THE INFLUENCE OF THE FORCE OF GRAVITY ON THE CIRCULATION OF THE BLOOD*. By LEONARD HILL, M.B., *Assist. Prof. of Physiology, University College, London. Grocers' Research Scholar.* (Twenty-five Figures in Text.)

Introduction. The influence of the force of gravity on the circulation is a question of very obvious importance, yet it is one curiously neglected by physiologists. The physician and the surgeon daily observe the effect of the position of the body upon the rate of the pulse, the sounds of the heart, diseases of the heart and lungs, hypostatic pneumonia, syncope, varicocele, erectile tumours, piles, varicose veins. The conditions of shock, anæmia, hæmorrhage, chloroform poisoning, are also seen to be largely affected by the position of the body. But on turning to the text-books of physiology nothing is to be found within their pages upon so important a theme, and on seeking still further into physiological journals and archives few and imperfect are the researches there chronicled.

History. One of the earliest observers in this subject was Piorry[1], the distinguished French physician. He insisted on separating cerebral syncope from cardiac syncope. "In cerebral syncope," he writes, "the heart continues to beat, but the beats have not force enough to overcome the resistance which is given by gravity." Therefore the activity of the brain is suspended. If the force of gravity is made to aid the heart in propelling blood to the brain the syncope will cease. Piorry observed several cases bearing on this point. In one instance he was suddenly called to a patient who had lost consciousness. The respiration was rare and stertorous, sensibility was abolished, the pulse very feeble, the heart very weak and irregular, and the face pale. The patient had been supported by his friends in the sitting posture for fifteen minutes. Piorry refused to bleed the patient and laid him down horizontally. Immediately his eyes opened, respiration was

* This paper was communicated to the Royal Society, Nov. 19, 1894, and an abstract is printed in the *Proc. R. S.* vol. 57.

accelerated, the colour came back to the face and in three minutes all the unfavourable symptoms had disappeared.

One such case arose from hæmorrhage, another from the emotional effect produced by a slight operation. Piorry was summoned to another patient who had been trampled upon in the belly by a horse. He was found supported by his friends in the sitting posture and almost dead. Piorry immediately placed him horizontally, and the patient at once recovered. After Piorry's departure the patient insisted on taking his seat again in his carriage. On doing so he immediately became unconscious and died.

Piorry further investigated the problem by experimenting on dogs. He placed them in the vertical feet-down position, and bled them from the jugular vein till syncope was induced. By placing them in the vertical feet-up position the animals were at once restored to consciousness. And every time that he repeated this experiment of alternating the positions he obtained the same result. "It is in consequence of gravity," writes Piorry, "that when the arms are held down, the veins swell and the capillaries are filled, and that the reverse occurs when the arms are held up, that varicoceles enlarge on standing up, and diminish in the horizontal position, and that the head and face redden when held down. It is in consequence of gravity that pneumonia invades the posterior border of the lung when the patient lies on his back, and for the same reason, if the patient for a length of time be laid upon his face the pneumonia appears in the anterior border of the lung."

Piorry concludes that the force of gravity has a very marked effect on the circulation and that this is especially observable in patients who are weakened by any cause. He affirms also that the effect of altering the position of a patient will determine the diagnosis between apoplexy and syncope.

Marshall Hall[2], in a research on the effects of loss of blood, found that after recovery from a severe hæmorrhage the syncopal condition could be at once reinduced in dogs by placing them in the vertical feet-down position, then "the countenance and eye languish, the head drops, the mouth opens, the respiration is panting, and the heart is scarcely to be heard." Immediate relief was given by reversing the position.

Basedow[3] found in a patient who had been bled for apoplexy that syncope was produced by the vertical feet-down position and abolished by the horizontal position. He pointed out that the influence of position on varicoceles, erectile tumours, œdemata, hypostatic pneumonia, indicate the effect of gravity, as do also the tendency to sleep and the slower and deeper respiration existent in the horizontal position, with the increase of pain in carious teeth, swelling of the nasal mucous membrane, increase of coughing in tubercular patients.

On trephining rabbits and placing them in the vertical feet-up position Regnard[4] found that at the end of five minutes the animals were still perfectly well, but on placing them in the vertical feet-down posture, after the space of two minutes, loss of sensibility was induced, the respiration became short and irregular, and all the signs of syncope were manifest.

Salathé[5] investigated the effect of gravity on rabbits. He found that in the vertical feet-down position the animals died in the course of fifteen minutes to two hours.

Progressive failure of the respiration and heart set in, followed by convulsions and finally by syncope. All these symptoms were abolished by placing the animals in the vertical feet-up position, and this position Salathé found could be maintained for a long time without any ill effect. Centrifugal force acted in precisely the same way.

Salathé[6] also investigated the effect of position on the cerebral volume. On applying a tambour to an infant six weeks old, he saw that on placing the child in the vertical feet-down position there was a fall of pressure, but on turning the child to the feet-up position a rise of pressure followed. In dogs he found acceleration of respiration and increase of cerebral volume occurred when in the feet-up position, but on the other hand, slowing of respiration and fall of cerebral volume followed on placing the dogs with the feet down.

In a patient from whom a large portion of the skull had been removed Brissaud and François Franck[7] noticed the aspirating effect of the 'feet-down position' on the volume of the brain. Franck believed in a compensatory aspiration of cerebro-spinal fluid into the subdural space because he observed the effect of gravity to be less upon the volume of the brain than upon the volume of the arm.

Schapiro[8] examined fifty soldiers and found that the pulse was more frequent in the standing position than in the horizontal. The average rate of increase was 14 beats. By compression of both femoral arteries the pulse rate became slower by an average of five beats, and the soldiers, who when standing, gave the greatest increase, on the compression of the femorals, showed the slowest pulse. By investigation with a sphygmomanometer Schapiro ascertained the difference of blood pressure to be 10—15 mm. Hg. in passing from the horizontal to the standing position.

Zybulski[9] determined that the blood pressure fell in dogs in the feet-down position and rose in the feet-up position. He placed the cannula in the axis round which the dogs were turned.

Friedmann[10] also recorded that the blood pressure fell in dogs experimented upon with the feet down.

In 1885 Hermann[11] placed the subject in the hands of two pupils, Blumberg and Wagner, with the object of investigating the dynamic and hydrostatic effects of gravity on the circulation. To do this he set them to find the 'indifferent point' of the circulatory system in order that the Hydrostatic effect might be eliminated and the Dynamic effect alone studied.

Hermann states his position thus: If one thinks of an aneroid manometer placed on any given spot in any given artery, and the position of the animal is changed, the observed changes of pressure will depend on

(*a*) the altered relationship of level between the given spot and the rest of the vascular system (hydrostatic moment),

(*b*) the altered relation between pressure and resistance produced indirectly by the change of position on the heart-beat, the filling of the heart, the vaso-motor nerves, etc. (dynamic moment).

Only the dynamic moment is of physiological interest, the hydrostatic moment will also be in evidence in the corpse so long as the blood is fluid.

If, on the other hand, the manometer is a hydrostatic one a third influence will come in, that is—if the manometer does not follow the alterations of position of the artery, but stands in a fixed position, as is usually the case, an influence namely of the absolute change of level of the given spot on the artery in relation to the manometer. This influence can only be eliminated by turning the animal round an axis which passes through the given spot on the artery.

In this last case however the influence *a* and *b* will still exist. Since the real object of research is *b*, and the manometer in kymographic researches is a fixed hydrostatic one the right course is to compensate *a* with *c*, that is, to turn an animal round an axis passing through the hydrostatic indifferent point of its vascular system. That is the point in which the hydrostatic pressure *a* does not alter when the vascular system is turned round the same. If the zero point of the manometer is placed at this level, the pressure at the given spot will be just so much heightened or lowered when the animal is turned round the axis, as the artery in comparison with the manometer sinks or rises.

In order to find this indifferent point Wagner washed out the blood of the animal with salt solution, filled up the vascular system with salt solution, placed the animal upon a board which turned on a horizontal axis, and then by altering the position of the body found the point through which the axis must pass in order to compensate *a* with *c*.

Having found this point in the dead animal Wagner applied it to the living animal, and henceforward assuming that he had entirely eliminated the hydrostatic moment carried out a series of experiments and drew his conclusions as to the dynamic effects.

This method of procedure, which is of course perfectly accurate when tested on a simple closed rubber schema, cannot be applied to the dead or living animal.

In investigating the subject I have found that on attempting to fill the circulatory system of the dead animal with salt solution, the arterial side of the system does not remain filled, for the salt solution rapidly leaks into the splanchnic venous area. By alternately placing the animal with feet down or with feet up a pumping action is produced which gradually forces the salt solution out of the arterial system into the venous side, where it remains. The indifferent point cannot therefore be found on the dead body. Farther, if it were possible to find the indifferent point on the dead body the indifferent point on the living body could not be deduced therefrom, because such indifferent point depends on the coefficient of elasticity which must constantly alter in the living animal with every alteration of the arterioles by vaso-constriction or dilatation.

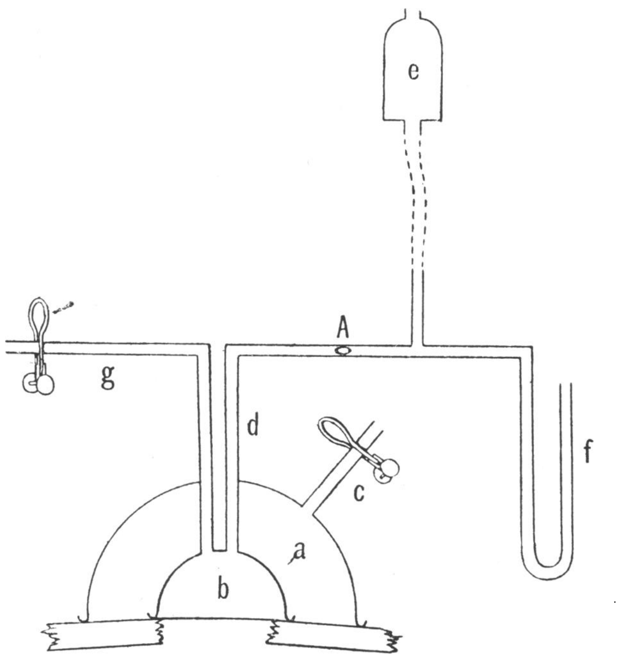
As regards the dynamic effect of gravity on the circulation, therefore, the work of Blumberg and Wagner cannot be accepted, and to my knowledge, as far as previous physiologists had recorded, the mere fact that the feet-down posture lowered arterial pressure and that the feet-up posture heightened it, was almost all that had been determined.

Method of Research. My attention was first drawn to the influence of gravity upon the circulation by observations which I made upon the normal intra-cranial tension in a patient of Dr Claye-Shaw. This patient had been trephined, and Dr Shaw asked me if I could estimate his normal intra-cranial pressure. I did so by an adaptation of the method for investigating intra-cranial pressure described by me in the *Proceedings of the Royal Society*, Vol. 55.

