PASSAGE OF INTACT IRON-LABELED ERYTHROCYTES FROM SUBARACHNOID SPACE TO SYSTEMIC CIRCULATION IN DOGS*

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IN the course of experiments in dogs in which injection of blood into the spinal subarachnoid space was followed by injection of saline, it was noted that in some instances the subarachnoid space to a very considerable extent was washed free of blood. It was decided to try to determine the disposition of the subarachnoid blood bytagging it with radioactive materials. At first, Cr⁶¹ was used. In 2 animals, 5.2 per cent and 41.1 per cent of the radioactivity was recovered in the blood of the recipients, respectively, within a few hours. In calculating the percentage of radioactivity recovered in the blood of the animal, the blood volume (ml.) was estimated by taking 7.2 per cent of the body weight in grams. However, only 50 per cent of the radioactivity of the Cr⁶¹ blood injected was confined to the red blood cells. In order to obtain blood with high radioactivity confined largely to the red blood cells, a donor dog was prepared by giving 5 daily injections of Fe⁵⁹, 2 microcuries each. Repeated assays showed over 99 per cent of the radioactivity confined to the red blood cells. The donor dog subsequently received additional injections of Fe⁵⁹ (Table 1).

In initial experiments moderately high intraspinal pressures were used, which produced occasional elevations of blood pressure and, at times, transitory respiratory arrest. Blood pressure, spinal subarachnoid pressure and respiration were recorded on a physiograph. Gravity pressures of 130 mm. of mercury and occasional injection pressures of from 300 to 400 mm. of mercury were used.

Animals often tolerated high pressures for short intervals better than more intermediate pressures for longer periods. From 12.4 per cent to 53 per cent of the radioactivity injected intraspinally (Fe⁵⁹ blood) was recovered in the blood of the recipient dogs (Dogs 3–6). By using smaller quantities of blood and more prolonged periods for the injection of saline following the blood (up to 6½ hours), similar percentages of recovery were found using gravity pressures as low as 50 mm. of mercury (Dogs 7–10). Finally, cisternal injections of Fe⁵⁹ blood, 7 to 10 ml., were made after removal of a slightly larger volume of cerebrospinal fluid (Dogs A–E). Up to 27 per cent of the radioactivity was

TABLE 1

Data on donor dog injected with Fe⁵⁹

<table>
<thead>
<tr>
<th>Date</th>
<th>Fe⁵⁹ Intravenous (microcuries)</th>
<th>Blood Withdrawals (ml.)</th>
<th>Hematocrit (per cent)</th>
<th>Net Count per Min. (1 ml.)</th>
</tr>
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<td>50</td>
<td>47</td>
<td>15,175</td>
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<td>53</td>
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<td>48</td>
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<td>50</td>
<td>46</td>
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<td>6-2-61</td>
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<td>50</td>
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</tr>
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<td>50</td>
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<td>18,623</td>
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<td>51</td>
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</tbody>
</table>

* This work was made possible by grant B1919-C1 from the United States Public Health Service.
recovered in 5½ hours and up to 51 per cent in 24 hours. No pressures were taken in these dogs, but any elevation of pressure was simply a physiological response to the presence of blood.

When multiple specimens were taken, there was always an increase in radioactivity in succeeding specimens. The radioactivity in the spleen (1 gm.) is usually ½ (or less) of that of the blood (1 ml.). The radioactivity of the plasma of the recipient dog varies between 1 and 5 per cent of that of the blood, but approximates 1 per cent when the experimental error of counting radioactivity is the least.

METHOD

Dogs were anesthetized with pentobarbital sodium, 30 mg./kg. intravenously. A lumbar laminectomy was performed just above the sacrum and a polyethylene tube was introduced about 5 cm. upward within the subarachnoid space. A ligature was placed around the dura mater and the contained spinal cord, cauda equina and polyethylene tube. A “T” connector was placed so that the subarachnoid tube was connected to a pressure transducer and to a syringe or a container for gravity injection. Between 10 and 45 ml. of radioactive blood were injected into the subarachnoid space and followed with varying quantities of normal saline, depending upon the flow under the pressure being used. Most of the specimens of blood from the dog that had received the radioactive subarachnoid injection were 4 ml. and some were 6 ml. The larger samples, especially when the count was only slightly higher than background, increased accuracy. Donor blood usually was taken an hour before introduction into the subarachnoid space, and was heparinized when it was taken. All specimens of blood from recipient dogs were heparinized when taken. The record of the dog, donor of Fe⁵⁹ blood, is summarized in Table 1.

