Red cell survival in patients with aortic valve disease

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The increased destruction of red cells after some corrective cardiac procedures has been recognized (Neill, Farman, Sigler, and Bahnsen, 1961; Sayed, Dacie, Handley, Lewis, and Cleland, 1961; Verdon, Forrester, and Crosby, 1963; Gehrmann and Loogin, 1964; Marsh, 1964; Reed and Dunn, 1964; Stevenson and Baker, 1964). Despite increased haemolysis, anaemia is not always present, since a normal bone marrow is capable of increasing red cell production six or seven times in response to a sustained demand. Red cell survival in a chronic haemolytic state may be reduced from 120 to 20 days, but the bone marrow may be able to maintain a normal red cell count in the peripheral blood. Anaemia results only when red cells are destroyed faster than they can be produced by the bone marrow (Fig. 1). An estimation of red cell survival using radioactive chromium (\(^{51}\)Cr) tagged cells can detect small increases in the rate of red cell destruction (Mollison, 1956). This technique has been used to study the red cell survival in various forms of aortic valve disease and after the insertion of valve prostheses.

PATIENTS AND METHODS

Three groups of patients with aortic valve disease were studied. They were patients with severe aortic regurgitation, patients with calcific aortic stenosis with a gradient of 50 mm. Hg or more across the aortic valve, and patients after the insertion of McGoon's aortic valve prostheses; the last group consisted of eight patients, four of whom had clinical evidence of residual aortic regurgitation.

The method used was originally described by Ebaugh, Ross, and Emerson (1953). Red cells, 10 ml., were tagged with \(^{51}\)Cr using a total dose of 35 mc. Autogenous cells were used except in patients studied during the first three months after operation when cross-matched fresh cells were used, as it has been shown that red cell survival is shortened by mechanical trauma during cardio-pulmonary bypass (Frey and Schmidt-Mende, 1963). Fresh cells have been shown to have a normal survival after transfusion in the absence of haemolytic factors (Mollison, 1956). The tagged cells were injected into the patient, and samples of blood were taken twice a week for six weeks. The residual radioactivity in the red cells was measured, corrected for radioactive decay, and plotted against time on semilogarithmic paper. The time taken for the radioactivity to drop to 50% of the original level (\(T_1\) \(^{51}\)Cr) is an index of the rate of destruction of the red cells as well as of the rate of elution of \(^{51}\)Cr from the cells. As the latter is constant, \(T_1\) \(^{51}\)Cr can be taken as a measure of red cell survival. The true red cell survival can be determined by correcting for the amount lost by elution. According to the formula given by Read, Wilson, and Gardner (1954), this may be expressed as:

\[
T_1 \text{ elution} \times T_1 \text{ }^{51}\text{Cr} \\
T_1 \text{ elution} - T_1 \text{ }^{51}\text{Cr}
\]

FIG. 1. Balance between red cell production and destruction under different conditions.

1 Presented at the meeting of the Society of Thoracic Surgeons, October, 1964
2 Present address: Brompton Hospital, London
cell survival in can be used were of later post-operative immediate survival in insertion of McGoon Aortic Calcific Aortic regurgitation After aortic stenosis, who had a slightly shortened red cell survival; none of these patients had clinical evidence of haemolysis. The red cell

TABLE I
RED CELL SURVIVAL IN PATIENTS WITH AORTIC VALVE DISEASE (as apparent \(^{51}\text{Cr} \) red cell half life)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Case No.</th>
<th>( T_1^{51}\text{Cr} ) (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic regurgitation</td>
<td>1</td>
<td>25†</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>25†</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25†</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Calcific aortic stenosis</td>
<td>7</td>
<td>27†</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>27</td>
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<tr>
<td></td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>25†</td>
</tr>
<tr>
<td>After insertion of McGoon prosthesis</td>
<td>12*</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>3*</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>23†</td>
</tr>
<tr>
<td></td>
<td>13*</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>14*</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>24</td>
</tr>
</tbody>
</table>

Normal range of \( T_1^{51}\text{Cr} = 23\frac{1}{2} \) to 27 days.
* Cases with clinical evidence of residual aortic regurgitation.

Mechanical destruction of red cells resulting in haemoglobinenaemia and haemoglobinuria can occur after strenuous exercise taken in the upright lordotic posture and not when the back is bent (Gilligan and Blumgart, 1941). This is thought to be due to kinking of blood vessels causing an abrupt change in the direction of blood flow when the back is hyperextended in association with a rapid circulation rate (Dacie, 1962). This suggests that turbulence can produce abnormal haemolysis. Our studies have shown that the red cell survival was not affected by the turbulence of aortic regurgitation nor by the fast turbulent flow of blood through the rough disorganized valves in calcific aortic stenosis.

Mechanical haemolytic anaemia after aortic valve replacement has recently been described (Gehrmann and Loogen, 1964; Marsh, 1964; Reed and Dunn, 1964; Stevenson and Baker, 1964). The mechanism of this condition is not known. Abnormal turbulence, chemically induced haemolysis, direct damage to the erythrocytes by coming in contact with the surface of the prosthesis or by being crushed between the rigid valve housing and the ball in a Starr-Edwards prosthesis are

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possible factors. The normal red cell survival in our patients with a competent McGoon prosthesis suggests that the presence of teflon within the circulation does not per se cause destruction of red cells. The shortened red cell survival in patients with residual aortic regurgitation after insertion of a McGoon prosthesis suggests that destruction of red cells is produced by a jet of blood playing against the aortic prosthesis. This is supported by the fact that all the reported cases of haemolytic anaemia following cardiac surgery there was evidence of persistent valvular obstruction or regurgitation after the insertion of prosthetic material for the repair of cardiac defects.

**SUMMARY**

The red cell survival in patients with aortic valve disease was studied using $^{51}$Cr-tagged red cells. All the patients studied had normal red cell survival except those with evidence of aortic regurgitation after the insertion of a McGoon prosthesis, who had a slightly shortened red cell survival. This is probably caused by the turbulent blood flow playing against the prosthesis.

**REFERENCES**


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