The trephine hole was protected by the scalp. To a cast of the patient's skull I had moulded a glass apparatus which as shown in the figure consisted of (*a*) an outside cupping glass which could be aspirated by a mercury pump through the tube *c*,

(*b*) an inside chamber which fitted to the edge of the trephine hole. From this inner chamber passed two tubes:

i. a tube (*d*) leading to a pressure bottle (*e*) and to a manometer (*f*),
ii. a tube (*g*) closed by a clip.



The skull previously shaved was well vaselined, the apparatus applied and the outside chamber aspirated. An air-tight joint between the inner and outer chambers was thus obtained around the trephine hole. The inner chamber was then filled with water from the pressure bottle by opening the clip on the tube *g*. The clip was next closed and the pressure bottle lowered till the water was on a level with the trephine hole. The tube *d* was then clipped for a moment and an air-bubble introduced at the point *A*. The clip being opened any alteration of pressure could be observed by the position of the air-bubble, and measured by altering the pressure bottle and bringing the air-bubble back to its initial position at zero pressure. I found that the pressure was negative while the man sat upright, but that it became positive as soon as the head was bent down towards the knees or on any expiratory effort. The air-bubble exhibited large cardiac and respiratory undulations. Experimenting on dogs I found that exactly the same thing occurred. The normal cerebral pressure became markedly negative in the feet-down posture and positive in the feet-up posture.

We have seen that Salathé and Brissand and Franck obtained the same result upon man.

For the further investigation of the subject I constructed an animal holder which could be swung round a horizontal axis. In this axis the cannula connected with the vessel under observation was always placed, and the cannula was itself connected with a fixed hydrostatic manometer.

'The hydrostatic and dynamic moments,' to use Hermann's expression, were investigated and separated, not by attempting to find the indifferent point, but by carefully observing the effects of dividing and stimulating the vagus, splanchnic nerves and spinal cord, and by watching the influence of anæsthetics, curare, and asphyxia.

The research has been carried out upon rabbits, cats, dogs and monkeys, and the same general results have been obtained from all. The animals were placed upon a board with the limbs fully extended and in the same direction as the longitudinal axis of the body.

The experiments group themselves under the following headings:—

Anæsthetics were used in all cases, and unless otherwise mentioned in the account of the experiments morphia was employed.

A. *Effects on the Circulation.*

i. Normal effect on arterial pressure,
   (*a*) With carotid artery in axis,
   (*b*) „ femoral „ „
   (*c*) „ splenic „ „
ii. Normal effect on venous pressure,
   (*a*) With splenic vein in axis,
   (*b*) „ femoral „ „
   (*c*) „ torcula Herophili in axis.
iii. Effect of anæsthetics.
iv. Effect of dividing the vagi.
v. Effect of dividing the spinal cord,
   (*a*) Influence on Heart.
vi. Effect of dividing the splanchnics.
vii. Influence of respiration and asphyxia.
viii. Influence of curare.

B. *Effects on Respiration.*

i. Normal effect.

ii. Effect of dividing the vagi.

The general results arrived at and which are worked out in the following tracings and notes, are that pressure falls in the carotid artery under the influence of gravity in the feet-down posture, and rises in the feet-up posture, that compensation takes place more or less in normal animals (that is to say, the hydrostatic moment is compensated for by a dynamic moment), that this compensation takes place by vaso-constriction in the splanchnic area in the feet-down position—with in some cases cardiac acceleration—and by cardiac inhibition and by vaso-dilatation in the feet-up position, that in conditions of shock from severe operative procedures of deep anæsthesia or curarisation with the spinal cord divided or with splanchnics cut—in any of these conditions the compensation is abolished in the feet-down position, and under the influence of gravity the pressure falls enormously through the blood passing into the veins of the splanchnic area. Finally the pressure in this condition can be restored immediately to the normal by firmly bandaging the abdomen, or by reversing the position of the animal.

I. Normal Effect.*

Tracing 1. Fox-terrier. Carotid in axis.

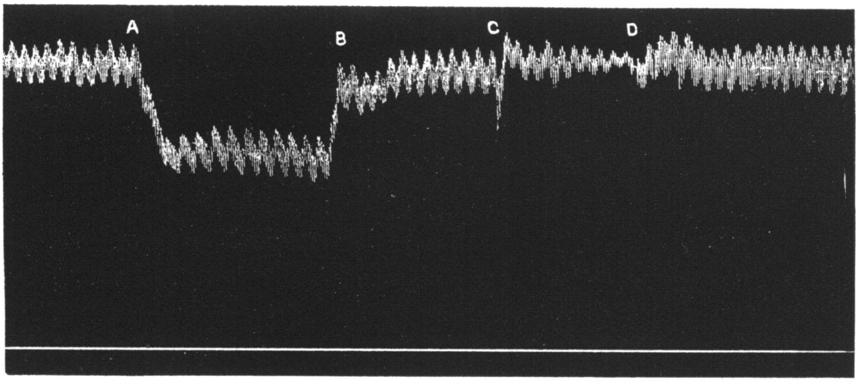
A. Vertical, feet down. C. Vertical, feet up.
B. Horizontal. D. Horizontal.

On placing the animal in the vertical feet-down position the pressure is seen to fall rapidly, and to remain permanently lowered. On restoring the animal to the horizontal position the pressure rises with equal rapidity to almost the original normal level. This rapid rise of pressure occasions a slight and compensatory fall followed by the absolutely normal condition.

On the vertical feet-up position being taken, momentary cardiac inhibition occurs with a fall in pressure, then a permanent rise of pressure follows, and on returning the animal to the horizontal position there is first a fall of pressure, then a slight compensatory rise and lastly the normal pressure is again restored. The greater effect is seen to be produced by the feet-down posture.

* Most of the tracings are reduced by one-third.

On rapidly alternating the positions, I have found that the blood pressure rises and falls with each change of movement.



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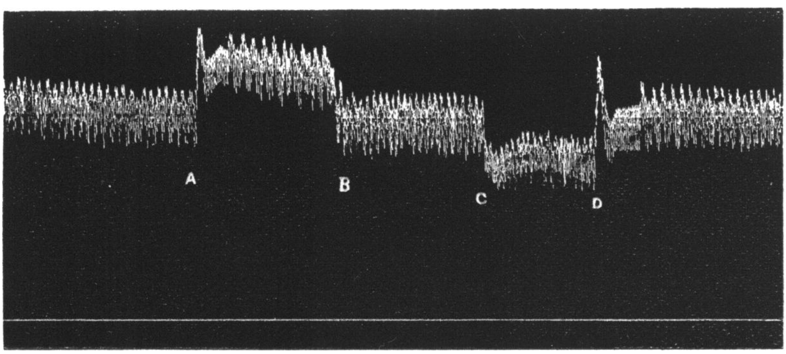
Tracing 2. From the same Fox-terrier as Tracing 1. Femoral in axis.

A. Vertical, feet down. C. Vertical, feet up.
B. Horizontal. D. Horizontal.

The effects are now shown to be exactly the reverse of those shown in the carotid trace. These two tracings therefore show the simple hydrostatic effects which I have found to be the same in all the animals examined, although they are more or less masked in different individuals owing to compensatory changes or dynamic effects.



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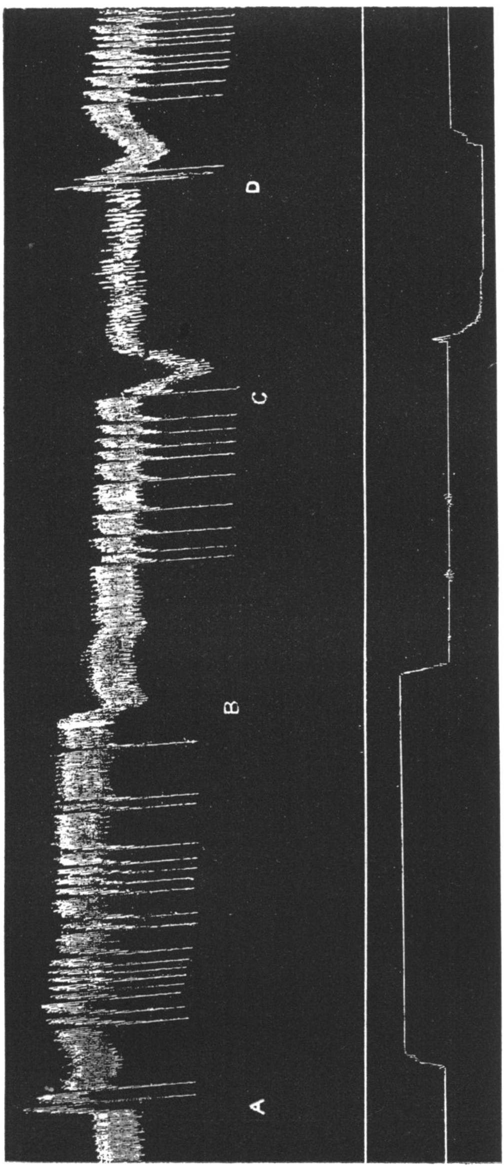
Tracing 3. Fox-terrier. The upper line shows the carotid trace. The lower line is a record of the intra-cranial pressure taken by the apparatus described by me, *Pr. Roy. Soc.* Vol. 55. The axis passed close to the trephine hole in which this apparatus was screwed, so that a correction is necessary for the changes of blood-pressure, since the carotid cannula was not in the axis. The necessary corrections for the absolute change of level of the cannula in relation to the manometer are made by deducting 7 mm. from the trace at A, 1 mm. from the trace at C.



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A. Vertical, feet up.
B. Horizontal.
C. Vertical, feet down.
D. Horizontal.

With these corrections made it will be seen that the hydrostatic effects were almost completely compensated for in the arterial system by the dynamic effects. Cardiac inhibition is found in the feet-up position, acceleration in the feet-down position.

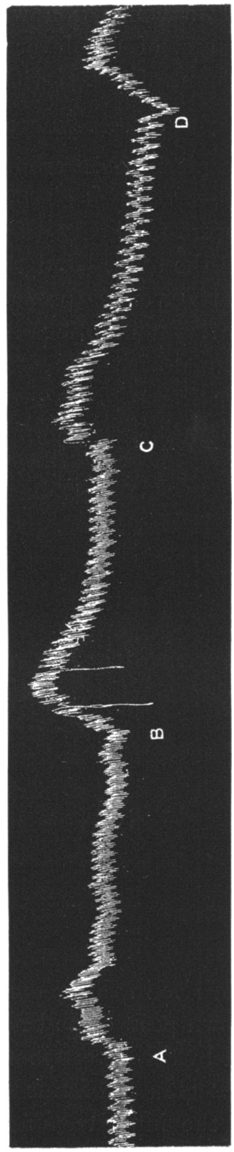
The intra-cranial pressure rises about 16 mm. Hg in the feet-up position and falls about 16 mm. Hg in the feet-down position.

This rise and fall follows the cerebral venous pressures. This can be demonstrated by taking the venous pressure in the torcula Herophili by the method described by me in the *Pr. Roy. Soc.* Vol. 55. (Compare Tracing 7.)

Tracing 4. Monkey (Macacus Sinicus). Vagi divided.

A. Vertical, feet down. C. Vertical, feet up.

B. Horizontal. D. Horizontal.



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This tracing shows that over compensation can take place in a monkey under morphia narcosis. The tracing was of exactly the same character before the vagi were divided.

