was extreme, and the blue discolouration became darker. Then the blue tints became lighter and the red patches paler and less swollen, and the patient herself gradually improved. She took food and stimulants well, but in extenuation of this she remarked to me that she took them as a duty, not that she desired them much. For a week or more the progressive improvement in the patient's condition was so marked that her relatives began to buoy themselves up with the hope that she would recover from this disease as well as she did from the other, and her constitution was highly praised by some in consequence of being the cause of her improvement. Unfortunately the hopes of the hopeful were doomed soon to be blighted, for, on the twelfth day from the onset of the disease, diarrhoea, delirium, and collapse again set in, and the poor lady rapidly sank. "After death it was discovered that the blue colour had extended up the thigh behind, nearly as far as the buttock, but not so high in front.

The point of greatest interest in this case lies, I think, in the gangrene. I have not seen before so large a portion of a limb destroyed by that disease as was the case in this patient. No doubt her bloodvessels, like her heart, were more or less diseased, thus favouring the formation of thrombi and emboli. The first attack which the limb sustained was doubtless caused by an obstruction in the femoral vein at or near Poupert's ligament, and the second by an obstruction in the popliteal or lower part of the femoral artery; and when the general and local symptoms and the results of the venous obstruction and the arterial obstruction were respectively contrasted, hardly any two diseases could have been more dissimilar. The obstruction to the venous blood in its course to the heart and lungs, or in its return journey, caused the extremity to swell in all directions; nevertheless, the limb made a good and speedy recovery. Of course, if the venous obstruction had been perfect, death of the limb would have been the result; but complete obstruction is not often the case, as there are generally some open and not affected veins that help to carry on a makeshift circulation till nature has time to rectify the disabled part. I think, however, that the generally favourable results in cases of this kind are in a great measure owing to the subordinate purpose which the venous blood serves in the body—that of conveying from the tissues effete matters to places where they can be discharged or ejected; and experience teaches that the principal vein in a limb can, without much danger to life, be greatly obstructed and its functions interrupted long enough to allow a collateral circulation to be established and the obstructing plug to be absorbed. But an obstruction in a large artery, unless there is provision for the immediate establishment of a compensating collateral circulation, is a very serious matter, as the case of this old lady shows, for the plugging of an artery deprives the portion of limb in front of the obstruction of its vital fluid, and, the vital fluid being cut off, the supplies are cut off, and, the supplies being cut off, collapse, starvation, and death of the tissues rapidly follow. I am not sure, however, that this patient's leg was entirely deprived of its arterial blood-supply, because the red and blue became lighter as the lady improved. In the first instance, the red and swollen patches on the instep and front of the leg may have been caused by regurgitation from the capillaries and veins, and afterwards the vitality of these patches may have been maintained by some small arterial vessel or vessels. The colour of the skin of the diseased leg impressed me much, and strongly reminded me of a case of hydrocyanic acid poisoning I once saw, in which the colour of the skin of the whole body was a beautiful purple; but in this lady the skin of the leg was a fine *bleu de roi*, whilst that on the toes and sole of the foot was a *gros bleu*, inclining in some places to a black. The fatal seizure may have been the result of the escape of septic fluid from the diseased part into the general circulation, or more probably it was caused by a new thrombus having been formed high up in the femoral artery, thus cutting off a larger portion of the limb from the circulation, and so giving rise to a further extension of the blue colour.

Lincoln.

THE ROYAL VACCINATION COMMISSION. — On Wednesday Lord Herschell presided at the first sitting of the Commission since the Christmas adjournment. Dr. Creighton's evidence, which was not completed at the last sitting, occupied the whole day.

THE EFFECT OF SECTION OF THE PHRENIC NERVES.¹

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(Concluded from p. 125.)

EXPERIMENTS TO SHOW THE EFFECT OF PHRENIC SECTION IN NORMAL ANIMALS, AND THE VALUE OF ABDOMINAL SUPPORT IN SUCH CASES.

Experiment 1.—Rabbit, buck, weight $1\frac{1}{2}$ kilogrammes, full grown.—4.30 P.M.: The phrenic nerves have had a ligature passed around them; anaesthesia by the minimum quantity of ether. In order that the animal may be as nearly as possible in its normal state when the phrenic nerves are severed, twenty-four hours will be allowed to elapse before these nerves are touched.—Next day (5.45 P.M.): Phrenic nerves divided. There is no struggling for breath, and the respiration is not greatly altered, except in so far as the movements of the diaphragm and abdominal walls are concerned. The animal remains very quiet, and, if undisturbed, fails to exhibit marked evidence of dyspnoea. It is to be noted that the number of respiratory movements with abdominal support made by the application of the hands to the animal's sides and the under surface of the abdomen is 72 per minute; but without support 78 per minute. The changes are so slight in this animal that we are inclined to believe that sufficient irritation of the phrenics has been produced during the twenty-four hours succeeding the operation to have caused the rabbit to breathe more with its chest, and so to have at least partially prepared itself for its new respiratory action. That this is more than mere supposition is proved by the position of the ligatures when taken away, for they are found to be matted together on each side, and shrunk by the juices of the parts.—Eighteenth day: Animal alive and well. The excursion of the ribs at the level of the sixth rib is 9 centimetres; at the level of the floating ribs it is 3 centimetres; midway between the abdomen and the ribs it is 2 centimetres. The increased costal movement is therefore very marked.

