THE MECHANISM OF PETECHIAL HEMORRHAGE FORMATION

By J. G. Humble, M.R.C.S., L.R.C.P.

The occurrence of petechial hemorrhages in the skin and mucous membranes is a well known sign in many hemorrhagic diseases and in other complaints. Little is known, however, of the mechanism by which they are produced or the exact segment of the vessel or vessels at fault. Histologic preparations show merely an exudation of red cells, sometimes of polymorphonuclear neutrophil leukocytes around the minute vessels in the dermis, the vessel walls themselves usually appearing intact. In the present investigations the formation of petechiae by the tourniquet test (capillary resistance test) in the skin of patients suffering from various hemorrhagic diseases has been studied by capillary microscopy.

METHOD AND APPARATUS

The patients lay comfortably in bed, the arm extended at right angles to the trunk, in the position of full supination resting on a firm table. The cuff of a blood pressure apparatus was adjusted to the upper arm and the skin in the antecubital fossa was shaved to remove hair and superficial squama. The area chosen was then covered with cedar wood oil. A Leitz "Ultra-Pak" microscope was used to study the skin vessels (11X objective with the dipping cone attached and a 10X ocular). By adjustment it is possible to obtain "optical continuity" from the oil to the lens system to avoid surface glare from the oiled skin. A clear view of the blood in the minute skin vessels is thus obtained at a magnification of 110X. The vessels that are seen with the cuff uninflated are few and far between and are the terminal capillary loops. They are usually found in clusters of three or four. The cuff is then gently inflated to a pressure of 90-100 mm. of mercury (or between the systolic and diastolic blood pressure). As the venous system of the skin fills with blood it is possible to see the previously invisible superficial plexus of minute venules and the connections of the end capillary loops to this plexus. In the creases of the elbow it is also possible to see the end of the precapillary arteriole by the blood spurting into view as the capillary loop from the depths of the skin (fig. 1). It is at this point that petechial hemorrhages form, irrespective of the type of disease studied. The behavior of the exuded blood and the shape and character of the lesion formed is, however, different in the various types of disease studied. The following cases have been thus studied:

1. Essential Thrombocytopenic Purpura—3 cases.
   (a) Sedormid intoxication—1 case.
   (b) "Gold" intoxication—1 case.
   (c) Novarsenobenzol intoxication—1 case.
   (d) Monocytic leukemia—1 case.
   (e) Banti syndrome—1 case.

From The John Burford Carlill Pathological Laboratories, Westminster Hospital School of Medicine, London, England.
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(II) Combined Form of Purpura.
Aplastic anemia, thrombocytopenia and hypoprothrombinemia.
(a) Idiopathic form—1 case.
(b) "Novarsenobenzol" intoxication—1 case.

(III) Non-Thrombocytopenic Purpura.
(a) Anaphylactoid purpura—2 cases.
(b) Essential hypoprothrombinemia—1 case.
(c) Potassium iodide sensitivity—1 case.
(d) Scurvy—1 case.
(e) Malignant hypertension—1 case.
The hematologic features of the cases are summarized in table 1.

In essential thrombocytopenic purpura the exudation of blood occurs at first as a shower of red cells, which can be seen to be hurled from the vessels, and which travel at least three times the diameter of the vessel before they are brought to rest.
There is no breach of the blood stream in the capillary, nor is it obliterated by pressure of the effused blood. The segment of vessel through which the red cells pass is very small in length, and the exuded cells form a thin disc, which later extends superficially to form a conical lesion around the arteriolar end of the capillary. The effused red cells are taken up by the skin lymphatics only very slowly. (fig. 2, 1-4).

**Secondary thrombocytopenic purpura.** In the Sedormid and "Gold" and N.A.B. intoxication cases studied, the lesions formed quickly and there was evidence that the red cells were rapidly taken up by lymphatics, as fine columns of red cells formed from the edges of the disc and rapidly extended.

**Monocytic leukemia.** In this case the blood left the vessel very rapidly indeed, and length of affected vessel was greater, for the effused blood formed a much thicker disc. It was rapidly, almost immediately, taken into the lymphatics.

**Anaphylactoid purpura.** In the two cases studied exudation was much more diffuse and there was considerable effusion of fluid as judged by the rapidity in which the details became obscured by edema. Lymphatic absorption is immediate. The iodide intoxication gave a similar picture.

**Essential hypoprothrombinemia.** This case was characterized by the curious way the effused blood tracked superficially around the capillary loop, with very little lateral extension of the lesion. Lymphatic absorption was very slow.