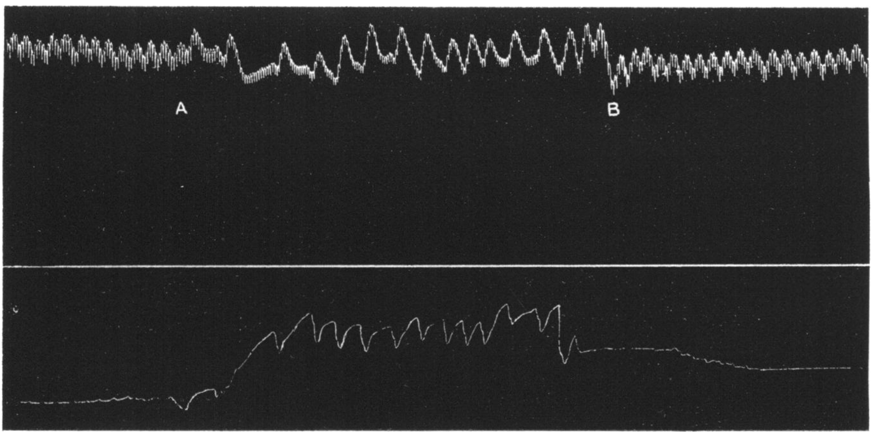
On placing the animal with the feet down the pressure rises, and on changing to the horizontal position the over compensation is still more plainly to be seen. At that moment while the vessels of the animal are still in a state of compensatory constriction, the rise of pressure due to the hydrostatic moment takes place and there is therefore a large rise. As the constriction passes off the normal level is again reached. In the feet-up position an over-compensatory dilatation is recorded. The hydrostatic moment of gravity is in the same direction in all the animals—rabbits, cats, dogs, monkeys. It is the dynamic moment that differs. The compensation with individual differences is incomplete in nearly all rabbits, cats and dogs, but in monkeys it is far more complete. There is, however, a striking difference in individual monkeys. The bonnet monkey of the present tracing over-compensated, while neither a Macacus Rhesus nor a Cercopithicus Callitrichus monkey compensated fully for either position. The question of compensation, as will be seen later, is affected by the anæsthetic, but these individual differences have been studied under the same uniformity of morphia narcosis.

Tracing 5. Fox-terrier. Splenic artery and splenic vein in axis. The cannula in the splenic vein was in connection with a fine-bored manometer filled with saturated $MgSO_4$ sol. This manometer was placed in connection with a delicate piston recorder. An elevation of 10 mm. of the lever of the piston recorder corresponded to a rise of 70 mm. of sat. $MgSO_4$ in the manometer.

A. Feet down. B. Horizontal.

On placing the animal feet downwards the pressure in the splenic artery scarcely varied, but the form and rate of the respiratory undulations were markedly different.

On the other hand the pressure in the splenic vein—that is to say the portal venous pressure—rose over 100 mm. $MgSO_4$ sol., while the respiratory undulations became very marked. At the moment of turning the animal with the feet down a slight rise was observable in the splenic artery and a slight rise in the splenic vein. I found that on placing the animal with the feet up a slight fall occurred in the splenic artery and



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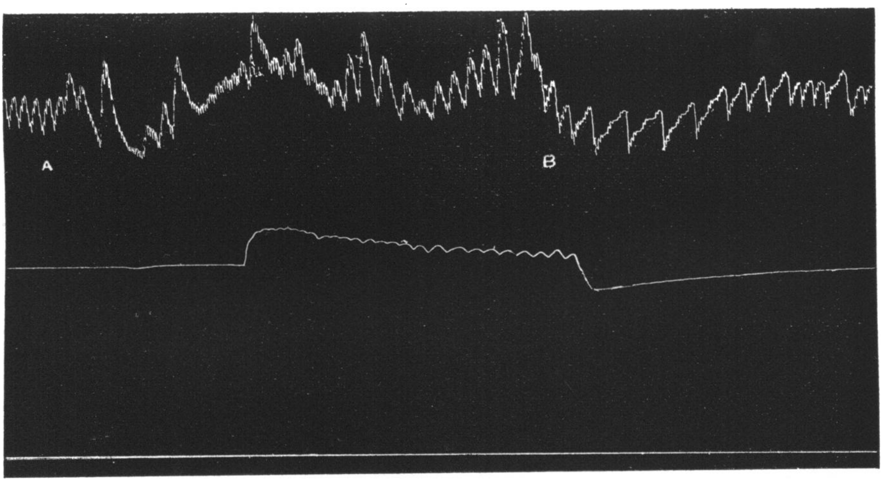
a slight rise in the splenic vein. The large rise of portal pressure in the feet-down position to be seen in the tracing, is as will be noticed later, caused by the determination of blood to the veins of the splanchnic area. In consequence of this there should be a fall on the arterial side, but under the influence of gravity the compensatory constriction in the arterioles of the splanchnic area prevented a more marked fall of pressure from being shown in the splenic artery.

Tracing 6. Fox-terrier. Femoral artery and femoral vein in axis. The pressure was recorded in the central end of the femoral vein, the valves having been destroyed by passing a stylet up into the vena cava. The vein was connected with the $MgSO_4$ manometer, and this itself was in connection with a delicate air tambour.

A. Feet down. B. Horizontal.

Upon placing the dog with the feet down, a rise in arterial pressure took place and there was also a marked change in the character of the respiratory undulations. The rise in the femoral vein trace did not take place *synchronously* with that in the artery owing to the vein having chinked whilst the change in the position was being made. The rise in the vein was equal to 200 mm. of $MgSO_4$ sat. sol.

On turning the animal's feet upwards the reverse effect was given and the venous pressure became negative.



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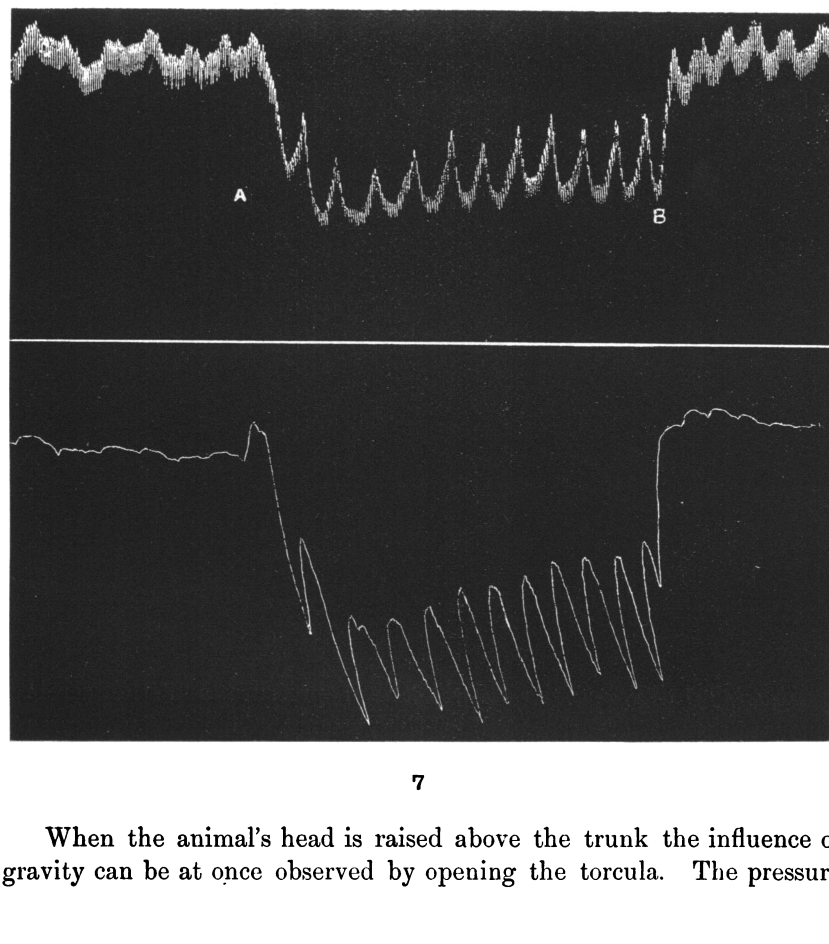
Tracing 7. Fox-terrier. The carotid pressure and the cerebral venous pressure are recorded in this tracing. The venous pressure was taken in the torcula Herophili by the method described by me in *Pr. Roy. Soc.* Vol. 55. A hole having been drilled into the torcula, the cannula was screwed in and connected with the venous manometer and the manometer with the piston recorder. The axis passed near the torcula so that a correction is necessary for the carotid, the recorded fall of pressure being slightly too little.

A. Feet down. B. Horizontal.

On turning the animal with the feet down the cerebral venous pressure fell more than 100 mm. of sat. Mg_4SO sol. below the zero pressure. The respiratory undulations are shown to be extremely exaggerated on both curves. On placing the animal feet upwards the reverse result was given. The effect on the cerebral venous pressure can be compared with the effect on intra-cranial pressure recorded in Tracing 3. Both methods give the same results. Intra-cranial pressure is always the same as the cerebral venous pressure.



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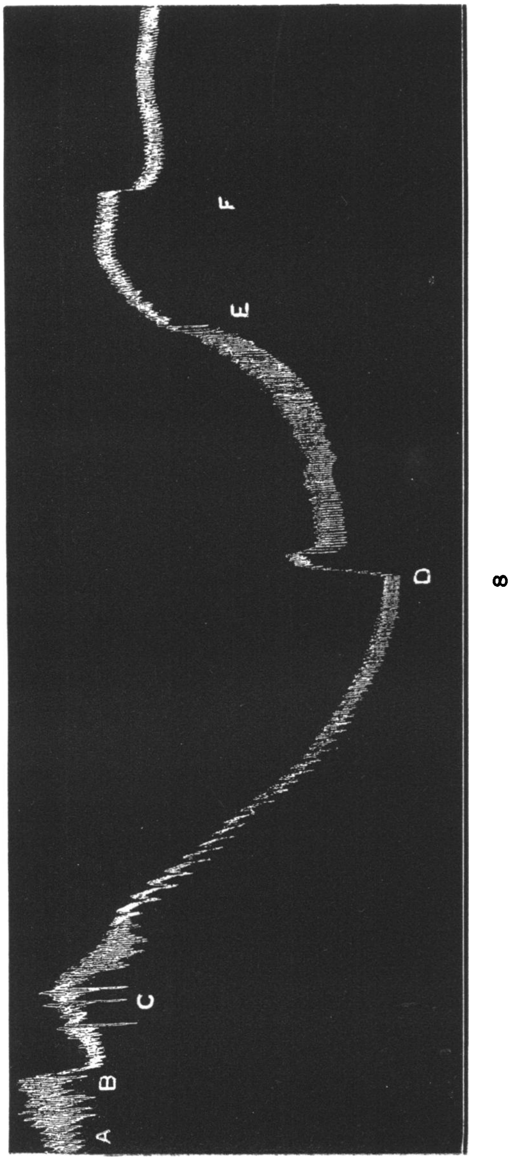
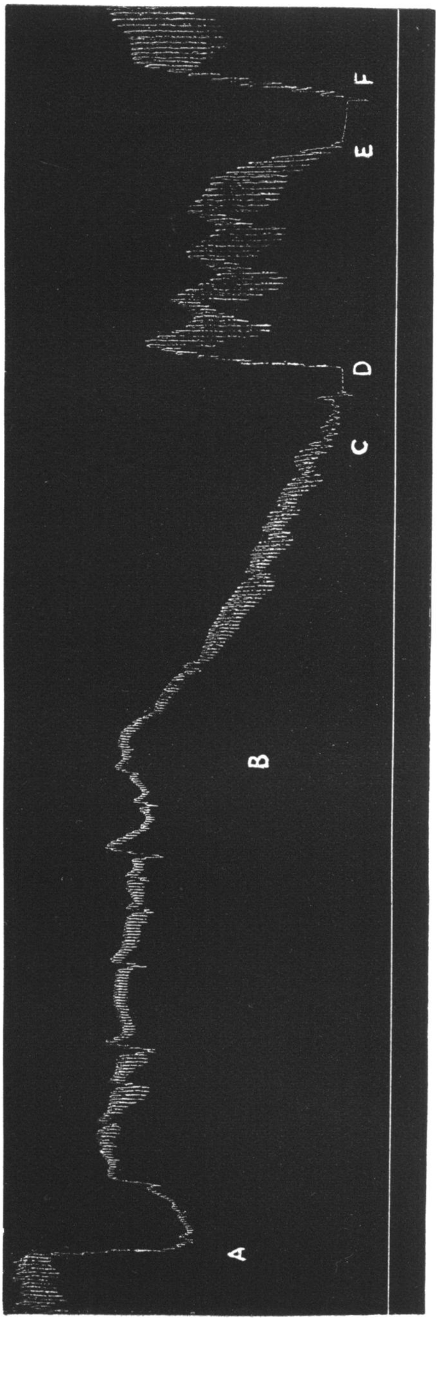
When the animal's head is raised above the trunk the influence of gravity can be at once observed by opening the torcula. The pressure is then negative and no blood flows out, but on depressing the head the blood at once begins to flow.