Experiment 2.—Rabbit, grey buck, weight 2 kilogrammes.—3 P.M.: Nerves taken up on ligatures.—5.50 P.M.: Both nerves severed. As no ether was administered, it was thought unnecessary to allow a greater lapse of time before the completion of the operation; there is no evidence of dyspnoea. The respiration is not stormy, and the general appearance is not one indicating systemic disturbance. The diaphragm can be seen to descend very markedly on expiration, and to ascend on inspiration.—6 P.M.: The animal has remained stationary since the last observation, apparently from a fear that the dyspnoea, which is not pressing while it is quiet, may increase on exertion. It is evident that there is really no lack of air in the lungs.—6.5 P.M.: Pressure on the abdomen slows the respiration and gives the animal entire relief, so that, forgetting its dyspnoea, it attempts to move about. The respiration is only 60 per minute when compression is used, but 90 per minute when no pressure is applied.—6.30 P.M.: The respiration is now 120 per minute, owing to a rapid run around the room when no pressure is applied, but pressure relieves the dyspnoea, and the respiration immediately drops to 84 per minute.—Nineteenth day: Alive and well.—Fifty-sixth day: Alive and well.—Sixty-fourth day: Killed. The diaphragm was found to be very much degenerated, being a mere transparent tissue-paper like membrane, while the thoracic capacity was remarkably increased. The pectoral and intercostal muscles were much hypertrophied.

Experiment 3.—Rabbit, doe, weight 2 kilogrammes, full grown.—2.10 P.M.: No anaesthetic used. Phrenics have had ligatures around them for twenty-four hours. She has to-day a breathing closely resembling that seen in the rabbit whose phrenic nerves have been already cut, and there is probably

¹ Part of a paper to which was awarded the Warren Triennial Prize, 1889.

irritation of the nerves produced by the ligatures. The respiration at this time (before section), without support, is 70 per minute, with support 60 per minute. When the animal is placed on its back between the knees of the experimenter, there is evident dyspnoea, and the respiration rises to 95.—2.30 P.M.: Phrenics are cut. The respiration is now 108 without support, and only 78 per minute with support.—2.40 P.M.: Respiration is now 94 without support, and 66 per minute with support. The animal has been very quiet since the last observation, which probably accounts for the less rapid breathing.—2.48 P.M.: Respiration without support is now 108 per minute owing to a run, with support 78 per minute.—Eighth day: Alive and well.—Sixtieth day: Alive and well.—Sixty-first day: Killed. The phrenic nerves on both sides were found to be cleanly and completely divided. The chest capacity is enormously increased. The thorax was most unlike that usually found in rabbits. In shape and muscular development it was strikingly similar to that of the dog. The diaphragm was practically converted into a fibrous membrane. The muscular portion was thin and atrophied, was easily torn by the nail, and when held to the light exhibited to the unaided eye many patches of complete degeneration.

Experiment 4.—Rabbit, weight 1 kilogramme, three months old. No anæsthetic used.—2 P.M.: Ligatures have no sooner been placed around the phrenics than evidences of dyspnoea present themselves; so it would appear that those nerves have been irritated or injured. The animal throws itself on its abdomen, on the table where it had been set free, as soon as possible.—2.40 P.M.: Phrenic section has been made without waiting for several hours to elapse. The dyspnoea is now very marked, and there is slight humping up of the back with each respiration. The fore feet are braced, as if for support. Respiration without support is 48 per minute, with support only 30 per minute. Support gives marked relief to the dyspnoea if applied properly. These counts of the respiration were made so frequently that there can be no doubt of their accuracy, nor of the value of the abdominal support in producing relief; thus when the support was given by means of a binder, on its removal dyspnoea increased instantly, and death occurred from asphyxia twenty-five minutes after the section of the phrenics.

Experiment 5.—Rabbit, weight 1 kilogramme, three months old.—2.30 P.M.: The phrenic nerves have just been taken up on ligatures and the wound closed.—4.4 P.M.: The respiration is at this time 60 per minute.—4.5 P.M.: The phrenics are now divided by jerking the ligatures.—4.6 P.M.: Respiration is now 96 per minute without support to the abdomen, but 60 with support applied by the hands. Binder was applied and allowed to remain.—4.36 P.M.: The respiration is still at 60 per minute.—4.45 P.M.: Dyspnoea is evidently increasing.—4.50 P.M.: Death from asphyxia.

