

The Journal of the American Medical Association

Published under the Auspices of the Board of Trustees.

VOL. XXXVIII.

CHICAGO, ILLINOIS, FEBRUARY 22, 1902.

No. 8.

Original Articles.

AN EXPERIMENTAL AND CLINICAL RESEARCH INTO COCAIN AND EUCAIN.*

GEORGE CRILE, M.D.
CLEVELAND, OHIO.

EFFECT ON PERIPHERAL NERVE TRUNKS.

The injection of eucain or cocaine into a nerve trunk so as to place all its structures in contact with the drug produces an effectual physiologic "block." By the word "block" is meant such condition of the nerve that neither afferent nor efferent impulses can pass, the conductivity being as completely interrupted as if the nerve were divided. While general anesthesia prevents the appreciation of pain and the production of voluntary motion, it does not prevent such other afferent impulses as those caused by mechanical, thermal or electrical stimulation of the nerve endings or trunks, which produce changes in the frequency and the amplitude of the respirations, in the frequency and force of the heart beats, and in vasomotor action. Either eucain or cocaine injected into a nerve trunk as above described prevents the passing of such afferent impulses, thereby preventing effects upon the respiration, the heart or the vasomotor mechanism, i. e., shock. Under general anesthesia, if the paw of an animal is subjected to the flame of a Bunsen burner, after the lapse of a short time the leg is drawn up by the contraction of groups of muscles in a deliberate but rather forcible manner, removing the foot from the flame. General anesthesia, no matter how deep nor what anesthetic employed, does not prevent such action of the muscles. It seems, if the expression may be allowed, to be an "unconscious purposive" action. Either eucain or cocaine injected into the path of these afferent impulses prevents this phenomenon. If it is intended to produce an immediate effect it is necessary to make a thorough injection. If a little time is allowed to elapse, the solution need not be directly injected into all the parts of the nerve trunk. Even if injected underneath the sheath, without penetrating the substance of the nerve trunk, a "physiologic" block may be produced. No unfavorable later effects were noted. In a number of cases in which the nerves were thus blocked, and the animals allowed to recover, there was but temporary functional impairment, and in no instance was there evidence of neuritis or of degeneration following. The effect of the eucain and cocaine upon nerve structures is apparently the same as their well-known general effects upon the protoplasm; that is, they temporarily suspend its functional activity.

They form no chemical combination and cause no destruction either of its physiologic properties or of its substance. As to afferent impulses, it was found that the cortical discharges of the brain were blocked either when they originated as a voluntary action, or when they originated as an artificial convulsion produced by the administration of the essential oil of absinthe. Even powerful electrical currents applied to the nerve trunk, near the block, were found to be incapable of forcing their impulses through the "block." What has been said of the effect of cocaine thus applied to the nerve trunks may be said of like injections into the spinal cord. The effect upon the optic nerve is that of at least partially blocking the impulses of the light waves and were the injections given directly into this nerve the "block" would probably be complete. Either eucain or cocaine when applied upon the medulla or fourth ventricle within a few seconds suspends the action of the respiratory center. This suspension is characterized by a gradually increasing slowness of respiration, together with gradually decreasing amplitude, so that within thirty seconds respirations cease. The blood pressure in nearly every instance suffers a profound depression, the nature of which is a gradual decline such as is observed on making a cross-section of the cervical spinal cord; that is to say, the vasomotor center or paths are anesthetized. Another effect of the application of eucain or cocaine upon the medulla or the floor of the fourth ventricle is immediate complete general anesthesia and immediate total loss of all voluntary action. The corneal reflexes are at once abolished and the pupils are dilated. When the paws of the dog are exposed to the flame of a Bunsen burner the legs are not drawn up, the blood pressure is not altered, and the heart's action is not affected. It is needless to say that there are no respiratory changes. In other words, application of these anesthetics upon the medulla or the floor of the fourth ventricle suspends temporarily all the manifest functions of that organ excepting the heart's action, and that is modified. General anesthesia may be indefinitely prolonged by repeated applications. Upon the vagi the effect of an injection of these drugs is to suspend their inhibitory action. The action of cocaine is probably a little more prompt than that of eucain; the latter, however, seemed to be quite as effective as the former. Cocaine and eucain block the impulses set up by electrical stimulation in nerve trunks even after death; that is, if after the death of an animal a nerve trunk is stimulated, within a certain time the muscles supplied will be thrown into contraction; but if cocaine or eucain is injected into the nerve trunk and a stimulus applied above it, no contraction will occur.

* The experimental research consisting of 89 experiments on animals, mostly dogs, will be published in detail elsewhere. This paper is a summary.

The physiologic action of cocaine and eucain, both local and general, are so nearly alike that one description may serve for both. The first effect, observed after

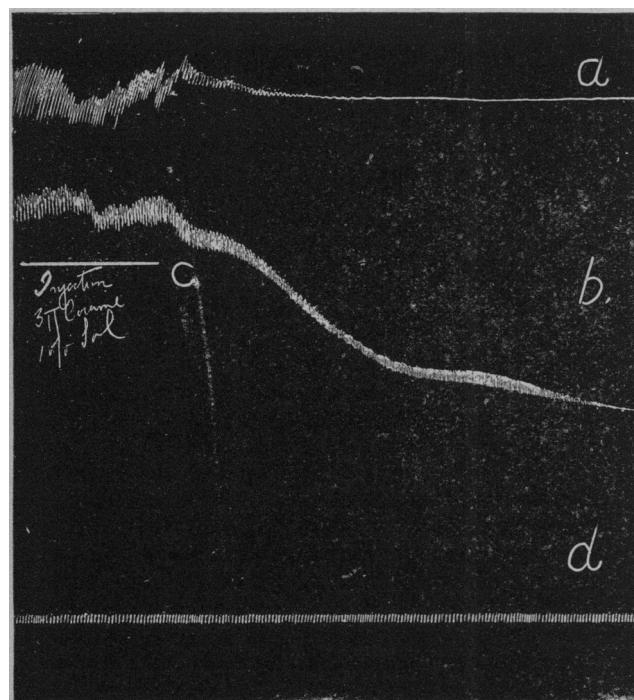


Fig. 1.—*a*, Respiration; *b*, blood pressure; *c*, signal; *d*, seconds. Injection in lumbar region with considerable force, showing how quickly both the respiratory and the vasomotor centers may be paralyzed. The secondary rise in the blood pressure was due to the first disturbance of the convulsive center in the medulla.

