ability of fertile eggs was decreased by levels of .01%, .03% and .06% of BAPN in the diet. Hatchability was reduced to 41% in the group receiving .01% BAPN after 4 weeks supplementation compared to the control at 61%. Hatchability decreased to 0 in 4 weeks at the .03% level and to 0 in 3 weeks in the group receiving .06% BAPN. Following removal of BAPN from the diet both egg production and hatchability increased and the percent of soft shelled eggs decreased. Hemorrhages were found in 40% to 80% of the dead embryos from the groups fed .03% and .06% BAPN.

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Secondary Shock in the Dog Produced by Total and Partial Aortic Occlusion.* (23135)

JAMES J. SMITH, ANDREW A. PANDAZI AND ROBERT A. GRACE
(With the technical assistance of Carol K. Lembck)
Department of Physiology, Marquette University School of Medicine, Milwaukee, Wisc.

Secondary shock is typically characterized by a reduced cardiac output, arterial hypotension and generalized stagnant anoxia. The result is usually a marked hypofunction of internal organs which if continued leads to death of the organism. Of the vital processes and organs which fail in irreversible shock, it is not known which failures are primary and which secondary, or conversely which systems or organs if protected from the anoxia would exert maximum survival benefit. There is reason to believe that increased perfusion of the liver(1,2) will lower the mortality in experimental shock but evidence of this type with reference to other organs or systems is scarce. It would seem that a method of producing experimental shock which permitted graded and controlled degrees of anoxia of various parts of the body might be helpful in this problem; regulation of degree of arterial flow appears to be one of the best means of achieving this. Aortic occlusion shock was produced by Erlanger and Gasser(3) but this method has since been little used.

The object of the present study was a) to determine whether repeatable experimental shock could be induced by total or partial aortic occlusion and b) to determine whether such a method might be effective in producing different degrees of anoxia in different parts of the body. The ultimate aim was to study the relative importance of various systems and organs in the genesis of fatal shock.

Methods. Mongrel dogs were anesthetized with morphine sulfate (3 mg/kg) and intravenous sodium barbital (120 to 180 mg/kg). Blood pressures were recorded with damped mercury manometers. Temporary occlusion of the lower thoracic aorta (Th 8-9) was produced either by careful tightening of a polyethylene noose placed surgically 2 to 3 weeks before, or by inflation of an intraaortic balloon catheter containing radioopaque liquid; the catheter was passed via the femoral or carotid artery under fluoroscopic guidance. The two methods yielded comparable results but the balloon catheter was used almost ex-

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TABLE I. Results of Temporary Occlusion of Lower Thoracic Aorta in Dogs (Th 8-9).

Group	Type of occlusion	Occl. time (hr)	No. of dogs	Mean wt (kg)	No. died	% mort.	Mean survival time (hr)
A	Total	1½ to 2	9	15.2	9	100	10.5
B	Partial	2 to 2½	8	15.3	3	37.5	45.3

clusively after early experiments because of its greater simplicity and ease of control. The volume of the balloon was regulated by means of a threaded shaft and piston attached to the syringe plunger; in this way degree of aortic occlusion and thus distal aortic pressure could be accurately controlled. Total and partial thoracic aortic occlusions were produced for periods ranging from 1½ to 2½ hours. In some experiments, occlusions resulting in a mean distal aortic pressure of 30 mm Hg were combined with simultaneous controlled bleeding from a carotid artery into an inverted reservoir containing Mepesulfate† in saline (200 mg %). These latter animals were therefore subjected to shock in which the mean aortic perfusion pressure above the diaphragm was 100 mm Hg and that below was 30 mm Hg. At the end of the hypotensive period the balloon was removed, the withdrawn blood reinfused and the wounds closed. In a number of animals, degree of oxygenation of the liver and lower segments of the body was studied by determination of blood oxygen content and capacity of arterial, hepatic venous and inferior vena caval blood before, during and after occlusion, using the methods of Van Slyke(4) and Roughton(5) for blood oxygen. Hepatic venous samples were obtained from a right hepatic vein via cardiac catheter; inferior vena cava samples were taken from a point 2 to 3 inches below the liver.