SPINAL SUBARACHNOID INJECTIONS

Dog 1. 5-24-61. 16 kg. male. 25 ml. Cr⁴⁴ blood intraspinally. Net count per min. of 1 ml. Cr⁴⁴ blood was 32,839. Sacrificed in 1 hr. to administration of blood. No saline followed. Spinal pressures to above 300 mm. of Hg. 5.2 per cent of radiation recovered in calculated total blood volume.

Dog 2. 5-25-61. 25.4 kg. male. 45 ml. Cr⁴⁴ blood intraspinally followed by 300 ml. N. saline in total of 2 hrs. Spinal pressures to above 300 mm. of Hg. Sacrificed. Net count per min. of 1 ml. Cr⁴⁴ blood was 32,839. 41.0 per cent of radioactivity recovered in calculated total blood volume.

Dog 3. 6-1-61. 16.5 kg. male. 17 ml. Fe⁵⁹ blood intraspinally. Sacrificed in 10.5 min. No saline followed. Spinal pressures to above 300 mm. of Hg. Net count per min. of 1 ml. Fe⁵⁹ blood was 4,464. 20.0 per cent of radioactivity recovered in calculated total blood volume.

Dog 4. 6-8-61. 18.8 kg. male. 20 ml. Fe⁵⁹ blood intraspinally followed by 308 ml. N. saline. Spinal pressures to above 300 mm. of Hg. Sacrificed in 3½ hrs. Net count per min. of 1 ml. Fe⁵⁹ blood was 15,176.53.0 per cent of radioactivity recovered in calculated total blood volume.

Dog 5. 6-15-61. 13.2 kg. female. 15 ml. Fe⁵⁹ blood intraspinally followed by 12.5 ml. N. saline in 1½ hrs. Sacrificed. Spinal pressures to above 300 mm. of Hg. Net count per min. of 1 ml. Fe⁵⁹ blood was 16,182. 21.0 per cent of radioactivity recovered in calculated total blood volume.

Dog 6. 6-22-61. 17.4 kg. male. 22.5 ml. Fe⁵⁹ blood intraspinally. Sacrificed in 3½ hrs. Spinal pressure of 110 mm. of Hg. and only terminally to 240 mm. of Hg. Net count per min. of 1 ml. Fe⁵⁹ blood was 16,394. Recovery in calculated total blood volume was 4.1 per cent in 1 hr., 6.8 per cent in 2 hrs., 12.4 per cent in 3½ hrs.

Dog 7. 6-22-61. 30.5 kg. male. 16 ml. Fe⁵⁹ blood intraspinally followed by 75 ml. N. saline. Spinal pressure, 50 mm. of Hg. Sacrificed in 3½ hrs. Net count per min. of 1 ml. Fe⁵⁹ blood was 19,161. Recovery in calculated total blood volume was 17.6 per cent in 1½ hrs., 41.6 per cent in 3½ hrs.

Dog 8. 7-6-61. 13.9 kg. female. 15.5 ml. Fe⁵⁹ blood intraspinally followed by 3.5 ml. N. saline. Spinal pressure, 50 mm. of Hg. Sacrificed in 3½ hrs. Net count per min. of 1 ml. Fe⁵⁹ blood was 21,073. Recovery in calculated total blood volume was 10.9 per cent in 2 hrs., 16.4 per cent in 3 hrs.

Dog 9. 7-13-61. 18 kg. male. 12 ml. Fe⁵⁹ blood intraspinally followed by 82 ml. of N. saline. Spinal pressure, 50 mm. of Hg. Sacrificed in 6½ hrs. Net count per min. of 1 ml. Fe⁵⁹ blood was 18,623. Recovery in calculated total blood volume was 13.3 per cent in 1½ hrs., 16.8 per cent in 3 hrs., 33.0 per cent in 4½ hrs., 45.8 per cent in 6½ hrs.

Dog 10. 7-13-61. 18.5 kg. male. 10 ml. Fe⁵⁹ blood intraspinally followed by 4 ml. of N. saline. Spinal pressure, 50 mm. of Hg. Sacrificed in 6½ hrs. Net count per min. of 1 ml. Fe⁵⁹ blood was 18,623. Recovery in calculated blood volume was 7.8 per cent in 1½ hrs., 12.0 per cent in 3 hrs., 14.6 per cent in 4½ hrs., 15.1 per cent in 6½ hrs.

CISTERNAL INJECTIONS

Dog A. 6-15-61. 16.5 kg. male. 10 ml. cerebro-spinal fluid withdrawn from cisterna magna and replaced by equal amount of Fe⁵⁹ blood. Net