原　　著

Changes of pH and Oxygen Tension in Blood in Induced Cerebral Anoxias in Dogs

by

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INTRODUCTION

A number of different mechanisms may cause the decreased amounts of oxygen delivered to the tissue. On the basis of these mechanisms the anoxia has been divided into five types: Anemic, stagnant, anoxic, histiotoxic types and demand anoxia[3]. The brain is very susceptible to deficient oxygen supply. For instance, a cessation of the cerebral circulation for only a few minutes, as occurred in cardiac arrest, results in loss of consciousness, and if prolonged, in irreparable injury to nerve cells. In an attempt to obtain quantitative evidence of relative oxygen requirement of the brain under its anoxic condition, SUGAR and GERARD used three time parameters: (1) Survival time, i. e., the duration of anoxia required to bring about the change in question; (2) revival time, i. e., the duration of anoxia which still permits reversal of this change when oxygen is restored; and (3) recovery time, i. e., the interval between readmission of oxygen and start of restoration to normal[22]. LENNOX, GIBBS and GIBBS found that the patients were always unconscious if the oxygen saturation in the blood of the internal jugular vein was 24% (about 18 mmHg) or less[14]. NOELL and SCHNEIDER observed that, in case of mild oxygen deficiency, the cerebral blood flow was dependent on arterial blood pressure and carbon dioxide tension in blood, whereas, in marked oxygen deficiency, the dilatation of the cerebral vessels appeared and the blood flow increased twice or three times as much as that in the normal condition. They found that, when dogs were exposed to anoxic anoxia, the cerebral vessels dilated at 80% saturation of oxygen in arterial blood (about 40 to 50 mmHg) and at about 50% saturation in venous blood (about 25 to 30 mm Hg)[16]. From these findings NOELL and SCHNEIDER[16], NOELL[17][18], OPITZ[19], and OPITZ and SCHNEIDER[20] succeeded in associating certain reaction to reduced oxygen supply with well reproducible values of oxygen tension in venous blood (pvO_2). They defined three characteristic threshold values of venous oxygen tension as follows:

1. Reaction threshold: $pvO_2 = 25\text{-}28$ mmHg. Beginning of dilatation of cerebral blood vessels.

2. Critical threshold: $pvO_2 = 17\text{-}19$ mmHg. Loss of consciousness. Below this level the oxygen uptake decreases more and more steeply and a vicious cycle would develop.

3. Lethal threshold: pvO_2 = about 12 mmHg. Dangerous to maintenance of life.

In this definition, however, it is not clear how long these threshold values should be maintained to produce clinical signs of cerebral anoxia or irreversible changes in the brain.

Since the introduction of polarographic method analysis, it has been possible to measure the oxygen tension and carbon dioxide tension of blood with a high degree of accuracy and reliability. With I. L. Meter, Model 113, the author measured changes of the oxygen tension and pH in the cerebral venous blood of dogs under anoxic conditions, to clarify the relationship between the duration of anoxia and its effect on reversibility of the cerebral function. Another purpose of the present study is to know whether or not such measurements with I. L. Meter are practically useful for diagnosis of impending cerebral anoxia.

MATERIALS AND METHODS

Fifty mongrel dogs, weighing 7 to 11.5 kg were used. After the intravenous administration of Nembutal, 20 mg/kg, they were intubated and connected to an infant circle, Type FK (ACOMA) and to an artificial respirator (TONOKURA). Respiration under positive and negative pressure was sustained throughout the experiments, with intermittent administration of Relaxin (Succinyl choline chloride), 5 to 10 mg, subcutaneously.

For pH and blood gas analyser system an I. L. Meter, Model 113, was used. The calibration of pH electrode was done with buffer solutions of pH 7.384 and pH 6.84. The pO_2 electrode was calibrated at two points with 100 % nitrogen gas and with room air. The pCO_2 electrode was not stable at all, and the measurement of blood carbon dioxide tension was given up.

In all cases the right femoral artery was catheterized and the blood pressure was continuously recorded on a polygraph recorder (NIHON KOHDEN). The cerebral venous blood was withdrawn through a polyethylene catheter, 1 mm in external diameter, which was threaded down the superior sagittal sinus to the confluence sinuum. A 3-way stopcock was attached to the external end of each catheter. On sampling, the first one cc of blood from the catheter was thrown, and the next 2 to 3 cc was aspirated into a syringe, inside of which was immersed with a dilute heparin solution and kept away from an air-bubble. The collected blood was immediately injected into the cuvettes of the I. L. Meter for measurement of pH and pO_2. The blood in the catheter and the cuvettes was washed out with heparin solution.

About 15 to 30 seconds elapsed before a stable plateau for reading occurred for pO_2 electrode, and only a few seconds for pH electrode. It took about 2 to 3 minutes to complete each measurement and to be ready for the next. In this series the measurement was repeated at 5 to 10 minute interval. The storage of the collected blood in ice water was not done, because of its rather time-consuming process and retarded response time for measurement. As it was impossible to collect both venous and arterial blood at the same time, the venous blood was withdrawn and injected into the cuvettes first, and then the arterial blood was sampled and measured 2 to 3 minutes later.

The normal mean values of pH and pO_2 of blood and their standard deviations were decided on 74 measurements in 18 samples: $pvH = 7.343 \pm 0.069$; $paH = 7.405 \pm 0.076$;

$pvO_2 = 35.1 \pm 7.7$ mmHg ; and $paO_2 = 88.1 \pm 12.4$ mmHg.

The following experiments were performed.

(I) CONTROLLED ARTERIOTOMY AND VENOUS RE-TRANSFSION. Arterial blood was withdrawn continuously or intermittently through the indwelling catheter in the left femoral artery, until the mean arterial blood pressure was reduced to 70 to 60 mmHg. This level was maintained for about 20 to 30 minutes, and then blood transfusion, sometimes with saline infusion, was started. During this period pH and pO_2 both in arterial and venous blood were measured.

(II) CONTROLLED HYPOTENSION WITH METHOBROMINE (Hexamethonium bromide). One hundred to 250 mg of methobromine was injected intravenously, and the mean arterial blood pressure was reduced to 70 to 60 mmHg or less, which was maintained for about 20 to 30 minutes. Then a small amount of 4 % ephedrine was injected subcutaneously to restore the blood pressure to the normal level. The total amount of methobromine required to reduce the mean blood pressure to 70 mmHg or less was variable in dogs. The initial doses given ranged from 25 to 150 mg.

(III) LIGATION OF THE COMMON CAROTID OR VERTEBRAL ARTERIES, OR BOTH. Two to four of these arteries were ligated near their origins. The occlusion was maintained, as a rule, until some changes of pvO_2 appeared.

(IV) INTRACRANIAL HYPERTENSION BY INFLATION OF SUPRATENTORIAL EXTRADURAL BALLOON. A burr hole, about 1 cm in diameter, was opened in the left parietal bone. A thin double-layered gummy balloon, tied at the tip of a polyethylene catheter was placed in the epidural space in a direction to the frontal lobe. Both burr holes for the balloon and the catheter were closed with dental cement and covered with overlying tissues. The major cistern was punctured with an 18-gauge needle, after the overlying skin was divided, and a catheter attached to the needle was connected to the transducer of the polygraph recorder for the measurement and recording of the intracisternal pressure. Intracranial hypertension was produced by a rapid injection of saline (less than 7 cc) into the epidural balloon. This cerebrospinal-fluid pressure was maintained at least 5 minutes, and then the increased pressure was reduced by removal of saline from the balloon. The average normal value of the intracisternal pressure in this study was 54.1 ± 47.4 mm of water on 23 measurements in 6 samples.