The reverse of these same phenomena can be observed in the central end of the femoral vein. No blood will flow from the cannula in the feet-up position, but when the animal is placed with feet down, the blood flows out freely.

From the above facts it is manifest that with the skull intact the circulation stagnates in the brain in the feet-down posture, and with the skull opened if the cerebral capillary blood pressure falls below that of a column of blood reaching from the heart to the brain, the capillaries will empty and the brain will collapse. This collapse of the brain can be experimentally observed by trephining the skull when the animal is in the feet-down position and the blood pressure is very low, and the same thing was noticeable in the patient of Dr Claye-Shaw; whenever this man stood upright, the scalp over the trephine hole was sucked in.



Tracing 8. Fox-terrier Anæsthetic, ether and chloroform in equal proportions. Carotid in axis.



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A. Moderate anæsthesia.
B. Feet down.
C. Anæsthetic pushed.
D. Feet up.
E. Anæsthesia still complete.
F. Horizontal.

The effect on the influence of gravity of pushing the anæsthetic is shown in this tracing. On placing the animal with feet down and putting it under moderate anæsthesia with a mixture of ether and chloroform the fall was slight. On rapidly pushing the anæsthesia the pressure ran down quickly towards the zero line. At the point D immediately after the withdrawal of the anæsthetic the animal was turned from feet down to feet up. The pressure rose considerably at once, and then more gradually till the animal still in a condition of deep anæsthesia was once more placed in the horizontal position. This tracing shows that the fall of pressure was due partly to vasomotor paralysis and partly to cardiac failure. The blood could be driven by gravity to the heart from the veins, but the heart could not pass it on to the arteries.

Tracing 9. Fox-terrier. Carotid in axis. Anæsthetic, Chloroform.

A. Feet down.
B. Chloroform pushed.
C. Chloroform removed.
D. Abdomen compressed.
E. Compression removed.
F. Feet up.

This tracing shows that the splanchnic area is the seat of the vaso-motor paralysis induced by the anæsthetic.

By firmly compressing the abdomen at a time when the pressure was rapidly sinking to zero, recovery was brought about. The pressure fell again immediately on removing the compression from the abdomen, to be once more restored by the feet-up position. It is noticeable however that the feet-up position did not restore the pressure to a higher level than that which was maintained in the feet-down position before the anæsthesia was pushed. This is due to the weakened action of the heart.

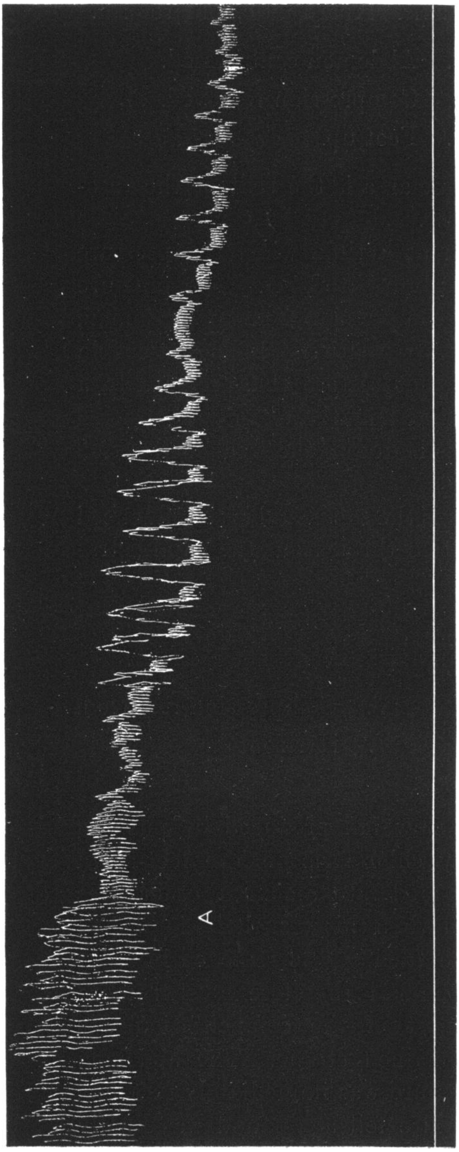
The effect of chloroform on monkeys is the same, and is uninfluenced by the maintenance of artificial respiration throughout the administration of the anæsthetic.

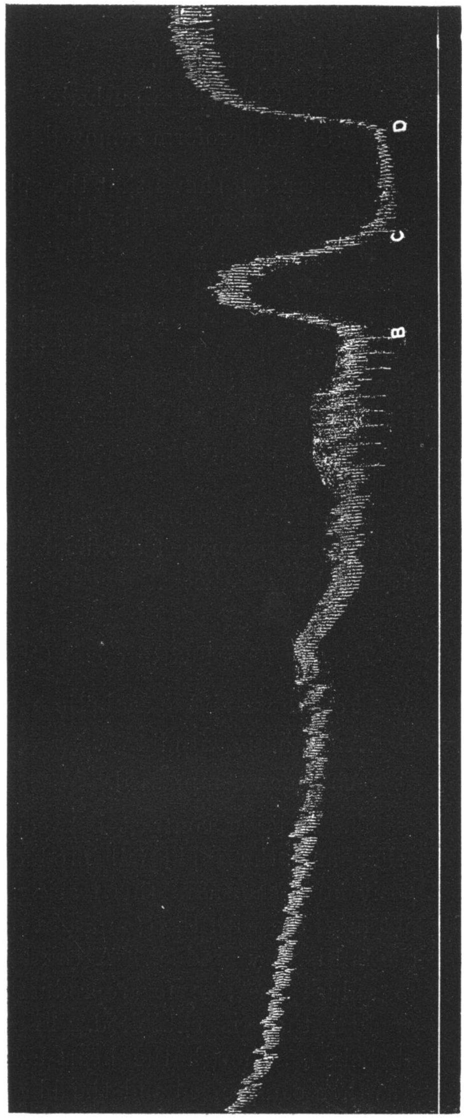
Tracing 10. Fox-terrier. Carotid in axis. Anæsthetic, Ether.

A. Feet down and anæsthetic pushed.
B. Anæsthetic withdrawn.
C. Abdomen compressed.
E. Compression removed.
F. Horizontal.

The striking contrast between the slow fall produced by pushing ether and the rapid fall produced by chloroform in the feet-down position is shown in this tracing. In moderate amounts, ether does not interfere with the compensation, and when this anæsthetic is pushed the fall is very gradual. A third of the tracing was removed in order to reduce the size for reproduction, the fall therefore is still more gradual than is exhibited. Finally most of the compensation was abolished, although the heart-beats remained strong. The abdomen was then compressed and the blood pressure was immediately restored. On removing the compression the pressure fell again, and was finally restored by placing the animal in the horizontal position.

Both ether and chloroform when pushed damage the compensation for some time after these anæsthetics have been removed.





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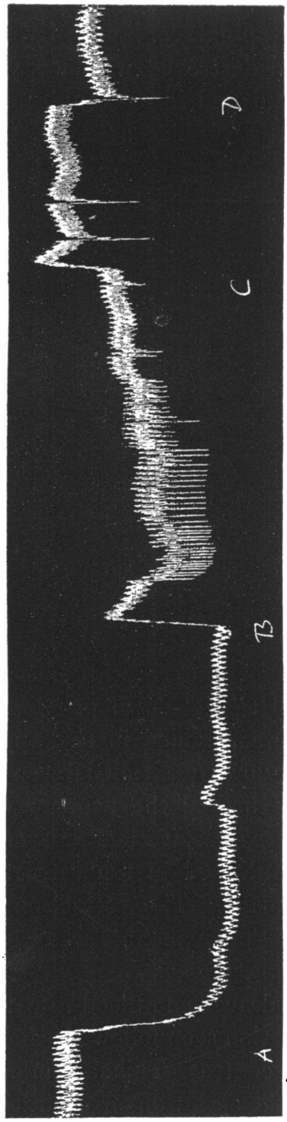
Tracings 11 and 12. Cat. Anæsthetic: Ether and chloroform (in equal proportions).

A. Feet down. C. Feet up.
B. Horizontal. D. Horizontal.

These tracings show the effect of the feet-down and feet-up positions before and after the division of the vagi. The animal was moderately anæsthetised.