the intravenous injection, is a temporary increase in the blood pressure. This increase appears almost immediately, and continues for a brief period of from five to twenty seconds, when the blood pressure returns to or near its former level. The heart strokes forming the curve are usually a little shorter, and the rapidity of the heart's action somewhat increased. No definite vasomotor change was indicated by the peripheral venous or peripheral arterial manometers. A water manometer recording the splanchnic blood pressure indicated a rise out of proportion to the rise in the general blood pressure. In rare instances there was a fall in the blood pressure, but compensation was immediately inaugurated and the lost pressure was quickly regained. In overwhelming doses with lethal effect the general blood pressure, in fact, all the pressures, rapidly sink to the abscissa line. It was noted that when the animal was under the systemic effect of these drugs the blood pressure curve was, as a rule, not so regular as under normal conditions. It was also noted that in a number of experiments the length of the stroke of the writing style, expressing the heart's action, was shortened under the systemic effects of these drugs. This ir-

regularity of the blood pressure curve was similar to the irregular curve when the animal was under physiologic dosage of atropin or when both vagi had previously been severed. It was also found that when animals were under the effect of these drugs, stimulation, by applying the electrodes upon the vagi, did not produce normal characteristic effect; that is to say, that while in normal conditions the application of a Du Bois Reymond electrode upon the vagi causes slowing or arrest of the heart; in animals under the systemic influence of cocaine or eucain the application of such stimulation to the vagi in most instances produced little or no effect. In a number of experiments it was observed that if after having secured a control tracing of the inhibitory effect of intralaryngeal manipulation the animal was subjected to a physiologic dosage of cocaine or eucain, a like manipulation of the larynx usually produced no inhibition. In the experiments in which inhibition was noted it was in most instances less than normal. The same may be said of other experiments upon the superior laryngeal nerve. The physiologic effect of cocaine and eucain in this respect is quite analogous to that of atropin, though the effect is not so marked. The increase in the blood pressure after the administration of cocaine is in a measure similar to that which follows section of both vagi. Taking into consideration all of the evidence, it would seem that cocaine and eucain partially or wholly suspend the inhibitory function of the vagi, whether produced by direct or indirect stimulation. While not prepared to make a positive statement on the subject, it appears that the increased rapidity of the heart's action under the influence of these drugs was due to the removal of the vagal influence and not to

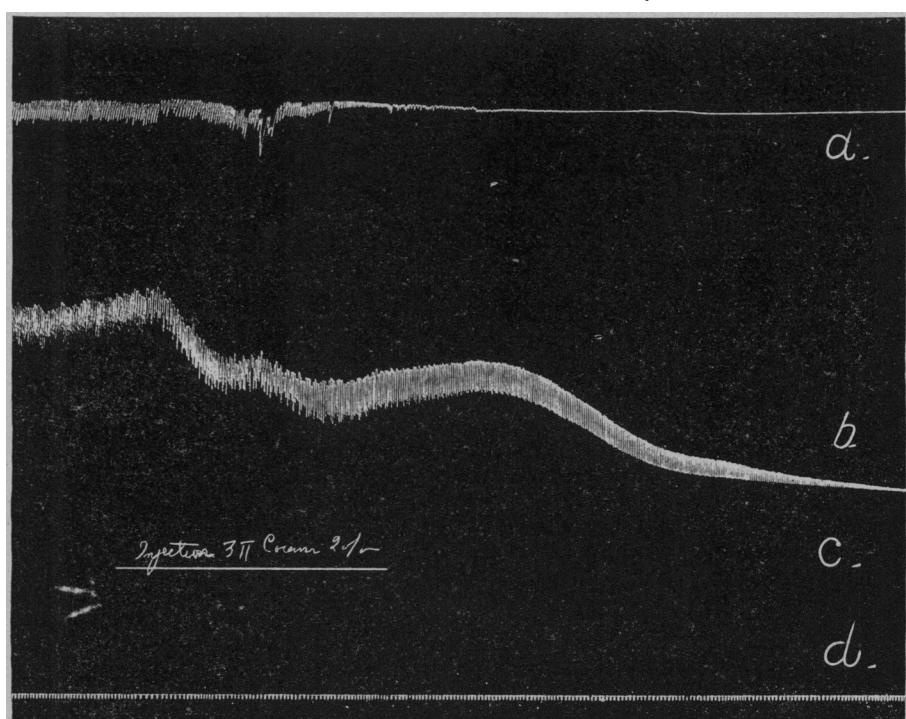


Fig. 2.—*a*, Respiration; *b*, blood pressure; *c*, signal; *d*, seconds. Effects of injecting two drams of cocaine into lumbar subarachnoid space. Note the gradual cessation of respiration, the irregular strokes occurring during the convulsions, the abrupt fall in the blood pressure due to paralysis of the vasomotor center in the medulla.

stimulation of the accelerators. The splanchnic area, especially the veins, when the abdominal viscera were subjected to exposure or irritation, or both, was dilated,

the intestines became red, extremely congested, and often livid. When the animal had been given a physiologic dose of cocaine or eucain and exposed to like experiment the splanchnic vessels did not dilate, except-

or exposure of the splanchnic area caused a fall in the general blood pressure proportional to the exposure or irritation and the condition of the animal. In some instances the fall was extremely rapid and the animal soon died, but in a series of experiments in which cocaine was systematically administered there was but a slight, if any, fall in the general blood pressure. There was a striking difference between the results in the control experiments and the "cocain" ones. In order to make the comparisons more reliable double experiments were performed. Two animals of as nearly the same size and under as nearly the same conditions as possible were placed side by side on similar dog boards, and precisely the same experiments were performed simultaneously upon each. In every instance the benefit of any doubt was allowed the control dog. The writing style recording the blood pressure and the respiratory action of each was placed in a vertical line, so that direct comparisons could be accurately made. The result of these double experiments may be summarized as follows: In the control dogs exposure and manipulation of the intestines produced a fall in the blood pressure; in the cocaine and eucain dogs, as a rule, no fall occurred. The cocaine and eucain dogs endured more mechanical injury than the control dog. The latter in every experiment died first. In burning the hind feet in the animals the blood pressure in the control rose higher and more promptly than in the cocaine or eucain dogs. In crushing the testicle the blood pressure fell more promptly and a greater distance than in the cocaine or eucain dogs. The same may be said of the manipulation of the larynx, stimulation of the vagi, operations in the pharynx, in short, of every portion of the body. The comparison between the appearance of the abdominal viscera in the control dog and that in the cocaine or eucain dog is that in the latter the intestines were of a peculiar shade of pale red, and the vessels were, if any change was noted, of less caliber than before the experiment; while in the control dog all the vessels were engorged, the viscera exceedingly red, and in many instances livid. It was at once apparent that the difference in the blood in the splanchnic area of these two animals was very great. Even the inferior vena cava was smaller in the cocaine animals. The effect upon the circulatory apparatus: first, an immediate rise takes place in the blood pressure lasting a few minutes; this is followed by a compensatory fall; later, a gradual rise occurs. The inhibitory influence of the vagus is partially or wholly suspended. The vasoconstrictor reflexes are considerably lessened. The circulatory apparatus is less responsive to stimulation. The latent period of vasoconstrictor reflex action is markedly increased. The vessels of the splanchnic area are contracted.

There is but little doubt that there is an increased tendency to clotting. Upon the respirations a small dose seemed to act as a stimulant. A medium dose seemed to lessen the length of the respiratory stroke, while a large dose caused respiration to gradually diminish. It was frequently observed that if a series of injections of these drugs were administered at given intervals a very marked tolerance was acquired, so that finally but little effect could be produced. It was also observed that animals under the influence of these drugs were more difficult to maintain in the condition of even surgical anesthesia. More general anesthesia seemed to be required, and the animals had a tendency to come unexpectedly out from its influence.