**Aplastic anemia.** Both cases reacted similarly. Two forms of lesion were produced, a large, rapidly forming hemorrhage which formed so rapidly that detailed observation was not possible, and a smaller lesion which resembled those seen in essential thrombocytopenia. Lymphatic absorption was very slow.

**Scurvy.** The petechiae which formed were of two types, (a) large (up to 2 mm. in diameter) and (b) small in size. The small lesions formed in the usual way from the arteriolar end of a single capillary loop, the large lesions formed similarly from a cluster of adjacent capillary loops, usually three in number, apparently arising from a common arteriol twig. These lesions rapidly became confluent and the combined lesion spread rapidly. The effused blood was quickly taken up by the lymphatics.

**Malignant hypertension.** The lesions here did not appear until the constricted capillary loops were fully dilated. The lesions spread rapidly and tended to be confluent (fig. 3). Absorption was moderately rapid.

**COMMENT**

It will be noted that despite the different causes for the purpuric manifestations, the lesions produced all lay in the same segment of vessel, the arteriolar end of the capillary loop. In no case were lesions found elsewhere.

It would seem under the conditions of this test that this small segment of the vessel is unable to prevent the escape of red cells from the lumen. It has been shown by McFarlane that the nailfold capillaries in various kinds of purpura display abnormal reactions to puncture with a quartz fibre, in that the capillary loop is unable to contract as do normal capillaries under similar stimuli. The part of the capillary from which the red cell exudation occurs is, moreover, that part
<table>
<thead>
<tr>
<th>No.</th>
<th>Diagnosis</th>
<th>Age and sex</th>
<th>Duration of symptoms</th>
<th>Nature of lesions</th>
<th>Bleeding Time</th>
<th>Coagulation time</th>
<th>Platelet count</th>
<th>Prothrombin index</th>
<th>Treatment and sequel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Essential thrombocytopenia</td>
<td>23, F</td>
<td>Age 2-6 and 11-23</td>
<td>Epistaxis</td>
<td>10 min ++</td>
<td>3 min. (venous)</td>
<td>25,000</td>
<td>1</td>
<td>Splenectomy age 6. Recurrence age 11. Symptomatic</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>23, F</td>
<td>9 mo.</td>
<td>Menorrhagia</td>
<td>10 min. + +</td>
<td>3 min. 10 sec. capillary</td>
<td>10,000</td>
<td>2</td>
<td>Splenectomy apparent cure</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>14, M</td>
<td>6 mo.</td>
<td>Purpuric rash on trunk</td>
<td>10 min. + +</td>
<td>2 min. (capillary)</td>
<td>1,700-65,000</td>
<td>3</td>
<td>Blood transfusion refused. Splenectomy</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>45, M</td>
<td>23 yr.</td>
<td>Purpuric rash on abdomen</td>
<td>10 min. + +</td>
<td>2 min. 5 sec. (capillary)</td>
<td>15,000-20,000</td>
<td>4</td>
<td>Splenectomy. Died 3 days later of coronary thrombosis</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>33, M</td>
<td>27 yr.</td>
<td>Purpuric rash—no inconvenience</td>
<td>10 min. +</td>
<td>8 min. 30 sec. (venous)</td>
<td>2,500</td>
<td>5</td>
<td>Nil</td>
</tr>
<tr>
<td>6</td>
<td>Sedormid</td>
<td>72, F</td>
<td>2 da.</td>
<td>Purpuric rash Hematuria</td>
<td>12 min. +</td>
<td>2 min. 10 sec. (capillary)</td>
<td>3,500</td>
<td>6</td>
<td>Death from coronary disease</td>
</tr>
<tr>
<td>7</td>
<td>Gold</td>
<td>55, F</td>
<td>2 wk.</td>
<td>Epistaxis</td>
<td>10 min. + +</td>
<td>8 min. 40 sec. (venous)</td>
<td>25,000</td>
<td>7</td>
<td>Recovered after two transfusions of blood.</td>
</tr>
<tr>
<td>8</td>
<td>N.A.B.</td>
<td>47, F</td>
<td>5 da.</td>
<td>Bruises on legs Melena Menorrhagia</td>
<td>10 min. + +</td>
<td>8 min. 10 sec. (venous)</td>
<td>4,500</td>
<td>8</td>
<td>Many transfusions. Recovery</td>
</tr>
<tr>
<td>9</td>
<td>Monocytic leukaemia</td>
<td>73, M</td>
<td>5 wk.</td>
<td>Bruises on arms</td>
<td>10 min. + +</td>
<td>8 min. (venous)</td>
<td>13,600</td>
<td>9</td>
<td>Died</td>
</tr>
<tr>
<td>10</td>
<td>Banti syndrome</td>
<td>51, F</td>
<td>All life</td>
<td>Bruising especially after operations</td>
<td>10 min. + +</td>
<td>7 min. (venous)</td>
<td>55,000</td>
<td>7</td>
<td>Splenectomy. Improved</td>
</tr>
<tr>
<td>11</td>
<td>Aplastic anemia</td>
<td>50, F</td>
<td>6 wk.</td>
<td>Vaginal hemorrhage</td>
<td>10 min. + +</td>
<td>16 min. 25 sec. (venous)</td>
<td>43,000</td>
<td>42</td>
<td>Died</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>No.</th>
<th>Condition</th>
<th>Age</th>
<th>Duration</th>
<th>Symptom</th>
<th>Duration</th>
<th>Hemoglobin</th>
<th>White Blood Count</th>
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</thead>
<tbody>
<tr>
<td>12</td>
<td>Aplastic anemia</td>
<td>32</td>
<td>3 mo.</td>
<td>Purpura legs; anemia</td>
<td>10 min. ++</td>
<td>3.4 g/dL</td>
<td>73</td>
</tr>
<tr>
<td>13</td>
<td>Anaphylactic purpura</td>
<td>5</td>
<td>3 wk.</td>
<td>Massive bruises of buttock</td>
<td>1 min. 10 sec.</td>
<td>4.5 g/dL</td>
<td>73</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>45</td>
<td>9 mo.</td>
<td>Petechial rash on arms</td>
<td>3 min.</td>
<td>8.0 g/dL</td>
<td>73</td>
</tr>
<tr>
<td>15</td>
<td>Essential hypoprothrominemia</td>
<td>26</td>
<td>25 yr.</td>
<td>Epistaxis</td>
<td>10 min. + +</td>
<td>9.0 g/dL</td>
<td>73</td>
</tr>
<tr>
<td>16</td>
<td>KI sensitivity</td>
<td>67</td>
<td>1 wk.</td>
<td>Purpuric rash on arms—legs</td>
<td>3 min.</td>
<td>9.0 g/dL</td>
<td>73</td>
</tr>
<tr>
<td>17</td>
<td>Scurvy</td>
<td>58</td>
<td>1 wk.</td>
<td>Hemorrhagic of ankles</td>
<td>2 min. 5 sec.</td>
<td>9.0 g/dL</td>
<td>73</td>
</tr>
</tbody>
</table>