RESULTS

1) CONTROLLED ARTERIOTOMY AND VENOUS RE-TRANSFUSION.

Twenty dogs were used for this experiment, including preparatory ones. The cases which showed characteristic changes of pH and pO_2 were presented as follows :

No. 17 : Sixty cc of blood was removed in 3 minutes, and the mean arterial blood pressure was maintained less than 60 mmHg (40 to 53 mmHg) for about 30 minutes (Table 1 and Figure 1).

(1) pH : Five minutes after start of arteriotomy there was an initial transient rise in paH, followed by its gradual fall. With a rapid drop of the blood pressure pvH also decreased. Both paH and pvH showed their lowest level, 7.140 and 7.011, 5 and 10 minutes after transfusion, respectively. Then a final rise occurred both in paH and pvH,

but they remained less than 7.3 and 7.2, respectively, in the first one hour after restoration of normal blood pressure.

(2) pO_2: Immediately after arteriotomy pvO_2 decreased to 20.0 mmHg, and then increased only slightly, but finally decreased again and showed 19.0 mmHg 30 minutes after arteriotomy. At this time when transfusion was started, it rapidly increased to 35.0 mmHg, and then began to decrease again and ranged from 20.0 to 23.0 mmHg for the rest of the first one hour after transfusion. Chnage of paO_2 was not remarked, but it showed a higher level during hypotensive period than before and after this period.

COMMENT: In this case, after restoration of blood pressure, there was a late fall in paH, pvH and pvO_2, which did not regain their normal level in the first one hour. This finding indicates the possibility of an irreversible process occurred during the induced hypotension, less than 60 mmHg, lasting for about 30 minutes. In other words, the recovery time in this case is more than one hour.

No. 21: During hypotensive period, the blood pressure was not reduced lower than 80 mmHg (Table 2 and Figure 2). After arteriotomy, there was an initial rise in paH and an initial fall in pvO_2, just as noted in above case. Both pvH and paH reduced as the time elapsed, but pvO_2 increased after the initial fall. When transfusion was started, pH and pO_2 both in the arterial and venous blood regained their normal value.

COMMENT: This case appears reversible, and indicates that induced hypotension, not less than 80 mmHg, does not develop irriversible change in nerve cells.

No. 22: Although 350 cc of blood was removed in 15 minutes, the mean arterial blood pressure did not uniformly fall less than 70 mmHg over the period of hypotension, lasting for 30 minutes. The paO_2 remained almost constant throughout the experiment, and change in paH, pvH and pvO_2 during the hypotensive period was only slight. The pvH decreased only slightly after transfusion (Table 3 and Figure 3).

COMMET: In this case, although the mean arterial blood pressure was maintained less than 80 mmHg for about 30 minutes, change in pH and pO_2 ranged within normal limits even after the hypotensive period. This finding indicates reversibility of this case after induced hypotension.

2) CONTROLLED HYPOTENSION WITH METHOBROMINE.

Ten dogs were used. Except the following cases intravenous administration of methobromine failed to drop the mean arterial blood pressure less than 70 mmHg.

No. 26: This dog was not connected to the respirator from the beginning of the experiment. With a rapid drop of blood pressure pH began to decrease, but pO_2 remained within its normal range. When the respirator was connected to the animal, both pH and pO_2 increased rapidly. The mean arterial blood pressure was maintained lower than 70 mmHg without respirator for about 20 minutes and with respirator for 55 minutes. After administration of ephedrine pvO_2 increased remarkedly first and then gradually decreased (Table 4 and Figure 4).

No. 27: Hypotension lower than 70 mmHg was maintained for 65 minutes. During the hypotensive period pvO_2 decreased, but remained at the reaction threshold value; pH and paO_2 increased rapidly. After restoration of blood pressure pvO_2 regained its normal value, and pH and paO_2 decreased only slightly (Table 5 and Figure 5).

Table 1. Controlled Arteriotomy and Venous Re-transfusion. (No. 17, 8.5 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.375	7.392	29.0	65.0	36.0	180/130	148
10	7.350	7.525	24.0	65.0	41.0	160/125	136
20	7.405	7.505	18.0	67.0	49.0	180/120	140
35	7.328	7.412	27.0	70.0	43.0	170/120	138
50	7.345	7.405	28.0	75.0	47.0	150/100	118
55	Arteriotomy, 60 cc in 3 minutes						
60	7.338	7.480	20.0	78.0	58.0	70/40	50
65	7.345	7.405	23.0	82.0	59.0	60/40	46
70	7.272	7.370	23.0	81.0	58.0	70/45	53
75	7.225	7.310	22.0	80.0	58.0	65/40	48
85	7.200	7.280	19.0	80.0	61.0	65/35	45
90	Rapid transfution of whole blood, 60 cc						
95	7.065	7.140	35.0	81.0	46.0	120/70	88
100	7.011	7.205	30.0	75.0	45.0	130/80	98
105	7.130	7.230	25.0	68.0	43.0	130/80	98
110	7.168	7.262	23.0	66.5	43.5	125/80	95
120	7.190	7.275	20.0	65.5	45.0	110/70	83
130	7.195	7.288	21.0	66.0	45.0	110/70	83
140	7.185	7.295	21.0	71.0	50.0	110/65	80
150	7.180	7.275	20.0	72.0	52.0	90/45	60

Table 2. Controlled Arteriotomy and Venous Re-transfusion. (No. 21, 11.5 kg, Female)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.326	7.428	31.0	88.5	57.5	190/145	160
10	7.345	7.455	22.0	87.5	65.0	190/150	163
20	7.355	7.465	26.0	89.0	63.0	180/140	153
30	7.337	7.436	22.0	80.0	58.0	190/140	153
50	7.305	7.385	31.0	95.0	64.0	180/140	153
55	Arteriotomy, 160 cc in 12 minutes						
65	7.293	7.405	21.5	97.0	75.5	95/75	81
70	7.252	7.310	24.5	90.0	65.5	100/70	80
75	7.223	7.245	26.5	90.0	65.5	110/70	83
80	7.190	7.272	31.0	85.5	54.5	125/80	95
90	7.177	7.252	34.5	86.5	52.0	125/90	101
93	Transfusion of whole blood started.						
100	7.210	7.292	31.5	93.0	61.5	170/115	133
110	7.233	7.317	31.0	93.0	62.0	175/120	138
120	7.232	7.332	28.5	94.5	66.0	170/120	136
130	7.241	7.345	29.0	91.0	62.0	160/120	133
145	7.212	7.282	29.0	99.0	70.0	170/100	123

Table 3. Controlled Arteriotomy and Venous Re-transfusion. (No. 22, 9.5 kg, Female)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.357	7.443	28.0	112.0	84.0	130/90	103
10	7.346	7.376	33.5	105.0	71.5	130/90	103
25	7.318	7.385	34.0	111.0	77.0	120/90	100
35	7.315	7.368	35.5	98.0	62.5	120/90	100
50	7.337	7.402	29.0	119.0	90.0	140/100	113
55	Arteriotomy, 350 cc in 15 minutes						
70	7.322	7.412	25.0	108.0	83.5	70/50	56
75	7.337	7.397	28.0	103.0	85.0	70/60	63
80	7.303	7.386	25.0	104.0	79.0	98/70	79
85	7.303	7.392	27.0	104.0	77.0	78/52	60
90	7.261	7.362	35.0	101.0	66.0	90/65	73
95	Transfusion of whole blood, started.						
115	7.242	7.282	38.0	101.0	63.0	140/100	113
125	7.252	7.337	37.0	116.0	79.0	150/110	123
135	7.272	7.346	39.5	121.0	81.5	165/115	128
150	7.265	7.372	34.5	115.0	80.5	160/110	126
160	7.262	7.350	35.0	113.0	78.0	155/110	125
175	7.292	7.346	35.5	108.0	72.5	145/105	118
190	7.273	7.335	39.0	116.0	77.0	170/115	133
200	7.252	7.332	39.0	119.0	80.0	160/120	133

