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PLASMA POTASSIUM CONTENT OF CARDIAC BLOOD AT DEATH

BY

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Potassium changes the properties of the surface layers of plant cells when its concentration passes a certain point (Osterhout, 3). The effects of lower concentration of potassium chloride on Nitella are perfectly reversible even after several hours of contact. With 0.05 M potassium, however, this reversibility ceases (Osterhout, 3).

The animal cell seems to be more sensitive to potassium as judged by the effects of lower concentrations on the electrocardiograph tracings in the dog (10), the cat (2), and the human (7). In the dog cardiac arrest occurs at a concentration between 0.014 and 0.016 M. It has been suggested that this is the critical concentration of potassium at which the heart stops, the evidence being obtained from intravenous injections of potassium salts into healthy dogs.

In pathological states caused by intestinal obstruction, intestinal fistulae, hemorrhage, and various types of trauma (table 1), the concentration of potassium in cardiac blood at the time of death varied between 0.0095 and 0.0114 M. in the cat (5, 6, 11, 12). In four dogs poisoned with potassium this average concentration was a little higher, 0.0152 M (4).

Winkler, Hoff and Smith (10), on the basis of their work on dogs, in which cardiac arrest was shown to be associated with a concentration of potassium between 14–16 mM. per liter suggested that there is a wide margin of safety for the human being, “since serum potassium would have to be increased by some 9 mM. per liter to reach a fatal level.”

No such potassium concentration in the cardiac blood of humans has been found in a series of cases studied during the past eighteen months.

Method. At the time of death, heart’s blood was withdrawn by cardiac puncture into a sterile dry syringe. From 5 to 6 cc. of this sample were introduced into a Sanford-Magath hematocrit tube containing heparin (Connaught); gently mixed, capped, and centrifuged at 2,000 r.p.m. for one hour. The plasma was removed immediately from the cells, and the

1 A study made possible by a grant from the Blood Transfusion Betterment Association, New York, New York.
potassium content of 0.5 ml was determined by a modification of the argenticobaltinitrite method (8, 9), the final color being read on the Evelyn Photoelectric Colorimeter with the appropriate filter.

With this method 17.2 mgm. per cent (0.0044 M) represents our normal value derived from determinations done on sixty healthy voluntary donors (table 2).

**TABLE 1**

Cardiac blood potassium

<table>
<thead>
<tr>
<th>NUMBER OF ANIMALS</th>
<th>LESION</th>
<th>RANGE</th>
<th>AVERAGE mgm. per cent</th>
<th>AVERAGE mM./l.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cats</td>
<td>Intestinal obstruction</td>
<td>33.8-66.6</td>
<td>44.5</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>Intestinal fistula</td>
<td>40.6-45.5</td>
<td>43.1</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>Hemorrhage</td>
<td>25.0-57.4</td>
<td>46.5</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td>Trauma</td>
<td>30.6-41.0</td>
<td>37.2</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Dogs</td>
<td>Poisoned with intravenous isotonic KCl</td>
<td>26.0-99.5</td>
<td>59.5</td>
<td>15.2</td>
</tr>
</tbody>
</table>

**TABLE 2**

Plasma potassium of normal venous blood*

Sixty donors

Average (mean) .................................................. 17.2 mgm. per cent
Median .............................................................. 17.2 mgm. per cent
Range ............................................................... 13.5-21.5 mgm. per cent
Standard deviation .............................................. 0.33 mgm.
Coefficient of variation ........................................ 1.9 per cent

* This group comprised 50 males and 10 females. Each value represents the mean of two aliquots of the original sample, 0.5 ml. of plasma being used.

**DISCUSSION.** Cardiac arrest appears to be associated with different concentrations of potassium, not only for different species but also for different individuals within the species. Plant cells seem to withstand higher concentration of potassium than do animal cells.

The narrow range of potassium between 17.2 mgm. per cent (0.0044 M) for normal circulating venous blood and 29.8 mgm. per cent (0.0076 M) for cardiac blood plasma at death indicates possibly that human cardiac
muscle is more susceptible to variations in concentration than certain plant and animal cells.