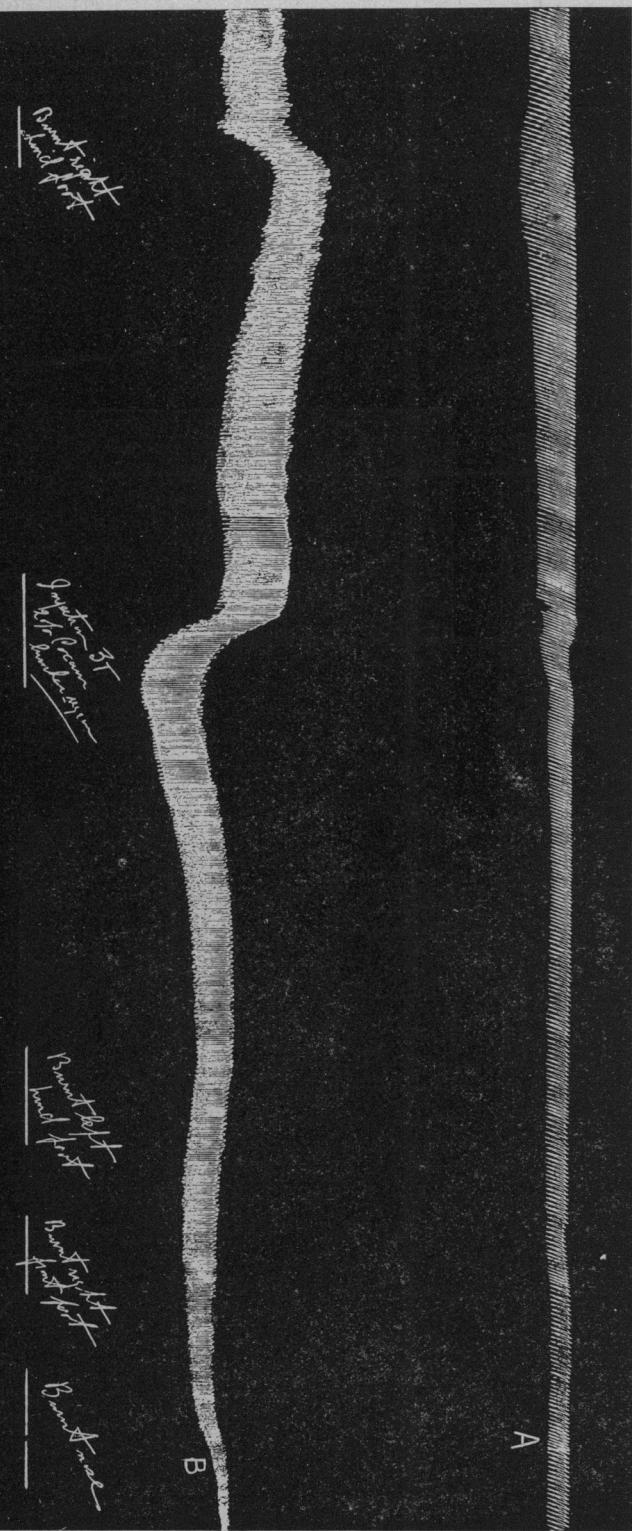


Fig. 3.—*a*, Respiration; *b*, blood pressure. As a control the hind foot was burned, causing a rise. Then cocaine solution was injected into lumbar region, after which burning of the foot caused no effect upon either the blood pressure or the respiration.

ing those at the bases of the intestines. The arteries became decidedly smaller and the intestines a peculiar palish red. In a large series of control experiments it was found that with but rare exceptions such irritation

SPINAL CORD ANESTHESIA.

Injection into the Spinal Cord.—In 1897, after performing the experiments upon nerve trunks showing that cocaine was capable of producing physiologic section, that is to say, the afferent or efferent impulses could not pass the point cocainized, and after having performed amputations on the human subject without pain and without shock by this method, similar procedures upon the spinal cord were suggested. The experiments along this line consisted in injecting the solution directly into the substance of the cord. This produced immediate anesthesia at all the points with which the cocaine came in contact. Although the anesthesia was immediate and complete, and for operative purposes was entirely satisfactory, it was obvious that this procedure necessitated a physical damage to the cord.

Recovery experiments were made as follows: The cord was anesthetized by injecting cocaine directly into its substance by means of a fine needle. The comple-

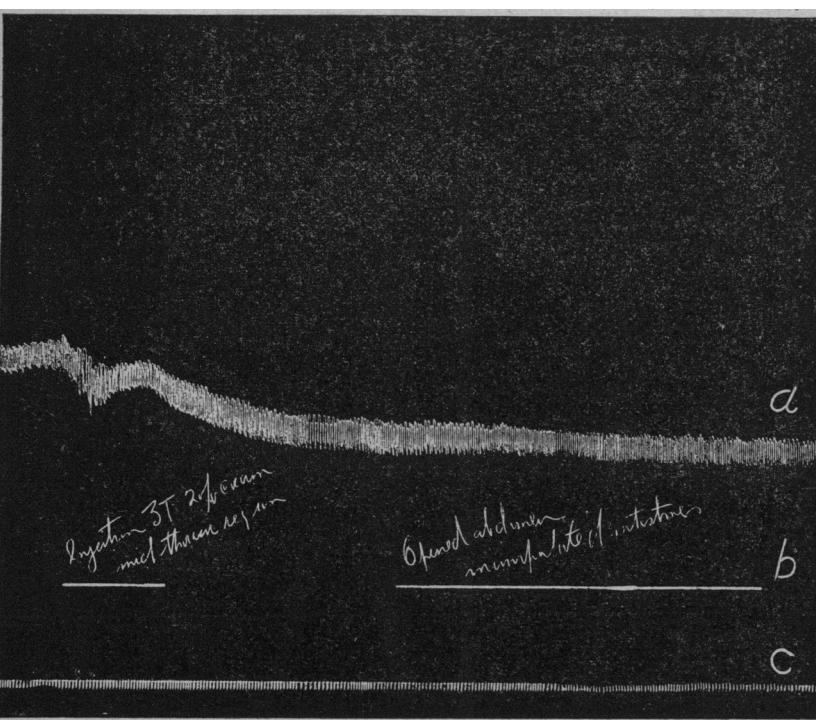


Fig. 4.—*a*, Blood pressure; *b*, signal; *c*, seconds. This experiment shows that after an injection in the thoracic region manipulation of the abdominal viscera does not affect the blood pressure.

ness of the anesthesia was proved, the animal allowed to recover, and after a lapse of varying periods of time was killed. The cord was subjected to microscopic examination. While in some of the cases it was impossible to detect any microscopic damage to the cord, there was found some round-celled infiltration and disturbance of the histologic arrangement. It was at that time concluded that this was not a justifiable procedure in any but most exceptional cases. Later experiments were made by injecting cocaine into the subarachnoid space. In dogs this space is so small that it is necessary to expose the cord in order to make an injection without traversing the cord. The injection of a 1 per cent. solution of cocaine into this space produced almost immediate anesthesia.

