de dishydrogenase glyceraldehyde-3-phosphatic.

ACKNOWLEDGMENTS

The cooperation of several hospitals, obstetricians and pediatricians in obtaining blood specimens is appreciated. The technical assistance of Peggy Hoffman and Mavis Moorman is gratefully acknowledged.

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Phosphate Partition in the Erythrocytes of Normal Newborn Infants and Infants with Erythroblastosis Fetalis. III. P³² Uptake and Incorporation

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