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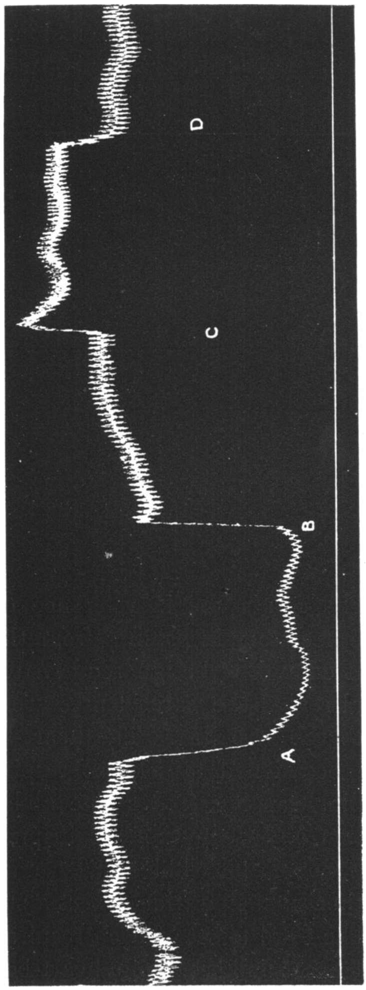

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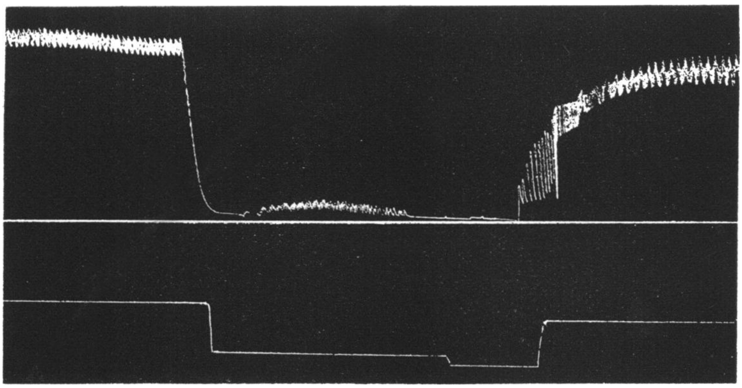
In Tracing 11 cardiac inhibition is seen to occur on rapidly returning the animal from the feet-down to the horizontal position, and again on placing the animal in the feet-up posture.

In Tracing 12 it is shown that this inhibition was abolished after the vagi were divided, and now when the animal was placed in the feet-up position cardiac acceleration followed.

Tracings 13 and 14. Fox-terrier. The spinal cord was divided between the 6th and 7th dorsal vertebræ and destroyed with a stylet as far as the 3rd dorsal vertebra. The carotid and intra-cranial pressures are recorded. The axis passed close to the trephine hole.



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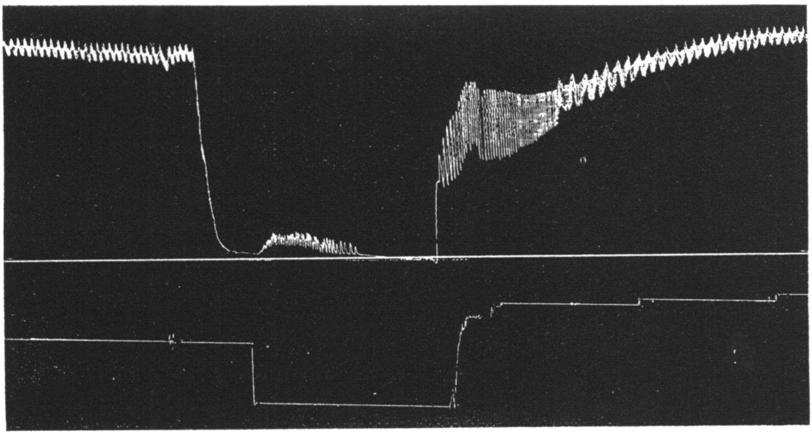
The correction, in reference to the axis, for the carotid pressure made necessary in passing from the horizontal to feet-down position is slight enough to be ignored. After the cord was divided in the upper dorsal region the carotid pressure in the feet-down position is seen to fall to the zero line. The heart-beats which succeed the primary fall were occasioned by violent respirations. These respirations are of a peculiar gasping type. The abdomen is maintained in the retracted position and deep thoracic inspirations are made. The retraction of the abdomen forces blood up from the veins of the splanchnic area while the thoracic inspirations exert a suction action.

The total effect of each respiration was to draw some blood into the right heart and occasion a heart-beat. Exhaustion soon followed, caused no doubt by the anæmia of the respiratory centre. This anæmia is shown by the fall in intra-cranial pressure, by the cessation of respiration and of the heart-beats, and by the apparent death of the animal. If, in such an experiment, the thorax is opened and the heart observed, the right side of the heart is seen to completely empty when the animal is placed in the feet-down position, but it continues to rhythmically contract.

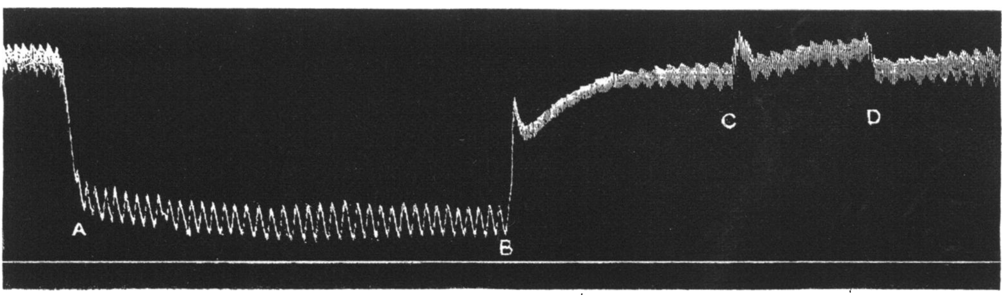
On turning the animal to the horizontal position the heart is seen to fill again immediately. The instantaneous recovery brought about by the horizontal position is shown in Tracing 13 and still better by the feet-up position in Tracing 14. The blood is actually shot out of the vena cava and from the veins of the splanchnic area into the heart.



14

From the tracings of the vena cava and the splenic vein it is clear that the blood passes into the veins of the abdomen, and this is also shown in the tracings which have been obtained with the femoral in axis after division of the spinal cord, and by the effect of bandaging the abdomen.

Tracings 15, 16 and 17. Fox-terrier. These tracings are obtained from the same animal as are Tracings 1 and 2, with which they should be compared. The spinal cord was divided at the 6th dorsal vertebra

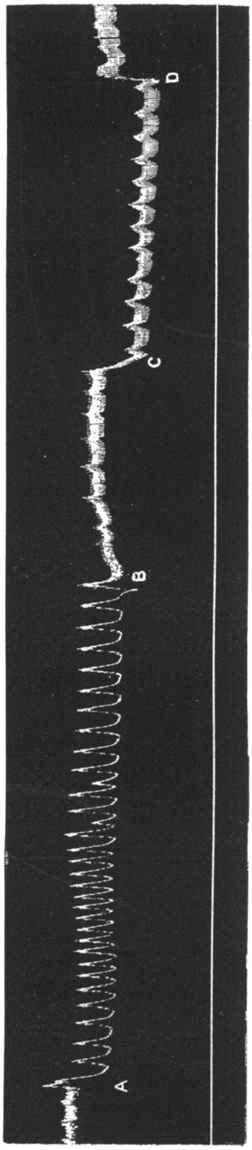


15

and the cord was destroyed with a stylet as far as the 3rd dorsal vertebra.

Tracing 15. Carotid in axis.

A. Feet down. C. Feet up.
B. Horizontal. D. Horizontal.



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The fall of pressure which followed upon turning the animal feet downwards was not so great as shown in Tracing 14, but the effect of the peculiar type of respiration is well seen. If this tracing is compared with Tracing 1, the effect of the division of the cord in abolishing the compensation will at once be seen and the danger of taking the vertical feet-down position in such a condition must be easily recognized.

Tracing 16. Femoral in axis.

A. Feet down. C. Feet up.
B. Horizontal. D. Horizontal.

On turning to the femoral trace and comparing it with Tracing 2 it will be seen that the hydrostatic moment except for a momentary rise is apparently abolished, and that pressure falls in the feet-down position. In both the Tracings 15 and 16, the feet-up effect, on the other hand, is practically the same as in Tracings 1 and 2. The fall of pressure, after the section of the cord is made, which occurs through the blood passing into the abdominal veins is so great as to obscure the manifestation of the hydrostatic moment in the femoral trace. That the hydrostatic moment is still present is at once seen by measuring the level of the carotid and femoral tracings respectively above the zero line. On calculating the difference between the two levels I found that it was equal to a pressure of about

406 mm. of blood, and upon measuring the length of the dog from the carotid to the femoral cannula I found it to be roughly 405 mm.

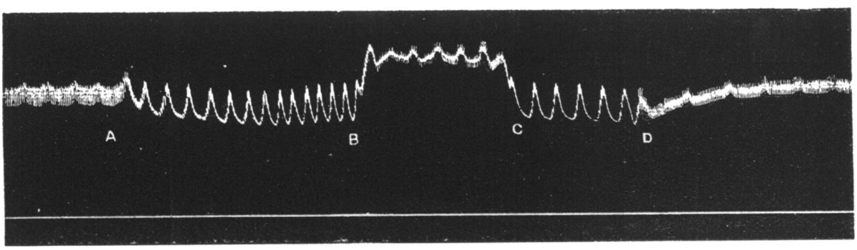
The difference between the tracings 1 and 2 and 15 and 16 lies in the fact that when the latter two were taken the splanchnic flood-gates had been thrown open.

Tracing 17. Femoral in axis.

A. Feet down.
B. One hand firmly placed on abdomen.
C. Hand removed.
D. Horizontal.

The effect of squeezing the abdomen with the hand or of firmly bandaging it shows still better where the blood lies. By placing one hand firmly upon the abdomen the femoral trace at B is converted from the condition of Tracing 16 into the condition shown in Tracing 2.

By a simple mechanical means the compensation has been perfectly restored. Immediately that the hand is withdrawn the pressure again falls to the old level.



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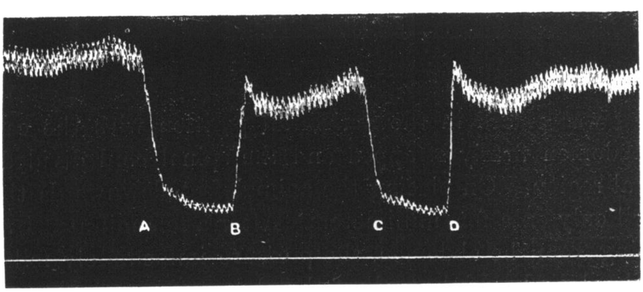
Tracing 18. Cat. Anæsthesia moderate. Ether and chloroform in equal proportions. Carotid in axis.



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A. Feet down.
B. Broad bandage drawn round abdomen.
C. Bandage removed.
D. Horizontal.

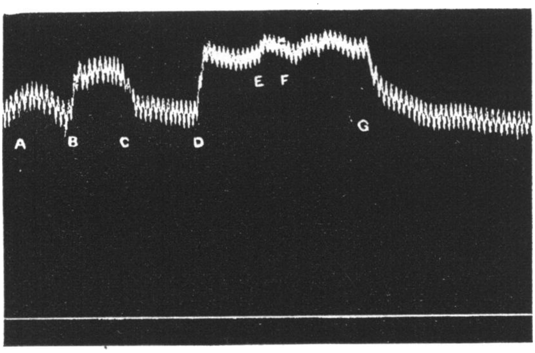
This tracing still better exhibits the effect of bandaging the abdomen. In the normal condition the animal had little power of compensation; this could however be artificially supplied to it, for as long as the bandage was maintained the pressure remained normal. It is possible by firmly strapping to drive the pressure up beyond what is even the normal level in the horizontal position.

Tracing 19. From the same Cat.

A. Horizontal.
B. Abdomen bandaged.
C. Bandage removed.
D. Feet up.
E. Abdomen bandaged.
F. Bandage removed.
G. Horizontal.