Table 4. Controlled Hypotension with Methobromine. (No. 26, 9 kg, Female)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.335	7.377	37.5	86.0	48.5	130/80	98
10	7.332	7.382	37.0	92.0	55.0	130/80	98
20	7.325	7.337	36.0	90.0	54.0	125/80	95
25	Methobromine, 25 mg, intravenously						
30	7.317	7.356	35.5	78.5	43.0	95/60	71
35	Methobromine, 50 mg, intravenously						
40	7.272	7.335	38.5	90.0	51.5	90/50	68
45	Methobromine, 25 mg, intravenously						
50	7.272	7.312	39.0	77.5	38.5	85/50	61
60	7.267	7.301	42.0	87.0	45.0	85/50	61
65	Respirator, on						
70	7.305	7.375	42.0	117.0	75.0	85/50	61
90	7.272	7.346	43.0	116.0	73.5	70/40	50
100	7.262	7.336	38.0	117.0	79.0	70/40	50
110	7.285	7.423	31.0	118.0	87.0	75/55	61
120	7.341	7.465	24.0	119.0	95.0	80/50	60
125	4% ephedrine, 0.2 cc, subcutaneously						
130	7.355	7.420	64.0	122.0	58.0	260/130	173
140	7.412	7.458	54.0	125.0	71.0	170/110	130
150	7.432	7.455	46.0	129.0	83.5	140/100	113
160	7.325	7.355	43.0	115.0	72.0	120/80	93

Table 5. Controlled Hypotension with Methobromine. (No. 27, 9.5 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.240	7.290	52.0	91.0	39.0	160/90	113
10	7.260	7.295	47.0	93.0	46.0	150/100	118
20	7.262	7.292	44.0	85.0	41.0	150/100	118
30	7.225	7.275	45.0	85.0	40.0	150/90	110
40	7.225	7.252	46.0	78.0	32.0	140/100	113
45	Methobromine, 50 mg, intravenously						
50	7.190	7.293	42.0	104.0	62.0	100/60	73
55	Methobromine, 150 mg, intravenously						
60	7.268	7.361	29.0	101.0	72.0	80/50	60
70	7.282	7.382	27.0	106.0	79.0	80/50	60
80	7.302	7.387	27.0	108.0	81.0	80/50	60
90	7.296	7.388	26.0	106.0	80.0	75/45	55
100	7.295	7.387	27.0	110.0	83.0	90/60	70
110	7.295	7.387	28.0	110.0	82.0	90/60	70
120	7.298	7.382	28.5	112.0	83.5	85/55	65
125	4% ephedrine, 0.4 cc, subcutaneously						
130	7.298	7.355	30.0	106.0	76.0	200/120	148
140	7.265	7.325	41.0	112.0	71.0	180/120	140
150	7.258	7.325	42.0	106.0	64.0	170/130	143
160	7.250	7.320	39.0	102.0	63.0	160/120	133

Table 6. Ligation of the Common Carotid Arteries. (No. 29, 11 kg, Female)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.323	7.377	29.0	76.0	47.0	165/110	128
10	7.350	7.396	26.0	74.0	48.0	170/110	130
20	7.336	7.408	31.0	72.0	41.0	170/110	130
30	7.308	7.384	27.0	74.0	47.0	175/115	135
40	7.332	7.387	31.0	82.0	51.0	185/115	138
50	7.307	7.376	33.0	82.0	49.0	185/115	138
55	Ligation of the left common carotid artery						
60	7.298	7.375	34.0	78.0	48.0	195/120	145
62	Ligation, off						
65	7.315	7.375	34.0	78.0	44.0	190/115	140
70	7.316	7.370	34.0	78.0	44.0	190/115	140
75	Ligation of the right common carotid artery						
80	7.310	7.385	32.0	80.0	48.0	205/130	155
82	Ligation, off						
85	7.314	7.380	34.0	80.0	46.0	200/125	150
90	Ligation of both common carotid arteries						
95	7.305	7.367	35.0	77.0	42.0	230/160	183
100	Ligation, off						
105	7.305	7.347	36.0	75.0	39.0	200/130	153
115	7.302	7.367	36.0	77.0	41.0	200/130	153
120	Ligation of both common carotid arteries						
130	7.279	7.335	37.0	75.0	38.0	200/150	183
140	7.262	7.318	39.0	74.0	35.0	230/155	180
143	Ligation, off						
150	7.255	7.313	36.0	71.0	38.0	200/150	168
160	7.263	7.322	31.3	75.0	43.5	120/150	170
170	7.248	7.306	31.0	68.0	34.0	220/150	173

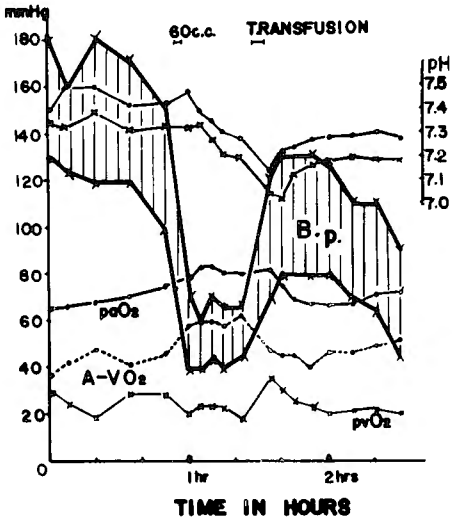

Fig. 1 Maintenance of mean blood pressure below 60 mm Hg for about 30 minutes resulted in a late fall of pH and pvO_2.

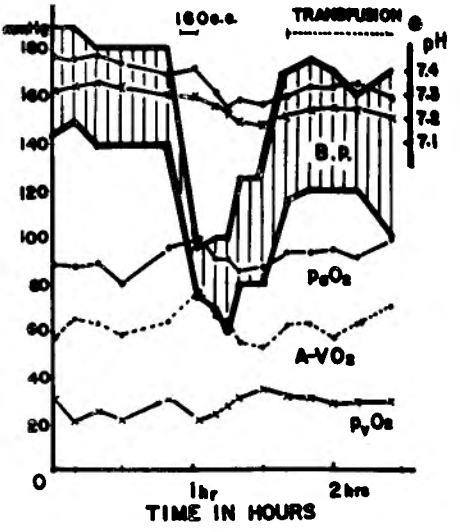

Fig. 2 Hypotension, not lower than 80 mm Hg, allowed a prompt recovery of both pH and pO_2, after the blood pressure regained its normal value.

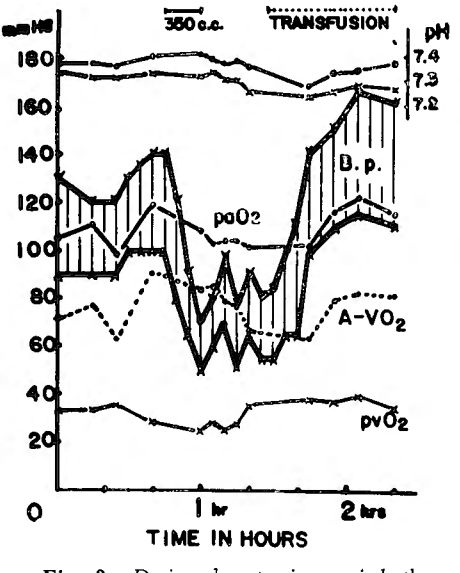

Fig. 3 During hypotensive period the blood pressure sustained more than 70 mm Hg. After restoration of blood pressure, both pH and pvO_2 regained their normal values.

