A STUDY OF TOLERANCE OF ETHER ANAESTHESIA TO DOGS WITH VARYING GRADES OF CHRONIC ANAEMIA

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Human patients having markedly low haemoglobin contents and who in the opinion of anaesthetists are unsuitable for ether anaesthesia, withstand anaesthesia very well without much deleterious effects. The knowledge becomes obscure to explain the compensatory mechanisms occurring in these subjects. How physiological changes operate that the patient can tolerate anaesthesia at lower haematocrit values is difficult to assess. Nunn *et al* (6) have discussed problems of oxygenation and oxygen transport to tissues during haemorrhage. Freeman (2) studied survival of bled dogs after halothane and ether anaesthesia. Freeman *et al* (3) have done experimental work on ventilation and perfusion relationship after haemorrhage. Whatever data is available is all applicable to tolerance of anaesthesia to acute anaemias. Practically no date is available in chronic anaemia subjects. In this preliminary report tolerance has been determined in dogs to general ether anaesthesia during chronic anaemia.

MATERIAL AND METHODS

Ten healthy mongrel dogs of either sex were chosen for experiments. Prior to being subjected to ether anaesthesia red blood cell count, haemoglobin percentage and packed cell volume of the blood was determined in all the dogs. The animals were then anaesthetised by ether anaesthesia through an Oxford Vaporiser. The anaesthesia was kept at a uniform surgical level (stage III between plane one and two-Guedel's classification, (4) by keeping a watch over the ether inhaled. The quantity of ether inhaled was diminished if the level of anaesthesia was deeper than required. This was achieved by varying the composition of ether air mixture by a regulator in the vaporisor. A check over eye reflexes and other superficial reflexes was kept and frequent ether estimation was done to avoid deeper anaesthesia. The heart rate and respiration record was kept at half hourly interval during anaesthesia. The animals were revived back to normal after they had been under anesthesia for six hours. Longer duration of exposure to anaesthesia was thought to be unnecessary as in clinical practice anaesthesia beyond six hours is hardly ever required. Most of the operations are completed within this period.

Cardiac output was determined by Hamilton's (5) dye dilution technique using Evans blue (T.1824). The dye dilution curve was drawn and cardiac output calculated. Ether estimation in the blood was done by method described by Andrew's *et al* (1).

200 ml. of blood was taken out from the animal every 4th day and the blood counts were repeated to find out the degree of anaemia. These anaemic animals were subjected to six hours ether anaesthesia again. It was noted whether they tolerated ether for six hours or not. In case they survived after this exposure, further

bleeding was done to bring them to still lower level of anaemia till they could not tolerate six hours of anaesthesia but died earlier. The time for which animals survived was taken as the indicator of tolerance at that particular haematocrit level. The experiments with varying grades of anaesthesia were not carried out because in most of the cases in clinical practice surgical level of anaesthesia is required.

RESULTS AND DISCUSSION

The results are shown in tables I, II, III, IV and V.

TABLE I

Initial and Terminal Blood Picture of Dogs Subjected to Ether Anaesthesia

Dog No.	Weight of dog in Kg.	Initial Blood Picture			Duration of tolerance in minute	Terminal Blood Picture		
		RBC count mill/Cu.mm.	Haemoglobin G/100 ml.	P.C.V. %		RBC count mill/Cu. mm.	Haemoglobin G/100 ml.	P.C.V. %
1.	11.4	5.38	9.8	42	360	4.42	7.5	32
2.	13.0	6.66	12.1	42	360	4.42	7.3	27
3.	14.0	7.5	14.5	46	360	4.27	10.2	40
4.	9.6	5.8	13.5	43	360	3.84	9.0	32
5.*	9.8	4.68	11.6	37	90	4.68	11.6	37
6.	10.2	5.38	11.8	38	360	4.56	8.7	33
7.**	11.2	6.59	14.4	53	360	5.8	14.2	47
8.	8.0	5.64	11.3	54	360	4.2	9.2	37
9.	11.3	5.81	14.0	51	360	3.01	8.0	27
10.	6.2	4.61	11.5	33	360	4.36	9.5	30

Note: *Dog No. 5 could not stand anaesthesia for more than 90 minutes. No specific cause ascribed.
**Dog No. 7 The anaemia was established upto RBC 5.8 mill/Cu. mm., Haemoglobin 14.2 G% and PCV 47%. The dog tolerated anaesthesia at this level for 6 hours. But died after 2 days without further anaemia or tolerance could be done.

TABLE II

Showing Duration of Tolerance with the Fall of Haemoglobin Percentage

Dog No.	Percentage fall of haemoglobin from the initial level	Duration of tolerance in minutes
1	24	55
2	39	220
3	29	165
4	33	145
5*	Died in initial expt.	90
6	26	285
7	Tolerance not done	—
8	20	320
9	43	140
10	17	267

Note—*Dog no. 5 could not tolerate anaesthesia for 6 hours at the very first exposure of ether, died in 90 minutes probably due to initial low haemotocrit value shown in table 1.