Subarachnoid Injection.—Effect on the Circulation: The effect of injecting a solution of cocaine into the subarachnoid space in the lumbar region was an immediate fall in the blood pressure, the beginning of the fall being almost coincident with the contact of the solution

of cocaine with the cord. The depth of the fall was proportional to the completeness and the anatomical parts involved. The curve in the descent of the blood pressure was gradual and even, after which a regular line was maintained for some distance, which indicated the loss of vasmotor control. The effect upon the blood pressure when the medulla or the fourth ventricle was cocainized was the greatest, the pressure falling almost to the abscissa line. When the entire cord had been subjected to the influence of cocaine and the pressure had fallen as above described, if any part of the body below the level cocainized was subjected to burning, crushing, or any other mechanical, thermal or electrical stimulation, no rise in the blood pressure occurred. There was usually but a trifling amount, if any, of compensation after the fall of the blood pressure until the cocaine effects passed off.

Effects on Respiration: The immediate effects on the respiration, after a subarachnoid injection of a compara-

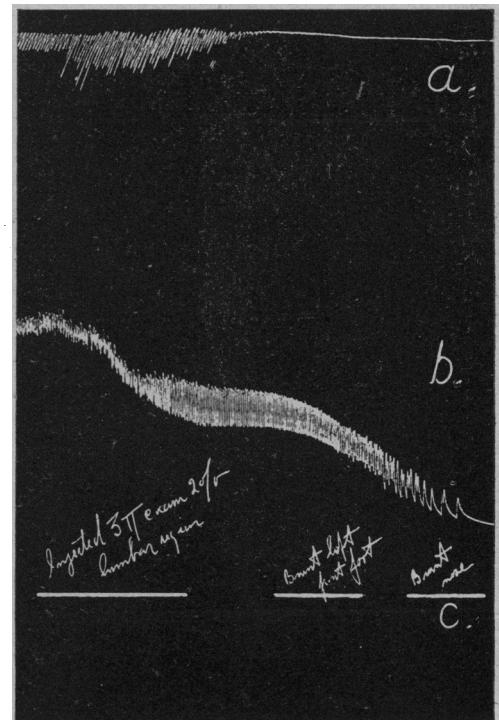


Fig. 5.—*a*, Respiration; *b*, blood pressure; *c*, signal. This experiment shows how quickly an injection in the lumbar region may kill, and that after the effect is obtained burning of the feet does not produce any change in the blood pressure.

tively small amount of cocaine in any part of the spinal cord, not involving the medulla, is acceleration. The application of a 1 per cent. solution of cocaine upon the medulla or the floor of the fourth ventricle produced within a period of time ranging from a few seconds to a few minutes, complete respiratory paralysis. There is first loss of the intercostal and extraordinary muscles, then the abdominal muscles and lastly the diaphragm. The action of the diaphragm becomes shallower at each contraction until it is entirely paralyzed.

The membranes of the cord are so nearly inelastic that for the present purpose they may be regarded as being so, while the cord itself is so nearly incompressible that it may be considered so. The subarachnoid space is always filled with its own fluid. If additional fluid is added, it must cause a displacement similar to that of fluid in a capillary glass tube. The rapid and uncontrollable ascent of the anesthesia of the cord was most striking. In order to better study this a series

of injections was made with cocaine solution colored with methylene blue. It was found that an ordinary injection in the lumbar region of one-half dram of this solution stained the entire cord and the under surface of the brain within thirty seconds. All the various localized functions of the cord and medulla were with rapidity anesthetized. The respiratory center in the medulla, for example, could be anesthetized by a lumbar subarachnoid injection within a few seconds, so rapidly did the fluid pass up the cord. Marked fall in the blood pressure and cessation of the respiration occurred within a few seconds, after a rather forcible injection in the lumbar subarachnoid space. The fluid ascended about as readily in the vertical posture as in an horizontal. There can be but little doubt that the effect is due to the local contact of the nerve structure and not to absorption. This view is in full accord with the action of cocaine on other nerve tissue. A solution injected with

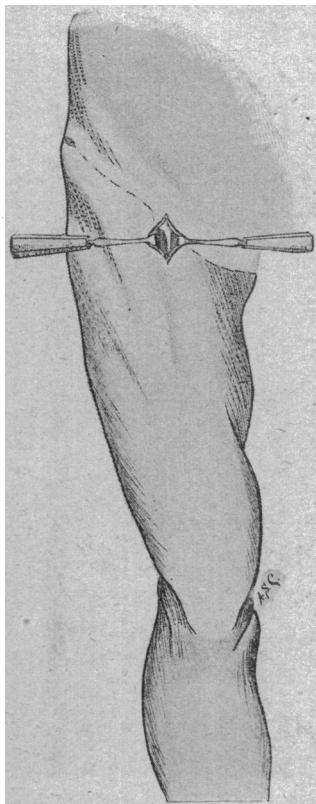


Fig. 6.—Showing the most accessible portion of the anterior crural nerve.

considerable force into the lumbar subarachnoid space was attended immediately by convulsions. The convulsions were due to the stimulation of the convulsive center in the medulla. The dosage used in these experiments was purposely made large to determine the control, or rather the want of control, the operator could have upon the extent of the anesthesia. In control experiments in which normal saline solution was injected into the spinal cord an immediate fall in the blood pressure occurred, but compensation quickly followed. The respirations were but slightly affected. There was the most striking difference between the overwhelming paralysis in the one case and the want of it in the other. The experiments showed that the operator has but little control over the extent of the anesthesia produced under the subarachnoid injection. While direct injection into the cord gave a complete control of the extent, it produced a distinct mechanical lesion. In the clinical reports of the subarachnoid anesthesia these experimental

data have been corroborated. This was most strikingly exhibited in a case described by Fowler in which the anesthesia during three minutes extended up to the level of the clavicle, at which time the patient became cyanotic and artificial respiration was necessary. Other observers have noted the marked effect on respiration, the lowered blood pressure, and the rapid pulse, the latter indicating that the cocaine solution was affecting the centers of the medulla. In 692 reported cases there were six deaths that were attributable to the anesthesia, a mortality rate at least fifty times greater than that of chloroform.

CLINICAL APPLICATION OF THE EXPERIMENTAL EVIDENCE.

Operations on the Extremities.—*Leg:* The “blocking” method was employed independently by Dr.

