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 Evan'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 upto 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.

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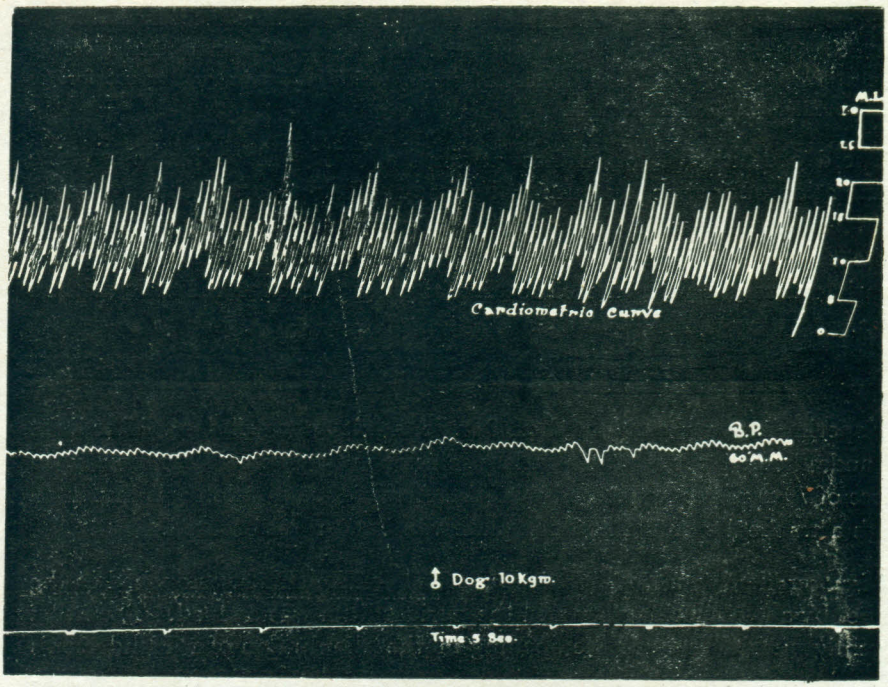
Dye dilution method.—Hamilton's method (1928) based on Stewart's principle was employed. Two hundred mg. of Evan's Blue (4 ml of a 5 per cent solution in normal saline) was injected instantaneously into the exposed left jugular vein and the time of injection was noted. Samples of arterial blood from 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 polyethelene 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.



Cardiac output by dyedilution and cardiometric methods.

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 mathemetical approximation suggested by Hamilton *et al.*, (1928). The cardiac 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 I

Cardiac output of anaesthetised dogs by dye dilution and cardiometric methods

No.	Weight of dog	Dye dilution method				Direct cardiometric method		
		Dye injected (I)	Average blood concentration of dye (C)	Time for first circulation (T)	Calculated cardiac output	Heart rate per minute (R)	Stroke volume (for both ventricles) ml (V)	Cardiac output $F = \frac{1}{2} \frac{RV}{100}$
	kg	mg	mg/litre	sec	litres			litres
1	10·0	200	226·6	52	1·018	168	11·98	1·006
2	15·5	200	244·0	35	1·405	240	11·23	1·348
3	12·0	200	341·0	36	0·977	195	10·48	1·037
4	13·0	200	308·0	44	0·885	174	9·28	0·807
5	14·0	200	220·0	46	1·186	210	12·30	1·291
6	15·5	200	294·0	27	1·512	216	15·30	1·652
7	13·0	200	182·0	26	2·564	264	20·00	2·640
8	10·0	200	311·3	36	1·070	210	10·44	1.096

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 estimations.

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

Cardiac output calculated per kg body weight

Expt. No.	Wt of dog	Dye dilution method		Cardiometric method	
		Total cardiac output	Output per kg	Total cardiac output	Output per kg
		kg output per ventricle per min in litres			
1	10	1.018	0.1018	1.006	0.1006
2	15.5	1.405	0.0906	1.348	0.087
3	12	0.977	0.0814	1.037	0.0864
4	13	0.885	0.068	0.807	0.062
5	14	1.186	0.085	1.291	0.092
6	15.5	1.512	0.0975	1.652	0.1065
7	13	2.564	0.197	2.64	0.203
8	10	1.070	0.1070	1.096	0.1096
Average			0.1038±40		0.1059±42

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