Remarks.—It is evident that in these young rabbits death was due to exhaustion of the thoracic muscles, and that as long as these functionally remain intact life was preserved. It is also evident that support does good in every case where it is applied. We have already spoken of the violent struggles which ensue when the phrenic nerves are divided, and it has been thought by Marekwald and others that the sensory fibres discovered by Budge and Panizza were the transmitters of a sufficient degree of pain to make it probable that this was the cause of the struggling movements. In our opinion, however, this is in part a mistaken idea, since we have found that rapid section of these nerves in older rabbits, when in a normal posture, is not followed by these struggles; and this observation has also been found to be correct in respect to the dog and goat. As the nerves are severed in both instances, the cause of the struggles must be the asphyxia which ensues when the animal is tied down on its back. The presence of sensory fibres, however, has been brought to our notice by the fact that violent struggles may take place when these nerves are picked up and irritated. This was especially marked in the horse. As we have established the fact that section of both phrenics proves, if the animal is tied on its back, fatal, it has seemed to us not only interesting, but of value practically to determine the effect of section of one phrenic at a time, and the result is to be seen in Experiments 6, 7, 8, and 9. In Experiment 6 the animal was full grown, but in Experiment 7 it was young and poorly developed. In the first, death did not follow; in the second, death did ensue. In Experiment 8 the rabbit was also a young one, and death again took place. Experiment 9 explains itself. The thought occurred that the exposure of the nerve and the necessary

irritation of it might sufficiently interfere with its function to be a cause of death. The result was interesting, for the rabbit lived and suffered no inconvenience. It may therefore be considered proved that while single phrenic section is not fatal in old rabbits, in young ones it often is so, but that the danger is much less if the nerve on one side is left absolutely untouched by the operator.

Experiment 6.—Rabbit, weight two kilogrammes, full grown. This experiment was to determine the effect of section of one phrenic nerve, and also whether a full-grown rabbit, if tied down after double phrenic section, would live. Left phrenic nerve was cut one week ago.—3.30 P.M.: Right phrenic nerve cut, death immediately came on. As one of the nerves had already been cut for so long there was a better chance for survival than if both had been cut at once, proving therefore, that dorsal decubitus causes death.

Experiment 7. (To determine effect of section of one phrenic nerve.)—Rabbit, weight $1\frac{1}{2}$ kilogrammes, not full grown. The animal is not strong and is poorly developed.—12 noon: Both phrenic nerves have been prepared for section.—12.25 P.M.—The left phrenic nerve has just been cut. There is marked evidence of dyspnoea. The head is held high in the air and the neck is extended.—Next day: Rabbit found dead in the cage this morning. There is tubercle of the liver, but not sufficient to cause death. There is venous engorgement of the right side of the heart, and the lungs are congested.

Although the last experiment virtually proves that section of one phrenic is followed in the strong rabbit by survival, for that animal lived for a week after the first section, this one was done for the purpose of determining the facts of the case positively.

Experiment 8.—Rabbit, weight 1 kilogramme, quite young.—3 P.M.: Both phrenic nerves prepared for section.—5 P.M.: Left phrenic nerve cut.—Next day: Found dead in cage from asphyxia. There is venous engorgement of the great vessels and the right side of the heart.

Experiment 9. (To determine whether the irritation of the uncut nerve by its being bared aided in causing death.)—Rabbit, weight $1\frac{1}{2}$ kilogrammes, age three months.—2 P.M.: Right phrenic nerve prepared. Section of right phrenic nerve. The left nerve is entirely untouched.—Second day: Still alive and eats well. It is worthy of note that in this animal the nerve was not even discovered, whereas in the other instances the nerve on one side was irritated by a ligature, although it was not cut. The left nerve in this case escaped entirely any traumatism in the operation.—Third day: Still as well as ever.—Twelfth day: Has been progressively wasting for several days and was found dead in the cage this morning from tuberculosis, as was proved by the necropsy. The post-mortem examination showed marked wasting of the diaphragm on the right side and hypertrophy of the opposite or left side.

Conclusions.—1. Injury or destruction of the phrenic nerves is not followed by death, as has heretofore been taught. 2. In injuries involving the diaphragmatic movements it is important that the patient shall not be anæsthetised, as under those circumstances the absence of voluntary aid in respiration may be attended by fatal results. 3. The seriousness of phrenic injury is in direct ratio to the dependence of the respiration of the normal animal on the diaphragm and to the ability of the chest walls to make compensatory movement. 4. The symptoms resulting from interference with the function of the phrenic nerves are as definite and characteristic as those following interference with any other motor nerve. There will always be well marked increase in the scope of the thoracic excursions and distinct reversal of the movements of the abdomen—i.e., the abdomen will retract on inspiration. 5. Fear of injury to one or both phrenic nerves need not prevent operations about the neck and upper portion of the chest, provided that due caution be exercised that the patient is but slightly under the influence of the anæsthetic at the time that danger of injury to these nerves is most imminent. Infancy, however, constitutes an exception to this rule; only absolute and pressing necessity for operation would afford justification for such a procedure in early life. 6. The real effects of section of the phrenic nerves being known, it follows that the nerve is subject to the same operation in case of injury as are other nerves of the body, such as suture. 7. In cases of injury to the phrenic nerves support should be given to the abdominal walls, to prevent movement of the same and to brace and steady the paralysed diaphragm, care being taken that the floating ribs are free.