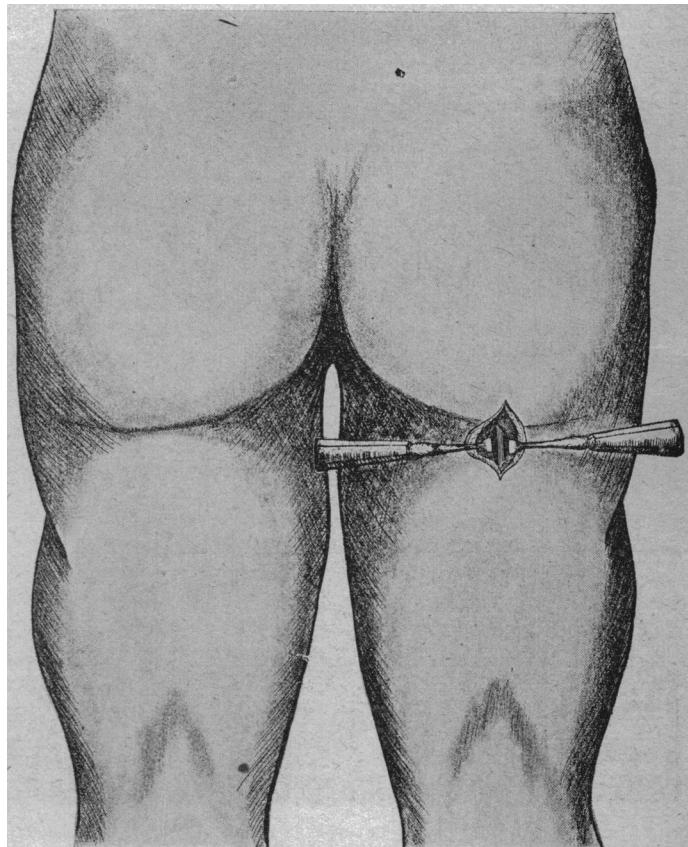


Fig. 7.—Showing the most accessible portion of the sciatic nerve.

Rudolph Matas of New Orleans, of which his brilliant monograph on anesthesia gives a full account. Applying the so-called physiologic “blocking” properties of cocaine or eucain to surgical practice, we have been enabled to perform certain operations upon the extremities without causing pain and shock by injecting a 1 per cent. solution of cocaine into the supplying nerve trunks. The external cutaneous nerve is so superficial that it is readily accessible. The anterior crural is readily exposed in its relations with the artery, and the sciatic at the margin of the gluteal fold along the inner border of the biceps muscle. In operations performed upon the area supplied by the “blocked” nerve trunks the afferent impulses can not reach the central nervous system. There is, therefore, neither pain nor shock. This method is of the greatest possible importance in operations in which general anesthesia is contraindicated. The operation under these circumstances can cause no more shock than if the member had no connec-

tion with the body, as the "block" for such purposes is equal to a physiologic amputation.

In this manner I have five times performed amputation of the leg below the knee, and in all but one the patient was not aware that the operation was performed until told of it afterwards. It is necessary to control the patient well. After preliminary preparations have been made, the patient's attention should be diverted. I have usually said that an examination and a dressing would be made requiring considerable time, and that the operation would be performed next day. In the meantime the eyes were covered. In the one case the patient became aware of the progress of the operation by hearing the noise of the saw while dividing the bone. The "block" continues from twenty-five to thirty minutes. The clinical observations are in entire accord with the experimental evidence.

Operations in the Area of the Distribution of the Ulnar Nerve: The superficial position of this nerve at

CASE 2.—A small boy discharged a pistol, which took effect in the ulnar side of the hand, tearing away the soft parts and a portion of the fifth metacarpal bone. By "blocking" the ulnar nerve at the elbow the wound was examined, and the fragments of the bone removed without pain. In this case there was no complaint of the burning sensation described in the preceding. The wound healed readily.

CASE 3.—In a tuberculous patient a local focus appeared in the metacarpal-phalangeal joint. In performing an operation for the removal of this focus, the ulnar nerve was "blocked." At first an attempt was made to secure anesthesia by injecting the solution around the nerve, but after waiting five minutes it was found that anesthesia was only partial and that it was necessary to inject the nerve itself. In performing the operation it is best to fix the nerve well against the bone and insert the needle gradually as anesthesia occurs in advance of the needle. After such an injection the anesthesia was complete and the operation was performed painlessly. The patient complained of some burning the first night, but the second day it decreased and was not again experienced.

In two other cases this nerve was in a similar manner

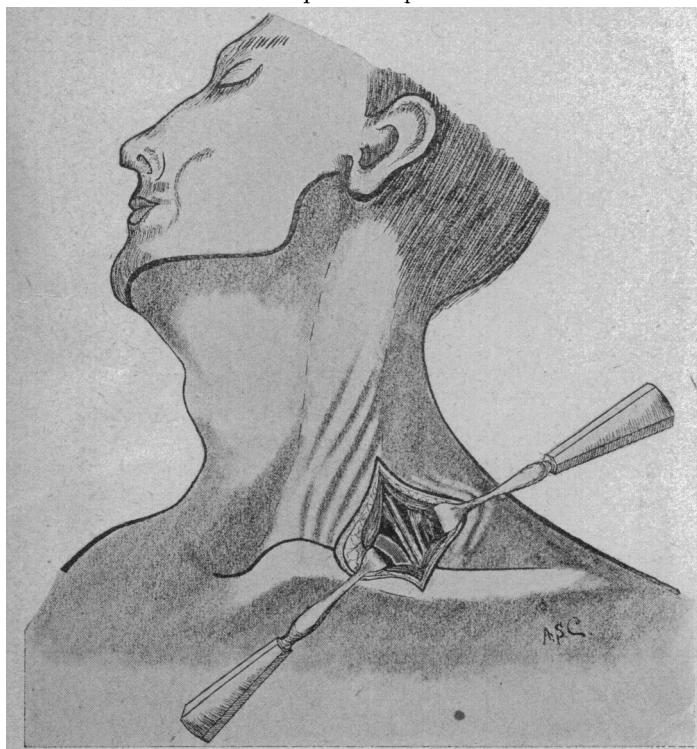


Fig. 8.—Point of election in making the incision for exposure of the subclavian artery and the brachial plexus.

the elbow joint enables the surgeon to apply a cocaine or a eucain "block" almost painlessly by inserting a hypodermic needle, first into its close vicinity, then into the trunk itself, injecting the solution on its way. After the lapse of ten minutes the entire area supplied will be rendered anesthetized, and if the patient's attention is diverted operative procedures, such as amputations and resections, may be performed painlessly and without the patient's knowledge.

CASE 1.—A railway employe, whose hand and little finger were severely crushed within the area of the distribution of the ulnar nerve, required amputation and revision. Bending the elbow, a wheal was produced by injecting a 1/12 per cent. solution of beta-eucain, thereby creating a painless path to the nerve trunk, which was then anesthetized. In a few seconds there was complete anesthesia, and the finger and the corresponding metacarpal bones were removed while the patient was an interested spectator. The night following this operation the patient complained of a burning sensation over the distribution of this nerve. There was some local tenderness at the point of injection, but this disappeared after several days.