TABLE III

Showing Variation in Heart Rate and Respiration Rate in Normal and Anaemic Dogs During Anaesthesia

Dog No.	Heart Rate per minute			Respiration Rate per minute		
	Before Anaesthesia	During anaesthesia		Before Anaeasthesia	During anaesthesia	
		Average in healthy dogs	Average in anaemic dogs		Average in healthy dogs	Average in anaemic dogs
1	136	140.2	183.3	34	36.2	31.3
2	146	149.6	156.3	27	31.6	40.2
3	150	154.0	175.4	41	43.2	37.6
4	124	132.6	150.4	36	38.3	41.2
5	118	124.3	—	29	31.2	—
6	126	134.2	182.6	32	34.1	37.2
7	128	148.2	—	29	31.6	—
8	132	139.6	154.2	30	36.1	42.0
9	96	108.2	124.6	27	31.8	37.6
10	144	149.2	175.6	26	29.6	34.2

TABLE IV

Showing Average Ether Level in Blood During Anaesthesia

Dog No.	Ether level in blood in healthy dogs (mg/100 ml.)	Ether level in blood in anaemic dogs (mg/100 ml.)	Percentage Deviation
1	78.0	82.0	5.1
2	90.1	87.5	—2.9
3	110.6	114.6	3.6
4	87.2	89.0	2.0
5	82.0	—	—
6	112.0	120.0	7.1
7	100.0	—	—
8	96.0	91.0	—5.2
9	119.2	116.6	—2.1
10	120.0	108.0	—10.0

An attempt to establish relationship between the anaesthesia tolerance of dogs to variable and low haematocrit values is being made in the present study. From Tables I, II, III, IV and V the following fact are evident :—

1. The red blood cell count in dogs initially varied from a maximum of 7.5 mill/ Cu. mm. to a minimum of 4.61 mill/ Cu. mm., average being 5.80 mill/ Cu. mm. in ten dogs. The haemoglobin ranged from 14.5 G to 9.8 G/100 ml. of blood, the

TABLE V

Showing Cardiac Output in Healthy and Anaemic Dogs During Anaesthesia

Dog No.	Cardiac output in healthy dogs (Litres/min)	Cardiac output in anaemic dogs (Litres/min)	% rise in cardiac output
3	2.6	2.8	7.7
4	1.5	1.7	13.3
6	1.8	2.6	44.4
7	1.2	—	—
10	1.33	1.86	38.4

average of ten dogs being 12.45 G%. The P.C.V. ranged from 33 to 54%, average being 43.9%. With these figures of haematocrit the dogs tolerated well anaesthesia for 360 minutes and recovery followed in 5 to 20 minutes without any untoward effect.

2. When chronic anaemia was established, the blood picture at which dogs did not tolerate anaesthesia for 360 minutes but died earlier is as under :—

	Maximum	Minimum	Average
RBC count in mill per Cu. mm.	4.68	3.01	4.19
Hb% in G.	11.6	7.3	9.0
P. C. V.	40	27	32.8

3. A definite decrease of anaesthetic tolerance has been observed with a fall of haematocrit value. The tolerance was reduced between a range of 55 minutes to 320 minutes with the average fall of haemoglobin in the range of 20 to 43% from the initial value. There occurred a fall in the tolerance to an average of 199.6 minutes, i. e. 62.5% of the initial tolerance with the reduction of haemoglobin to an average 28.80% below the intial value.

4. The heart rate in all the dogs varied from 96 per minute to 150 per minute in healthy dogs before anaesthesia (Average 130/min.). During anaesthesia in these dogs average increased heart rate recorded was 6.2% above the initial value. In anaemic dogs, the rise was on an average of 15.4% more than the intial pre-anaesthetic value.

5. The respiration rate on an average was 31.1/min. before anaesthesia in healthy dogs and showed an increase of 10.3% on an average from the initial rate during anaesthesia. In anaemic dogs, the rise of respiration was on an average of 20% from the original rate during anaesthesia.

6. Cardiac output estimated in five dogs showed the average value of 1.68 litres/min. During anaemia it showed a rise to 2.24 litres per minute on an average. A rise of 7.7 to 44.4% is observed during anaemia.

The reduced tolerance to ether is obvious from the above results. The cause of death can be attributed to number of factors. At terminal stages it is quite probable to imagine a combined effect of various types of anoxia to be the cause of death. Haematocrit values have their primary importance as the oxygen transport system. Adequate supply of oxygen basically is needed for the tissues. In anaemic dogs, obviously the oxygen carrying capacity must be less due to diminished amount of haemoglobin as compared to the normal animals. This is evident from the fact that respiratory and heart rates alongwith cardiac output increases more in the former, (Table III & V). Depending on the extent and duration of oxygen debt certain compensatory cardio-respiratory changes occur to minimise this oxygen inadequacy. But there being a limit, the compensation breaks after that critical limits and the animal dies.

Freeman (2) recently has assessed factors which come into play in subjects who were bled during and just before anaesthesia. They attributed defective ventilation and gaseous exchange as the primary cause of death.

To eliminate factor of histotoxic anoxia which may cause death due to direct effect of ether on tissue cells, an effort is made to keep the ether level fully controlled within limits of surgical anaesthesia. Frequent estimation of ether in blood (table IV) shows insignificant rise of ether level in dogs which tolerated anaesthesia for lesser period of time.

The heart rate, respiratory rate and cardiac output point to the compensatory mechanism operating in anaemic dogs. The increased cardiac output in anaemic dogs (table V) shows increased demand of oxygen in the tissues. But at the terminal level the burden on the heart function crossed the critical limits. The increased work load of heart with relative anoxia of myocardium ultimately precipitated failure. This may or may not be superimposed with stagnant anoxia in late stages.

Anaemic anoxia is probably the major concievable factor which is due to diminished haematocrit value. The available oxygen for tissue oxidation is considerably reduced. This starts the vicious circle into motion in which all compensatory mechanisms fail and the animal dies.

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