Results. In 2 groups of animals (Group A and B), total and partial occlusions of the lower thoracic aorta at levels of Th 8-9 were produced for periods of 1½ to 2½ hours. In the partial occlusions most of the animals were subjected to mean distal aortic pressures of either 40 or 30 mm for periods of 2 hours. The general results are summarized in Table I.

† The anticoagulant Mepesulfate was kindly supplied by Hoffmann-LaRoche, Inc., Nutley, N. J.

During the occlusion the skin temperature of the lower half of the body decreased markedly, respiratory rate and depth was diminished, particularly in the animals in Group B, and bloody diarrhea often supervened. In Group A post-occlusion blood pressures were often markedly decreased from the control values and most of these animals died in coma within 12 hours after release of the balloon. At autopsy these dogs had considerable amounts of bloody fluid in the large and small intestine but relatively little gross congestion of the mucosal and serosal vessels of these organs. The lungs were wet and severely congested.

Both of these types of experiments had certain disadvantages—in the total occlusion the stress was too severe and in the partial occlusions the central hypertension and pulmonary congestion were undesirable concomitants.

In Group C a combined hemorrhagic aortic-occlusion stress was produced by occluding the aorta to a distal arterial pressure of 30 mm Hg while simultaneously bleeding the central portion of the arterial bed to a fixed hypotensive level of 100 mm Hg. The aortic occlusion was produced 2 to 3 inches above the coeliac axis artery (Th 8-9) so that a severe arterial hypotension existed throughout the subdiaphragmatic aorta and its branches. As controls, Group D animals were subjected only to hemorrhagic hypotension of 100 mm; in these experiments the balloon catheter was inserted but not inflated. The results are shown in Table II and the blood pressure responses of all the groups are summarized in Table III.

To obtain a measure of the effect of these procedures on state of oxygenation of the involved tissues, the oxygen content and capacity of hepatic venous and inferior vena caval blood were determined in some of the animals. As measurements of the state of oxygenation, such values are by no means

TABLE II. Summary of Combined Hemorrhagic-Aortic Occlusion Shock.

Group	Type of shock	Duration of shock (hr)	No. of animals	Mean body wt (kg)	No. died	% mort.	Mean survival time (hr)
C	Hemo + aortic occl. (100-30 shock)	2½	12	10.5	10	83.3	13.1
D	Hemo only (100 mm shock)	2½	12	12.9	1	8.3	34.0*

* Single animal.

TABLE III. Blood Pressure Responses of Dogs Subjected to Occlusion of Lower Thoracic Aorta (Th 8-9).

Group	No. of animals	Type of occlusion	Mean arterial blood pressures (mm Hg) Before	During occlusion† Carotid	Femoral	After
A	9	Total	113.7 ± 24.0*	173.4 ± 16.7	14.7 ± 2.9	88.3 ± 32.1
B	8	Partial	121.8 ± 21.8	181.6 ± 15.4	35	124.1 ± 30.1
C	12	Partial + hemo.	117.3 ± 17.2	100	30	113.7 ± 14.7
D	12	None—hemo. only	125.5 ± 18.1	100	100	126.3 ± 18.3

* Refers to stand. dev. of distribution.
† Representative pressures taken at midpoint of occlusion period.

exact indices: the saturation of venous blood draining a part however is undoubtedly a reasonable function of the tissue pO_2 and as such represents the summated effect of both the oxygen supply and oxygen utilization of the part. The venous saturation values are given in Table IV.

Discussion. Irreversible shock produced by the combined hemorrhage-aortic occlusion technic described above resembles experimental hemorrhagic shock in many respects. During the stress there is a decrease in body temperature, increase in heart rate, depression of reflexes and tendency to 'take up' blood from the reservoir. Following release of the occlusion and reinfusion of the withdrawn blood the arterial blood pressure returns to control levels or above, heart rate declines and circulation through the occluded areas returns to approximately normal. Over the following 6 to 24 hours blood pressure gradually declines, bloody diarrhea often occurs and death supervenes in about 80% of cases. One of the more notable contrasts with hemorrhagic shock is the lack of the usual accelerated respiratory rate and air hunger; instead, the animals in hemorrhage-aortic occlusion shock showed a decrease in respiratory rate to levels of 2 to 6 per minute. This was undoubtedly due to increased arterial flow to the head region.