### TABLE 3

**Potassium content of cardiac blood at death**

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Initials</th>
<th>Age</th>
<th>Sex</th>
<th>Hospital Number</th>
<th>Diagnosis</th>
<th>Operation</th>
<th>Plasma K mgm. per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/29/37</td>
<td>W. N.</td>
<td>62</td>
<td>M</td>
<td>527156</td>
<td>Multiple fractures and contusions; laceration of aorta</td>
<td>Debridement</td>
<td>28.5</td>
</tr>
<tr>
<td>3</td>
<td>10/14/37</td>
<td>N. L.</td>
<td>28</td>
<td>F</td>
<td>530208</td>
<td>Idiopathic gastro-intestinal hemorrhage</td>
<td>Exploratory</td>
<td>24.0</td>
</tr>
<tr>
<td>4</td>
<td>11/23/37</td>
<td>F. F.</td>
<td>55</td>
<td>M</td>
<td>536668</td>
<td>Perforated duodenal ulcer</td>
<td>None</td>
<td>31.9</td>
</tr>
<tr>
<td>5</td>
<td>2/24/38</td>
<td>D. P.</td>
<td>25</td>
<td>F</td>
<td>542008</td>
<td>Paraganglioma of adrenal cortical tissue</td>
<td>Partial resection. Operative death</td>
<td>34.1</td>
</tr>
<tr>
<td>6</td>
<td>6/5/38</td>
<td>M. L.</td>
<td>45</td>
<td>F</td>
<td>374569</td>
<td>Chronic cholecystitis, chole-lithiasis, subphrenic and subhepatic abscesses</td>
<td>Cholecystectomy, incision and drainage abscesses</td>
<td>28.6*</td>
</tr>
<tr>
<td>7</td>
<td>9/12/38</td>
<td>J. Me.</td>
<td>70</td>
<td>M</td>
<td>555217</td>
<td>Carcinoma of colon metastases to liver</td>
<td>Exploratory</td>
<td>26.3</td>
</tr>
<tr>
<td>8</td>
<td>9/27/38</td>
<td>M. K.</td>
<td>26</td>
<td>F</td>
<td>550662</td>
<td>Intestinal obstruction complicating pregnancy</td>
<td>Ileostomy</td>
<td>28.9</td>
</tr>
<tr>
<td>9</td>
<td>11/4/38</td>
<td>L. W.</td>
<td>31</td>
<td>F</td>
<td>549037</td>
<td>Mesenteric thrombosis</td>
<td>Enterectomy</td>
<td>38.0</td>
</tr>
<tr>
<td>10</td>
<td>11/7/38</td>
<td>E. Me.</td>
<td>62</td>
<td>F</td>
<td>564918</td>
<td>Acute pancreatitis</td>
<td>None</td>
<td>31.6</td>
</tr>
<tr>
<td>11</td>
<td>12/13/38</td>
<td>L. V.</td>
<td>73</td>
<td>F</td>
<td>560067</td>
<td>Diabetic gangrene</td>
<td>Amputation</td>
<td>32.6</td>
</tr>
<tr>
<td>12</td>
<td>2/17/39</td>
<td>L. H.</td>
<td>58</td>
<td>F</td>
<td>565522</td>
<td>Carcinoma of breast</td>
<td>Mastectomy</td>
<td>26.1</td>
</tr>
<tr>
<td>13</td>
<td>2/24/39</td>
<td>A. M.</td>
<td>55</td>
<td>M</td>
<td>572368</td>
<td>Pneumonia, type III</td>
<td></td>
<td>27.9</td>
</tr>
</tbody>
</table>

Average................................................................................................................................. 29.8

* Not separated from cells immediately.

Standard deviation from the mean 3.6 mgm. Coefficient of variation 14.5 per cent.

#### SUMMARY

1. In cats dying from varied types of induced shock, the average concentration of potassium in the heart's blood taken at the time of cardiac arrest was 42.8 mgm. per cent (0.0109 M).

2. In dogs following intravenous injections of isotonic potassium in lethal doses, the concentration amounted to 59.5 mgm. per cent (0.0152 M) (table 1).

3. The average venous plasma potassium in sixty young human adults was 17.2 mgm. per cent (0.0044 M) (table 2).

4. The average plasma potassium of cardiac blood taken at death was 29.8 mgm. per cent (0.0076 M) (table 3).

We wish to express our appreciation to both the attending and resident staff of the hospital for their cooperation in securing the cardiac blood samples.
REFERENCES