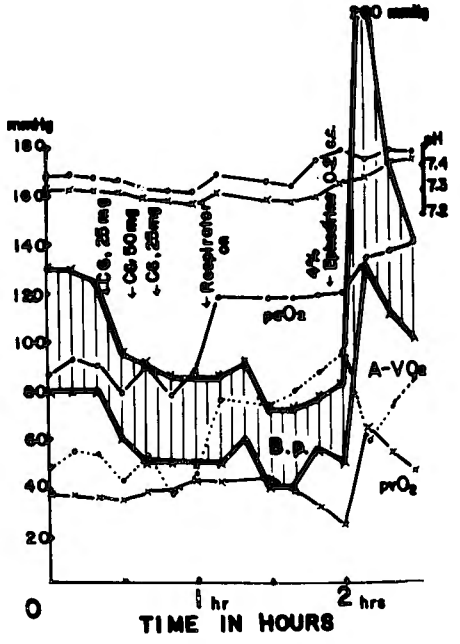

Fig. 4 The mean blood pressure was maintained lower than 70 mm Hg for 75 minutes without resultant fall in pH and pO_2.

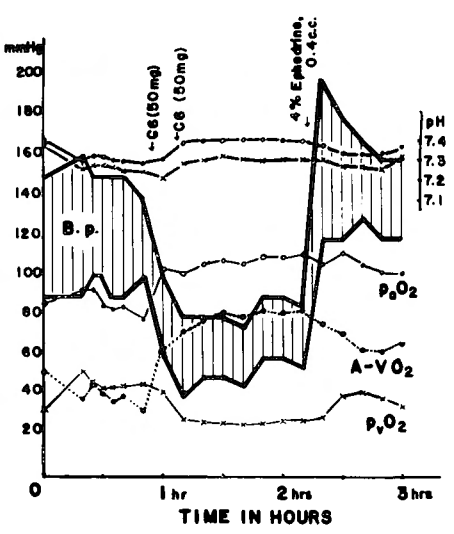

Fig. 5 After hypotensive period for about 65 minutes, pvO_2 recovered its normal value, and paO_2 and pH decreased only slightly.

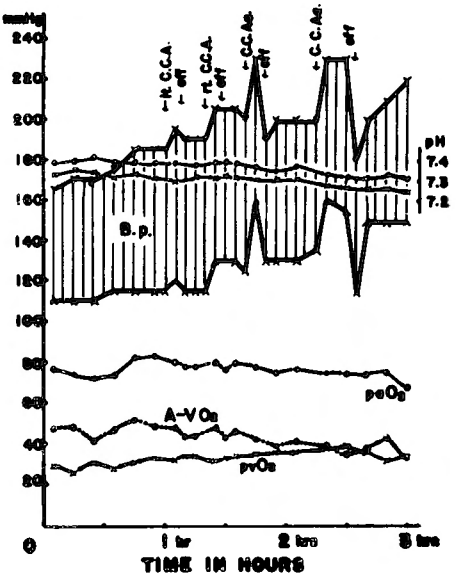

Fig. 6 Temporary occlusion of the common carotid arteries did not cause remarkable changes of pvH and pvO_2.

COMMENT : As shown in these cases, a drug-induced hypotension (less than 70 mmHg for more than one hour) did not cause final fall of pvH and pvO_2 after restoration of blood pressure with ephedrine injection. This finding may suggest that in this kind of hypotension the blood pressure of 70 mmHg does not mean its critical value for cerebral ischemia, probably because of adequate capillary circulation.

3) LIGATION OF THE COMMON CAROTID OR VERTEBRAL ARTERIES OR BOTH.

This procedure was carried out on 10 dogs, among which the following cases showed characteristic responses.

No. 29 : Either unilateral or bilateral ligation of the common carotid artery did not cause remarkable changes of pvH and pvO_2 (Table 6 and Figure 6).

N.o 30 : The ligation of the common carotid arteries were performed at first and about 30 minutes thereafter the right vertebral artery was occluded. This procedure caused only slight change of pvO_2, but after the ligations were reopened, pvO_2 showed a late fall, followed by a gradual rise. However, it did not regain its normal value in the first 35 minutes after reopening of the ligations. Both arterial and venous pH ranged within normal limits during this course (Table 7).

COMMENT : This case showed a late fall of pvO_2 after the ligations were released, but was followed by its gradual rise which was more than 23.0 mmHg. This dog survived more than 20 hours without remarkable neurological disturbance.

No. 33 : The common carotid and the vertebral arteries on both sides were ligated simultaneously and about 35 minutes afterward the ligations were released. The paO_2, pvH and paH remained almost within normal ranges during this course, but pvO_2 decreased significantly after the ligation of four arteries. The pvO_2 ranged from 26.0 to 21.0 mmHg

during the occlusion, and after the ligations were reopened, it remained at 20.0 to 22.0 mmHg for the first 15 minutes thereafter. This dog could not survive more than 24 hours (Table 8 and Figure 7).

COMMENT: A rapid fall in pvO_2 after the simultaneous occlusion of four arteries indicates an abrupt interruptrion of blood supply to the brain. After the ligations were released, measurement of blood pH and pO_2 was undertaken only twice because of instability of the pO_2 electrode. However, remaining low value of pvO_2 after reopening of ligations for the first 15 minutes may prospect his death.

No. 34: Four arteries were ligated one by one at 5-minute interval. Thirty five minutes after the ligations were completed, pvO_2 decreased to 17.5 mmHg. Five minutes later then the ligations were released, which yielded a rapid rise in pvO_2 as shown in Table 9 and Figure 8. This case was rather hyperventilated.

COMMENT: Characteristic changes of pvO_2 noted in this case were a rapid fall after the ligations were completed and a rapid rise after the ligations were reopened. The occlusion of four arteries for about 40 minutes did not produce irreparable damage to the brain. If the occlusions would have been sustained longer, this dog could not have survived.

Table 7. Ligation of Both Common Carotid and One Vertebral Arteries. (No. 30, 11.5 kg, Female)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.265	7.362	36.0	80.0	44.0	140/60	88
10	7.305	7.371	33.0	76.0	43.0	140/60	88
20	7.287	7.344	36.0	74.0	38.0	140/60	88
25	Ligation of both common carotid arteries						
30	7.282	7.313	40.0	68.0	28.0	180/100	128
40	7.245	7.320	40.0	68.0	28.0	175/95	123
50	7.290	7.370	34.9	69.0	35.0	165/95	113
55	Ligation of the right vertebral artery						
60	7.320	7.389	28.5	66.5	38.0	170/100	123
70	7.326	7.395	26.0	68.0	42.0	160/90	113
75	Ligation, off						
80	7.365	7.480	22.0	75.0	53.0	110/50	70
90	7.350	7.412	22.0	75.0	53.0	120/65	83
100	7.293	7.387	24.5	75.0	50.5	115/65	81
110	7.305	7.387	25.0	73.5	48.5	120/70	88

4) INTRACRANIAL HYPERTENSION.

Ten dogs were used for this experiment.