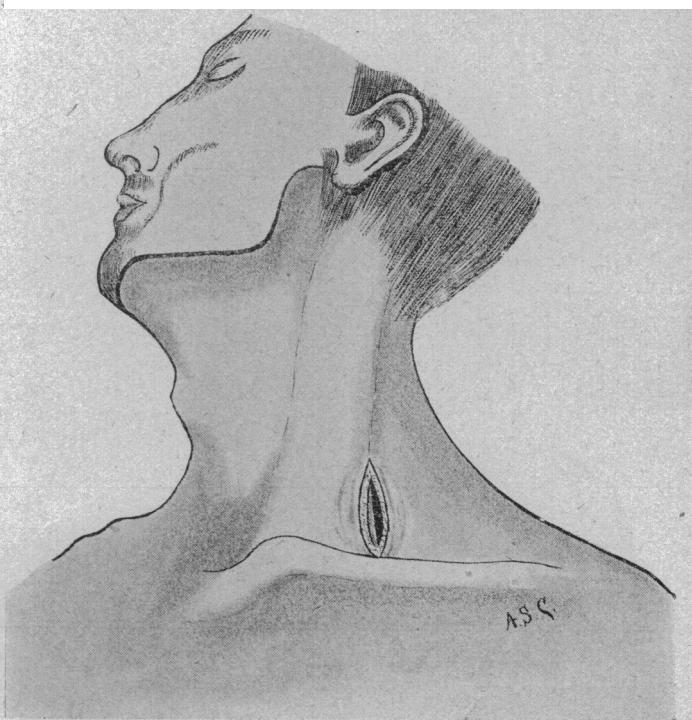


Fig. 9.—Showing the point of election for exposing the subclavian artery and the brachial plexus.

"blocked." In each the anesthesia was complete in five to ten minutes and no after-effects were noted. In no case was there any interference with the function of this nerve in consequence of the injection. Neither did the points at which the injection was made remain tender. No neuritis followed.

Amputations at the Shoulder Joint.—Amputations at the shoulder joint are usually indicated on account of a serious accident or disease, and in consequence such operations are frequently performed under unfavorable circumstances. There has been considerable mortality following this operation, even under the more favored conditions. In operations for malignant disease in the aged, and operations in the presence of profound depression or shock, general anesthesia adds seriously to the danger. There are many instances of contraindication to the use of general anesthesia. A method by which this operation may be performed without general anesthesia, without shock and without hemorrhage, was devised in accordance with the experimental evidence

set forth in the preceding pages, and put into practice in June, 1898.

Technique: The technique is based upon the fact that nerve trunks may be safely and effectually subjected to a physiologic "block" by injecting cocaine or eucain in a comparatively weak solution, and that arteries may be, with entire safety, temporarily closed without injuring their walls. Fortunately, in the application of these principles, in amputation of the shoulder joint the subclavian artery is in close surgical relation with the brachial plexus so that the same incision may be utilized for exposing the nerve and the blood supply.

CASE 1.—Female, aged 74, was suffering from sarcoma of the arm, situated in the lower third and extending well down to the elbow. There was a metastatic growth in the axilla. She was suffering great pain and the tumor was growing

extending the dissection a trifle farther downward and inward the arching subclavian artery was brought into the field. In making this dissection it is important to keep the field of the operation entirely free from blood, so that the translucency of the tissue will permit the ready recognition of the anatomic structures in their minutest detail. It will then be possible to detect small nerve twigs before they are encountered and enable the operator to subject them to local anesthesia in advance. In this way the area supplied by these branches may be anesthetized. The small vessels may be caught with narrow-bladed forceps, between which the incision may be carried. The smaller nerve twigs are usually found running along the blood vessels or in the connective tissue planes. It was observed in this dissection that in the deeper structures the sensory nerve supply is not so abundant as in the more superficial. After exposing the trunks of the brachial plexus, there being but a slight amount of pain in the dissection, they

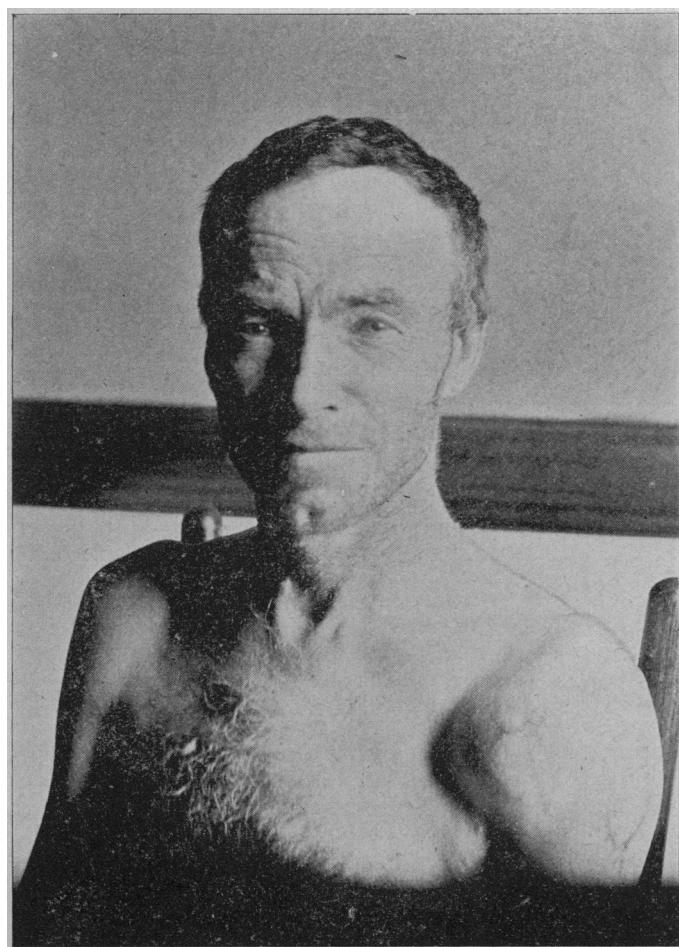


Fig. 10.—Showing sarcoma of the head of the humerus, involving the scapula.

rapidly. Owing to her extreme age, an amputation at the shoulder joint by the methods hitherto in vogue, giving a general anesthesia without "blocking" the nerve trunks to protect her against the afferent impulses caused by the mechanical irritation of the amputation and thereby producing shock, would have been a risk too great to assume. It was decided to perform the operation by employing the technique above described. An incision was made along the outer border of the sternomastoid muscle under 0.1 per cent. infiltration cocaine anesthesia. The incision was carried through the superficial and the deep fascia, exposing in the first part of the incision the external jugular vein. The lower part of the incision was carried well down on the clavicle. The omohyoid muscle was retracted downward, the anterior angle of the trapezius backward and the posterior margin of the scalenus anticus forward, thereby exposing the trunks of the brachial plexus, and by