In this tracing is shown the slight effect of bandaging the abdomen in the horizontal position and the insignificant effect in the feet-up position in contrast to the enormous effect in the feet-down position.

In another experiment I determined the effect of bandaging the abdomen in a still more significant way.



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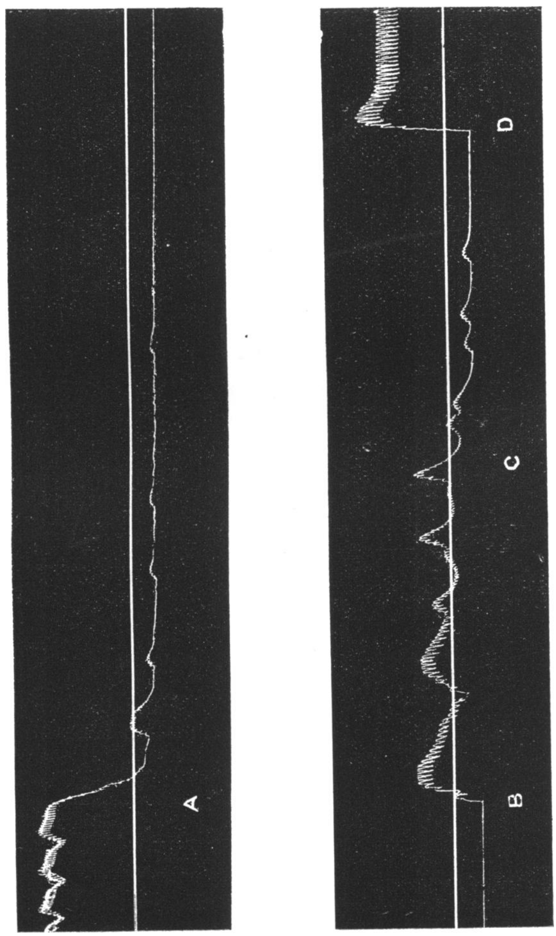
The dog was placed in the horizontal position with the carotid in axis, the abdomen firmly strapped and the spinal cord divided in the upper dorsal region. On placing the animal feet downwards the blood pressure fell only on a few millimeters. After a few minutes I removed the strapping from the abdomen, the pressure immediately fell to zero and the animal died. If the wall of the abdomen is very freely divided by a crucial incision when the animal is in the feet-down position, the blood pressure will fall largely in consequence of the withdrawal of mechanical support from the splanchnic vessels.

I was interested in finding an observation recorded by Stephen Hales[12] in his classical researches on blood pressure—"When the blood had subsided a little in the tubes which were fixed to the arteries of these dogs, it would, as in the horses, rise on a sudden considerably on deep sighing, as also on pressing the dogs' bellies hard with the hand the blood would immediately rise about six inches and subside as much on taking off the hand, and it was the same on several repetitions."

Roy and Adami[13] found that compression of the abdomen increased the quantity of blood thrown out by the heart, to the extent of 29·6 p.c. (or even more) during the period of compression.



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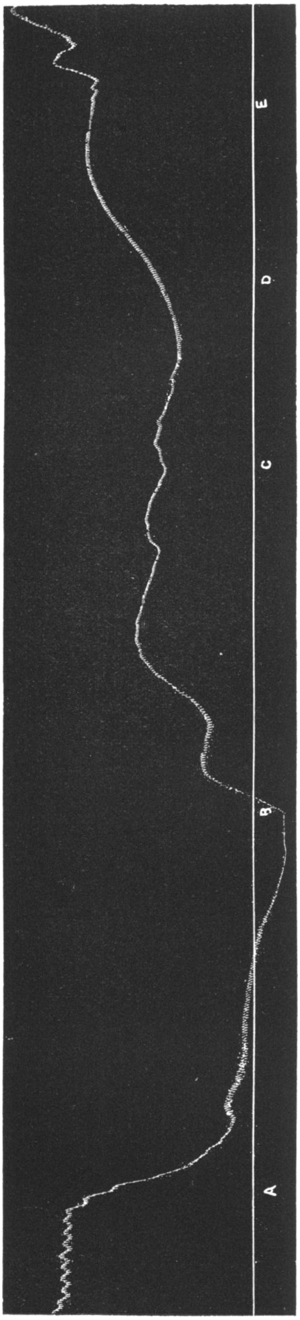


21

Tracing 20. Fox-terrier. Spinal cord divided at the level of the 6th dorsal vertebra and destroyed up to the 3rd dorsal vertebra with a stylet.

A. Feet down.
B. Lower segment of cord excited.
C. Excitation removed.
D. Horizontal.

In this tracing is seen the effect of stimulating the lower segment of the spinal cord after it had been divided.

On turning the animal feet downwards the pressure fell below the zero line in the horizontal position to the zero line in the feet-down position. A few of the peculiar respiratory gasps followed, the effect of which is shown on the trace.

At B the cord was excited with a weak interrupted current, the blood pressure immediately rose and respiration again began. At C the excitation ceased, and after a few more respiratory gasps, the pressure again fell to zero.

At D the animal was once more placed in the horizontal position and immediate recovery followed.

Tracing 21. Fox-terrier. Carotid in axis. Vagi divided. Left splanchnic divided. Thorax opened. Artificial respiration.

A. Feet down.
B. Left splanchnic excited.
C. Excitation removed.
D. Excitation on.
E. Excitation off.

After any severe operative procedure the effect of the feet-down position is always markedly increased.

This tracing shows the result of the division of one splanchnic nerve and of the operative procedures necessary for exposing both splanchnics. The nerves were found by resecting the last rib and opening the thorax.

On placing the animal feet downwards the pressure fell to zero. At the same time the tube for artificial respiration chinked owing to the change of position.

At B is shown the effect of exciting the peripheral end of the left splanchnic and immediately after an asphyxial rise of pressure took place, so that the pressure did not fall at C when the excitation was cut off.

At D the splanchnic was again excited and with the help of the increasing asphyxial rise the pressure was finally driven up above its level in the horizontal position seen at the beginning of the experiment.

In conditions uncomplicated by asphyxia, stimulation of the splanchnic gives a rise in pressure which is followed by an immediate fall when the excitation is removed.

I have found in monkeys that the fall of pressure is less severe after the spinal cord was divided, but otherwise the results given are exactly the same. The splanchnic flood-gates cannot be opened so widely in the monkey and the effect of gravity is therefore less dangerous.

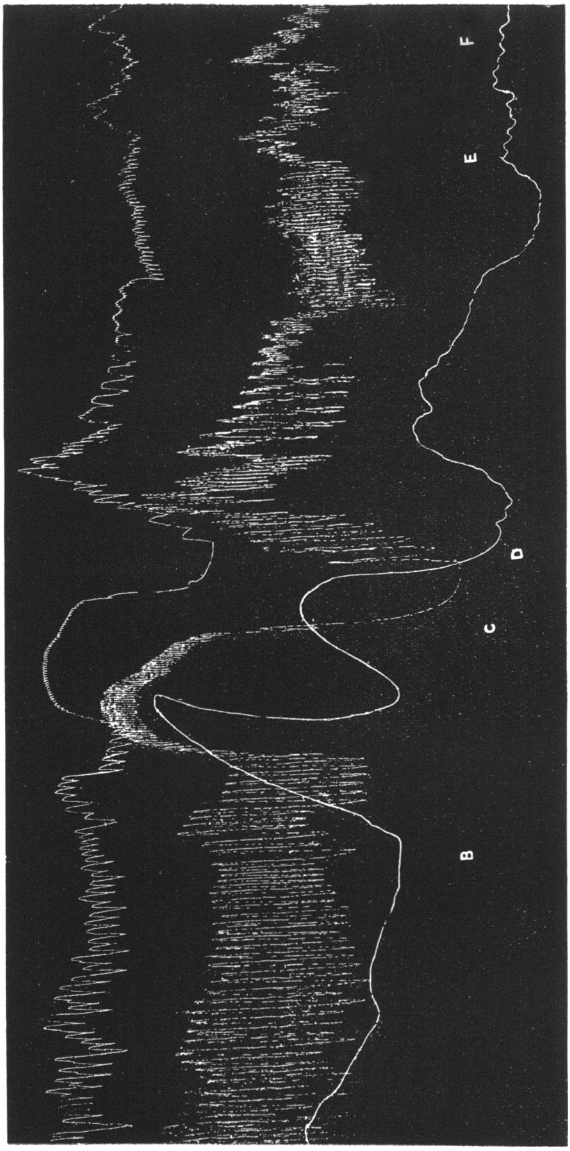
Tracing 22. Large mongrel Terrier. Curari in addition to morphia.

B. Abdomen bandaged. E. Abdomen bandaged.
C. Bandage removed. F. Bandage removed.
D. Respiration renewed.

In this tracing is shown the effect of bandaging the abdomen in asphyxia. The uppermost trace is that of the peripheral end of the carotid, the middle trace is that of the central end of the carotid, and the lower trace is that of the cerebral venous pressure taken in the torcula Herophili.

The bandage was applied at the point when the pressure was just beginning to fall, and the result was an immediate rise of pressure and great acceleration of the heart produced by the sudden access of a large quantity of blood. This was followed by sudden failure of the heart and the fall of the blood pressure to zero. On supplying it with artificial respiration the animal rapidly recovered and the effect of rebandaging the abdomen after recovery is seen to be very slight.

This tracing shows the danger of throwing too much work on the heart when in an impoverished state, and points to the protective nature of the vaso-motor paralysis in the splanchnic area.



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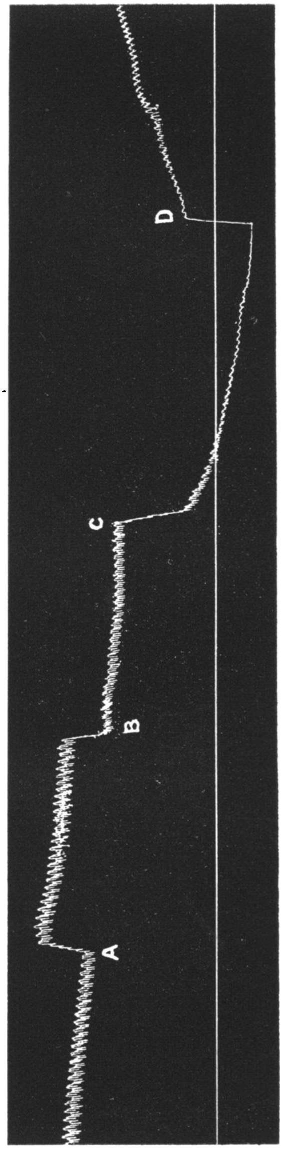

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Tracing 23. Fox-terrier. Carotid in axis. Vagi divided. Artificial respiration. Curari in addition to morphia.

A. Feet up. C. Feet down.
B. Horizontal. D. Horizontal.

This tracing exhibits the vaso-motor paralysis produced by a large dose of curari.

Compensation is abolished; on placing the animal feet downwards the pressure is seen to fall to the feet-down zero line. On returning the animal to the horizontal position recovery takes place at once.

Effect on the Respiration.