No. 38: The intracisternal pressure (ICP) was 110 mmH_2O before the inflation of the epidural balloon. Its rapid inflation yielded increase in ICP up to 272 mmH_2O, which was sustained for about 20 minutes. Then the balloon was deflated. During this period no change were noted both in pH and in pO_2 (Table 10).

No. 40: This case was somewhat hyperventilated. With a gradual inflation of balloon the ICP increased to 400 mmH_2O or more over the period of 75 minutes, but no remarkable changes were noted both in pH and in pO_2 (Table 11 and Figure 9).

Table 8. Ligation of Both Common Carotid and Both Vertebral Arteries. (No. 33, 10.5 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.395	7.485	36.0	67.0	51.0	150/100	116
10	7.445	7.495	31.5	82.0	50.5	150/100	116
20	7.352	7.430	34.0	88.0	54.0	150/100	116
25	Ligation of four arteries						
30	7.388	7.495	21.5	92.0	70.5	200/130	153
35	7.388	7.475	22.0	89.0	67.0	170/120	136
40	7.375	7.415	21.0	79.0	58.0	170/120	136
45	7.340	7.372	23.0	72.0	49.0	180/120	140
55	7.315	7.367	23.0	81.0	58.0	190/130	143
65	7.290	7.355	26.0	83.0	57.0	190/130	143
75	7.288	7.355	23.5	83.0	59.0	190/125	145
85	7.323	7.428	22.0	86.0	64.0	170/120	136
90	Ligation, off						
95	7.360	7.458	20.0	83.0	63.0	135/95	108
105	7.365	7.435	22.0	88.0	66.0	130/90	103

Table 9. Ligation of Both Common Carotid and Both Vertebral Arteries. (No. 34, 8.5, kg, Female)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	MABP (mmHg)
0	7.405	7.495	27.0	94.0	67.0	170/110	130
10	7.425	7.520	23.0	89.0	66.0	180/105	130
20	7.392	7.456	24.5	79.0	54.5	180/100	126
30	7.380	7.445	24.0	78.0	54.0	170/100	123
35	Ligation of the left common carotid artery						
40	7.385	7.455	22.0	77.0	55.0	180/105	130
45	Ligation of the right common carotid artery						
50	7.395	7.482	26.0	87.0	61.0	195/115	141
55	Ligation of the left vertebral artery						
60	7.412	7.432	39.0	83.0	44.0	210/120	150
65	Ligation of the right vertebral artery						
70	7.345	7.412	23.0	77.0	55.0	220/135	153
80	7.346	7.440	20.5	87.0	66.5	220/135	153
90	7.365	7.467	20.0	80.0	60.0	220/150	173
100	7.370	7.470	17.5	69.0	61.5	220/150	173
105	Ligation, off						
110	7.305	7.405	29.0	80.0	51.0	190/120	143
120	7.290	7.345	28.0	86.0	58.0	190/120	143
130	7.305	7.420	21.0	92.0	68.0	190/130	150
140	7.282	7.335	28.0	86.0	58.0	190/130	150
150	7.252	7.315	30.0	86.0	56.0	190/130	150
160	7.256	7.355	31.0	86.0	55.0	190/130	150
190	7.315	7.405	21.0	900.	69.0	180/120	140
180	7.315	7.365	28.0	86.0	58.0	180/120	140

Table 10. Intracranial Hypertension. (No. 38, 10 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	ICP (mmH_2O)
0	7.418	7.500	28.0	81.0	53.0	130/80	110
10	7.385	7.462	31.0	88.0	57.0	130/80	110
20	7.390	7.440	37.0	82.0	45.0	130/80	110
30	7.378	7.440	32.0	81.5	49.5	130/80	110
35	Inflation of epidural balloon						
40	7.380	7.435	33.0	81.0	48.0	120/70	272
50	7.380	7.440	32.0	82.0	50.0	130/100	272
55	Deflation of the balloon						
60	7.390	7.432	36.0	81.0	45.0	120/80	0
65	Re-inflation of the balloon						
70	7.380	7.420	32.0	88.0	56.0	110/60	272

Table 11. Intracranial Hypertension. (No. 41, 10 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	ICP (mmH_2O)
0	7.480	7.558	27.0	102.0	75.0	150/100	6.8
10	7.468	7.523	31.0	98.0	67.0	160/105	6.8
20	7.472	7.532	32.0	101.0	69.0	150/90	13.6
25	Inflation of epidural balloon						
30	7.485	7.528	33.0	96.0	63.0	160/90	136
40	7.470	7.520	32.0	92.0	62.0	165/115	136
45	Inflation of the balloon						
50	7.405	7.450	30.0	93.0	63.0	165/115	272
55	7.460	7.505	31.0	91.0	60.0	165/115	272
60	7.430	7.450	29.0	87.0	58.0	170/100	245
65	Inflation of the balloon						
70	7.365	7.410	27.0	88.0	61.0	170/100	408
75	7.365	7.495	26.0	90.0	64.0	170/100	408
80	7.425	7.490	26.0	91.0	65.0	170/100	408
85	Inflation of the balloon						
90	7.340	7.395	32.0	90.0	58.0	170/100	816
95	7.325	7.385	31.5	90.0	58.5	170/100	640
100	7.420	7.470	34.0	90.0	56.0	170/100	615
105	Deflation of the balloon						
110	7.410	7.480	40.0	96.5	56.5	170/100	68
120	7.412	7.470	33.0	92.0	59.0	140/90	163
130	7.410	7.480	33.0	92.0	59.0	160/100	353
135	Inflation of the balloon						
140	7.515	7.460	35.0	94.0	59.0	150/90	816
150	7.360	7.520	36.5	97.0	60.5	150/90	573
155	Deflation of the balloon						
160	7.355	7.400	39.0	99.0	60.0	140/80	68

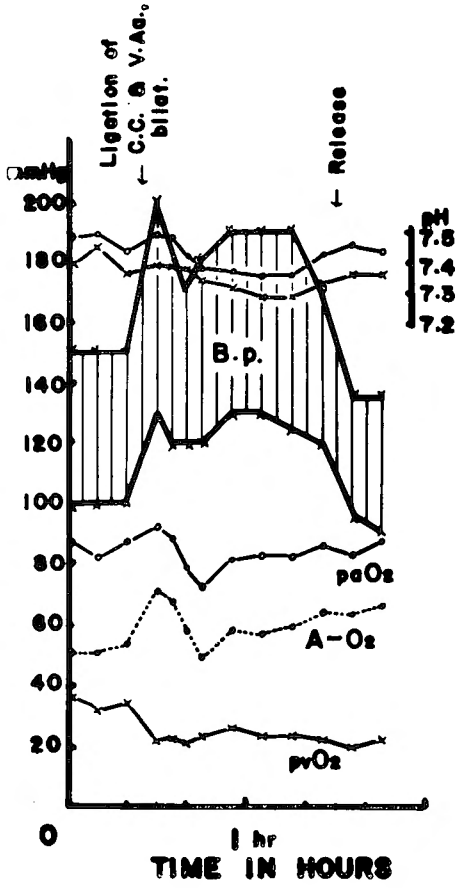

Fig. 7 A rapid fall in pvO_2 after the simultaneous occlusion of four arteries. This case did not survive more than 24 ho urs after the prccedure.