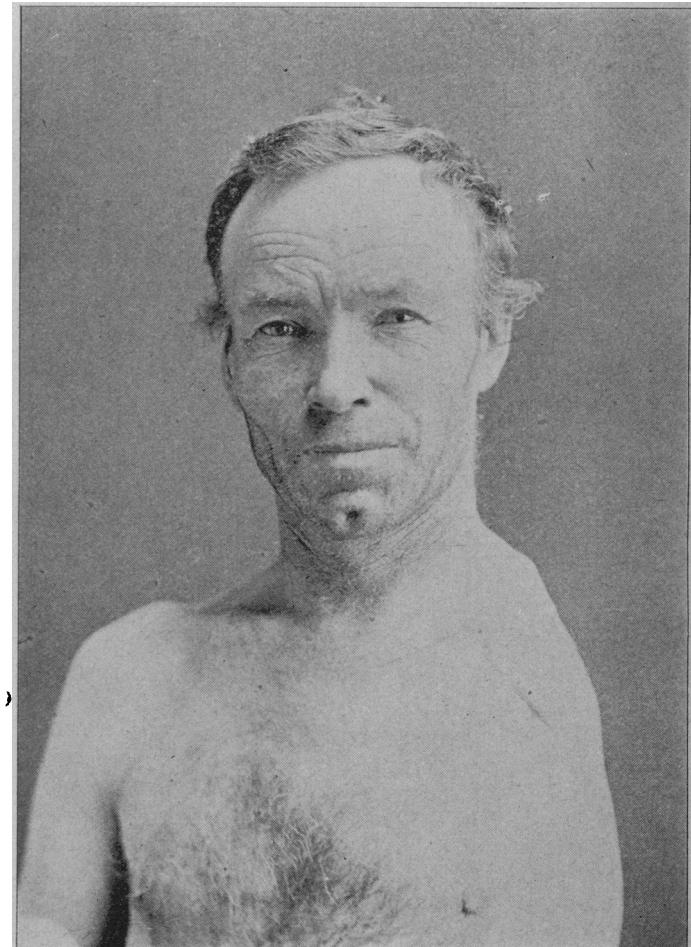


Fig. 11.—Patient upon whom excision of the left half of the shoulder girdle was made.

were subjected to a physiologic blocking by injecting first on their outer covering, then into their substance, a 0.5 per cent. solution of cocaine, just sufficient to cause a localized swelling. It required but a small amount of solution. After injecting each trunk there was a total loss of sensation and of motion in all the parts supplied by the brachial plexus. The subclavian artery was then closed by means of a special clamp, over the blades of which rubber tubing was drawn. The blades were then approximated by adjusting the screw sufficiently to close the lumen of the vessel. The patient was then told that the operation would not be performed at that time, but would be deferred until the next day. A towel was thrown over her eyes, and under the pretext of making a careful examination of her arm the amputation was made without her knowledge. The flap on the outer and posterior aspects over the deltoid was made rather low, because of the sub-

cutaneous distribution of the branches of nerves from the cervical plexus, which, of course, had not been included in the physiologic block.

She experienced no pain except a slight one as the incision was carried around the posterior surface of the upper portion of the arm supplied by the suprascapular nerve. The pain was, however, comparatively slight and was felt only during the incision of the skin. During the disarticulation the patient was not aware that she was being touched. After the operation had been completed it was found that there was absolutely no shock and that the operation had made no appreciable impression on her. The vessels were all picked up and tied before releasing the clamp from the subclavian. The total amount of cocaine used in the operation was about $\frac{1}{8}$ grain. A portion of this amount was recovered by sponging away the free solution in the wound. When the patient was returned to her bed she was not aware that her arm had been removed. She soon missed it, and manifesting some excitement, was informed by the nurse. She experienced some pain for a few hours after the operation and vomited several times the first night. She made a good recovery from the operation and there was nothing in the after-progress of the case different from operations performed in the usual way.

CASE 2.—Amputation of the arm at the middle was performed by the same technique as the preceding without producing any pain and without the slightest shock. Patient made a good recovery. The operation was performed on account of moist gangrene of the forearm in a patient having advanced pulmonary tuberculosis.

Amputation of Half the Shoulder Girdle.—This operation has been performed a number of times by various methods. The purpose of discussing it is to point out a technique by means of which hemorrhage and shock may be wholly avoided. Under general anesthesia an incision is made over the clavicle and the inner half of this bone is resected, after which the subclavian vein and the trunks of the brachial plexus are exposed. The trunks are then subjected to a physiologic block of cocaine and eucain in comparatively weak solution, say 0.5 per cent. The brachial plexus is next severed and the artery and vein closed by ligature. The incision for the further technique in removing the scapula will vary with the object for which the operation is done. The amount of shock will be limited to what will be produced by making the incision through the structures supplied by the nerves from the cervical plexus, which is almost nil.

Observations on the Pharynx.—Clinical experience, as well as physiologic experiments, have demonstrated that when the pharynx is subjected to a considerable manipulation, especially that portion nearest the glottis, reflex inhibition both of the respiration and of the heart may occur. The respiratory inhibition is the more frequently produced. In the cases in which manipulation required considerable force the heart may be inhibited, causing collapse. I have observed this reflex inhibition of both the heart and the respiration in removing a tumor of considerable size from the nasopharynx. In operations for removing adenoid growths from the nasopharynx these phenomena have also been observed. In extracting large foreign bodies collapse may be produced. Not infrequently, in performing difficult operations in this portion of the pharynx, reflex inhibition confuses the operator. The respiratory inhibition is likely to give the impression that the patient is suffering from a mechanical obstruction. The inclination might be to clear out the upper respiratory passage, but this additional

irritation would increase the symptoms. In the experiments it was found that reflex inhibition in this area may be prevented by the local application of a 2 per cent. solution of cocaine. The solution may be as weak as an 1 per cent., or even a 0.5 per cent., and be effectual. A hypodermic injection of atropin prevents reflex inhibition of the heart. In cases necessitating the removal of adenoid growths and tumors of the pharynx the efficiency of these drugs was proved. It is advisable, before beginning the technique of an operation involving this area, to make a local application of a solution of eucain or cocaine, and a hypodermic injection of atropin, to prevent reflex inhibition. If during an operation inhibition does occur, the distinction between inhibition and obstruction must be borne in mind, for if the case is one of obstruction there will be increased respiratory efforts, but if it is a reflex inhibition respirations instantly cease. In obstruction the pulse continues unaltered for some time before it becomes markedly slower. In reflex inhibition the pulse is instantly and markedly slowed or arrested.

Laryngotomy.—Not infrequently in this operation at the moment the larynx is opened the patient goes into a state of collapse from which he may not recover. This operation is more frequently performed on children, oftentimes in great haste, under the stress of circumstances. If the operation is performed through the cricoid, collapse at the moment of entering does not occur. If made higher, it is very likely to occur, the reason being that in the higher operations the inhibition area of the larynx is mechanically stimulated. This causes a reflex inhibition, as in operations upon the pharynx. The superior laryngeal nerves are endowed with very strong inhibitory functions which are more active in the upper part of the larynx. The clinical observations are in entire accord with the experimental evidence.

CASE 1.—Dr. M. called in a colleague to aid in performing a laryngotomy upon a child who had a grain of corn in the larynx. The operation was successful until the larynx was opened, when suddenly collapse occurred, resuscitation seeming impossible. During the first stages of the collapse the corn was removed. Artificial respiration was maintained for a time, though life seemed extinct, when suddenly respirations began and there was an uneventful recovery.