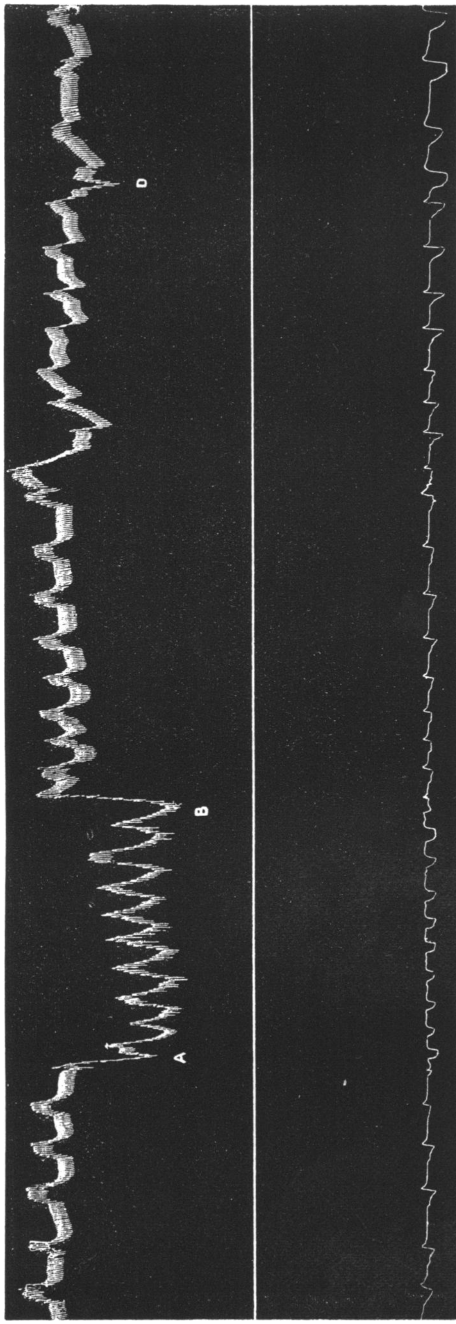
Tracings 24 and 25. Fox-terrier. Carotid in axis.

Tracing 24.

A. Feet up.
B. Horizontal.
C. Feet down.
D. Horizontal.

This tracing shows the usual effect on the respiration of altering the position of the animal. The feet-up position accelerates respiration, and the feet-down position inhibits it.

The respiratory record was taken by means of a broad band of strapping passed round the thorax and attached to a Paul Bert tambour. This tambour was connected with a Marey's tambour. It was impossible to employ



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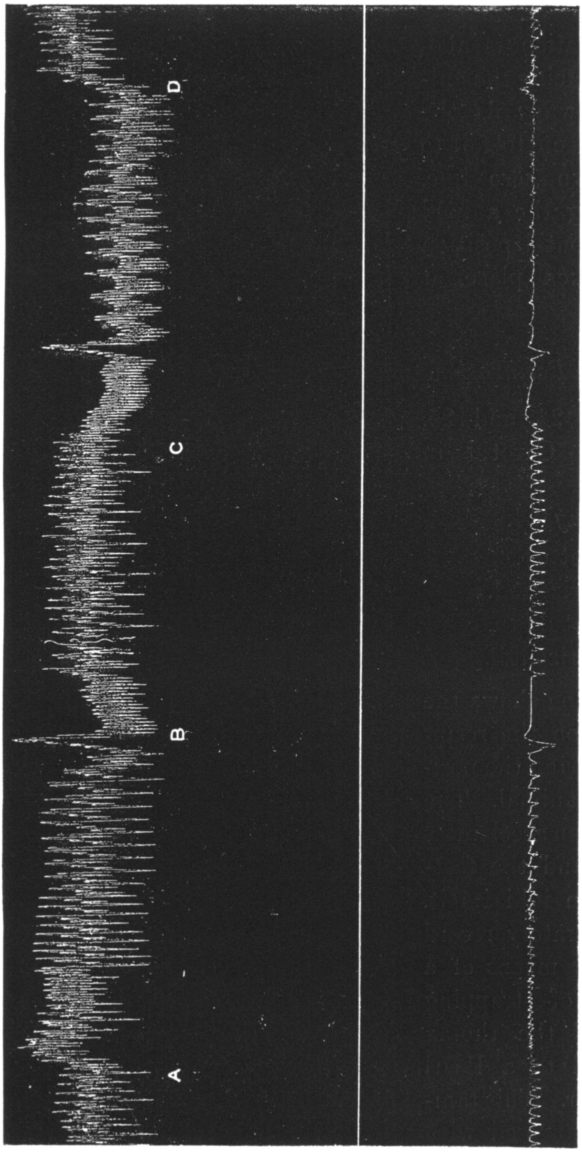
any more accurate method of recording the respiratory movements owing to the alterations of the animal's position. On observing the animal, the respiration was seen to be of the diaphragmatic type in



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the feet-up position and of the thoracic type in the feet-down position. The difference in type becomes very marked in conditions where there is a large fall of blood pressure in the feet-down position, as after division of the spinal cord. The marked alteration of the respiratory undulations has been already seen in many of the blood pressure tracings.

The animals maintain a retraction of the abdomen and aspirate blood into the heart by deep thoracic inspirations. Dividing the vagi abolishes the inhibitory or accelerating effect produced by the alterations of position, but it does not alter the types of respiration.

Tracing 25.

A. Feet down.	C. Feet up.
B. Horizontal.	D. Horizontal.

In this tracing is shown the effect in the same animal of dividing the vagi. Respiration is now accelerated by the feet-down position.

The influence of the changes of position on the respiration had previously been observed by Blumberg and Wagner.

Conclusions.

There is little difficulty in interpreting these experiments and in drawing the following conclusions from them. (1) That the force of gravity must be regarded as a cardinal factor in dealing with the circulation of the blood; (2) that the important duty of compensating for the simple hydrostatic effects of gravity in changes of position must be ascribed to the splanchnic vaso-motor mechanism; (3) that the effects of changing the position afford a most delicate test of the condition of the vaso-motor mechanism; (4) that the amount of compensation depends largely on individual differences; (5) that the compensation is far more complete in upright animals, such as the monkey, than in rabbits, cats, or dogs, and, therefore, is probably far more complete in man; (6) that in some normal monkeys over-compensation for the hydrostatic effect occurs; (7) that in the normal monkey and man gravity exerts but little disturbing influence owing to the perfection of the compensatory mechanism; (8) that when the power of compensation is damaged by paralysis of the splanchnic vaso-constrictors, induced by severe operative procedures or by injuries to the spinal cord, by asphyxia, or by some poison such as chloroform or curare, then the influence of gravity becomes of vital importance; (9) that the feet-down position is of far greater moment than the feet-up position, because when the power of compensation is destroyed the blood drains into the abdominal veins, the heart empties, and the cerebral circulation ceases; (10) that, generally speaking, the feet-up position occasions no ill consequence; (11) that the horizontal and feet-up positions at once abolish the syncope induced by the feet-down position by causing the force of gravity to act in the same sense as the heart, and thus the cerebral circulation is renewed; (12) that firmly bandaging the abdomen has the same effect (while the heart remains normal, and so long as the mechanical pressure is applied to the abdominal veins, the pressure cannot possibly fall); (13) that if the heart is affected, as by chloroform or curare poisoning, the restoration of pressure is incomplete, and it is possible that the heart may be stopped altogether by the inrush of a large quantity of blood, caused by too rapid an application of pressure on the abdomen (more work would be thrown upon the heart than in its impoverished condition it could perform); (14) that vagus inhibition and cardiac acceleration are subsidiary compensatory mechanisms in the feet-up and feet-down positions respectively; (15) that chloroform rapidly paralyses the compensatory vaso-motor mechanism and damages the heart; (16) that ether, on the other hand, only paralyses the compensatory vaso-motor mechanism very slowly and when pushed in enormous amounts; (17) that the vaso-motor paralysis induced by these anæsthetics lasts for some considerable time after the removal of the anæsthetics; (18) that chloroform can, by destroying the compensation for gravity, kill the animal if it be placed with the abdomen on a lower level than the heart; (19) that elevation or compression of the abdomen immediately compensates for the vaso-motor paralysis produced by chloroform; (20) that compression or elevation of the abdomen, coupled with artificial respiration and with squeezing of the heart through the thoracic walls, is the best means of restoring an animal from the condition of chloroform collapse; all these results agree entirely with McWilliams', and are opposed to those of the Hyderabad Commission. (21) that the feet-down position inhibits respiration, and the feet-up position accelerates it; (22) that these respiratory results probably depend upon the stimulation of sensory nerve endings by changes of tension brought about by the alterations of position, because the results are abolished by dividing the vagi; (23) that in the feet-down position the respiration is thoracic in type, and the abdomen is retracted; in the feet-up position the respiration is diaphragmatic and the abdomen freely expanded; (24) that these types of respiration tend to compensate for the effects of gravity on the circulation, for the retraction of the abdomen in the feet-down position mechanically supports the abdominal veins, whilst the thoracic inspirations aspirate blood into the heart. In the feet-up position the full and free expansion of the abdomen withdraws all obstacles to the compensatory dilatation of the abdominal veins.

PRACTICAL APPLICATION TO MEDICINE AND SURGERY.

The great importance of the position of the body in the methods of treatment employed in medicine and surgery is confirmed by these experiments. They above all point to the necessity in cases of syncope, shock, hæmorrhage and chloroform poisoning, of maintaining the cerebral circulation and filling the heart by elevating or strapping the abdomen.

Syncope. That the influence of gravity is brought to bear on the ordinary emotional syncope is clear from the success of the usual treatment of lowering the patient's head between the knees. Syncope is commonly regarded as being due to a cessation of the action of the heart. It is however well known that in numberless cases of syncope the heart does not cease to beat, but continues to pulsate rapidly and very feebly, although no sign of the radial pulse can be felt.

In Quain's *Dict. of Med.* 1894, it is stated that "Syncope consists essentially in sudden failure of the action of the heart." Now, no nerve is known which can produce such an effect except the vagus nerve, and we have not the slightest ground for assigning this action to that nerve.

Foster[14] speaks of this phenomenon as being produced by natural vagus stimulations differing altogether from our coarse electrical stimulations. But the vagus inhibition which occurs in the feet-down position and in asphyxia, both of which are 'natural' stimulations, exactly resembles the inhibition produced by our coils and batteries. There is therefore no evidence that the condition of the heart in syncope is produced by vagus excitation.

In the *Reference Handbook of the Med. Sciences,* New York, 1888, the view is put forward that "in most instances fainting must be regarded as an influence of emotions upon the centres of the vaso-constrictor nerves of the cerebral hemispheres." This theory cannot be supported, for it has hitherto been impossible to determine the existence of any cerebral vaso-constrictor nerves, and we may rest assured that even if these nerves do exist they are quite insignificant in their action.

The symptoms of syncope are exactly similar to those conditions observed in an animal placed feet downwards with the power of compensation destroyed by the production of vaso-motor paralysis. The empty heart continues to beat rapidly and feebly but the pulse cannot be felt, the cerebral circulation ceases and hence consciousness is abolished. A deep sigh is the first obvious sign of an improvement. A sigh is a deep thoracic respiration with retraction of the abdomen. The compensatory effect produced by such a respiration is observable in many of the tracings. The animal or the patient in the condition of syncope is immediately restored on being placed in the horizontal or feet-up posture.