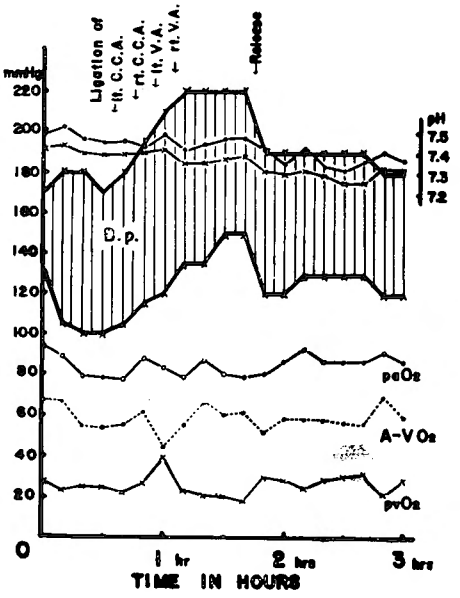

Fig. 8 A rapid fall of pvO_2 after the completion of ligations and its rapid rise after the reopening were remarked.

No. 41 : The ICP was maintained more than 200 mmH_2O for about 30 minutes, but no remarkable changes of pH and pO_2 were noted (Table 12 and Figure 10).

No. 43 : In this case intermittent inflation of the epidural balloon produced increased ICP more than 200 mmH_2O and less than 550 mmH_2O, but no significant changes of pH and pO_2 were occurred. At the end of this procedure the ICP did not return its normal level because of developing cerebral swelling and ICP remained at 250 mmH_2O. The balloon was then rapidly inflated again, and the ICP increased more than 400 mm H_2O for about 15 minutes. During this period pvO_2 increased significantly more than 50 mmHg, and when the balloon was deflated, the ICP began to decrease less than 400 mmH_2O, which resulted in a corresponding decrease in pvO_2 to almost normal level (Table 13 and Figure 11).

COMMENT : Only this case showed a significant change in pvO_2, when a probable brain swelling was superimposed by a further increase in the ICP (more than 400 mm H_2O). This may indicate that there is some critical threshold value of ICP at around 400 mmH_2O or more.

Table 12. Intracranial Hypertension. (No. 41, 10 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	ICP (mmH_2O)
0	7.355	7.417	40.0	89.0	49.0	150/90	13.6
10	7.371	7.410	42.0	91.0	59.0	160/90	27.2
20	7.370	7.400	44.0	91.0	47.5	160/90	27.2
25	Inflation of epidural balloon						
30	7.365	7.385	53.0	92.0	39.0	150/90	95.2
35	Inflation of the balloon						
40	7.348	7.405	37.0	92.0	55.0	150/80	136
50	7.368	7.410	40.0	94.0	54.0	150/80	176.8
60	7.362	7.397	45.0	96.0	51.0	150/90	231.2
70	7.362	7.390	41.0	90.0	49.0	140/80	231.2
75	Inflation of the balloon						
80	7.357	7.390	45.0	91.0	46.0	140/80	367
90	7.355	7.390	46.0	94.0	48.0	140/80	204
95	Deflation of the balloon						
100	7.355	7.390	47.0	85.0	47.0	110/90	41
110	7.358	7.395	41.0	95.0	54.0	110/90	41
120	7.360	7.395	38.0	95.0	57.0	110/90	54.4

Table 13. Intracranial Hypertension. (No. 43, 10 kg, Male)

Time (minutes)	pH V	pH A	pO_2 (mmHg) V	pO_2 (mmHg) A	A-V O_2 (mmHg)	ABP (mmHg)	ICP (mmH_2O)
0	7.310	7.360	46.0	93.0	47.0	130/100	110
10	7.327	7.367	44.0	94.0	50.0	130/100	110
20	7.322	7.365	44.0	91.0	47.0	130/100	110
25	Inflation of epidural balloon						
30	7.320	7.365	42.0	89.0	47.0	130/110	204
35	Inflation of the balloon						
40	7.310	7.365	44.0	91.0	47.0	130/100	204
50	7.325	7.375	38.0	86.0	48.0	130/110	340
55	Inflation of the balloon						
60	7.330	7.370	37.0	87.0	50.0	140/120	408
65	Inflation of the balloon						
70	7.290	7.365	40.0	93.0	53.0	140/120	544
80	7.280	7.320	40.0	82.0	42.0	140/100	408
85	Deflation of the balloon						
90	7.315	7.350	46.0	83.0	37.0	140/100	190
100	7.315	7.340	39.0	82.0	43.0	140/100	190
110	7.315	7.360	34.0	91.0	57.0	130/100	250
120	7.310	7.375	34.0	91.0	57.0	140/100	250
125	Inflation of the balloon						
130	7.280	7.345	52.0	86.0	34.0	190/150	544
140	7.275	7.350	54.0	85.0	31.0	140/120	408
145	Deflation of the balloon						
150	7.280	7.350	40.7	86.0	46.0	110/70	340
160	7.305	7.385	42.0	80.0	38.0	90/60	340
170	7.270	7.315	45.0	80.0	35.0	80/60	272

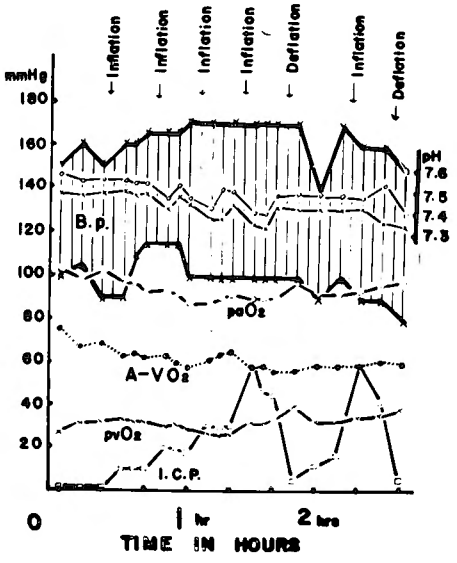

Fig. 9 The increased intracisternal pressure (ICP) up to 400 mmH_2O (30 mmHg) or more did not produce significant change of pvO_2.

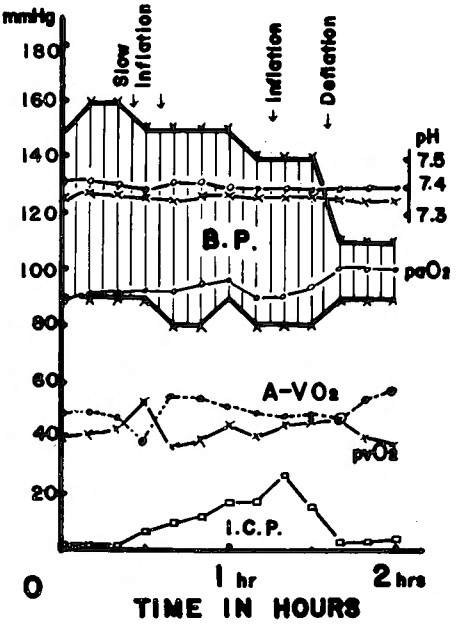

Fig. 10 The ICP was maintained more than 200 mmH_2O (15 mmHg) for about 30 minutes without remarkable changes of pH and pO_2.

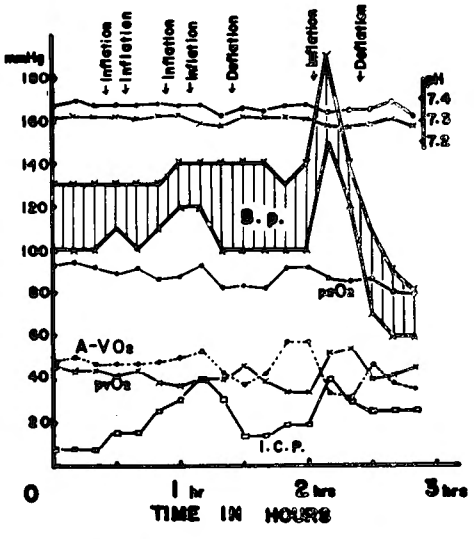

Fig. 11 A probable brain swelling, superimposed by a further increase in ICP (more than 400 mmH_2O), produced a rapid rise in pvO_2.