12 Normal: "-"
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Fig. 2. Simplified drawing of the terminal vessels as seen through the microscope to illustrate the formation of a petechial haemorrhage in essential thrombocytopenia purpura.

Fig. 3. Photomicrograph of lesion from case 16: (a) small early petechial hemorrhage; (b) larger lesion; (c) dilated capillary loops; (d) relatively constricted loop.

from which fluid leaves the vessels for the tissues normally. Landis1 showed by direct measurement that the intracapillary pressure at this point is higher than
elsewhere in the loop. Furthermore, the lesions occur at a point where the tightly constricted precapillary arteriole dilates suddenly to form the capillary loop. It is evident that this arteriolar-capillary junction is of great importance in the maintenance of blood flow and the nutrition of tissues generally. It is tempting to postulate that a selective poisoning of this junction could produce hemorrhages in the mucosae and also cause thrombocytopenia by an upset of megakaryocyte nutrition. The poison must leave the circulation for the tissues at the point described, and the cells of the vessel wall must be thus exposed to a much greater selective concentration than elsewhere. This theory can be applied to essential thrombocytopenic purpura on the assumption that the spleen produces a toxic substance. It explains the prompt cessation of hemorrhage immediately following splenectomy in this disease. Similar explanations can be deduced to fit other hemorrhagic syndromes and diseases.

SUMMARY AND CONCLUSIONS

1. The capillary resistance test has been studied by a special technic of capillary microscopy.
2. Seventeen cases of hemorrhagic diseases of differing etiology have been thus studied.
3. The site of capillary hemorrhage has been localized to the arteriolar end of the capillary loop.
4. Selective damage to the arteriolar-capillary junction will explain many types of hemorrhagic syndromes.

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REFERENCES

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