It therefore seems legitimate to suggest that ordinary emotional syncope is produced by sudden and temporary inhibition of the vaso-motor centre caused by some painful and powerful sensory stimulation. Asthenic individuals with the least power of compensation would be most prone to syncope. The evolutionary etiology of syncope, if I may enter so far on the path of speculation, possibly lies in the fact that danger is avoided by the sudden fall into the horizontal position and the simulation of death. This theory of syncope can be easily tested on patients by the results obtained on firmly pressing or strapping the abdomen. The customary practice of placing the patient's head down between the knees to remove faintness points to the truth of this view, and it is interesting to note that patients who faint while in the sitting posture frequently fall forward with the arms folded against the abdomen so that the weight of the trunk is supported by the knees and the arms are pressed against the abdomen.

Dr T. Sayer has put the views suggested by me as regards syncope to a practical test. He was treating a patient for an ulcer on the finger, when the man suddenly became faint with sickness and noises in the head. On feeling the radial artery Dr Sayer found the patient to be almost pulseless, he then applied firm pressure to the abdomen, the pulse immediately strengthened and the sickness and noises disappeared. When the compression was withdrawn all the symptoms immediately returned, to be once again abolished by a fresh application of pressure.

The power of compensation is probably largely affected by the habits of the individual animals. Gerdy pointed out that vine-dressers become for instance able to work all the day in a bending position with the head down.

Salathé suggested that patients who have lain long in bed lose the power of adapting themselves to change of position and become like quadrupeds and hence the faintness, dizziness and danger of syncope which occur during convalescence when the patient first rises from bed.

Dr George Oliver[15] has investigated the effects of position on the diameter of the radial artery in man, by means of his most ingenious instrument, the Arteriometer. Many of his results obtained by an entirely independent method agree exactly with the results obtained by me on monkeys. Dr Oliver writes—"In many cases of apparent increase of the calibre in recumbency, the artery enlarges just as the patient assumes this posture, but in a minute or so settles down to a lower point—either uniform with or below that of the sitting posture." This is exactly the effect I have obtained in normal monkeys in good condition, the first effect (hydrostatic) of turning the animals from the feet-down position to the horizontal is a rise of blood pressure, the second effect (dynamic) is over-compensation, producing a slight and maintained fall.

Again Dr Oliver writes—"The first form of variation characterized by the minimum calibre as it is found in recumbency is that which is commonly followed in vigorous subjects of both sexes; and the second in which the recumbent is the maximum calibre, is apparent for variable periods during the digestion of a full meal, after a certain amount of muscular effort, and generally when the body is tired as the result of labour and exercise, or is below par." "When asthenia was the predominant clinical condition, the radial calibre in the standing posture was often remarkably reduced." This second condition is exactly the same as the result obtained by me in the monkey weakened by operative procedures, anæsthetics, etc.

The first day after I returned to the laboratory after a severe attack of influenza Dr Oliver found the diameter of my radial artery to be 1·6 mm. sitting and 1·9 mm. recumbent. One week later the diameter was 1·9 sitting and 1·55 recumbent, and I had completely recovered my compensatory power, and had lost all feeling of faintness on rapidly changing my position.

On the first day compensation was supplied to me by compression of my abdomen, and the diameter of my radial was driven up from 1·6 mm. to 1·9 mm. (sitting) by this means.

I believe that the arteriometer will afford an accurate method of testing from day to day the power of compensation in changes of position, and therefore of the condition of the vaso-motor mechanism and the value of the lines of treatment pursued.

Shock. The significance of these experiments in regard to shock cannot be doubted. After death from shock or syncope the abdominal veins on post-mortem examination are commonly found to be engorged with blood. "The story told by the symptoms of shock is one of depression of all the vital functions associated with the evidence of a diminished circulation of blood in those portions of the periphery which we can examine during life. The integument is blanched and shrunken, the pulse is thready or imperceptible, the veins are collapsed, and open wounds unless involving large arterial trunks bleed slightly or cease to bleed[16]."

These symptoms are exactly exhibited by an animal which after the production of vaso-motor paralysis in the splanchnic area is placed feet downwards. Since Goltz's experiments of paralyzing the splanchnic vessels in the frog by sharply striking the abdomen, splanchnic paralysis has been the commonly received explanation of the pathology of shock. Many of the after-effects of shock can be associated with the consequent cerebral anæmia. In a case of shock after operation when the patient remained in a befogged mental condition, Dr Oliver found that the radial diameter was half what it became when the patient recovered.

In the animals experimented upon by me, the severer the operative procedures undergone, especially when the abdominal viscera are implicated, the less perfect has been found the compensation. If the cause of shock is to be found in vaso-motor paralysis of the splanchnic area, with the consequent advancing cerebral anæmia, the symptoms can, in all probability, be at once removed, as is found in animals, by firmly strapping the abdomen.

It seems possible therefore that bandaging or elevating the abdomen may be a treatment of some value in cases of shock and especially where an operation is urgently required.

Hæmorrhage. The influence of position after severe hæmorrhage was long ago experimentally proved by Marshall Hall[2]. From the present research it seems evident that it is the abdomen that must be elevated and bandaged; this treatment applied to the limbs only as is the usual practice can be of far less value. Neither can the injection of normal saline be of much benefit, for as long as the splanchnic flood-gates be open wide the salt solution will simply collect in the all-devouring abdominal veins. The rapidity with which normal saline, without causing more than a very small and only temporary rise of the arterial pressure, can be driven into the circulation is a fact well known[17]. The injection of saline on the other hand causes a marked and far more permanent rise in venous pressure.

Chloroform. That the danger of administrating chloroform is increased in the vertical position or with the head raised above the trunk is obvious from the results recorded in this paper. It is possible that death may result from vaso-motor paralysis although the empty heart is continuing to beat. This result is entirely opposed to the evidence of the Hyderabad Commission.

The influence of abdominal compression in immediately removing the effect of the vaso-motor paralysis has been made manifest, and this is in complete agreement with some earlier observations of MacWilliam[18]. Vomiting is regarded by anæsthetists as a sign of improvement in chloroform collapse and the act of vomiting compresses the abdomen.

It is important to remember that the vaso-motor paralysis continues for some little time after the removal of the anæsthetic, and hence on this ground and also by reason of the shock after operation, it is indicated that the patient's abdomen should be elevated or compressed. The causes of death from chloroform are undoubtedly as MacWilliam has said three in number, (1) respiratory failure, (2) vaso-motor paralysis, (3) dilatation of the heart from poisoning of the cardiac muscle.

The first and second causes of danger can be immediately abolished by artificial respiration and abdominal compression, the third cause is almost always irremediable.

In one or two cases I have been able to remove the dilatation of the heart by rhythmically compressing it and thus artificially renewing the blood supply to the poisoned cardiac muscle. At the same time artificial respiration must be maintained; the abdomen on the other hand must not be forcibly compressed, because the heart is in a state of dilatation and paralysis, which state would only be increased by forcing a large quantity of venous blood into the heart.

MacWilliam has also succeeded in overcoming the dilatation of the heart in the same way. All my results as regards chloroform are in the closest agreement with those of MacWilliam.

Trephining. In the light of these experiments the existence of an open trephine hole or the removal of large pieces of the cranium must be seen to have a most important effect on the cerebral circulation. As long as the skull is closed the cerebral vessels cannot empty under the influence of the hydrostatic moment even if the compensation be weakened or abolished—that is unless cerebro-spinal fluid be secreted into the intra-cranial cavity to a corresponding amount, and this is negatived by some few experiments which I have carried out on the subject. So soon however as the skull is opened and atmospheric pressure is brought to bear upon the brain, the cerebral capillaries will immediately collapse and the blood be withdrawn from the brain, whenever the cerebral capillary pressure falls below that of a column of blood, the height of which is measured from the heart to the brain.

This explains the rapid death which can be sometimes induced in animals by placing them feet downwards after trephining the skull, as Regnard and Salathé have found.

Heart Disease. The position selected by patients suffering from lung or heart disease can be explained, for it is manifest that the upright posture will afford the greatest relief by diminishing pulmonary congestion through the retention of a large quantity of blood in the splanchnic area.

In this connection Dr C. J. Bond[19] has experimentally shown that the supine position is less favourable to the patient than the prone position, owing to the chinking of the base of the heart and the venæ cavæ in the supine position, brought about by the weight of the heart itself.

Binders and Abdominal Belts. The common practice of wearing abdominal belts for weakness, and the application of binders after parturition, find a physiological explanation in the results of this research. Roy and Adami have suggested that the almost universal practice of wearing waist-belts and stays is due to the fact that compression of the abdomen increases the output of the heart and the blood supply to the brain and muscles.

As however I have shown that the normal monkey compensates perfectly for changes of position, and Dr George Oliver has by measurements with the arteriometer found the same thing in normal healthy men and women, the practice of tight-lacing cannot be supported on physiological grounds, and probably owes its origin far more to the instinct of sexual attraction.

Cases are occasionally recorded of patients some of whom lose their memory in the standing position, and regain it in recumbency; others can only do mental work when in the horizontal position, and others suddenly are at a loss for memory when attempting to address a public meeting.

The Rabelaisian effects of fear which are so commonly manifested by men before battles, examinations, public performances, etc., the vomiting, diarrhœa and involuntary micturition, and the loss of memory more rarely met with, may all be associated with splanchnic paralysis and determination of blood to the abdomen. In such cases a tight abdominal belt might be of considerable service, as in any other condition in which the normal compensation for gravity is abolished.

REFERENCES.

1. Piorry. Arch. Gén. de Méd. 1826.
2. Marshall Hall. Med. Chir. Trans. 1832.
3. Basedow. Woch. f. d. ges. Heilk. Berlin, 1838.
4. Regnard. Rech. sur la congestion cérébrale th. d. Stras. 1868.
5. Salathé. Trav. du labor. de M. Marey. 1877.
6. Salathé. Trav. du labor. de M. Marey. 1876.
7. Brissaud and Franck. Trav. du labor. de M. Marey. 1877.
8. Schapiro. Jahrb. der Anat. u. Phys. 1881.
9. Zybulski. Medic. Woch. St Petersburg, 1878.
10. Friedmann. Med. Jahrb. d. ges. d. Aerzte. Wien.
11. Hermann, Blumberg and Wagner. Pflüger's Arch. Vol. XXXIX.
12. Stephen Hales. Statical Essays. Lond. 1733. Vol. II. p. 33.
13. Roy and Adami. "Waist Belts and Stays." National Review, Nov. 1888.
    Roy and Adami. B.M.J. Dec. 1888.
14. Foster. Text Book of Physiol. Vol. I. p. 345, 1888.
15. Oliver. Pulse Gauging. Lewis. Lond. 1895.
16. Quain's Dict. of Med. 1894.
17. Johanssen and Tigerstedt. Scand. Arch. f. Phys. 1889. p. 396.
    Bayliss and Starling. Journ. of Phys. April, 1894.
18. MacWilliam. B.M.J. 1892.
19. Bond. B.M.J. Dec. 1885.