DISCUSSION

1) Induced Hypotension (Experiments I and II).

Blood pressure readings below normal need not be associated with shock. In circumstances that produce shock, such as for instance hemorrhage, the initial compensatory mechanism occurred is a constriction of the metarteriolar sphincter, followed by shifting of interstitial fluid into the blood stream to maintain the circulating volume at an adequate level. However, if hemorrhage continues without adequate replacement or if anoxic or stagnant anoxia is superimposed, then arteriolar and capillary dilatation and stasis will develop, which results in a reduction of venous return and a fall of cardiac output with subsequent failure of compensation, hypotension, and the development of "frank

shock". If shock is not promptly corrected there occurs irreversible damage to the tissue.

Another mechanism by which hypotension may be produced is one in which primary dilatation of the arteriolar bed occurs. Thus, by augumenting grossly the vascular bed and by decreasing peripheral resisitance, a fall in arterial blood pressure ensues. Capillary circulation should remain adequate, hence venous return remains satisfactory and cardiac output is only moderately reduced. This kind of hypotension may be produced by lumbar anesthesia or by administration of a ganglion blocking agent.

HAMPTON and LITTLE cites that capillary circulation is adequate when the pressure at the arteriolar end of the capillary exceeds the sum of the venous pressure and the colloid osmotic pressure of the plasma, a total of about 32 mmHg in normal man. Arterial pressures in excess of 32 mmHg are expended solely in overcoming peripheral resistance, and when this factor is removed, a systolic pressure somewhat in excess of 32 mmHg will provide adequate tissue oxygenation[8].

The amount of cerebral blood flow is dependent upon the cerebral vascular resistance. The arterial blood pressure which is necessary to produce cerebral ischemia is affected by peripheral vascular resistance. When the cerebral vascular resistance is very low, the signs of cerebral ischemia will not appear until the blood pressure decreases significantly low, while with higher cerebral vascular resistance the signs of cerebral ischemia will appear at the higher level of the arterial pressure. For this reason there exists a direct relation between cerebral blood flow and the mean arterial blood pressure, only when the cerebral vascular resistance remains constant[7]. FINNERTY et al. studied 44 patients who were placed on either controlled hypotension with methonium compounds or postural hypotension, and concluded that in all subjects signs and symptoms of cerebral ischemia developed, when the cerebral blood flow was reduced to 31.5 cc per 100 g of brain per minute and that a critical level of arterial pressure for cerebral ischemia did not exist[7]. This finding suggests that the critical value of cerebral blood flow is more clinically useful than that of mean arterial blood pressure, when we want to know whether or not a patient may develop signs of cerebral ischemia. By contrast, SCHNEIDER proposes that we may call the mean blood pressure of 60 to 70 mmHg the critical level of blood pressure, because only when the mean arterial pressure is below this level, there is a corresponding decrease in blood flow[21].

In this experimental series the mean arterial blood pressure was lowered to 70 mmHg or less by either rapid arteriotomy or administration of methobromine, but this level of blood pressure did not equally affect the oxygen supply to the brain in each case. In induced hypotension by rapid arteriotomy the oxygen tension in venous blood (pvO_2) reduced with a fall of blood pressure, while in the drug-induced hypotension it ranged almost within normal limits, or in other words it increased rather than decreased. In addition, in the first experiment, restoration of blood pressure more than 80 mmHg, after maintaining the mean pressure below 70 mmHg for about 20 to 30 minutes, did not allow recovery of blood pH and pO_2 to their normal levels. However, the cases which showed the mean arterial pressure more than 70 mmHg during hypotensive period regained their normal pvO_2 after recovery of blood pressure. On the contrary, in the experiment II, a drop of blood pressure below 70 mmHg did not produce a fall of pvO_2. These

findings indicate that in ischemic anoxia the mean blood pressure of 60 to 70 mmHg appears critical for cerebral ischemia, while in the drug-induced hypotension this does not mean a critical level at all. As indicated in this study, the mean arterial blood pressure of 60 to 70 mmHg or less should be maintained for more than 20 minutes to produce irreversible damage to the brain even in ischemic anoxia.

HIRSCH et al. studied relationship between oxygen consumption of the brain and pvO_2 on isolated heads of experimental animals and found that the rate of oxygen consumption of the brain did not change at the level of pvO_2 of 38 to 22 mmHg, while at 19 to 17 mmHg it began to decrease[10]. They also described that at the level of 20 to 21 mmHg the rate of decrease in oxygen consumption of the brain varied, but was not more remarkalbe than that below 19 mmHg.

In this study the reversible cases rapidly regained the normal value of pvO_2 after restoration of blood pressure, while in the irreversible ones the pvO_2 remained below 23.0 mmHg about one hour after the start of transfusion. In the latter cases pvO_2 during hypotensive period ranged below 23.0 mmHg. These findings indicate that there may be an "alarming level" of pvO_2 at 23 to 21 mmHg, which may be clinically useful to know an impending cerebral anoxia.

2) Ligation of the Cervical Vessels to the Brain (Experiment Ⅲ).

The effect of ligation of the vessels to the brain depends on how much the collateral circulation has developed. In the dogs the development of the collateral circulation is remarked[1)4)12)]. ANDREYEV studied the effect of occlusion of both common carotid and both vertebral arteries, and found that the development of collateral passages began immediately after ligation of the arteries was completed and was established in approximately from four to six weeks. When four arteries were simultaneously ligated in his cases, about 40 % of the animals died within 24 hours with symptoms of acute bulbar anemia and the rest developed either temporary or permanent functional disturbances of higher nervous activity[1)2)]. ISHIKAWA in our laboratory also studied on dogs and found that occlusion of any three of these four arteries produced a complete escape or a fall in cortical oxygen tension of 10 to 15 % in the territory supplied by the middle cerebral artery. In all these dogs no pathological changes were noted symptomatically and anatomically. Occlusion of both common carotid and both vertebral arteries produced a fall in cerebral oxygen tension of 30 to 40 % in 8 dogs and a complete escape or a fall of 10 to 15 % in another 2 dogs. The former died within 24 hours[11)]. In HANDA's studies on cerebral infarction in dogs all dogs with 3 vessel occlusion survived without any neurologic deficits and showed no softenings in the brain. In the 4 vessel occlusion group, 2 dogs out of 10 survived and showed no infarcts, and the remaining 8 died within 24 hours after operation[9)]. MEYER et al. used monkeys and reported that ipsilateral occlusion of one carotid artery alone was insufficient to cause significant ischemia, unless collateral circulation was poor, due to an anomaly of the circle of Willis or low blood pressure. Occlusion of both carotid arteries in their study produced a decrease in jugular pO_2 and pH, and increase in jugular pCO_2. When all 4 arteries were completely occluded by inflation of a cuff around the neck or by significant decrease in the mean systemic blood pressure below 40 to 50 mmHg, severe cerebral ischemia resulted, and

jugular pO_2 fell to zero or near zero levels[15]. These studies, however, dos not show how long the animal can tolerate these anoxic conditions.