CASE 2.—I was called to see a child 3 years old having a large bean lodged in the larynx. The history of the case was that while playing the bean, in a fit of laughter, was inspired into the larynx. Paroxysms of coughing followed, occurring at intervals. Each time the child stopped breathing, it became cyanotic and apparently dead. After a brief interval respirations returned, another paroxysm soon followed with a repetition of the collapse. From these symptoms alone the location of the bean was diagnosed as being in the upper part of the larynx. An operation under local anesthesia was performed. The incision was made through the cricoid cartilage, below the so-called inhibition area, and the laryngeal mucosa was treated with a 2 per cent. solution of cocaine, after which the larynx could be readily explored, the bean located and removed without inducing reflex inhibition.

Cases might be multiplied, but the foregoing are typical. The difference between reflex inhibition and obstruction is very marked. Reflex inhibition can not be produced by a foreign body at any point below the so-called inhibition area of the larynx. The importance of the use of local anesthesia, to prevent reflex inhibition in laryngeal operations, can not be overstated.

In all the operations upon the larynx, especially in laryngectomy and intralaryngeal procedures, the use of cocaine and eucain is of the greatest importance. In laryngectomy especial attention has been called to the

collapse that not infrequently appears while removing the larynx from its attachments.

Bardenhauer encountered this three times in one case while inflating the Trendelenburg apparatus. In intubation sudden death frequently occurs, the collapse being due to reflex inhibition of either the respiration or the heart, or both. Cocain or eucain applied to the mucous membrane wholly prevents such reflex inhibition. If such local application can not be applied, all the necessary arrangements for the maintenance of artificial respiration may be made in advance. A hypodermic injection of atropin will prevent the cardiac inhibition, so that, without the use of local anesthesia, atropin, with artificial respiration, may be depended upon to carry the patient over the inhibition crisis. In 156 intubations, I have encountered reflex inhibition six times, twice fatal, and they occurred before the nature of the inhibition was comprehended. Since making use of the experimental data, no case has been lost from reflex inhibition or "laryngeal collapse."

Death can not occur as a result of reflex inhibition if a preliminary hypodermic of a physiologic dose of atropin is given. The use of cocaine is not practical in intubations for diphtheritic stenosis.

CLINICAL SUMMARY.

In the clinical use of cocaine and eucain particular attention is called to a most important feature, viz., that shock is almost wholly avoided, because all afferent impulses are blocked. It is now known that afferent impulses set up by injury or operation are the causes of shock. These impulses are but slightly modified by general anesthesia. The afferent impulse, constituting pain, is abolished by general anesthesia, but those affecting the vasomotor, the respiratory, and the cardiac mechanisms are not controlled; but cocaine or eucain absolutely blocks their passage, making a physiologic amputation of the part. These anesthetics wholly prevent reflex inhibition, the principal causes of collapse in certain operations and injuries, e. g., operations on the larynx and pharynx. Given hypodermically, the experimental evidence shows that they diminish shock in operations on the splanchnic area and absolutely alter this area in the processes of operation or exposure, as abundantly proved by the series of double experiments.

I have had but two opportunities of testing this clinically, both in operations for gunshot wounds of the intestines, and in each the experimental evidence seemed to be corroborated. Comparative results require such a large number of observations that I prefer for the present to offer no more than the clinical suggestion.

CANCER OF THE PENIS.*

HENRY H. MORTON, M.D.

Clinical Professor of Genito-Urinary Diseases in the Long Island College Hospital; Genito-Urinary Surgeon to Kings County and Long Island College Hospitals and the Polhemus Memorial Clinic.

NEW YORK CITY.

Malignant disease of the penis occurs almost invariably as epithelial carcinoma and begins with about equal frequency on the inner surface of the prepuce or upon the glans.

According to Jacobson, its mode of commencement is varied. It appears most frequently as: 1. A wart or warty excrescence. 2. Sometimes, however, it makes its appearance as a small nodule or knot of induration under the surface of the mucous membrane. 3. Again, epithelioma is observed occurring under the form of a

superficial excoriation or raw patch, resembling the erosions found in balano-posthitis. 4. It may develop as an ulcer resulting from the transformation of a chancre or the breaking down of an old cicatrix, or sometimes from a crack or tear on the margin of a tight foreskin.

In cases of extreme rarity epithelioma of the penis develops from the extension of the malignant process outwards from the urethra or upwards from the scrotum.

Etiology.—Under the head of predisposing causes, age plays an important role, and epithelioma of the penis is very rarely found except between the fiftieth and seventieth years.

The next most important predisposing cause is phimosis. Demarquay found that out of 59 cases of epithelioma of the penis 42 had long and phimotic foreskins, and many authors have called attention to the fact that the circumcised Jews are almost entirely free from this disease.

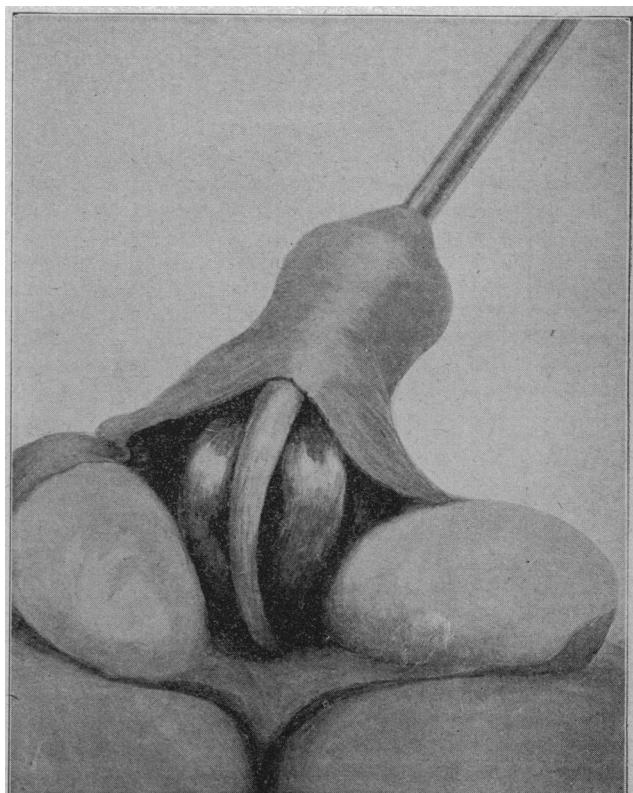


Fig. 1.—Incision dividing scrotum into two halves and exposing corpus spongiosum, urethra, corpora cavernosa and triangular ligament.

Even though the glans be covered with a long foreskin, if the individual attends to the daily cleansing of the balano-preputial sac, there is no opportunity for irritating secretions to be retained; but we notice that cancer of the penis almost always occurs in men in the lower walks of life, of neglectful and uncleanly personal habits.

Any condition which gives rise to a balano-posthitis, such as the retention of decomposed smegma and urine under a phimotic foreskin, particularly if aggravated by a gouty diathesis in the patient, excites a persistent and long-continued irritation. In an elderly person in course of time the simple inflammatory process undergoes a transition into carcinoma of a polymorphous type, composed of large pavement cells and small epithelial cells.

Course.—No matter in what form the disease had its origin, its course is one of extension at the edges, accom-

* Read before the New York State Medical Association.