EVALUATION OF DYE DILUTION AND CARDIOMETRIC METHODS
OF CARDIAC OUTPUT ESTIMATION IN DOGS

By

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The cardiac output of 8 anaesthetised dogs was determined simultaneously by the dye dilution method using Evans's blue as well as by direct measurement with Henderson's cardiometer in order to compare the two methods. The average cardiac output per kilogramme of body weight has been found to be 103 and 105 ml respectively by the two methods with an average variation of 1.9 per cent. Thus the dye dilution method gives results in close approximation to direct cardiometry which justifies its greater use for routine estimation of cardiac output.

The dye dilution method has attained a definite place in the routine determination of cardiac output for the study of circulatory hemodynamics, both in health and disease. The present study has been undertaken, to evaluate the accuracy of this indirect method of cardiac output estimation, by comparing its results with those obtained by the direct cardiometric method in dogs.

METHODS

Experiments were conducted on 8 male, adult, mongrel dogs. After light ether anaesthesia 1 per cent chloralose solution was given intravenously in the dose of 70 mg per kg of body weight. Artificial respiration was instituted through a tracheal cannula and adequate ventilation was ensured.

Direct cardiometric method (Henderson, 1906) —The chest was opened in the mid-line by an electric cautery and the pericardium was opened. The heart was gently pushed through the opening in the diaphragm of a Henderson's cardiometer up to the auriculo-ventricular groove. The cardiometer was connected to a piston-recorder writing on a Brodie's kymograph. At the end of the experiment, when the dog was dead, the cardiometer tracing was calibrated by injecting known amounts of saline in the cardiometer with the heart still in position. Cardiac output per ventricle was calculated by multiplying the heart rate with half the stroke volume obtained from the cardiometer tracing.

1 This work formed part of a thesis accepted for the M. Sc. (Med.) degree of the University of Rajasthan.
Dye dilution method.—Hamilton's method (1928) based on Stewart's principle was employed. Two hundred mg. of Evan's Blue (4 ml of a 5 per cent solution in normal saline) was injected instantaneously into the exposed left jugular vein and the time of injection was noted. Samples of arterial blood from the right carotid artery were collected into a series of paraffinised test tubes. Between 20 to 35 samples were taken within 1 min of the dye injection. This was achieved by putting the test tubes on a circular frame fitted around a kymograph drum and revolving slowly with it while blood trickled down from an overhanging polyethylene tube connected to the needle. To prevent coagulation the needle and the tube, they were dipped in liquid paraffin and cooled in ice before hand.

After separating the serum from the blood samples, the concentration of the dye in each was determined colorimetrically by comparison with a suitable standard solution having 100 mg, 50 mg or 25 mg of the dye per litre. The concentrations of the dye were plotted on semilogarithmic ordinates against time in secs. From this graph the average concentration of the dye through its first circulation was deduced by a mathematical approximation suggested by Hamilton et al., (1928). The cardiac output was then calculated
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within 1 min of the dye injec-
tubes on a circular frame fitted
ly with it while blood trickled
connected to the needle. To
be, they were dipped in liquid

samples, the concentration of
by comparison with a suit-
25 mg of the dye per litre.
logarithmic ordinates
concentration of the dye in blood
mathemetical approximation
output was then calculated

using Kinsman's formula (1929), \( F = 60 \times \frac{I}{C \times T} \) where \( F \) is the output in
litres per minute, \( I \) is the amount of dye injected in mg, \( C \) is the average
concentration of the dye in blood as mg per litre and \( T \) is the duration in
seconds of the first circulation i.e. till the dye begins to recirculate.

RESULTS

The results of simultaneous estimation of cardiac output by the dye
dilution and cardiometric methods in 8 dogs are given in Table I.

<table>
<thead>
<tr>
<th>No.</th>
<th>Weight of dog (kg)</th>
<th>Dye injected (I) (mg)</th>
<th>Average blood concentration of dye (C) (mg/litre)</th>
<th>Time for first circulation (T) (sec)</th>
<th>Calculated cardiac output (litres)</th>
<th>Heart rate per minute (R)</th>
<th>Stroke volume (ml) (V)</th>
<th>Cardiac output (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.0</td>
<td>200</td>
<td>226.6</td>
<td>52</td>
<td>1.018</td>
<td>168</td>
<td>11.98</td>
<td>1.006</td>
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<tr>
<td>2</td>
<td>15.5</td>
<td>200</td>
<td>244.0</td>
<td>35</td>
<td>1.405</td>
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<td>193</td>
<td>10.48</td>
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<td>200</td>
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<td>34</td>
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<td>174</td>
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<td>1.007</td>
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<td>5</td>
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<td>200</td>
<td>220.0</td>
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<td>1.186</td>
<td>210</td>
<td>12.30</td>
<td>1.291</td>
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<td>15.5</td>
<td>200</td>
<td>291.0</td>
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<td>1.512</td>
<td>216</td>
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<td>1.652</td>
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<td>200</td>
<td>182.0</td>
<td>26</td>
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<td>264</td>
<td>20.00</td>
<td>2.640</td>
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<td>8</td>
<td>10.0</td>
<td>200</td>
<td>311.3</td>
<td>36</td>
<td>1.070</td>
<td>210</td>
<td>10.44</td>
<td>1.096</td>
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</table>

DISCUSSION

A large number of methods have been developed for estimating cardiac
output in man since this is a very important circulatory parameter to be
known in different physiological as well as pathological conditions. Some of
these methods have a high degree of accuracy but unfortunately require a
very specialised technique not possible to perform every where, e.g. the Fick's
principle and radioisotope methods. Others like the pulse-pressure method
are simple but too crude. Between such extremes, the dye dilution method
stands as a via media and has, therefore, found wide favour for routine esti-
mations.

In order to establish the reliability of the dye dilution method Moore
et al., (1929) and Hamilton et al., (1948) compared its results with those
obtained by making use of the Fick's principle. They found a variation of
4.79 per cent and 25 per cent, in dogs and human beings respectively. How-
ever, in the present study, a comparison with the cardiometric method, which can be taken to be a direct and standard measurement of cardiac output, has given only an average variation of 1.9 per cent (Table II), the values being 103 ± 40 and 105 ± 42 ml respectively per kg body weight. It appears, therefore, that the dye dilution method gives results closely comparable to that obtained by direct cardiometry and can be advocated for routine estimation of cardiac output in experimental animals or human beings.

Table II gives the cardiac output calculated per unit weight of the animal. The average output by the dye dilution and cardiometric methods comes to be 103 and 105 ml/kg body weight respectively with an average variation of 1.9 per cent.

**Table II**

<table>
<thead>
<tr>
<th>Expt. No.</th>
<th>Wt of dog</th>
<th>Dye dilution method</th>
<th>Cardiometric method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total cardiac output</td>
<td>Output per kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kg output per ventricle per min in litres</td>
<td></td>
</tr>
<tr>
<td>1</td>
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<td>1.918</td>
<td>0.1018</td>
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<td>13</td>
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<td>0.197</td>
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<td>10</td>
<td>1.070</td>
<td>0.1070</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>0.1038±40</td>
<td></td>
</tr>
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</table>

I am extremely grateful to Professor B. S. Kahali, Head of the Department of Physiology, Medical College, Srinagar for his kind guidance and interest in this work.

**REFERENCES**