The oxygen saturations of venous blood below the occlusion point varied considerably from animal to animal but did reveal the unmistakable and drastic degree of stagnant anoxia which prevailed particularly in the liver. The degree of hepatic anoxia was closely comparable to that previously reported

TABLE IV. Oxyhemoglobin Saturation of Venous Blood in Aortic Occlusion Shock.

Group	Type of shock (No. of animals)	Mean HbO_2 saturations (%) Hepatic vein Before	During	After	Inf. vena cava* Before	During	After
A	Total aortic occl. (5)	56.9 ± 10.68	5.1 ± 7.44	44.3 ± 17.92	74.1 ± 4.79	31.4 ± 14.06	56.2 ±16.32
C	Hemo. + partial occl. (5)	75.7 ± 10.06	6.8 ± 7.61	77.4 ± 7.87	83.4 ± 3.78	27.0 ± 17.26	79.5 ± 9.27
D	Hemo. only—to 100 mm Hg (6)	76.4 ± 5.69	28.9 ±24.88	62.0 ± 10.58	82.7 ± 7.16	69.8 ± 10.84	74.6 ± 9.15

* Sampling done below liver. ± refers to stand. dev. of distribution.

in hemorrhagic shock in the dog(6).

The results indicate that hemorrhage-aortic occlusion results in a repeatable type of experimental shock in the dog which simulates pure hemorrhagic shock in most of the important essentials. The method permits simultaneous and independent control of arterial perfusion pressures to different segments of the body. While it has the advantage of achieving differential perfusion without the necessity of extensive surgery or extracorporeal circulation, its application is somewhat limited by the anatomical vagaries of the arterial supply of the involved organs.

Summary. 1) A combination of hemorrhagic and partial aortic occlusion produces a controllable degree of hypotensive shock in the dog which closely resembles hemorrhagic shock. 2) The method provides an opportunity to study the effects of differential arterial perfusion of different body segments.

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Effect of X Irradiation on Increase in Rat Liver Tryptophan Peroxidase Produced by Adrenal Steroids.* (23136)

JOHN F. THOMSON AND FLORENCE J. KLIPFEL

Division of Biological and Medical Research, Argonne National Laboratory, Lemont, Ill.

On the basis of measurements of liver glycogen and blood glucose in X-irradiated rats, Mole has recently taken issue with the concept that irradiation stimulates the adrenals (1). He suggested that the failure of X-irradiated adrenalectomized rats to synthesize glycogen is due not directly to lack of cortical hormones but rather to a low level of blood glucose, below the threshold for glycogen deposition; and that glycogen synthesis following administration of cortisone is the result of an increase in concentration of glucose in blood to a level favoring deposition of glycogen. Mole concludes that X irradiation has not been shown to increase adrenal activity, and that the irradiated rat actually uses cortisone more efficiently than controls.

One change which takes place in irradiated rats is an increase in tryptophan peroxidase activity of the liver(2). This increase does not occur in adrenalectomized rats, and hence resembles the increases produced by a number of amino acids and pharmacodynamically active agents(2,3,4), rather than the increase produced by tryptophan, which is considerably greater and is not prevented by adrenalectomy(3). However, the level of the enzyme can be increased in adrenalectomized rats by administration of cortisone or hydrocortisone, the response being roughly proportional to the dose over an appreciable range (5). We felt that this system would be suitable for studying any possible improvement in efficiency of utilization of the glucosteroids in irradiated animals.

Methods. Female rats of the Sprague-Dawley strain, 6 weeks old, were adrenalectomized 5 days before irradiation; during this time they received 1% saline *ad libitum*, and were injected with desoxycorticosterone acetate (1 mg/kg) on alternate days. Exposure to X rays was at the rate of 200 r/min from a machine operated at 250 kv, 15 ma, 0.5 mm Cu plus 3 mm bakelite filters, 27 cm distance. A dose of 600 r total-body irradiation was used throughout. Cortisone acetate (20 mg/

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