In this experimental series either unilateral or bilateral ligation of the common carotid arteries did not produce remarkable changed of pvH and pvO_2. When bilateral ligation of the common carotid arteries was superimposed by unilateral ligation of the vertebral artery, no remarkable change of pvO_2 was recognized during the period of occlusion, but after the ligations were released, pvO_2 showed a late fall, approaching the critical threshold value, followed by a gradual rise (No. 30). Simultaneous ligation of 4 arteries produced a rapid fall in pvO_2, and after the ligation was reopened 35 minutes afterward, it did not regain its normal value, but remained at 20 to 22 mmHg for the first 15 minutes (No. 32). This case did not survive more than 24 hours after operation. In another case when each of 4 arteries was occluded one by one at 5 minute interval, pvO_2 decreased rapidly down to 17.5 mmHg in 35 minutes, but it rapidly regained its normal value immediately after the ligations were released (No. 34). This difference of responses of pvO_2 in both cases consists in the difference of effectiveness of their collateral passages, but in the latter case further maintenance of occlusions might have produced irreparable damage to the brain.

In this study the most characteristic finding is the change of pvO_2 after release of occlusion of at least 3 arteries (both common carotid and one of the vertebral arteries). In cases which showed a rapid fall of pvO_2 to the critical threshold value after the ligation was completed, its rapid rise was noted after the ligation was released, only when the occlusion was maintained for about 30 minutes. In other cases which did not show a fall of pvO_2 below 23.0 to 22.0 mmHg and remained around this level, it did not rise, but held the similar level or tended to fall more for 20 to 60 minutes after the occlusions were released. A similar response of pvO_2 was recognized in the experiment I (rapid arteriotomy). Here, again, it is indicated that maintenance of pvO_2 below 23.0 mmHg for more than 30 minutes may produce irreversible damage to the brain.

3) Acute Intracranial Hypertension (Experiment Ⅳ).

One of the most important effects of increased intracranial pressure is that on cerebral circulatory functions. According to the Monroe-Kellie-Cushing doctorine, it would be presumed that intracranial pressure would increase cerebrovascular resistance and thereby decrease cerebral blood flow[13]. CUSHING observed that in anesthetized dogs vasopressor response did not appear until the intracranial pressure reached the systemic blood pressure (Cushing phenomenon), and concluded that this pressor response was caused by medullary ischemia[5)6)]. KETY, SHENKIN and SCHMIDT studied 13 patients with increased intracranial pressure (all but one were suffering from brain tumors), and found that there were good correlations between cerebrospinal fluid pressure and mean arterial blood pressure, cerebrovascular resitance, and cerebral blood flow, as well as a satisfactory correlation between cerebral blood flow and mean arterial blood pressure. They concluded that there appeared to be a critical level which intracranial pressure should attain before significant cerebral circulatory embarrassment occurred. In their studies this level was close to 450 mmH_2O[13].

In this study, although the intracisternal pressure was rapidly increased more than 400 mmH_2O, no significant changes of pvO_2 and pH were recognized. In most cases it

was difficult to maintain the increased intracisternal pressure at a certain level constantly for more than 10 minutes after inflation of extradural balloon. It is also doubtful that the intracisternal pressure would represent the true intracranial pressure in this kind of procedure. THOMPSON and MALINA described that a rapid rise in the supratentorial pressure produced pressure gradient between supratentorial and infratentorial spaces which caused acute dynamic axial distortion of the brain stem[23]. Although this theory is still controversial[24], it is most probable that when the supratentorial, epidural balloon is rapidly inflated just as done in this series, the intracerebral pressure may not be equally elevated everywhere in the brain and may not be precisely represented by increased intracisternal pressure. For this reason, even if the intracisternal pressure was elevated rapidly more than 400 mmH_2O, the intracerebral pressure was not enough to produce circulatory embarrassment of the brain in general, hence no change of pvH and pvO_2 was recognized in this study. Only in one case in which repeated manipulations caused cerebral swelling, the intracisternal pressure was not lowered with deflation of the epidural balloon, but gradually increased. In this case, when the intracisternal pressure was increased from 250 mmH_2O to 400 mmH_2O, pvO_2 increased rapidly and significantly, but when the intracisternal pressure was reduced below 400 mmH_2O, there occurred the corresponding decrease in pvO_2. This finding may be correspond with existence of a critical level of intracranial pressure at which circulatory embarrassment ensues, but further investigations are necessary to confirm this event on cerebral swelling.

SUMMARY

1) The following experiments were performed on 50 dogs, to clarify the relationship between the duration of cerebral anoxia and its effect on reversibility of the cerebral function : (1) Controlled arteriotomy and venous re-transfusion ; (2) controlled hypotension with hexamethonium bromide ; (3) ligation of cervical vessels to the brain ; and (4) acute intracranial hypertension with rapid inflation of epidural balloon.

2) When the venous oxygen tension of 23 to 21 mmHg is sustained for more than 20 minutes, it may produce irreversible damage to the brain. We may call this level an "alarming level" of the pvO_2 for impending cerebral anoxia. The effect of pvH on cerebral functions is not clearly understood in this study.

3) A critical level of the mean arterial blood pressure in ischemic anoxia at which signs of cerebral ischemia appears may exist at 70 to 60 mmHg or less, but in a drug-induced hypotension this level does not mean critical at all.

4) An acute intracranial hypertension which is produced in a few minutes does not produce acute circulatory embarrassment of the brain in general, even if it is increased more than 400 mmH_2O and maintained for about 10 minutes or less. Only diffuse increase in intracranial pressure which is more than 400 mmH_2O may cause generalized circulatory embarrassment in the brain.

5) The I. L. Meter is not useful enough to check up on an impending cerebral anoxia, because for this purpose continuous measurement and recording of pH, pO_2 and pCO_2 in blood is much more desirable.

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和文抄録

実験的脳酸素欠乏症に於ける血中 pH 及び酸素分圧の変化に就いて

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脳酸素欠乏症は，種々の機序によって起ることが知られている．臨床的に，この状態を診断又は予知する一つの方法として，脳静脈血中の酸素分圧を測定する方法がある．そして，その値が，17～19mmHg 以下になれば脳酸素欠乏症を生ずるとされている．しかし従来の諸家の研究では，中等度の脳静脈血中の酸素分圧低下と，その持続時間とが，脳機能の可逆性又は不可逆性変化に及ぼす影響については，あまり明らかにされていない．

本研究では，この関係を明らかにするため約50頭の雑犬を用いて次の4つの実験を行なつた．(1) 脱血法による低血圧実験；(2) メトブロミン投与による低血圧実験；(3) 頸部動脈結紮法及び (4) 急性脳圧亢進実験である．尚血中pH及び酸素分圧測定には I. L. Meter 113型を使用し，脳静脈血は，上矢状洞より採血した．

次の様な結論を得た．

(1) 脳静脈血中の酸素分圧を 23～21mmHg 又はそれ以下に，20分以上維持出来た全例（2例）で，脳機能の不可逆性変化を生じた．この値を，脳酸素欠乏症に対する "alarming level" と呼ぶことにした．

(2) 脱血よる低血圧では，平均血圧が 70～60 mmHg 又はそれ以下になると，脳乏血状態を生ずるが，メトブロミン投与による低血圧では，この値は，まだ脳機能に対しては，critical ではない．

(3) 両側総頸動脈及び両側椎骨動脈を，約20～30分以上閉塞してから解放すると，4例中2例で脳機能に不可逆性変化が表われた．

(4) 急性脳圧亢進症では，大槽内圧が，400 mm 水柱以上になつても脳静脈血中の酸素分圧には変化はなかつた．

(5) pHの影響は明らかではなかつた．